MAIZE GENETICS COOPERATION

NEWS LETTER

35

April 15, 1961

The data presented here are not to be used in publications without the consent of the authors.

Department of Botany
Indiana University
Bloomington, Indiana

CONTENTS

******

I. FOREWORD

For the first time a new method of reproduction was used in preparing the 1960 Maize Genetics Cooperation News Letter. Although a grant from the National Science Foundation materially aids in meeting the cost of the News Letter, our financial resources were insufficient to meet the cost of multilithing so we were forced this year to resort to the less satisfactory method of mimeographing. It is with regret that this was done but we had to face up to the harsh realities of our meager resources.

You should note that there is a new section for requests of specific stocks. If this proves to be useful, it will be included in future News Letters.

The size of the News Letter has grown markedly in recent years and it has been suggested that material of purely agronomic interest be excluded from future issues. We are in agreement with this sentiment and next fall in our letter requesting contributions we will ask for notes and progress reports of research on genetic (broadly defined) studies.

The editorial assistance of Miss Ellen Dempsey, who has been responsible for editing and assembling the 1961 News Letter, is gratefully acknowledged.

M. M. Rhoades

II. REPORTS FROM COOPERATORS

BALL STATE TEACHERS COLLEGE
Muncie, Indiana

1. The relationship of aneuploidy to sterility in tetraploid maize.

Several studies have failed to show a relationship between aneuploidy and sterility in 4N maize (Punyasingh, 1947 Gen. 32:541; Kadam, 1944 Ind. J. Gen. and Plt. Br. 4:8; Fischer, 1941 Gen. 26:151; Warfield, MNL 1956). These results are not expected from the study of autotetraploids of other plants. Einset, 1947 (Am. J. Bot. 34:99) found a marked difference in fertility between euploid and aneuploid plants of tetraploid Lactuca.

It is clear that several complications arise if such a difference in fertility does not exist in maize. Most importantly, there would not be a clear limit to the range in aneuploid chromosome numbers. In fact, however, the pooled data of 557 plants of Randolph, 1935 (J. Agr. Res. 50:591), Kadam, 1944, and Catcheside, 1956 (Hered. 10:205) indicate that chromosome numbers do not occur beyond the range of 36 to 43 in the progeny of 40 chromosome plants. More significantly, Shaver (1960 U. of Ill. dissertation) in a study of 325 plants, found that the range in chromosome number among the progeny of randomly intercrossed euploids and aneuploids was likewise limited to 36 to 43.

It seems obvious that the apparent limit to the degree of aneuploidy in maize must relate to differential fertility of euploid and aneuploid gametes or zygotes or both, or that a very complex explanation for these limits must be given. If one is unwilling to take the latter course, one should expect to find a positive relationship between (at least female) sterility of a tetraploid maize plant and its degree of aneuploidy.

In the present study, 356 plants of 4N Argentine Flint were counted from root tips. Chromosomes were shortened by the method of Shaver (1960) and stained by the method of Randolph, 1935 (Stain Tech. 10:95). It seemed apparent that 4N Argentine Flint had a greater than expected proportion of euploids. Of 111 plants completely analyzed, 63.1% had 40 chromosomes. Aneuploids were correspondingly rare. These results are summarized in table 1.

Even though the Argentine Flint population is the progeny of randomly intercrossed parents of undetermined chromosome number, its distribution is highly significantly more narrow than the progeny of the pooled data of 40 chromosome plants. The more meaningful comparison, with the random progeny of Shaver, of course, shows an even greater difference. It must be admitted that, since 4N Argentine Flint seems to have a different aneuploid distribution than other maize tetraploids, it may also be different in other respects.

Table 1. Chromosome Numbers of 4N Argentine Flint, and Two Other Tetraploid Populations

Chromosome Number	Argentine Flint	Progeny of Euploid Autotetraploid Zea[1]	Random 4N Zea Population[2]
36		.7%	.9%
37		.4%	1.2%
38		7.5%	9.5%
39	14.4%	10.2%	15.7%
40	63.1%	60.7%	51.7%
41	14.4%	17.6%	14.8%
42	7.2%	2.3%	5.2%
43	.9%	.5%	.9%
Number of plants	111	557	325

1. Pooled data of Randolph, 1935, Kadam, 1944, and Catcheside, 1956.
2. Shaver, 1960.

After the initial analysis of 111 plants, the remainder were merely scanned to pick up the more rare and extreme aneuploids. At pollination, bulked pollen from 38 chromosome plants was applied to silks of 38 chromosome plants, 39's to 39's, etc. Pollinations were repeated every 24 hours to ensure that every silk was fertilized.

Pollen fertility of individual plants was assessed by fixing anthers destined to anthese within 24 hours, and then excising and staining the pollen. Pollen grains with obvious defects were considered to be aborted.

Ovule sterility was assessed by chopping off the tips and butts of each mature ear, thus removing the areas of irregular kernel distribution and areas of frequent "natural" abortion. The kernels were then removed from the rachis, the chaff removed by scraping, and the number of original ovules could then be counted and compared to the number of kernels actually produced.

Table 2 shows the pollen fertility of different chromosome number classes. All possible t-test comparisons reveal that all aneuploid classes differ significantly from the 40 chromosome class, but do not differ among each other.

Table 3 shows the ovule fertility of each chromosome class. All possible t-test comparisons reveal that all aneuploid classes except the scanty 38 class differ significantly from the euploid 40 class, but that the aneuploid classes are not significantly different from one another.

Table 2. Pollen Fertility Among Chromosome Number Classes of 4N Argentine Flint Maize.

Chromosome Number	Number of Plants	Average % Fertile
38	5	91.9
39	8	91.6
40	32	96.1
41	14	91.6
42	11	89.6

All Possible t tests	
38 vs. 39	t = .181
38 vs. 40	t = 5.250**
38 vs. 41	t = .18
38 vs. 42	t = .96
39 vs. 40	t = 2.73*
39 vs. 41	t = .04
39 vs. 42	t = .61
40 vs. 41	t = 4.81**
40 vs. 42	t = 3.24**
41 vs. 42	t = .81

Table 3. Ovule Fertility Among Chromosome Number Classes of 4N Argentine Flint Maize.

Chromosome Number	Number of Plants	Average % Fertile
38	2	30.7
39	12	60.6
40	29	76.6
41	15	67.4
42	9	48.0

All Possible t tests	
38 vs. 39	t = 2.09
38 vs. 40	t = 3.33
38 vs. 41	t = 2.58
38 vs. 42	t = 1.08
39 vs. 40	t = 4.42**
39 vs. 41	t = 1.60
39 vs. 42	t = 1.43
40 vs. 41	t = 3.22**
40 vs. 42	t = 3.51**
41 vs. 42	t = 1.68

Next, correlation coefficients were run to determine if male and female fertility from plant to plant were related. As shown in table 4, even though all r values are positive, only within the 42 chromosome class was the correlation significant at the 5% level. However, the r value for the overall population was highly significant. One can conclude that aneuploidy affects both male and female sterility, but that additional factors may have an additional, and perhaps largely independent, effect.

It is believed the present results differ partially from those of other workers because of the fact that in this study experimental units were classified for chromosome number directly by cytological methods, whereas this stratification in other researches was merely tested as a statistical possibility. However, one cannot rule out the

Table 4. Coefficient of Correlation Between Male and Female Fertility of Individual Plants.

Within the 39 class:	r = .329
Within the 40 class:	r = .252
Within the 41 class:	r = .289
Within the 42 class:	r = .632*
Overall disregarding classes:	r = .458**

possibility that 4N Argentine Flint, a long-time tetraploid, may behave differently than other maize autotetraploids in the characters studied.

D. L. Shaver

CARGILL, INCORPORATED RESEARCH DEPARTMENT
Grinnell, Iowa

Studies at this station involving ultraviolet irradiation of pollen attempt to demonstrate some of the subtle changes which may be masked in large scale and/or long continued irradiation of this type in heterozygous populations. Recurrent irradiation involving 60-110 plants per generation in the check and treatment populations of homozygous diploid HD73, and long term inbred B14 have, after four generations of irradiation, yielded nothing of the spectacular. Irradiation has resulted in poorer stands in some generations, and in the occurrence of occasional monoploids and a single triploid (unproven cytologically). The series will be continued for two or more generations with seed of each generation placed in cold storage. Plans call for an eventual variance analysis in several quantitative traits to detect the presence of induced effects of an individually small, but cumulative, nature.

The possibility of selection pressure accompanying the exposure of pollen to ultraviolet was tested in 1960 in a latin square trial comparing the double cross (Wf9xM14) x normal (Os 420x187-2) with (Wf9xM14) x irradiated (Os420x187-2). The three-way crosses (Wf9x M14) x normal Os420, (Wf9xM14) x irradiated Os420, (Wf9xM14) x normal 187-2, and (Wf9xM14) x irradiated 187-2 were also included. Irradiation had no detectable effect upon harvest moisture or stalk quality. Yields of the two three-way crosses, in sharp contrast to the very slightly reduced double cross, were markedly lowered. The reduction was significant in the case of (Wf9xM14) x irradiated Os420. The full significance of this has not yet been determined.

The irradiator involved consists in principle of three 15 watt germicidal tubes mounted four inches above a cardboard plate. Pollen is exposed as an agitated cloud atop this vibrating plate. Inch high sides allow the cloud to be shifted back and forth to avoid pooling. A one minute exposure, as used in these studies, gives approximately a 50% mortality. Complete mortality has resulted from four minutes of exposure. Plate capacity is such that an individual exposure in the recurrent irradiation study involves the bulked pollen of ten plants. A 110-160 volt AC car generator enables a closed laboratory (station wagon) to be placed right beside the rows to be worked.

E. E. Gerrish

COLORADO STATE UNIVERSITY
Fort Collins, Colorado
Department of Agronomy

1. The Colorado corn collection.

Colorado is still a fertile source of open-pollinated corn varieties, even though hybrids are rapidly becoming predominant. The percentage of corn acreage planted to hybrid seed in Colorado may be compared with that for the United States as follows (Colorado Agricultural Statistics, 1956 Final, 1957 Preliminary: 44; 1958 Final, 1959 Preliminary: 51):

Year	Colorado	United States
1940	1.9%	30.5%
1950	52.0%	78.0%
1959	81.5%	94.8%

In order to preserve sources of genetic diversity, a number of open-pollinated varieties were collected during the autumn season of 1960.

Although the climate of Colorado is generally cool and dry there is a great diversity of environments. Corn is grown at elevations of 3500 feet in the northeast and southeast to 8000 feet in the San Luis Valley of south central Colorado. The growing season for corn varies from 100 days in the San Luis Valley to 190 days at Grand Junction on the Western Slope. Dryland corn is grown on the sandy soils of the eastern plains under an average annual precipitation of 15 to 18 inches. In 1958 irrigated corn accounted for 68 percent of the total acreage and 87 percent of the total production in the state.

The open-pollinated varieties tend to be grown in "clusters" within certain regions. This is particularly true in the drylands. In such cases some of the samples are undoubtedly quite similar genetically; but through knowledge obtained concerning the morphology of each variety, its original source and the direction of any artificial selection that had been applied, obvious duplicates were avoided.

Each collection consisted, whenever possible, of approximately 50 ears or one-half bushel of shelled grain. An attempt was made to include 10 representative ears with each shelled sample. Many of the collections were made by county agents or the farmers themselves. The farmers were asked to select the sample in the same way that they would select their own seed. Thus, only a few of the collections are random samples.

The collections in table I are classified according to (1) endosperm type and (2) kernel color. The influence of two distinct sources can be noted. Most of the collections are derived from varieties which were brought across the plains by emigrants from the central states, beginning in 1858. Along the southern border of Colorado are vestiges of the Mexican strains (variegated colors, flinty and/or floury endosperm) which came in with the early penetration of Mexican settlers into the Rio Grande and Arkansas basins. While not commercially important, these types are particularly well-adapted to short, cool seasons, semi-arid conditions and high altitudes. In most cases 10 representative ears were chosen from each collection for measurement of ear length, ear diameter, and row number, and for determination of surface texture. The surface texture of an ear refers to the surface of the kernel tops and represents an average. A sample of ears, all medium rough to the touch, would be scored the same as one in which half the ears were rough and half smooth. The numbers or descriptions underlined in the case of kernel color and row number are modal classes.

In table II the length of culture does not necessarily represent the actual number of generations that have been grown, since farmers often use seed from a good year for planting in several successive years; there is, however, a general relationship. Relative maturity applies to the number of days from planting to the time at which a particular variety is well dented and safe from frost damage. This is difficult to determine accurately. In addition, a variety which matures in 85 days at 6500 feet may react differently at 8000 feet. Many of the maturity estimates are simply a combination of, e. g., knowledge that a variety has medium maturity for a certain area plus information on the planting dates and average growing season for the region. Because of the "premium" placed on maturity in Colorado there is a tendency to grow varieties which do not utilize the full growing season.

In table III the description "good" isolation refers to those varieties which have been grown for certification, in isolated areas or under careful supervision with respect to isolation. The length of time that selection was practiced for a certain character may range over the entire number of generations grown (most cases were of this type) or may represent a lesser number of generations. Under original source, both the parental strain and locality were listed, if known. The amount collected refers to the actual seed supply on store under refrigeration in the Department of Agronomy. Many varieties had germination percentages in excess of 95%, and only a few showed less than 80% germination. Some varieties had been stored on farms for several years prior to 1960.

Three pound samples of most of the collections have been placed in the National Seed Storage Laboratory at Fort Collins for permanent maintenance. Collection numbers with an asterisk in table I are those not stored in the National Laboratory.

This collection is not complete. An effort will be made to add more varieties, as well as more information on some of those already collected. Reference can be made to the March-April, 1961, issue of Colorado Farm and Home Research (in press) for additional, general information concerning the varieties and their contributors. It is hoped that some of these materials can be used in a corn breeding program for Colorado. They may also be of value in genetic studies and for breeding programs in other localities. One of the first steps in their utilization will be to obtain comparative data on production and other agronomic characteristics in several environments. The Department of Agronomy will be glad to furnish seed samples upon request.

David W. Crumpacker

Table I. Morphology of kernel and ear.

Collection Number	Endosperm Type	Kernel Color	100 Kernel Weight (gm.)	Cob Color	Ear Length (in.)	Ear Diameter (in.)	Row Number	Surface Texture of Ear
1	dent	yellow	33	red	7.5	2.0	12, 14, 16, 18	rough
2	dent	yellow	33	red	7.5	2.0	14, 16, 18, 20	rough
3	dent	yellow	28	red	7.5	2.0	14, 16, 18	rough
4	dent	yellow	33	red	8.5	2.0	14, 16, 18	rough
5	dent	yellow	29					
6	dent	yellow	32					
7	dent	yellow	35					
8	dent	yellow	28	red	8.0	2.0	14, 16, 18	rough
9	dent	yellow	29					
10	dent	yellow	30	red	7.5	2.0	14, 16, 18	medium
11*	dent	yellow	30	red	7.0	2.0	14, 16, 18	medium
12	dent	yellow	29	red	6.5	2.0	14, 16, 18, 20	rough
13	dent	yellow	24					
14	dent	yellow	30	red	7.5	2.0	12, 14, 16, 18	medium
15	dent	yellow, some white caps	29	red, some white	7.5	2.0	12, 14, 16, 18	medium
16	dent	yellow	32	red	7.5	2.0	12, 14, 16	medium
17	dent	yellow	32	red	7.5	2.0	10, 12, 14, 16	medium
18	dent	yellow	28	red	7.0	2.0	12, 16, 18, 20	medium

Table I. (continued)

Collection Number	Endosperm Type	Kernel Color	100 Kernel Weight (gm.)	Cob Color	Ear Length (in.)	Ear Diameter (in.)	Row Number	Surface Texture of Ear
19	dent	yellow	30	red	7.0	2.0	12, 14, 16, 18	medium
20	dent	yellow	35	red	9.5	1.5	12	smooth
21	dent	yellow	34	red	9.0	2.0	14	smooth
22	dent	yellow, some burnt orange, a few white caps	36	red	8.0	2.0	12, 14, 16	medium
23	dent	yellow	25 graded small					
24	dent	yellow	31	red	8.5	2.0	16, 18	medium
25	dent	yellow	31	red	7.0	2.0	12, 14, 16, 18, 20	medium
26	dent	yellow	33	red	10.0	2.0	14, 16	smooth
27*	dent	yellow	32	red	9.0	2.0	14, 16	smooth
28	dent	yellow	31	red	8.0	2.0	12, 14, 16, 18	medium
29	dent	yellow	39	red	9.5	2.0	12, 14, 16	rough
30	dent	yellow	28	red	9.0	2.0	16, 18, 20, 22, 24	smooth
31	dent	yellow	33	red	8.0	2.0	14, 16, 18, 20	medium
32	dent	yellow	29	red, occasionally white	9.5	2.0	16, 18, 20, 22, 24	rough
33	dent, occasionally light dent or flint	red, yellow, yellow with red stripes or sections, occasionally white caps	30	red, white	7.5	2.0	10, 12, 14, 16, 18	medium

Table I. (continued)

Collection Number	Endosperm Type	Kernel Color	100 Kernel Weight (gm.)	Cob Color	Ear Length (in.)	Ear Diameter (in.)	Row Number	Surface Texture of Ear
34	dent, occasionally flinty	red, yellow, yellow with red stripes or sections	20	red, white	6.0	1.5	12, 14, 18	smooth
35	dent, some floury	red	35	red	9.0	2.0	12, 14, 16	medium
36	dent	white	29	white	7.0	2.0	12, 14, 16	medium
37	dent	white	31					
38	dent	white	29	white	8.0	2.0	12, 14, 16, 18	medium
39	dent	white	35	white	8.5	2.0	12, 14, 16, 18	medium
40	dent	white	33	white	7.5	2.0	12, 14, 16	smooth
41	dent	white	30	white	8.5	2.0	12, 14, 16	medium
42	dent, occasionally flinty	white	23	white	6.5	1.5	10, 12, 14, 16	smooth
43	dent, some flour and flint	white, some purple, a few yellow	28	red, white	7.5	2.0	12, 14, 16	medium
44	dent, flint	blue, purple, white, a few yellow	24	white, occasionally red	8.0	1.5	10, 12, 14	smooth
45	flint, occasionally light dent	white	31	white	9.5	1.5	10, 12, 14	smooth
46*	flint	white, yellow, olive, blue, red, pink, purple, occasionally red striped	23	white	6.5	1.5	8, 10, 12	smooth

Table L. (continued)

Collection Number	Endosperm Type	Kernel Color	100 Kernel Weight (gm.)	Cob Color	Ear Length (in.)	Ear Diameter (in.)	Row Number	Surface Texture of Ear
47	flour, some flint	gray, blue, purple, occasionally white	19	white	6.5	1.5	12, 14, 16	smooth
48	flour, occasionally flinty	gray, blue, purple reddish-purple, some burnt orange and white	24	white	6.5	1.5	8, 10, 12, 14, 16	smooth
49	flour, occasionally light dent or flint	gray, blue, purple occasionally white	28	white, occasionally red	7.5	1.5	10, 12, 16	smooth
50	flour, some flint	white, occasionally yellow or purple	23	white	7.0	1.5	10, 12, 14	smooth

Table II. Information on environment and relative maturity.

Collection Number	Place of Culture	Length of Culture (yr.)	Approximate Annual Precipitation (in.)	Approximate Elevation (ft.)	Relative Maturity of Variety (days)
1	N. W. of Haxtun, Logan Co.	13	17	4000	
2	N. W. of Dailey, Logan Co.	10	17	4000	105-110
3	N. of Haxtun, Phillips Co.	14	17	4000	
4	N. of Haxtun, Phillips Co.	37	17	4000	110-115
5	N. W. of Haxtun, Phillips Co.	36	17	4000	105-110
6	N. of Haxtun, Phillips Co.	20	17	4000	
7	N. W. of Haxtun, Phillips Co.	15	17	4000	
8	N. W. of Holyoke, Phillips Co.	10	18	3800	90
9	S. W. of Holyoke, Phillips Co.	9	18	3800	105-110
10	S. E. of Brush, Washington Co.	20-30	17	4600	
11	S. of Akron, Washington Co.		17	4600	
12	N. W. of Yuma, Yuma Co.	1	17	4100	
13	N. E. of Yuma, Yuma Co.	10-15	17	4100	
14	W. of Wray, Yuma Co.	25	17	3800	
15	N. of Wray, Yuma Co.	10	18	3800	
16	N. W. of Wray, Yuma Co.	2	18	3800	
17	S. of Eckley, Yuma Co.	15	17	4000	
18	N. E. of Flagler, Kit Carson Co.	27	16	4700	

Table II. (continued)

Collection Number	Place of Culture	Length of Culture (yr.)	Approximate Annual Precipitation (in.)	Approximate Elevation (ft.)	Relative Maturity of Variety (days)
19	N. E. of Burlington, Kit Carson Co.	4	17	3800	
20	N. W. of Eads, Kiowa Co.	more than 20	15	4300	115-120
21	N. W. of Eads, Kiowa Co.	more than 20	15	4300	120-125
22	E. of Drennan, El Paso Co.	39	15	6100	90
23	S. E. of Ft. Collins, Larimer Co.	34	I 1/	5100	105-110
24	E. of Pueblo, Pueblo Co.	35	I	4600	
25	E. of Pueblo, Pueblo Co.	82	I	4600	
26	Calif. Mesa near Delta, Delta Co.	42	I	5300	110
27	Western Slope, probably Mesa or Delta Co.		I		
28	Fruita, Mesa Co.	15	I	4500	95-100
	Eckert, Delta Co.	20 or more	I	6100	
29	N. E. of Grand Junction, Mesa Co.	more than 15	I	4700	
30	N. E. of Grand Junction, Mesa Co.	38	I	4700	160-170
31	W. of Fruita, Mesa Co.	3	I	4500	120-130
32	S. W. of Cortez, Montezuma Co.	about 30	I	4800	130-140
33	E. of Drennan, El Paso Co.	12	15	6100	80-85
34	S. E. of Calhan, El Paso Co.		15	6500	
35	Purdy Mesa on Kannah Creek, Mesa Co.		I	5000	

1/ Irrigated.

Table II. (continued)

Collection Number	Place of Culture	Length of culture (yr.)	Approximate Annual Precipitation (in.)	Approximate Elevation (ft.)	Relative Maturity of Variety (days)
36	S. of Dailey, Logan Co.	36	17	4000	100-105
	Iliff, Logan Co.	(total)	15	3800	
37	N. W. of Wray, Yuma Co.	25	18	3800	
38	N. of Wray, Yuma Co.	15	18	3800	
39	N. of Burlington, Kit Carson Co.	30	17	3800	
40	Arapahoe, Cheyenne Co.	over 20	16	4000	90
41	N. W. of Eads, Kiowa Co.	over 30	15	4300	
42	Calhan, El Paso Co.	about 50	15	6500	
43	W. of Walsenburg, Huerfano Co.	4	15	6300	
44	N. E. of Platner, Washington Co.		17	4400	
45	N. W. of Eads, Kiowa Co.	54	15	4300	95-105
46	Dolores Co.	1	16	6500	90-100
47	Chama, Costilla Co.		I	8200	80
48	San Pablo, Costilla Co.	39	I	8200	
49	W. of Walsenburg, Huerfano Co.	43	15	6300	
50	W. of Walsenburg, Huerfano Co.	90	15	6300	

Table III. Isolation, selection, source, and amount collected.

Collection Number	Isolation	Selection Practiced	Original Source of Variety	Amount Collected (lb.)
1		lodging resistance, 1-2 ft. ear ht., small cob, short shank, 16 rows; deep, well dented kernel, square base	Haxtun area, 1947	11.6
2	poor	earliness, 16 rows or more, deep kernel	Yuma area	22.8
3	fair	lodging resistance, heavy tassel, 3 ft. ear ht., short shank, 16 rows; deep, dark colored kernel	Haxtun area, 1946	12.6
4	good	short plant, 3 ft. ear ht., moderately rough ear, 16 rows, medium maturity	mixture of Minn. 13 and Reid Yellow Dent; Haxtun area, 1915	22.2
5	fair	16-18 rows; deep oily kernel, shallow yellow cap, some reddish color	Akron area, 1923	24.2
6	fair	moderately rough ear, 16 rows; oily kernel, deep color, square base	Haxtun area, 1938	23.8
7	fair	medium-large ear and kernel	Haxtun area	19.2
8	fair	earliness, rough ear; small, red cob; some reddish kernels	Haxtun area, 1949	13.6
9	fair	earliness	Yuma area, 1950	18.2
10	fair	kernels firmly packed on ear	Yuma area	17.8
11				0.9
12	fair		Yuma area	16.2
13	poor			46.4
14	fair	lodging resistance, 3 ft. or more ear ht., large ear, deep kernel	Yuma area, 1935	15.2

Table III. (continued)

Collection Number	Isolation	Selection Practiced	Original Source of Variety	Amount Collected (lb.)
15	poor			11.6
16	good		Eckley area	37.0
17	poor			12.6
18	good	ear size and shape	Minn. 13; Potter, Nebraska, 1930	51.6
19	poor	large ear	Wray area, 1956	5.4
20		12 rows; long, smooth ear; earliness	Lancaster Surecrop, Pennsylvania	15.0
21		14 rows, smooth ear, medium maturity	Lancaster Surecrop, Pennsylvania	3.8
22	fair	tall plant, thick stalk, 20 in. or more ear ht., medium rough ear, earliness	Drennan area, 1921	32.7
23	good	Colorado 13 type, earliness	Minn. 13; Longmont-Platteville area about 1915-1917	73.2
24	fair	Colorado 13 type	Minn. 13; Colorado Springs area, 1920	7.0
25	fair	Reid Yellow Dent type	Reid Yellow Dent Pueblo area, 1875	18.6
26	good	well filled ear, uniform row no.	Minn. 13; Fort Collins-Longmont area, 1918	6.4
27			Golden Glow	0.9
28	fair	ear of uniform diameter	Cedaredge area	16.6
29			Iowa Goldmine, Iowa	13.4

Table III. (continued)

Collection Number	Isolation	Selection Practiced	Original Source of Variety	Amount Collected (lb.)
30	fair		Uintah Basin, Utah, 1922; originally from Iowa	14.4
31	fair		Minn. 13; Utah, 1957	17.8
32	good	large, rough, ear, tightly packed kernels; red cob, deep kernel	Reid Yellow Dent x White Elephant; S. W. of Cortez, 1930	21.8
33	fair	yellow kernel with red stripes	Fountain area, 1948	39.5
34	good			15.2
35			Bloody Butcher	12.4
36	good	cylindrical ear, 16 rows, white dent kernel	mixture of local white variety and an early white variety from Minnesota; Iliff, 1922-1924	21.9
37	good	ear size, kernel depth		40.4
38	good		probably Iowa Silvermine	11.6
39		large, uniform ear, white kernel		5.8
40	good	ear length, white cob		15.2
41		white dent kernel	native white dent	12.0
42	good		Iowa Silvermine; Calhan area, about 1910	13.4

Table III. (continued)

Collection Number	Isolation	Selection Practiced	Original Source of Variety	Amount Collected (lb.)
43	poor	white dent kernel	Mexico City, 1955	7.2
44				7.4
45		white flint kernel	Australian White Flint; Fort Scott, Kansas, 1906	10.2
46	poor		Maxwell, N. M., 1960	1.3
47	good	purple kernel	Chama area, grown for many years	3.0
48	good	dark red kernel and blue kernel		3.4
49	poor	purple kernel	Mexico, 1917	5.8
50	poor	white flour kernel	Taos, N. M., 1870	4.0

CONNECTICUT AGRICULTURAL EXPERIMENT STATION
New Haven 4, Connecticut

1. Further tests for identity of different sources of sterile cytoplasm.

The 1960 MNL (p. 13) reported our results of preliminary genetic tests to compare nine (our types A-I) additional sources of sterile cytoplasms with S and T types. In the same MNL (p. 21) Buchert reported tests on the same nine sources. Evidence from both series of tests indicated that the nine independent sources carried S type cytoplasm. The origins of the nine new sources are given in the 1960 MNL (p. 14).

In 1960 two additional genetic tests were conducted which support the earlier findings. Each of the new sources of sterile cytoplasm is in process of being combined with the genotypes of inbreds A158 and WF9, from 2 to 10 backcrosses having been made to date. The A158 series of steriles was crossed by NY16, a restorer for both S and T. As previously reported, however, restoration in types A-I was approximately 50%. This was taken as evidence that all nine cytoplasms were S type, since according to Buchert's findings on the behavior of S restorer genes in heterozygous condition (MNL, 1959), pollen grains with the non-restoring allele abort and restoration is thus only 50% in the presence of S cytoplasm. In contrast, restorer genes for T type cytoplasm give close to 100% restoration when heterozygous. It was pointed out in the previous report that if the A-I restored steriles do have S cytoplasm and typical S restorer genes they should give all fertile offspring when crossed as pollen parents to the appropriate A158 A-I sterile seed parents, but should segregate sterile and fertile when crossed as seed parents by normal A158, since gamete selection occurs in the pollen but not in the egg cells. Accordingly, each of the F_1's between the A158 A-I steriles and NY16 was used as pollen parent on the corresponding A158 sterile, and as seed parent in crosses with normal A158. In each case the same restored sterile F_1 plant was used as male and female parent. For each restored single cross the left column in table 1 gives the results when the restored single cross was used as seed parent, and the right column when it was used as pollen parent. As seen from the table the expected results were obtained except for families of A158G and A158H, each of which gave one sterile plant when the restored F_1 served as male parent. These same families, however, also contained some partially restored types. Evidently, the restorers from NY16 were less effective in combination with the residual genotype of A158G and A158H, and it is probable that the two plants classified as sterile did have the major S restorer gene from NY16.

The second genetic test for characterization of the new sources of sterile cytoplasm involved the use of A158 restored lines previously shown to carry exclusively S or exclusively T restorers. These tester lines of A158 originally carried both S and T restorers from Ky21, but

by repeated backcrosses to one type of cytoplasm restorers for the other type were lost. Thus each of the A158 steriles was crossed by A158TF4 (carrying T restorers only) and by A158SF5 (carrying S restorers only). Both the TF and SF restorer lines were homozygous for the restorer genes. The results are listed in table 2. In addition to the A-I steriles, this test also included sterile cytoplasms J, K and L, and an M14 with sterile cytoplasm from Reid's yellow dent obtained from Iowa. This test confirms that sources A-I, as well as sources K and L, and the Reid sterile contain S type cytoplasm.

Source J, which came from a Bolivian variety, is apparently T type, since it was not restored by the A158SF tester. Other evidence for this is the fact that the Bolivian variety which furnished the J cytoplasm had T, but not S, restoring genes. Further, heterozygous J type restored steriles (with the restorer from the Bolivian variety) are approximately 100% rather than 50% fertile.

Table 1.

	♀ x A158			A158 sterile (A-I) x ♂		
	F	S	PF	F	S	PF
A158S12 x NY16	8	11	1	21	0	0
A158A6 x NY16	15	6	1	19	0	0
A158B8 x NY16	12	7	1	17	0	0
A158C5 x NY16	13	6	2	21	0	0
A158D1 x NY16	13	5	3	21	0	0
A158E4 x NY16	13	8	0	18	0	0
A158F3 x NY16	11	9	1	21	0	0
A158G x NY16	9	10	0	10	1	5
A158H x NY16	12	9	1	11	1	5
A158I x NY16	13	6	0	19	0	1

Table 2.

	A158TF4 #10♂			A158SF5 #19♂		
	F	S	PF	F	S	PF
A158T8	20	0		0	18	
A158S13	0	22		17	0	
A158A7	0	18		19	0	
A158B9	0	19		20	0	
A158C6	0	19		20	0	
A158D2	0	17		9	0	8
A158E5	0	19		19	0	
A158F4	0	20		18	0	
A158G1	0	16		21	0	
A158H1	0	20		18	0	
A158I1	0	20		18	0	
A158J3	-	-		0	15	
A158K1	0	19	1	19	0	
A158L1	0	23		16	0	4
M14 Reid sterile	0	21		20	0	

Harry T. Stinson, Jr.

2. Behavior of Ind 33-16.

Josephson and Jenkins showed (Jour. Amer. Soc. Agron. 1948) that male sterility in certain double cross hybrids involving the inbred 33-16 was due to the presence of 33-16 cytoplasm. Cytoplasm from 33-16 is represented in our collection by source H, which, as shown above, is identical with S type cytoplasm by all genetic tests. Since the inbred 33-16 is fertile, it presumably has a full complement of all necessary S restorer genes. However, certain findings of Josephson and Jenkins raise questions about the nature of fertility restoration in 33-16. Of the five single crosses involving 33-16, three were listed as fertile with only 1-15% sterile plants. But two single crosses, 33-16 x K63 and 33-16 x Mo2 RF, were reported to give 95% and 99% sterile plants respectively. The latter results are unexpected, and suggest either that all, or some, of the restorer genes in 33-16 are recessive, or that K63 and Mo2 RF possess dominant genes which prevent normal expression of the 33-16 restorers.

Crosses recently grown at this Station provide some information on the behavior of 33-16. First, it is clear that 33-16 does carry restorer genes for S type cytoplasm. Moreover, like S restorers from other sources, the restorers in 33-16 are dominant. The single crosses A158S13 x 33-16, WF9S13 x 33-16, as well as A158 steriles A-I x 33-16 and WF9 steriles A-I x 33-16 were fertile. Further, pollen fertility appeared to be approximately 50% in the plants of these single crosses examined with a hand microscope in the field, and an actual count of pollen stained with IKI in the hybrid WF9S12 x 33-16 revealed 55% well filled grains. Thus, when heterozygous, the S restorers in 33-16 appear to behave like typical S restorers in their effects on pollen viability. Preliminary evidence for allelism between the S restorers from Ky21 and 33-16 was found in the cross A158SF4 (homozygous for S restorers from Ky21) x 33-16, where the three plants examined appeared to be nearly 100% restored. If the restorer genes from the two sources were non-allelic and completely independent, 25% of the pollen grains would lack restorers and abort, fertility thus being only 75%.

The cross WF9T11 x 33-16 was completely sterile; 33-16 does not, therefore, have the two genes needed to restore WF9T steriles.

Since the restorer genes in 33-16 are apparently dominant like other known S restorers, attention was also directed toward the inbreds K63 and Mo2RF, the two inbreds Josephson and Jenkins reported to give sterile F_1 hybrids with 33-16 as seed parent. When grown in Connecticut the hybrid 33-16 x Mo2RF was almost completely sterile; anthers were extruded in an irregular pattern, and little or no pollen was shed. The cross 33-16 x K63 was more fertile, but was not fully normal, the anthers frequently failing to open.

These inhibitory effects of Mo2RF and K63 on pollen restoration were not expressed on S restorer genes from Ky21. Crossed to A158SF lines homozygous for Ky21 restorers, both Mo2RF and K63 gave fertile

plants with the expected 50% viable pollen. Thus, Mo2RF and K63 do not invariably prevent restoration in single crosses with restored steriles, and the high degree of sterility observed in the crosses 33-16 x Mo2RF and 33-16 x K63 must in some manner depend upon the genotypes peculiar to these hybrids.

Several investigators have pointed out that certain inbreds, including restorer lines, may lack one or more "modifier" genes which complement the "major" restorer genes in bringing about complete restoration. Sterility in the two exceptional single crosses could be explained by assuming that Mo2RF and K63 do not carry all of the necessary modifiers. However, these modifiers must be present in 33-16 since it contains S cytoplasm and is fully fertile (in Connecticut at least). Presumably, therefore, 33-16 would contribute the necessary modifiers to the single crosses with Mo2RF and K63. But it could be argued that the modifiers in 33-16 are recessive and that Mo2RF and K63 carry the dominant alleles. In other words, pollen fertility in S cytoplasm would require in addition to dominant restorer genes, one or more recessive modifiers, which are absent in Mo2RF and K63. If this is true, it is difficult to explain why Mo2RF and K63 did not also produce sterile offspring when crossed to the restored S sterile line A158SF (restorers from Ky21).

A possible, formal explanation for the observed results can be suggested. The restorer system in 33-16 may require recessive modifiers which are not essential for restoration in A158SF which has restorers from Ky21. The inbreds Mo2RF and K63 would carry the dominant alleles of these modifiers whose presence would prevent complete fertility in single crosses with 33-16, but would have no effect on F_1's with A158SF. The fact that 33-16 restores A158S and WF9S in F_1 would mean that the latter two inbreds carry the recessive modifiers. This is also indicated by the crosses 33-16 x A158 and 33-16 x WF9, both of which are fertile, and by the cross A158SF x 33-16 which is close to 100% fertile.

Evidence bearing on the above formal scheme can be obtained from the comparative behavior of A158SF with restorers from Ky21 and A158SF with restorers from 33-16. These two restored lines with a common A158 residual genotype might be expected to breed differently (when crossed by Mo2RF and K63, for example) if the S restorer systems in 33-16 and Ky21 differ in their requirements for modifier genes.

Harry T. Stinson, Jr.

3. <u>The ms_1ms_1 genotype in T cytoplasm.</u>

As pointed out in earlier notes all evidence indicates that genic and cytoplasmic male sterility are controlled by completely independent genetic systems. As part of this evidence we have previously cited the behavior of a <u>ms_1ms_1</u> genotype in plants with S cytoplasm and S restorer

genes (MNL 1959, p. 14). Such plants were male sterile, thus demonstrating that the ms_1 gene operates in S cytoplasm and is not inhibited by S restorer genes. We have now obtained ms_1ms_1 individuals with T cytoplasm and T restorers.

The procedure by which this combination was produced is the same as that described earlier, and takes advantage of the close linkage between the ms_1 and y loci. C103T$Rf_1rf_1Rf_2Rf_2YYMs_1Ms_1$ plants were crossed as female by a WF9 stock heterozygous at the ms_1 locus, i.e. WF9$rf_1rf_1rf_2rf_2YyMs_1ms_1$, and several fertile F_1 plants were selfed. White kernels on 2 segregating ears were planted. Ignoring X-overs, these white kernels should be of the genotype $yyms_1ms_1$, and 9/16 of them should carry the Rf_1Rf_2 genes. If the ms_1 gene does not produce male sterility in T cytoplasm in the presence of the T restorer genes, 9/16 of the plants from white kernels would be expected to be fertile. The actual results in the two families were 38 sterile:1 fertile and 39 sterile:0 fertile. The ms_1ms_1 genotype, therefore, must be unaffected by T cytoplasm and T restorers.

Harry T. Stinson, Jr.

CORNELL UNIVERSITY
Ithaca, New York

1. Cytogenetic changes induced by vegetable oils in Zea mays - a preliminary study.

Certain vegetable oils have been found to induce cytological and genetic changes in wheat.[1] Based on these findings, a similar project was initiated[2] to study the effects of castor and peanut oils on corn.

Procedure. Corn seeds were treated by soaking in castor and peanut oils for periods of 6, 12, 18 and 24 hours. Wiped dry, the seeds were germinated in petri dishes. Controls of untreated seeds were also set up. Excised root tips were fixed in fresh Carnoy's acetic-alcohol for

---

1. Swaminathan, M. S. and Natarajan, A. T. Cytological and Genetic Changes Induced in Vegetable Oils in Triticum. Journal of Heredity July-August, 1959. pp. 177-187.

2. This study was made possible by a grant under the National Science Foundation Teacher Research Participation Program. The project was carried out under the direction of Dr. Margaret Thompson, Department of Plant Breeding, Cornell University.

two hours, washed in 70% ethyl alcohol and then rinsed in water. If necessary, the root tips may be preserved at this point by allowing them to remain in the 70% ethyl alcohol. A 10% solution of formalin was used for hardening. The root tips were permitted to remain in the hardening solution for 4 hours. This was followed by treatment with 4% sodium hydroxide solution for 2 hours. The roots were then washed in water and immersed in 10% acetic acid to eliminate all traces of the sodium hydroxide. If the roots must be preserved for study at a future date, they may be placed in fresh 70% ethyl alcohol. The squash technique was used for the preparation of the root tips for staining. Aceto-carmine was used for staining.

Results. Table 1 indicates the number of mitotic figures and abberations that appeared for each of the time intervals and for the controls completed in this preliminary study.

Table 1

Frequency of mitotic figures and abberations in root tips of Zea mays treated with castor and peanut oils

Figures	Control	Castor Oil (No. of hrs.)				Peanut Oil (No. of hrs.)			
		6	12	18	24	6	12	18	24
Prophase	8	39	86	35	35	26	68	91	
Metaphase	18	37	52	52	35	56	99	56	
Anaphase	24	25	71	69	35	75	161	53	N
Telophase	4	22	25	32	22	21	29	57	o
Lagging at metaphase	2	21	14	13	4	15	13	3	
Two nucleoli	5	20	9	9	13	8	16	91	D
Binucleated	3	2	0	5	2	3	3	1	a
Lagging at anaphase	0	12	6	8	5	4	6	3	t
Anaphase bridge	0	10	8	8	5	5	17	8	a

Micronuclei appeared in a total of three cells from four root tips of seeds that had been treated for 18 hours with castor oil.

In the above data, cells were noted where the chromosomes failed to move with the others to the metaphase plate or to the poles during the anaphase. These chromosomes were found at random positions throughout the cell. Table 1 indicates these as "Lagging." Cells were also

noted where a bridge of chromosomes was formed from one pole to the other during anaphase. These are referred to in Table 1 as "Anaphase bridge."

Interpretation of the Data. In any interpretation of data, it is important that the number of cases be statistically significant. In this preliminary study, only one root tip was examined for each of the time intervals indicated in Table 1, with the exception of four root tips from seeds that had been treated for 18 hours with castor oil. The number of cells per root tip, however, was large. The following trends were noted:

1. The number of mitotic figures was greater in the treated seeds than in the controls. Since the root tips were cut the same length and at the same time of the day, the vegetable oils may be acting as a stimulant in cell division.

2. The number of cells with mitotic aberrations was greater in the treated seeds than in the controls. There was no apparent effect on the number of binucleated cells.

3. The number of cells with two nucleoli in the treated material (91) is significantly greater than in the control (5). Further data are required to determine the effect of the peanut oil on the role of chromosome 6 in the formation of the nucleolus.

Fred Winston

DEKALB AGRICULTURAL ASSOCIATION, INC.
DeKalb, Illinois

Fifteen commercial hybrids were placed in eight different 7 x 7 latin square experiments last summer. The arrangement of the hybrids within the plots and the plot locations are shown in Tables 1 and 2. Averages are for number of fertile (F.) and sterile (S.) tassels. Partial fertiles of all classes were included in the sterile count for each entry. Yield deviation is the total of the deviations for each of three pairs of restorer vs. normal version of a hybrid. Where the restorer version outyielded the normal one its deviation is a plus figure. LSD's at the 5% level are given in bushels per acre for each experiment. One general conclusion which may be drawn is that at no environmental region under test did the percent of fertile tassels reach the danger level. It is interesting to note in table 1 that the ratio of fertile to sterile tassels decreased at each extremity of the "corn belt." Also of interest is the indication from the same table that a higher plus yield deviation is correlated with the lowest ratio of fertile to sterile tassels. The negative yield correlations are disappointing but not discouraging. As restored versions of male parental lines are improved negative yield differences tend to diminish.

Loring M. Jones

Table 1

Comparison between Restorer Pilot Production and Sterile-blended or Normal Commercial Production, 1960

Expt.	R51-2			R51-3			R51-4			R53-1			R53-2			R53-3			R53-4		
DeKalb	Fremont, Neb.			Dayton, Iowa			Grinnell, Iowa			Morris, Ill.			Crawfordsville			Marion, Ohio			Lancaster, Pa.		
Hybrid	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield
# 1	185	78	109.5	205	69	111.8	142	117	85.2	139	137	121.2	144	138	121.5	158	125	142.5	169	56	68.0
# 1R	184	81	113.4	217	54	117.3	191	65	89.1	158	117	122.2	151	126	126.2	186	95	139.8	214	47	84.1
# 2	191	64	100.5	217	58	108.0	151	98	83.2	167	112	112.0	147	126	109.8	161	121	135.1	186	50	73.1
# 2R	181	72	108.6	162	105	113.1	128	136	90.9	124	153	115.2	89	193	124.7	119	150	142.6	210	47	78.2
# 3	202	65	117.3	211	66	121.8	148	119	90.8	140	136	124.2	84	194	126.6	118	162	151.1	230	33	94.5
# 3R	160	85	122.8	233	51	118.7	171	97	96.4	166	115	134.7	105	172	138.2	162	119	152.8	210	29	86.6
# 4R	174	82	113.6	198	75	107.9	105	141	88.1	131	148	121.6	114	162	124.8	135	150	139.6	224	46	89.8
Ave.	182	75		206	68		148	110		146	131		119	159		148	132		206	44	
LSD 5%			9.7			8.3			6.5			6.4			8.4			7.7			10.5
Yield deviation between pairs			+17.5			+7.5			+17.2			+14.7			+31.2			+6.5			+13.3

Expt.	R50-2			R50-3			R50-4			R52-1			R52-2			R52-3			R52-4		
DeKalb	Fremont, Neb.			Dayton, Iowa			Grinnell, Iowa			Morris, Ill.			Crawfordsville			Marion, Ohio			Lancaster, Pa.		
Hybrid	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield
# 5										147	132	122.0	145	120	121.9	145	133	138.4	213	47	81.1
# 5R	151	125	106.9	187	90	106.7	105	158	88.5	123	157	117.7	98	168	134.5	117	172	139.9	216	49	79.3
# 6	181	98	114.3	191	89	120.7	110	162	102.8	120	155	126.3	123	151	134.0	110	169	143.1	222	49	92.0
# 6R	177	96	101.6	191	85	108.8	132	140	88.5	126	153	118.2	122	146	128.1	125	158	136.9	222	56	87.5
# 7	187	76	112.9	210	65	116.2	140	115	94.6	131	147	126.0	135	127	127.4	158	123	139.3	244	32	93.6
# 7R	158	118	116.4	202	69	115.8	109	163	103.0	111	167	126.6	108	166	135.2	131	153	140.9	239	38	91.2
# 8	166	85	110.2	192	85	109.0	109	145	91.4												
# 8R	161	104	107.2	209	69	111.1	129	118	82.7	145	132	109.1	146	132	137.2	142	142	134.4	209	57	84.4
Ave.	169	100		197	79		119	143		129	149		125	144		133	150		224	47	
LSD 5%			N.S.			8.7			10.4			6.7			N.S.			N.S.			7.3
Yield deviation between pairs			-12.2			-10.2			-14.6			-11.8			+14.5			-3.1			-8.7

Table 2
Comparison between Restorer Pilot Production and Sterile-blended or Normal Commercial Production, 1960

Expt.	R48-1			R48-3			R49-1			R49-2			R49-3		
DeKalb	N. Platte, Neb.			Humboldt, Iowa			Oelwein, Iowa			Waterman, Ill.			Deshler, Ohio		
Hybrid	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield
# 9							276	0	97.4	255	0	114.2	263	1	122.8
# 9R	86	191	127.4	103	176	80.6	36	245	103.2	67	211	118.6	71	198	133.8
# 10	233	44	120.2	280	0	73.3									
# 10R	108	170	126.2	104	176	76.5	68	309	94.5	68	208	112.5	93	172	125.2
# 11	271	7	117.1	280	0	83.3	283	6	100.1	250	0	119.5	240	36	117.2
# 11R	181	97	129.4	143	137	77.8	160	121	98.7	123	156	124.4	128	140	123.0
# 12	212	39	104.6	280	0	78.4	281	0	106.4	231	0	118.0	252	20	114.0
# 12R	148	128	115.1	137	143	72.7	177	104	101.7	112	164	118.8	127	145	118.0
Average	177	97		190	90		183	112		158	106		168	102	
LSD 5%			N.S.			N.S.			5.9			6.2			7.9
Yield deviation between pairs			+28.8			-8.0			-0.3			+10.1			+20.8

Expt.	R54-1			R54-2			R54-3			R55-2			R55-3		
DeKalb	Topeka, Kansas			Shenandoah, Ia.			Marshall, Mo.			Tuscola, Ill.			Mt. Carmel, Ill.		
Hybrid	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield	F.	S.	Yield
# 1R	205	47	128.0	143	139	109.9	182	89	141.0						
# 4	103	94	121.9	94	208	106.0	152	121	139.1	123	132	140.0	135	139	101.2
# 4R	110	79	124.4	119	156	114.8	143	124	136.5	134	130	139.3	127	140	95.7
# 13	129	76	124.1	109	187	113.5	131	143	134.2	127	138	127.4	138	133	94.8
# 13R	92	124	124.9	80	228	112.6	79	198	133.5	82	170	129.7	85	176	90.0
# 14	105	98	127.2	110	162	104.7	138	134	139.8	130	132	139.1	113	156	102.5
# 14R	169	115	118.5	79	215	81.1	166	107	121.3	155	112	121.0	191	77	92.1
# 15R										145	121	131.8	127	140	97.9
Average	130	90		105	185		142	131		128	134		131	137	
LSD 5%			N.S.			10.5			5.0			9.8			7.8
Yield deviation between pairs			-5.4			-15.7			-21.8			-16.5			-20.7

GEORGIA EXPERIMENT STATION
Experiment, Georgia

1. Recovery of loose pericarp in the F_2 progeny from crosses between inbred lines.

In our previous reports (Jour. Heredity 49: 128-131, 158; 51: 15-18, 1960) it was postulated that, in addition to the effect of the amount and the position of hard and soft starches in the endosperm of corn, loose pericarp may be involved in bringing about various degrees of denting or roughness of grain.

The results of 1960 seemed to support this assumption.

The following inbred lines were used: Inbred NC4F11 has rough grain resembling that of Gourdseed, and which is classified as grade 4. Ears of inbred lines GE54, P111, and NCAS21A are smooth except for prominent silk scars which make them prickly to the touch and are classified largely as of grade 2. Inbred CI21 have perfectly smooth ears of grade 1.

The ears of the F_1 progeny from the cross of NC4F11 with other inbred lines are largely of grade 4, and the F_2 progeny segregated for grades 1 to 6 (Table 1).

Table 1. Frequency distribution for pericarp grades in the F_2 from crosses of NC4F11 inbred line with other inbreds.

Cross	Progeny pericarp grades						
	1	2	3	4	5	6	Total
GE54 x NC4F11	7	34	64	66	3	2	176
P111 x NC4F11	35	40	79	15	1	-	170
CI21 x NC4F11	37	14	61	56	2	-	170

The ears of the F_1 progeny from the cross of GE54 with other inbred lines are largely of grade 2, and the F_2 progeny segregates for grades 1 to 5. (Table 2).

Table 2. Frequency distribution for pericarp grades in the F_2 from crosses between GE54 and other inbred lines.

Cross	Progeny pericarp grades						
	1	2	3	4	5	6	Total
GE54 x P111	48	59	11	-	2	-	120
GE54 x NCAS21A	50	99	28	5	3	-	190
GE54 x CI21	37	77	5	-	-	-	119

Somewhat different results were obtained from the Flint - Gourdseed varieties cross. The smooth grain of Flint is dominant over rough grain of Gourdseed. In the F_2 progeny several ears were of grades 2 to 4 (Table 3).

Table 3. Pericarp grades in the F_2 of Flint - Gourdseed cross.

Cross	Progeny pericarp grades						
	1	2	3	4	5	6	Total
Flint x Gourdseed	153	2	6	3	-	-	164

The appearance of ears with pericarp grades 5 and especially of grade 6 seemed to support our assumption that the genes for loose pericarp are not uncommon, and that the rough grain is the result of interaction of denting (genes for hard and soft starches?) and for loose pericarp.

G. A. Lebedeff

HARVARD UNIVERSITY
Cambridge, Massachusetts

1. Further data on the compound nature of the tunicate locus.

In a previous News Letter (No. 34) we reported that "mutations" from Tu to tu^h were accompanied by crossing over between Su and Gl_3, genes on either side of the Tu locus. An additional population was grown in 1960 and in the three years since this experiment began a total of 10,248 plants have been classified. Of these, 5273 were tunicate and 4975 were nontunicate. The significant deficiency of nontunicate plants is probably due to the linkage of tu and su and the poorer germination of sugary seeds as compared to starchy in 1960 when poor stands were obtained.

Of the 5273 plants classified as some form of tunicate, four were definitely half tunicate. All four of these plants proved to be crossovers, two of the genotype Su gl_3 and two su Gl_3. This indicates that the "mutations" are due to crossing over within a compound locus and that the rate of crossing over is one in 1318 or .08 percent.

Three additional plants classified as possible mutations but representing the noncrossover genotype, Su Gl_3, proved upon testing to be not mutations to half tunicate but phenocopies. This evidence, though negative in nature, provides a further indication that mutations from Tu to tu^h are the product of crossing over.

These half-tunicate mutations are being introduced as rapidly as possible into isogenic stocks through repeated backcrossing to the inbred A158. Those originating from the crossover Su gl_3 represent the left hand or l (levo-) component of the compound tunicate locus and those from the crossover su Gl_3, the right hand or d (dextro-) component. If these two components prove to be identical then it is probable that the tunicate locus is one which has originated during domestication and in this case the wild locus probably was tu^h. If the two components prove to be different then the following two possibilities must be considered. (a) The wild locus is Tu since it seems highly improbable that the two components have become differentiated during only a few thousand generations of evolution under domestication. (b) There are two wild loci, tu^h-l and tu^h-d, each characteristic of a distinct wild race of maize. During domestication these two loci have been brought together on the same chromosome to produce the present Tu locus.

In two stocks which are now five eighths A158 the two components are consistently slightly different. The genotype containing the l component having slightly longer, more hairy pistillate glumes than the genotype containing the d component. The differences may, however, be due not to the components themselves but to other genes on the same chromosomes and they may disappear as additional backcrosses make the stocks more nearly isogenic.

In any case it now appears certain that wild corn was a form of pod corn either tunicate or half tunicate. If the latter, it is possible that there were two slightly different forms of half tunicate.

P. C. Mangelsdorf
W. C. Galinat

2. The behavior of pod corn in a simulated wild habitat.

In a recent paper "Reconstructing the Ancestor of Corn" it was shown that by combining the primitive characteristics of pod corn and popcorn it was possible to produce a corn bearing part of its seeds in the tassel and the remainder in one or more small ears arising from the higher nodes of the stalk and having only a few husks which open at maturity allowing the seeds to be dispersed. It was assumed that this corn represented a genetic reconstruction of the ancestral form and an accompanying drawing showed how this ancestral form might have grown in several different environments including a poor site in nature in competition with other vegetation. Under these conditions it was assumed that it would produce no ears but would have an unbranched terminal inflorescence with staminate spikelets borne above and pistillate spikelets below on the same unbranched spike.

When this drawing was made we had not actually produced such plants but on the basis of observations of depauperate plants over a period of years we were reasonably certain that homozygous pod-popcorn plants grown under an unfavorable environment would have the characteristics illustrated. We have now grown the reconstructed ancestral form in a simulated wild habitat and the results are in general agreement with our expectations.

Seedlings of a homozygous pod-popcorn which had been inbred for four generations were started in small pots, eight seeds to a pot. The seedlings, already somewhat stunted by crowding when compared to normal corn seedlings the same age growing in a cultivated field, were transplanted to a fence row consisting of a thick sod made up of various weeds and grasses the principal one of which was the aggressive perennial couch grass, Agropyron repens. The hills were planted two feet apart and were not cultivated. Under these conditions the plants were quite stunted, most of them growing no taller than the couch grass and other grasses with which they were competing, but all produced tassels. The tassels were unbranched or only sparsely branched and bore staminate spikelets above and pistillate spikelets below. In their general botanical characteristics these plants were the exact counterpart of the plant illustrated in the article referred to above except that they were much shorter in stature. Plants of this type have a means of seed dispersal and should be capable of surviving in the wild in a suitable environment.

The second experiment, one which has demonstrated a marked selective advantage of pod corn in a simulated wild habitat, involved the planting in this same fence row of a population consisting of heterozygous tunicate and nontunicate plants in equal numbers. These plants, not being inbred but the product of a backcross, were much more vigorous than the homozygous tunicate plants described above and grew surprisingly well in the limited space available to them and in competition with aggressive weedy grasses. Both tunicate and nontunicate plants reached a height of 3-4 feet and both produced tassels. At this point the selective advantage of the tunicate plants became apparent, for, while the majority of the tassels of the nontunicate plants were sparsely branched and strictly staminate, most of the tassels of the tunicate plants were branched and all bore some pistillate spikelets.

The tunicate plants had an average of 4.0 branches per tassel compared to 1.7 for the nontunicate plants and an average of 77.8 pistillate spikelets compared to an average of 3.6 pistillate spikelets for the nontunicate plants. Since practically all of the pistillate spikelets set seed in both genotypes, the selective advantage of the tunicate over the nontunicate plants in seed production was more than 20 fold. At the time that pollen was being shed no plants of either genotype had ears.

One of the characteristics of pod corn is that it concentrates its energy in the terminal inflorescences at the expense of the lateral ones. The result is that homozygous pod corn grown under cultivation in well-fertilized fields is often quite monstrous. But the very characteristics which make pod corn sometimes monstrous under cultivation are those which provide it with a substantial selective advantage in a simulated wild habitat and which, presumably, would do so in nature. Under these conditions tunicate plants also have a means of dispersal which cultivated corn, its grain-bearing, lateral inflorescence tightly enclosed in husks, lacks. As the seeds ripen the tassel branches become brittle and are easily broken by birds attempting to consume the seeds or by strong winds; the seeds drop to the ground in clusters where, in a situation involving a mild climate with a distinct dry season, they would remain until the beginning of the next rainy season. It is possible that even in this climate some will survive the winter and produce seedlings in the spring. However, not all of this dispersal has occurred at once but has been spread over a period of months. Even as late as December about one third of the seeds still remained on tunicate plants either at the base of branches or the central spike. These too will probably be dispersed as the tassel branches weather, weaken, and break away.

P. C. Mangelsdorf
W. C. Galinat

3. Pointed kernels, a simple Mendelian character.

Among our various stocks of homozygous pod-popcorn some have round and some have pointed kernels. F_1 hybrids usually have kernels more or less intermediate in shape and in F_2 populations both parental types reappear. This suggested that the pointed shaped kernels might be governed by a relatively small number of loci.

During the past season we classified four progenies segregating for kernel shape. In a total of 80 plants, 60 had kernels exhibiting some degree of pointing and 20 had round kernels. Thus the pointed shape seems to be a simple Mendelian character exhibiting incomplete dominance.

Pointed shape appears to be linked with Tu on chromosome 4. In these particular crosses the pointed shape was introduced by a non-tunicate popcorn, Palomero Toluqueño, of Mexico. The distribution of pointed, intermediate, and round seeds in the genotypes, Tu tu and tu tu, is shown below. The Tu Tu plants were usually not classifiable with respect to kernel shape.

Shape	Tu tu	tu tu	Totals
Pointed	29	2	31
Intermediate	16	13	29
Round	3	17	20

We have called attention elsewhere (Mangelsdorf and Reeves, 1959) to the fact that wild corn was probably both pod corn and a popcorn with pointed kernels. The pointed shape is necessary to enable the kernels to fit snugly in the protective shell provided by the glumes of tunicate maize. These data indicate that two of corn's primitive characters, tunicate and pointed kernel shape, were Mendelian dominants which could have been lost through simple mutation. If the loci for tunicate and pointed seeds are linked, as the above data indicate, then chromosome 4, which carries these genes as well as the Ga locus, probably also a wild locus, must have been one of the most important chromosomes distinguishing wild from cultivated corn.

P. C. Mangelsdorf

4. Linkage relations of the tunicate inhibitor.

In a previous News Letter we reported a gene which has an inhibiting effect upon the action of the Tu and tu^n loci reducing their expression by approximately half. The data available indicated linkage with Y on chromosome 6 but were not conclusive. Additional data subsequently obtained support the earlier indication. A backcross population was classified as follows: yellow inhibited 142; yellow normal 90; white inhibited 62; white normal 155. The two middle classes are the crossovers and represent 33.9 percent of the total. The data leave little doubt that the inhibiting gene is located on chromosome 6. We have no tests to show whether it is to the right or left.

If wild corn was a pod corn, then its genotype probably included two other loci interacting with the Tu locus: a gene for pointed kernel shape on chromosome 4, reported above, and a gene partly inhibiting the expression of Tu or tu^n which the data immediately above show to be located on 6.

P. C. Mangelsdorf

5. The genotypes of two primitive races of maize.

A race of corn with cherry pericarp collected in Panama and Costa Rica and similar to the race, Kculli of Peru, appears to have virtually all of the known pericarp and plant colors. Not all of these are visible in the "pure" race but become so with outcrossing to other races. When cherry pericarp is removed through outcrossing red pericarp becomes visible; when all pericarp color is lacking purple aleurone becomes apparent. In the absence of purple aleurone, brown and orange aleurone can be identified. Thus this race seems to have the following color genes on seven of corn's ten chromosomes: P on chromosome 1, A or A^b on 3, Pr on 5, Pl on 6, Bn on 7, C on 9, and an R allele on 10. Since several of these genes have no visible effects except in combination with others, it is unlikely that they were brought together in one genotype by conscious hybridization and selection on the part of Indian plant breeders. It seems more probable that they represent an assemblage of genes found in one race of wild corn. If so, this race is quite distinct in its genotype from certain other races such as Palomero Toluqueño of Mexico which had an entirely different assemblage of wild genes including Ga, at one time probably Tu, and a gene for pointed kernels on chromosome 4, genes for pilose leaf sheaths on chromosomes 3 and 9 (Paxson, MNL NO. 27), and I on chromosome 9. In this race, too, it is highly unlikely that Indian plant breeders consciously brought all of these together through hybridization and selection--it seems much more probable that Kculli and Palomero Toluqueño have stemmed from distinctly different races of wild corn and that both are probably different from Chapalote, the race found most commonly in archaeological sites.

P. C. Mangelsdorf

6. Oldest prehistoric maize from Mexico may be wild maize.

What is probably the oldest prehistoric maize so far discovered was turned up last winter in preliminary excavations of Aeyerada Cave near Tehuacan in the state of Pueblo, Mexico. The cobs are small and slender and distinctly tapering at both ends. The pedicels are elongated and the glumes and other floral bracts are relatively long and foliaceous. The shape of the cob is typical of Chapalote, one of the ancient indigenous races of Mexico and the predominating race found in the majority of archaeological sites in northwestern Mexico and southwestern United States.

Radiocarbon determinations of this early maize have not yet been made but associated remains indicate that the level at which these primitive cobs occurred is at least 6000 years old. This is older than any other prehistoric maize so far described. We think that this maize is one representing the earliest stage of domestication or possibly wild maize.

P. C. Mangelsdorf
R. S. MacNeish

7. Variable penetrance of mutations resulting from teosinte introgression.

Defective seeds: Bianchi has reported that a defective seed mutant occurring in teosinte derivatives "disappears" when crossed with one of our multiple-gene testers. To determine whether this phenomenon is common, we crossed a single plant of a stock homozygous for *de*^{t5} with a number of inbred strains. In the F_2 endosperm generation there was no segregation for defective seeds in crosses involving the inbreds WMT277 or B10. When the strains used were WMT275, Oh28, 38-11, or C20 part of the F_1 ears did not segregate and the remaining ears had only a few defective seeds. In crosses involving an inbred strain of Wilbur's flint and Ind. P39 only part of the ears were segregating but these had quite a number of defective seeds. In crosses of Hy and A158 all of the F_1 ears were segregating but the former had only a few defective seeds, the latter approximately 25 percent.

Dwarf plants: In a similar experiment we crossed a single plant of a stock homozygous for an extreme dwarf which occurred as a mutant in a teosinte derivative. In the F_2 generation involving an inbred of Wilbur's flint, C103, C106, and WMT275 there was no segregation for dwarf plants. In crosses involving inbreds A158, Ind. P39 and Wf9 there was clear cut segregation of the dwarf character.

Another mutant dwarf, averaging about half the height of normal plants, was crossed on a number of inbred strains. In an F_2 involving Ind. P39 the segregation was normal; in F_2's involving an inbred strain of Wilbur's flint, Pa70, Os420, and W23 dwarfs appeared in all progenies but not in normal Mendelian ratios. In a total population of 110 plants only six dwarfs occurred.

A third dwarf, one with slender leaves, was crossed on inbreds Ind. P39, WMT275, and an inbred strain of Wilbur's. Dwarfs appeared in all three F_2 progenies but in low frequencies, five dwarfs in a total population of 67 plants.

Significance: Of the three inbred strains most commonly involved in these crosses, two, Wilbur's and Ind. P39, were crossed by all four mutants and one, WMT275, by three. In the crosses with Wilbur's and WMT275 the mutants failed to reappear in the F_2 or appeared in very low frequencies. In the crosses involving Ind. P39 segregation occurred in all F_2 populations but one of the recessive mutants, slender dwarf, had a low frequency. The results are consistent with the hypothesis that some of the mutants occurring in strains into which teosinte chromosomes have been introduced are not the result of lesions in the hereditary material but are due to blocks of teosinte genes which have deleterious effects in certain

genetic milieus. Whether the mutant expresses itself in one genotype because the inbred involved is already "loaded" with teosinte genes or fails to express itself in another because the inbred strain is relatively free of teosinte genes or is already strongly "buffered" against their effects are questions still unanswered.

P. C. Mangelsdorf

8. Heterosis in tripsacoid derivatives of maize.

The object of this study has been to determine whether the chromosomes or chromosomal segments which contribute to the tripsacoid features of certain races of maize are heterotic or not when in heterozygous combination in the near isogenic background of an inbred A158. For this purpose, all possible crosses were made between strains of A158 which had been modified by introducing chromosomes or chromosomal segments extracted from tripsacoid races of maize from Argentina, Bolivia, Paraguay, Brazil, Venezuela, Nicaragua, Honduras and Mexico. The F_1 plants were grown in the summer of 1960 and heterosis was measured for each intercross in terms of averages of (1) days to anthesis, (2) height of the plant from base to the first tassel branch, (3) length of central spike, and (4) yield of grain. The results, though preliminary, indicate that chromosomes producing tripsacoid effects are usually heterotic when in heterozygous combination. Maximum heterosis has been observed in crosses of Honduras x Brazil, Coroica (Bolivia) x Brazil, Coroica x Argentina, and Honduras x Argentina. However, the combinations Paraguay x Coroica, Coroica x Venezuela, and Honduras x Venezuela are in general deleterious. This may be because the same chromosomes are contributed by each of the parents resulting in nearly homozygous condition.

Evidence is accumulating which shows that these chromosomes, except those extracted from Mexican and Honduras varieties, are the result of direct Tripsacum introgression since teosinte is unknown in the other countries represented by these studies.

S. M. Sehgal

9. A new method for estimating teosinte and Tripsacum introgression into maize.

The method used by Wellhausen et al (1952) to estimate teosinte introgression in races of maize in Mexico was highly subjective and was based upon approximate scores of 0-4 for the induration of rachis and lower glumes. In the present study, a somewhat objective approach

is attempted. Two types of modified strains of A158 have been used: (1) those which are homozygous for introduced teosinte chromosomes or chromosome segments and (2) strains homozygous for introduced chromosomes or chromosomal segments extracted from races of maize which are not in obvious contact with teosinte.

After removal of the grains, the cob is securely fastened in a vise and sawed longitudinally between the two consecutive rows of spikelets with a scroll saw holding a fine-toothed blade. The split halves of the cob are then smoothed with the help of a fine file until a few spikelets in the middle of the cob are exposed in a longitudinal section. Further smoothing is done with the aid of an electric sander employing a fine aluminum oxide abrasive paper. The data have been taken from five to seven spikelets from the middle of each cob under a dissecting microscope. Averages from five to seven cobs of each stock are then compared with the unmodified inbred A158 for each of the following characters: (1) length and angle of inclination of the rachilla, (2) width of the cupule, (3) shape of the lower glume, (4) degree of induration of rachis, cupule tissue and lower glume. The "impressor hardness tester" has been used for this purpose.

Studies have not yet been completed to give exact estimates of teosinte and Tripsacum introgression, but from the preliminary data, it seems evident that both teosinte chromosomes and "extracted" chromosomes produce in general the same effects. These are: (1) shortening in the length of the rachilla and its position somewhat inclined to the axis; (2) widening of the cupule; (3) lower glume curved upwards; (4) great induration of the tissues, especially those of rachis, cupule and lower glume.

S. M. Sehgal

10. Tripsacum floridanum crosses readily with corn.

What may be the most primitive species of Tripsacum, T. floridanum (n=18), which is now isolated geographically from corn in the Everglades region of southern Florida, has a high degree of crossability with corn. Each of the thirty-five ears with shortened styles which were pollinated with T. floridanum pollen yielded at least a few hybrid kernels and, as might occur naturally, some of these hybrid kernels germinated without benefit of embryo culture. The crossability of corn with other diploid species of Tripsacum is very much lower as found by Mangelsdorf and Reeves (1939) and other recent workers.

A counterpart of this situation occurs in some Peruvian races of corn which have been isolated geographically from Tripsacum and which cross more easily with Tripsacum (Farquharson, 1957).

If T. floridanum is the most primitive species of its genus as studies of its morphology indicate and if it is an amphidiploid of two n=9 species such as Manisuris, as certain cytological data suggest, then its crossability with corn may be more than a matter of segregation and drift. The polyploid nature of T. floridanum may have enabled it to overcome the genetic barriers which originally separated its n=9 ancestors from wild corn (n=10). This idea has some support in the fact that a higher level of polyploidy in the n=36 forms of Tripsacum dactyloides helps to overcome the present genetic barriers to crossing with corn (Weatherwax, 1955 p. 11).

The present high degree of incompatibility between Tripsacum and corn in Mexico and Guatemala may have resulted from a limited amount of reciprocal introgression between them as the range of this first species of Tripsacum overlapped with that of corn. Such reciprocal introgression might also account for the present tripsacoid races of corn and maizoid species of Tripsacum.

A possible alternative explanation of T. floridanum's crossability is that it is a peripheral species which, extending its range and becoming no longer sympatric with maize, lost some of the genetic factors which had previously served as barriers between the species.

The distribution of T. floridanum in the Everglades National Park is spotted. Once it takes hold in the rough oolite region between the pine lands and the glades or at the margins of small hummocks in the glades, it may spread out to several hundred clumps. Its numerous short tillers and narrow stiff leaves cause it to blend in with the other grasses and sedges about it.

Collections of T. floridanum at a number of sites in the Park have been made in an attempt to find a reduced n=9 form and to study variation in this species.

W. C. Galinat

11. The association of pollen grain size with ear length in corn.

After observing the features of a certain unusually long ear of open-pollinated Longfellow Flint corn, it occurred to the writer that the adjustments related to the evolution of increased ear length in ears enclosed in husks might include an increase in pollen grain size. This open-pollinated ear was divided into four regions, each

of which has a bearing on the hypothesis. In the terminal region, the grain was partly destroyed by birds. Proceeding downward the next region had scattered purple kernels indicating some outcrossing with foreign pollen. Still lower all of the grains were yellow as if they had resulted solely from selfing or sibbing, and finally the lowermost region was barren. These differences were interpreted to indicate that, although the unusually large pollen of Longfellow Flint had sufficient energy and/or cytoplasm to grow down the styles further than the foreign pollen, it was not able to reach the ovules at the base of this very long ear. Inasmuch as the loss of grain from near the tip of the ear would have been proportionately greater if the ear and husks were shorter, natural selection would favor longer ears which were associated with larger pollen or pollen with an ability to send tubes all of the way down the longer styles of such ears. Also, artificial selection by man for longer ears would have a similar or supplemental effect in increasing pollen grain size, especially if because of bird or insect damage to the tip a higher percentage of the lower kernels were planted.

A preliminary test of this theory was made with data already available. The results were even more striking than expected. The r-test showed a highly significant correlation at the one percent level between ear length and pollen grain size as shown in the accompanying table.

Probably the correlation is not the result of pleiotropic action by single genes. Rather the increase in pollen grain size seems to be a secondary effect of selection in long-eared corn. Where necessary, the corn breeder might improve seed set at the base of the ear by just planting the "large rounds" which screen out from this region.

The association of pollen grain size with ear length in corn.

Race and stock	Ear length (c m)[1]	Pollen size (u)[2]
Nal Tel, Mex. 1749	7.9	81.2
Polomero Toluqueño, Mex. 1757	10.2	77.4
Tepecintle, Mex. 1718	10.4	79.1
Conico, Mex. 1751	13.6	89.5
Cacahuacintle, Mex. 1758	14.5	82.9
Tabloncillo, Mex. 1779	16.4	101.4
Vandeño, Mex. 1719	17.2	83.9
Tuxpeño, Mex. 1750	19.7	95.0
Jala, Mex. 1787	30.5	101.4
Ihuesillo, Costa Rica 1045[3]	33.0	106.2

[1]from Wellhausen, E. J., et al - Table 14 in Races of maize in Mexico, 1952

[2]from Mangelsdorf, P. C. - unpublished

[3]Ear length from actual specimen

r = 0.881* (coefficient of simple linear correlation)

With 9 degrees of freedom at 1% level, significance = 0.735* (Tables of Snedecor, G. W., 1955)

*Highly significant since r is greater on the 1% level.

W. C. Galinat

12. Reciprocal introgression of high and low condensation in the American Maydeae.

The inflorescences of Tripsacum, teosinte and primitive corn are elongate and, in the staminate portions, are pendant as a result of low or relaxed condensation. But selection for higher kernel-row-number during domestication of corn has resulted in compact inflorescences with high or tight condensation. This high condensation might be associated with an objectionable fasciation or flattening of the ear, as it is in certain popcorns, if it were not for teosinte introgression in the more evolved races. Apparently the effects of genes for high condensation and fasciation in corn are modified by genes for low condensation from teosinte to the extent that the cob attains many rows but remains symmetrical. This observation was first made on some 700 year old cobs from Richards Cave, Arizona, in which there was a tendency for strongly fasciated cobs to be less Tripsacoid (Galinat, et al, Bot. Mus. Leaf 17 (4)). Reduced condensation, which may come directly from Tripsacum introgression in certain South American races of corn (Mangelsdorf), may be so extreme as to allow space for the grain of the race Coroico to round out in shape and tesselate or interlock (Cutler, 1946.). Ordinarily the internodes are so short (condensed) that the adjacent pairs of grain are staggered by only one-half their thickness but in Coroico the internodes become sufficiently long for the kernels to round out and interlock so that the right member of one pair falls into a vertical row with the left member of the adjacent pair. The over-all effect is to reduce the kernel-row-number by one-half, a result which could also be achieved by the abortion of one member from each pair.

Reciprocal introgression of high condensation from maize into teosinte causes the primitive rectangular outline of the rachis segment to become compressed to a more triangular form. (Galinat, Bot. Mus. Leaf. 17 (8)).

Corn with more than an average amount of fasciation should be more tolerant of reduced condensation from teosinte than the average strain. Inbreds with obvious fasciation (e.g. Iowa 5125) might be modified and improved by introducing one or two teosinte chromosomes.

W. C. Galinat

13. Chromosomes in the F_1 hybrids of maize and Jutiapa teosinte from Southern Guatemala.

Microcytes of F_1 hybrid plants of Wilbur's flint x Jutiapa teosinte and its reciprocal cross showed that meiotic chromosomes are sticky throughout all stages of this division. Chromosome knobs are usually fused into masses of heterochromatin, rendering chromosome identification and knob count extremely difficult.

At pachytene a paracentric inversion occupying the middle region of the long arm of chromosome 1 and equivalent to about one-fifth of its length was found. In addition to In 1 a practically terminal inversion in the short arm of chromosome 9 was definitely identified. Like In 9's in other previously reported teosinte varieties, this inversion underwent various configurations, predominantly loops, at pachytene. Measurements at pachytene showed the length of this In 9 to be about 62 per cent of the total length of the short arm, about the same length as in In 9's previously reported.

At metaphase I occasionally a few large sporocytes fail to undergo regular chromosome congress. Instead, the chromosomes form several chromatin masses scattering in the cytoplasm. These chromatin masses are well stained, but they no longer show any chromosome individuality. This phenomenon may be due to incompatibilities probably existing between the germplasm of maize and that of Jutiapa teosinte.

At anaphase I, chromatid bridges and fragments were counted in a total of 509 randomly chosen sporocytes. As shown in Table I, about 20 per cent of these sporocytes have either one bridge and one free fragment, or one free fragment without bridge. Three sporocytes having one bridge but without fragment were unexpectedly encountered.

At anaphase II the frequency of the occurrence of chromosome bridges was unexpectedly low. In a total of 415 single cells only one cell having a chromosome bridge was observed. (Table I.)

Table I. Frequency of dicentric bridges (B) and acentric fragments (F) at anaphases I and II of F_1 plants of maize and Jutiapa teosinte.

	Anaphase I						Anaphase II based on single Cell Counts	
	0 B 0 F	1 B 1 free F	0 B 1 free F	1 B 0 F	0 B 2 F's	1 B 1 attached F	0 B	1 B
Frequency	405	53	46	3	1	1	414	1
% of total	79.5	10.4	9.0	0.6	0.2	0.2	99.8	0.2

Y. C. Ting

14. Low temperature effects on chromosomes similar to those of X-rays.

In the winter of 1959, inflorescences of nine F_1 plants of Wilbur's flint x Jutiapa teosinte and its reciprocal cross were collected and fixed with aceto-alcohol fixative in Homestead, Florida. The time of fixation of these inflorescences was about one week after frost occurring on the 24th of January, which killed a part of the winter-grown maize plants. When microsporocytes of these inflorescences were investigated with standard squash technique, synizetic knob, ubiquitous univalents, mitotic chromosomes, chromatin aggregates, precocious division, elongated spindles and micronuclei were constantly observed. These irregularities are similar to those induced by x-rays. However, when the same materials were grown in Jamaica Plain, Mass., in the summer of 1960, the above abnormalities were rarely obtained with the same technique. It seems difficult to exclude a conclusion that these irregularities are probably induced by low temperature.

Y. C. Ting

15. Cross-sterility in Chalco teosinte.

Eleven Chalco teosinte plants grown from open-pollinated seeds were employed as seed parents and crossed with our standard inbred strain of Wilbur's flint. Only four seeds were produced. The total number of receptive silks involved was estimated at 785, which

represents an 0.5 per cent of seed set. When Wilbur's flint was used as the female parent, the seed set was normal and abundant. It appears likely that the low percentage of seed set on the Chalco teosinte is due to a barrier similar to the Ga factor found in the majority of popcorn varieties and in many varieties of Mexican maize. Chalco teosinte--one of the most maize-like teosintes--has absorbed R plant coloration and pilose leaf sheaths of the predominating maize of the vicinity. These facts on cross sterility may indicate that it has also absorbed the Ga locus.

Y. C. Ting

UNIVERSITY OF ILLINOIS
Urbana, Illinois
Department of Agronomy

1. Effect of natural and artificial selection on seed set of elongate-derived autotetraploids.

A major disadvantage of raw tetraploids derived from diploid species is reduced fertility. We have found that newly-established tetraploid stocks are relatively sterile. However, pronounced improvement in seed set has been encountered in synthetic varieties created by pooling the derivatives of corn belt inbreds. Doubtlessly natural and artificial selection both have contributed to the improvement since mass selection has been practiced since the inception of the experiment.

Summary of Fertility Data in Tetraploid Synthetic Varieties, 1958 - 1960

Synthetic	Seed Set (%) 1958	1959	1960
B	59_2	68_3	76_4
C	54_1	59_2	65_3

The subscripts indicate the number of generations the synthetic has existed as a tetraploid, i.e., the number of generations separating it from its diploid ancestors.

Individual ears have been encountered that have exceedingly high seed set, as high as 94% in fact.

D. E. Alexander

2. Inbreeding depression in autotetraploid maize.

The rate at which autotetraploids approach homozygosity during inbreeding is slower than in diploids. In diploids, loss in vigor during selfing parallels loss in heterozygosity. If, in autotetraploids, one assumes that:

(1) homozygosity, per se, is responsible for reduction in vigor,
(2) all three heterozygotes are equal in vigor (AAAa = AAaa = Aaaa),
(3) only chromatid segregation occurs,
(4) the ultimate amount of vigor loss is 73% (based on Jones' diploid single cross data),
(5) all plants are euploid,

then it turns out that the reduction in vigor from the S_0 to the S_1 amounts to approximately 7%. If one considers chromosomal segregation only, the value amounts to approximately 3%.

In 1959, 40 S_0 and S_1 families were compared in a replicated split-plot trial. The S_1 was found to be considerably less vigorous, as measured by yield of grain, than we had expected. The S_1, on the average, yielded 70% as much as the S_0, a value comparable to that encountered in diploid material. However, in 1960, 25 S_0 - S_1 comparisons were made, and the S_1 mean yield was 82% of the S_0.

A significant family x generation was found in the 1960 data. Six of the 25 families showed less than 10% loss in vigor after a generation of selfing.

D. E. Alexander
E. H. Sonnemaker

3. Tetraploid genetic stocks now available.

We now have marker stocks of the following types available and will share them with those interested in them:

sugary 1
white endosperm
waxy
golden 1
chocolate pericarp
liguleless 1
ACRPr (probably homozygous)
brown midrib 1

A number of combinations of these, and other mutants, are made up. New stocks are also being worked up.

In addition, diploid stocks homozygous for el are available. These stocks are of different maturities and are related to the inbreds, WF9, W22, W23, Oh40B, K155 and R4. Hybrids between some of these strains also are available.

C. S. Levings, III
D. E. Alexander

4. Performance of advanced generations of hybrids of autotetraploid maize and Euchlaena perennis.

In 1957, crosses were made between elongate-derived autotetraploid strains of corn and the 40 chromosome teosinte, E. perennis. The F_1 was weakly perennial. One plant was maintained in a pot in the greenhouse for three years and continued to flower intermittently for two and a half years before dying.

Advanced generations of the hybrid continue to resemble the F_1 closely with respect to tillering, plant morphology, flower morphology and time of flowering. A few segregates, however, have been found that possess eight-rowed and six-rowed ears; none of the segregates is strongly rhizomatous.

These observations suggest that preferential pairing occurs. This has not been verified cytologically, however.

Seed of E. perennis and of advanced generations of the hybrid through F_6 is available to anyone interested.

D. E. Alexander
J. B. Beckett

5. Genetic location of centromeres in maize.

Ordered tetrads of some of the fungi provide us with a mechanism for the mapping of centromeres. Autotetraploid maize likewise provides us with a unique mechanism for the mapping of centromeres although this mechanism differs from that of the ordered tetrads. This technique is based upon the occurrence of the phenomenon of double reduction. Double reduction occurs when the meiotic mechanism partitions 2 chromatids from 1 chromosome to the same gamete, which is in contrast to the ordinary circumstance when each gamete regularly receives one chromatid from each of 2 chromosomes of the 4. α has been designated by Mather as the coefficient of double reduction. In order for this phenomenon to take place a single cross-over must occur

between the centromere and the locus in question and the crossover chromosomes at first division must segregate to the same interphase nucleus. The segregation of crossover chromosomes to the same interphase nucleus has been designated as genetic non-disjunction in the literature. Genetic non-disjunction, if it occurs at random, will occur 1/3 of the time.

The formula for computing the coefficient of double reduction is: $\alpha = ae$, where a equals the frequency of genetic non-disjunction and e is the frequency of crossing-over between the centromere and the locus in question. By solving this formula for e we can obtain the frequency of crossing-over, $e = \alpha/a$.

Mather has presented formulas for the solution of alpha by combining the backcross and F_2 data into maximum log likelihood equations. Presently, this backcross and F_2 data is being obtained for marker genes on chromosomes 2, 3, 4, 5, 6, 9, and 10. From this data estimates of alpha value will be obtained and subsequently the amount of crossing-over between marker gene and the centromere will be ascertained. The value of e (i.e. the cross-overs between the centromere and the marker locus) represents the map units between the centromere and the gene in question. Hence it will be possible to genetically locate many of the centromeres of maize.

C. S. Levings, III

UNIVERSITY OF ILLINOIS
Urbana, Illinois
Department of Botany

1. Colorless components of the A^b:Ec and A^b:P complexes in maize.

It has been reported earlier (MNL 33) that when alpha derivatives of crossover stable, crossover mutable and noncrossover classes from A^b:Ec and A^b:P are compounded with A^b and A alleles, colorless cases (a^*) of both crossover and noncrossover origins are recovered from all three classes of alphas from A^b:Ec and from the crossover mutable alphas of the A^b:P source; the crossover stable and noncrossover pale isolates from A^b:P do not yield any colorless cases of recombinant origin. On the basis of similarity in frequencies of a^* cases of crossover origin in case of crossover stable and noncrossover alpha isolates from A^b:Ec, and the complete absence of a^* derivatives of crossover origin from noncrossover and crossover stable pale cases from the A^b:P source, it was concluded that the noncrossover alpha isolates are not a result of the mutation of the β element of the respective A^b complexes. The two classes of alpha

occurrences, crossover stable and noncrossover, are thus structurally similar and there is no indication of a separable element at the site of β. In the process of production of pale derivatives as noncrossovers, β thus appears to be eliminated from the complex.

The noncrossover a* cases from heterozygotes involving the three classes of alphas from each source represent isolates from the α-bearing strand; one exceptional case, however, turned out to be a single-step change of A^b:Ec to a colorless state. The crossover a* cases from alphas of the A^b:P source (designated α:P) where only crossover mutable alpha cases yield such derivatives, represent recombination for the proximal marker (T) of the α-carrying strand and the distal marker (sh or et) of the homologue. The crossover a* cases from alphas of the A^b:Ec source (α:Ec), where all three classes of pale derivatives yield such cases, are found to be recombinants between the distal marker of the alpha-bearing chromosome and the proximal marker of the homologous strand. The direction of the recombination leading to the isolation of a* cases of crossover origin shows that, in case of α:P, the colorless component or components are situated at the left of the α element and, in case of α:Ec, at the right.

Data on frequencies of recovery of colorless cases from the various sources have been presented earlier. Some of the a* cases obtained have not been tested for the mutability in presence of Dt and the dominant or recessive brown nature of the pericarp in the presence of P. A summary of results of the tested cases is presented below and the discussion that follows is restricted to these a* cases.

Table I

Tests on a* cases

Description of a* cases	No. of a* cases from α:Ec		α:P	
	Co	Nco	Co	Nco
From crossover stable				
Mutable, recessive brown ..	0	0	0	1
Stable, " ..	4	5	0	1
" , dominant brown ..	0	2	0	0
Indecisive, " ..	0	1**	0	1
From crossover mutable				
Mutable, recessive brown ..	3	8+1**	2**	0
" , dominant brown ..	0	3	1	4+1**
Indecisive, recessive brown ..	0	1	0	0
From noncrossover				
Stable, recessive brown ..	5	7	0	1
" , dominant brown ..	0	7	0	3
Indecisive, " ..	0	1	0	0

Co- crossover, Nco- noncrossover.
**From heterozygotes lacking distal marking in α:Ec and proximal marking in α:P. In these α itself serves as a marker.

Recovery of crossover a* cases from the crossover stable α:Ec shows that such alpha isolates are often associated with a separable, null level element which is stable under the action of Dt and is associated with recessive brown pericarp. Of the 13 crossover stable α:Ec cases used in the experiment, four gave stable, recessive brown a* isolates of crossover origin and of the 12 noncrossover α:Ec cases tested, five appeared to be associated with such a separable element. The direction of recombination isolating the a* cases indicates that the colorless, stable, recessive brown-acting element is situated at the right of the component in A^b:Ec. Colorless cases of crossover origin from the crossover mutable α:Ec source, of which 10 cases were included in the study, are all mutable and recessive brown. As the mutability of a crossover mutable α has been shown by Dr. Laughnan to be dependent on the association of α with the a:standard, which is itself mutable and recessive brown-acting, the a* cases of crossover origin from this source may represent the a:standard element either singly or in association with the stable, recessive brown element recognized in case of the crossover stable and noncrossover α cases. The newly identified element, situated between α and β in A^b:Ec complexes and predicted by Dr. Stadler in 1951, is tentatively designated a^{rb}.

The similarity of structure between the crossover stable and noncrossover α isolates shows that the noncrossover process is an aberrant type of crossing over, which isolates the existing components of a complex and is not connected with intragenic mutation. As such, the characteristics of the noncrossover a* cases can be used to identify the colorless elements in the A^b:Ec complex. All noncrossover a* cases from crossover stable and noncrossover α:Ec sources are stable and are either recessive or dominant brown-acting. From the crossover mutable α:Ec, the noncrossover a* cases are recessive or dominant brown, but are mutable. Since crossovers have so far separated only the a^{rb} element, the dominant brown element, designated a^{db} and recovered among noncrossovers, seems to be situated in such a position that it can be excluded in a crossover. This is possible when it is closer to the α component than is the a^{rb} element. The evidence presented suggests that the A^b:Ec complex consists of four elements, α, a^{db}, a^{rb}, and β, arranged in that order.

Four crossover stable, six crossover mutable and seven noncrossover α cases from the A^b:P source were used in the present experiment. The crossover stables and noncrossovers did not yield any a* cases of recombinant nature. Two of the crossover mutable α:P cases gave three colorless derivatives of crossover origin, one producing one and the other, two; the latter are mutable and recessive brown as is the a:standard. The single a* case of crossover origin, deriving from a heterozygote marked on both sides, proved to be mutable but showed dominant, instead of the recessive brown pericarp character normally associated with the a:standard element. As such, the two

mutable, recessive brown cases are held to represent the a:standard element either singly or in association with a colorless, recessive brown element, not so far identified through crossovers. Since the single crossover a* case is mutable, but dominant brown, the a:standard element of the mutable α:P is located in such a manner with respect to the dominant brown-acting element, that a crossover event can either include or exclude the latter. As in the case of the a^{db} element of the A^b:Ec, this element, which also may be designated a^{db}, is thus situated closer to α than is the a:standard element of the crossover mutable α:P.

Tests on the noncrossover a* cases from crossover stable and noncrossover α:P isolates show that all such colorless cases, except one, are stable but recessive or dominant brown. This exceptional case is mutable and recessive brown.

Noncrossover a* cases which are stable and dominant brown may or may not include the recessive brown null element, but the stable recessive brown cases clearly lack the dominant brown element. As noncrossover a* cases, which are either dominant or recessive brown but stable, are recovered from crossover stable and noncrossover α:P cases, both colorless elements, one dominant brown (a^{db}) and one recessive brown (a^{rb}) appear to be associated with A^b:P.

Since crossover a* cases from crossover mutable α:P are mutable but recessive or dominant brown-acting, the a:standard element in mutable alphas may be located at one of three positions--β, a^{rb}, or a^{db}. The direction of recombination and the fact that the a^{db} may or may not be included in a crossover show that this element is closer to α than is the a^{rb}. Thus the A^b:P complex, as is the A^b:Ec complex, is composed of at least four elements arranged in the order β:a^{rb}:a^{db}:α. With respect to the centromere, the two complexes thus represent inversions of a locus consisting of at least four elements, the two median elements showing colorless nature; one of them is recessive brown-acting (a^{rb}) and the other, dominant brown-acting (a^{db}) but both are stable under the action of Dt.

No explanation is at present possible for the mutability of a recessive brown colorless case of noncrossover origin from the crossover stable α:P source.

M. S. Sarma

Present address: Botany Department
U. P. Agricultural University
Pant Nagar
Distt. Nainital
U. P., India

UNIVERSITY OF ILLINOIS
Urbana, Illinois
Department of Plant Pathology

and

IOWA STATE UNIVERSITY
Ames, Iowa
Department of Agronomy

1. Sources of resistance to rust, Puccinia sorghi Schw.

An effort is being made to assemble as many sources of resistance (expressed in the seedling stage) to P. sorghi as possible from all regions of the world for a comprehensive genetic study of host: parasite interactions. Sixty-four resistant strains were located between 1953 and 1957 (Phytopathology 47:187-191). Subsequently 14 additional resistant strains have been located or received from other workers. To date sources of resistance have been obtained from Argentina, Australia, Canada, Ethiopia, Guatemala, Kenya, Mexico, Peru, South Africa, Turkey, U. S., and Yugoslavia. Many of these sources of resistance are available for exchange with other workers. Receipt of resistant types from indigenous varieties outside of the U. S. and Mexico would be greatly appreciated.

The genes for rust resistance from the various sources are being transferred to inbreds B14 and R168 by backcrossing. These "nearly isogenic" lines will be used for genetic studies with the fungus P. sorghi.

A. L. Hooker

2. Another locus for resistance to P. sorghi located in Australian inbred lines.

Studies involving F_1, F_2, and backcross progenies derived from crosses of rust-resistant Australian inbreds 25, M16, and MN14 with the rust-susceptible inbreds B14, Oh07K, R168, and W153R revealed single dominant genes for resistance in each of the resistant inbreds. This is illustrated by the following data obtained from tests with rust culture 90laba.

Cross	No. of plants observed Res.	Susc.	Expected ratio	P Value
(25 x W153R) F_2	94	34	3:1	.10-.20
(25 x W153R) x W153R	64	70	1:1	.10-.20
(25 x R168) F_2	104	19	3:1	.01-.02
(25 x R168) x R168	63	64	1:1	.90-.95
(M16 x B14) F_2	76	23	3:1	.50-.70
(M16 x B14) x B14	73	61	1:1	.20-.30
(M16 x Oh07K) F_2	92	26	3:1	.30-.50
(M16 x Oh07K) x Oh07K	60	73	1:1	.20-.30
(NN14 x R168) F_2	97	40	3:1	.20-.30
(NN14 x R168) x R168	67	73	1:1	.50-.70
(NN14 x B14) F_2	100	32	3:1	.80-.90
(NN14 x B14) x B14	66	61	1:1	.50-.70

The three rust-resistant inbreds were crossed with Syn A having gene $\underline{Rp}^3$ for rust resistance and advanced to the F_2 generation. The F_1 was also crossed with R168. Tests with rust culture 90laba, giving resistant reactions with Syn A and the Australian inbreds, indicated that the gene(s) in the Australian inbreds assort independently of $\underline{Rp}^3$. The following data were obtained:

Cross	No. of plants observed Res.	Susc.	Expected ratio	P Value
(25 x Syn A) F_2	121	13	15:1	.05-.10
(25 x Syn A) x R168	99	35	3:1	.70-.80
(M16 x Syn A) F_2	120	9	15:1	.70-.80
(M16 x Syn A) x R168	103	28	3:1	.30-.50
(NN14 x Syn A) F_2	116	4	15:1	.10-.20
(NN14 x Syn A) x R168	111	19	3:1	<.01

It is interesting to note that tests conducted at Grafton, New South Wales with these Australian inbred lines indicate that they all have the same recessive gene for resistance to certain Australian cultures of P. sorghi (K. S. McWhirter, Personal Communication).

A. L. Hooker

3. Inheritance of resistance to P. sorghi in three sources of resistance from Mexico.

Rust resistant inbreds Mex 185-1 (Queretaro V 260-1-2-1), Mex 189 (Queretaro VI 366) and Mex 212 (Queretaro V 231-5-2-1) were obtained by crossing the Mexican sources with corn belt inbreds, backcrossing to the corn belt inbreds, and selfing. These inbreds were crossed with the susceptible inbreds B14, R168, and W153R. F_2 populations and backcrosses to the susceptible inbred were evaluated with rust culture 901aba. Single major gene ratios were obtained as indicated in the following data:

Cross	No. of plants observed Res.	Susc.	Expected ratio	P Value
(Mex 185-1 x R168) F_2	84	43	3:1	.02-.05
(Mex 185-1 x R168) x R168	62	65	1:1	.70-.80
(Mex 185-1 x B14) F_2	92	32	3:1	.80-.90
(Mex 185-1 x B14) x B14	34	38	1:1	.10-.20
(Mex 189 x R168) F_2	82	38	3:1	.05-.10
(Mex 189 x R168) x R168	63	63	1:1	>.99
(Mex 189 x W153R) F_2	191	55	3:1	.30-.50
(Mex 189 x W153R) x W153R	67	63	1:1	.70-.80
(Mex 212 x R168) F_2	95	33	3:1	.80-.90
(Mex 212 x R168) x R168	68	60	1:1	.30-.50
(Mex 212 x B14) F_2	84	27	3:1	.80-.90
(Mex 212 x B14) x B14	58	58	1:1	>.99

Inbreds Mex 185-1 and Mex 189 were crossed with Syn. A, Mex 212 crossed with B. Y. Dent, and Mex 185-1 crossed with Mex 212. These single crosses were advanced to the F_2 and crossed with R168 or B14. The following data were obtained in greenhouse tests with rust cultures 901aba and 928b which are avirulent to the resistant inbreds:

Cross	No. of plants obtained Res.	Susc.	Expected ratio	P Value
(Mex 185-1 x Syn A) F_2	100	12	15:1	.05-.10
(Mex 185-1 x Syn A) x R168	95	36	3:1	.50-.70
(Mex 189 x Syn A) F_2	132	0	1:0	
(Mex 212 x B.Y. Dent) F_2	127	0	1:0	
(Mex 212 x B.Y. Dent) x R168	484	1	1:0	
(Mex 185-1 x Mex 212) F_2	95	5	15:1	.50-.70
(Mex 185-1 x Mex 212) x B14	84	14	3:1	.01-.02

These data indicate that the gene for rust resistance in Mex 185-1 assorts independently of genes at the Rp locus (Syn A and B.Y. Dent) and that the genes in Mex 189 and Mex 212 are either at or closely linked to the Rp locus.

A. L. Hooker
W. A. Russell

4. A gene in P.I. 163558 (Guatemala Flint) for resistance to P. sorghi.

Inheritance studies involving F_1, F_3, and backcross progenies derived from a cross of a rust-resistant inbred selected from P.I. 163558 with the susceptible inbred B14 indicate that P.I. 163558 contains a single dominant gene for resistance to P. sorghi. This is indicated by the following number of resistant, segregating, or susceptible progenies obtained following the selfing of F_2 and backcross populations:

Cross	No. progenies observed Res.	Seg.	Susc.	Expected ratio	P Value
(B14 x PI163558) F_3	24	44	18	1:2:1	.50-.80
(B14 x PI163558) x B14 selfed	0	16	13	0:1:1	.50-.80

P.I.163558 was crossed with K148 containing Rp^3, advanced to the F_3 generation and tested with cultures 904d, 908R, and 928b of P. sorghi. P.I.163558 and the F_1 were resistant to all 3 cultures while K148 was resistant to culture 928b but susceptible to cultures 904d and 908R. The following data indicate that the gene in P.I.163558 is either at the Rp locus or closely linked to it.

Cross	Rust Culture	No. progenies observed Res.	Seg.	Susc.	Expected ratio	P Value
(K148 x PI163558) F_3	904d	15	22	10	1:2:1	.50-.80
"	908R	15	22	10	1:2:1	.50-.80
"	928b	47	0	0	1:0:0	

W. L. Hagan

5. Recessive resistance to P. sorghi.

F_1, F_2, and backcross data obtained in greenhouse tests during January, 1961, indicate that resistance to culture 928bb of P. sorghi is controlled by three independent loci in inbreds (A277 x 41 • 2504B)-1-47-1-1-1-1-1 and Midland-125-3-1-3-5-1. These inbreds are highly resistant to rust culture 928bb while F_1's with the susceptible inbred B14 are susceptible. The highest degree of resistance appears to be due to the completely recessive condition. The proposed type of gene action is as follows:

Genotype	Rust reaction
First dominant gene	Susceptible
Second dominant gene	Susceptible in absence of dominant gene 3
Third dominant gene	Intermediate (inhibits dominant gene 2, but not gene 1)
Multiple recessive	Highly resistant.

The following data support the above hypothesis:

Cross	No. of plants observed Res.	Inter.	Susc.	Expected ratio	P Value
(A277 x 41.2504B) x B14 F_2	3	17	86	1:12:51	.30-.50
[(A277 x 41.2504B) x B14] x (A277 x 41.2504B)	11	27	63	1:2:5	.80-.90
Midland 125 x B14 F_2	1	9	71	1:12:51	.10-.20
(Midland 125 x B14) x Midland 125	8	24	61	1:2:5	.50-.70

Inbreds (A277 x 41.2504B) and Midland 125 give differential and reciprocal reactions with various cultures of P. sorghi and on this basis must be regarded as having different genotypes for rust resistance.

N. R. Malm

6. Location of genes determining resistance to Puccinia sorghi in corn inbred selection (Oh45 x W92)-2-5-2.

Studies on the inheritance of resistance to corn leaf rust, Puccinia sorghi, have demonstrated that the resistance in Cuzco,

GG208R, K148, B38, B49 and P.I. 172332 is due to 6 distinguishable alleles at the Rp locus on the short arm of chromosome 10. An analysis of another source of resistance, (Oh45x W92)-2-5-2, had indicated that this source has 2 or more genes determining resistance and none of these is allelic with the series in chromosome 10. For example, segregations in progenies from B14 x (Oh45 x W92)-2-5-2, where B14 is the susceptible parent, indicate that more than one gene pair is segregating. F3 progenies from K148 x (Oh45 x W92)-2-5-2 have indicated that (Oh45 x W92)-2-5-2 has 2 or more genes and that none of these is allelic to K148. Thus far, only one dominant gene has been found in K148.

Selection (Oh45 x W92)-2-5-2 (resistant) was crossed with a series of translocation stocks and the single crosses were crossed with waxy B14 (susceptible) where waxy was used as the marker gene, or a susceptible sweet corn where sugary was the marker gene. The translocation stocks have the waxy gene where chromosome 9 is involved and the sugary gene where chromosome 4 is involved. The translocations are in M14 which is susceptible to all cultures of rust used in the study. Although all of the translocations show susceptibility in the field there may be some variation among them in genes affecting resistance because they have not all been backcrossed to M14 an equal number of times.

The table given below summarizes the translocation stocks used, breakage points, rust cultures, segregation counts and calculated X^2 values. The translocation breaks do not include all arms but in most chromosomes the location of breakage is such that linkage would be detected except for genes near the end of the chromosome. Chromosome 7 was not included because the progenies obtained did not segregate for waxy. Seedling tests giving counts of resistant and susceptible plants were made in the greenhouse using rust cultures 901ab and 917a, both of which are avirulent to (Oh45 x W92)-2-5-2 but virulent to the translocation stocks, waxy B14 and the sugary stock.

The X^2 values were calculated using Fisher's formula $X^2 = \frac{(ad-bc)^2N}{(a+b)(a+c)(b+d)(c+d)}$ for one degree of freedom. The continuity correction was applied only in the case of T4-9b. Continuity corrections were not applied in other cases because they would not have changed the interpretations.

Counts of resistant and susceptible seedlings in the segregating progenies suggest the presence of one to 4 genes for resistance. This apparent variation in number of gene pairs segregating is probably due to differences in genotypes among the translocation stocks used. For example, in the tests using culture 917a, the data indicate that 4 complementary genes are involved in T1-9, T2-9b and T4-9b: 3 complementary genes may be segregating in T5-9c, T8-9d and T9-10b: and

Counts of seedlings resistant and susceptible to rust cultures 917a and 901ab in normal starch and mutant (waxy or sugary) classes in progenies of ((Oh45 x W92)-2-5-2 x translocation) x waxy B14 or x sugary.

Translocation	Position of breaks	Rust culture	Number of seedlings: Normal starch Resistant	Normal starch Susceptible	Mutant Resistant	Mutant Susceptible	X^2 Values
T1-9 (wx)	1L.19-9S.20	917a	3	53	3	55	0.002
		901ab	18	42	26	33	2.526
T2-9b (wx)	2S.18-9L.22	917a	4	55	2	56	0.667
		901ab	6	53	4	50	0.267
T3-9c (wx)	3L.09-9L.12	917a	5	50	5	53	0.008
		901ab	5	54	7	52	0.371
T4-9b (wx)	4L.90-9L.22	917a	8	55	1	58	3.908*
		901ab	36	76	28	88	1.808
T4-9g (wx)	4S.27-9L.27	917a	25	35	10	51	9.398**
		901ab	63	59	27	77	15.447**
T1-4a (su)	1L.51-4S.69	917a	15	44	8	45	2.253
		901ab	30	85	12	96	8.171**
T4-5j (su)	4L.21-5L.36	901ab	34	26	12	40	12.986**
T4-8a (su)	4S.59-8L.19	901ab	20	40	8	49	5.980*
T5-9a (wx)	5L.69-9S.17	901ab	25	33	16	37	1.983
T5-9c (wx)	5S.07-9L.10	917a	12	49	4	62	5.334*
		901ab	37	77	14	103	14.092**
T5-9 (wx)	5L.06-9L.07	917a	20	41	2	61	18.621**
		901ab	17	100	6	76	2.454
T6-9 (wx)	6L.13-9ct.	917a	15	44	13	46	0.187
		901ab	20	45	11	47	2.265
T8-9d (wx)	8L.09-9S.16	917a	6	53	7	51	0.107
		901ab	7	54	3	46	0.942
T9-10b(wx)	9S.13-10S.40	917ab	9	52	6	55	0.684
		901ab	6	53	1	58	2.430

* significant at the 5% level
** significant at the 1% level

2 complementary genes may be segregating in T4-9g, T6-9 and T1-4a. Similar segregations may be followed through for 901ab, but since the number of genes segregating in some progenies is not always the same as for 917a it is evident that resistance to 901ab is determined by genes at different loci.

The X^2 values indicate linkage between resistance to 917a and non waxy in T4-9b, T4-9g, T5-9c and T5-9. Since none of the other stocks involving chromosome 9 shows a significant X^2 value it may be assumed that chromosomes 4 and 5 in (Oh45 x W92)-2-5-2 carry genes that determine resistance to 917a. T1-4a did not show linkage, thus the gene in chromosome 4 is probably to the right of 4S.27 and too far from 4S.69 to show linkage. In tests using culture 901ab, linkage between resistance and non waxy or non-sugary is indicated in T4-9g, T1-4a, T4-5j, T4-8a and T5-9c. Since T5-9 (5L.09) and T5-9a (5L.69) do not show linkage but T5-9c (5S.07) and T4-5j (5L.36) indicate linkage, it seems likely that the linkage in T4-5j is in chromosome 4 and not chromosome 5. Other translocations involving chromosomes 8 and 9 did not show linkage. Therefore, chromosome 5 apparently carries a gene for resistance to 901ab in its short arm and chromosome 4 has a gene near to the centromere. The linkage relationships between resistance and translocation breakage points indicate the genes determining resistance to 917a are not the same as those giving resistance to 901ab. This is in agreement with data obtained in previous tests of F_3 progenies from K148 x (Oh45 x W92)-2-5-2. Selection (Oh45 x W92)-2-5-2 may have additional genes affecting resistance to 901ab and 917a but escaped detection due to arms not being adequately covered.

W. A. Russell
Iowa State University

A. L. Hooker
University of Illinois

UNIVERSITY OF ILLINOIS
Urbana, Illinois
Department of Agronomy

and

PRIDE COMPANY, INC.
Glen Haven, Wisconsin

1. The effects of semi-sterility on yield components of corn.

The effect of reduced seed set on yield components was studied using three-way crosses and backcross families segregating for reciprocal translocations. The yields of normal and semi-sterile plants of near identical genotypes were compared in two experiments.

The first experiment compared the yields of normal and semi-sterile plants of 9 three-way crosses and backcross families planted at 12,000 plants per acre, while the second experiment compared the yields of normal and semi-sterile segregates of three families planted at three different planting rates.

Data were taken and treated statistically on yield per ear, number of second ears, yield per plant, ear length, weight per 100 kernels, row number, and moisture in grain.

Significant differences were found between the normal and semi-sterile segregates in all comparisons except moisture in grain and row number. Semi-sterile segregates heterozygous for the translocation displayed a mean fertility of 50.74 percent.

The first chart shows the mean values for all comparisons in the first experiment.

	Ear length	Wt/100 K (Grams)	Ears/Plt.	% of Normals Yield/Ear	% of Normals Yield/Plt.
Semi-steriles	7.84*	36.97**	1.21**	69.54	73.30
Normals	7.66	28.66	1.04		

* Significant at .05
** Significant at .01

Although only fifty percent of the kernels developed on the semi-sterile segregates, increases in kernel size and ear length made it possible for them to yield 70 percent as much per ear as the fully fertile ears. The increase in number of second ears on the semi-sterile segregates resulted in a per plant yield of 73 percent of the yield of the normals.

The following chart shows the yields of the semi-steriles, expressed as percent of normal sibs, in the second experiment.

Semi-sterile segregates of:	Plants per Acre 8000	12000	16000
N6 BC_1	82.81	110.80	101.94
WF9 BC_1	54.83	82.39	79.61

Compensation for reduced seed set by the semi-steriles was again manifested by increased kernel size, increased ear length, and greater number of second ears. Unexpectedly, the N6 semi-sterile segregates were particularly able to compensate and yield as well, or even better at the higher rates, than the normal segregates.

The sugar content of certain normal and semi-sterile stalks was also determined 60 days after pollination. The mean of sugar analyses of stalk juices, as well as lodging data, are presented below:

	% Sucrose	% Stalk Breakage	% Root Lodging
Semi-steriles	13.49	14.33	38.77
Normals	9.11	53.70	22.23

The limited number of kernels on the semi-sterile plants apparently resulted in a build-up of sugars in the sporophyte. Although increased seed size was displayed on all semi-sterile ears, a fifty percent sterile ear would require kernels twice as large as those on a fully fertile ear before it would store an equal amount of nutrients.

Apparently physiological or morphological barriers exist which prevent kernels on semi-sterile plants from becoming twice as large as those on siblings of similar genotypes. However, some yield compensation on semi-steriles was made in the form of limited increase in kernel size, the formation of second ears, and, to a smaller extent, a slight increase in ear length.

Charles E. Heathman
D. E. Alexander

INDIANA UNIVERSITY
Bloomington, Indiana

1. Alteration of recombination frequencies in A- by B-chromosomes.

Closely related lines of Black Mexican sweet corn with and without B-chromosomes were crossed to chromosome-2, -3, and -9 testers. Root-tips were obtained from the F_1 seedlings and the number of B-chromosomes possessed by each plant ascertained. The F_1 plants were then backcrossed to their respective testers and the recombination frequencies between the gene markers determined.

Table I presents the data obtained using a $\underline{yg_2}$ - $\underline{c}$ - $\underline{sh_1}$ - $\underline{wx}$ chromosome-9 tester.

Table I. Frequencies of crossover classes from backcross of $\frac{Yg_2 \ (1) \ C \ (2) \ Sh_1 \ (3) \ Wx}{yg_2 \qquad c \qquad sh_1 \qquad wx}$ ♀ X yg_2 c sh_1 wx ♂

No. of B-chromosomes	Crossover region							Total Progeny
	(1)	(2)	(3)	(1,2)	(1,3)	(2,3)	(1,2,3)	
0	18.6	2.9	16.9	0.26	0.40	0.058	<.0001	8565
1-4	18.3	3.2	17.8	0.24	0.60	0.096	.0002	4156
6-9	15.1**	3.7	20.7**	0.56	1.87**	0.655**	<.0009	1069
1-9	17.7	3.3	18.4*	0.31	0.86**	0.211*	.0002	5225

* Significantly different from 0 B-chromosome class at 5% level
** Significantly different from 0 B-chromosome class at 1% level.

The data indicate that the addition of B-chromosomes results in an increased recombination frequency between $\underline{c}$ and $\underline{sh_1}$ as well as between the $\underline{sh_1}$ and $\underline{wx}$ loci. The higher the number of B-chromosomes present in the F_1 plant the greater the increase in these regions. Turning now to a consideration of the $\underline{yg_2}$ - $\underline{c}$ region a completely opposite effect due to the B-chromosomes is encountered. In this region the larger the number of B-chromosomes the lower the frequency of single crossovers.

A comparison of the 6-9 B-chromosome vs the non-B-chromosome classes shows that the frequency of double crossovers is increased in all regions studied and table II gives the coefficient of coincidence values for these regions.

Table II. Coefficient of coincidence values (data from Table I)

No. of B-chromosomes	Crossover region		
	(1,2)	(1,3)	(2,3)
0	0.48	0.13	0.12
1-4	0.41	0.18	0.17
6-9	1.00**	0.60**	0.85**
1-9	0.53	0.26**	0.35**

** Significantly different from 0 B-chromosome class at 1% level.

It may be noted that B-chromosomes decrease chromosomal interference in all three regions and the effect is greater with the higher number of B's.

To state the results differently, the decrease in interference was found to be greatest near the centromere as was the increase in single crossovers. However, the latter effect was reversed near the end of the short arm of chromosome 9 (the presence or absence of a knob in this region has not yet been ascertained).

Supernumerary chromosomes have been known for some time to exist in many plants and animals; however, cytogeneticists have in most cases been unable to ascribe a particular function to them. The data presented above suggest one such function. This idea is supported by studies by Barker (Heredity 14:211-214, 1960) in the grasshopper Myrmeleotettix maculatus. He found that populations which possessed supernumerary chromosomes had a higher chiasma frequency than populations which lacked them.

The corresponding data with other chromosome testers is being analyzed. Also studies are being carried out utilizing larger numbers of B-chromosomes.

George P. Hanson

2. Crossing over and segregation in plants heterozygous for T6-9b.

It was reported previously that plants heterozygous for T6-9b (breaks:6L.10-9S.37) give an excess of the normal chromosomes when used as female parents in the backcross. Normal and translocated chromosomes are recovered with about equal frequencies from the heterozygous male. The progeny of the two backcrosses (♂ and ♀) also differ in that crossing over in the short arm of chromosome 9

is more frequent in the microsporocytes than in the megasporocytes although it is less than normal in both cases. When the genes tested are in repulsion phase, one class of crossovers may be confused with tertiary trisomes (6, 9, and 6^9), which occur with a low frequency in both backcross populations. In these cases the crossover frequency was obtained by doubling the value found for the reciprocal crossover class. When the genes are in coupling phase the tertiaries are included with the non crossovers and have a negligible effect on the crossover frequency. Some reduction in the frequency of crossing over in 9S is expected because all tested plants were heterozygous for a large terminal knob and for wd. Since not all the progenies were tested for yg, the population totals for Yg-Sh and Sh-Wx values differ. The data are given below:

Constitution	Heterozygous parent	Yg-Sh Σ	Yg-Sh %	Sh-Wx Σ	Sh-Wx %	%Wx	Total recombination
$\frac{T\ Wx\ Sh\ wd\ k_L}{N\ wx\ sh\ Wd\ K^L}$	♀	561	1.1	1963	0.97	33.0	2.07
"	♂	1617	9.2	6525	13.8	51.5	23.0
$\frac{T\ Wx\ sh\ Wd\ K^L}{N\ wx\ Sh\ wd\ k}$	♀	530	0.2	1026	1.2	35.3	1.4

The position of the knob on the translocated or on the normal chromosome has little effect on the transmission of the translocated chromosomes (Wx marks the break point) or on the frequency of crossing over in 9S. The structural heterozygosity from both the translocation and the presence of the large knob on one of the homologues results in defective pairing of 9S in pachynema and it is not surprising to find a great reduction in crossing over in this arm.

Ellen Dempsey

3. Crossing over in plants homozygous for T6-9b.

In plants homozygous for T6-9b, crossing over was tested in the Yg-C and C-Wx regions. Duplicate plantings were made from the same ear; family 23234 was grown in the greenhouse and 24124 in the field. PMC were obtained from plants in family 24124 and all had knobless chromosomes 9. Probably most of the plants in family 23234 had the same constitution, but the possibility exists that a few may have been $K^L9/k9$. The crossover values from ♂ and ♀ backcrosses are shown in the table with the standard values (Emerson, Beadle, and Fraser) and some of Rhoades' for comparison.

Backcrosses of $\frac{wx\ c\ Yg}{Wx\ C\ wd}$

		Yg-C	C-Wx	Σ	Total recomb.	% doubles	coin.
23234 ♀ B.C.	T/T	11.8	33.2	578	45	1.4	.36
24124 ♀ B.C.	T/T	9.6	37.4	1024	47	0.39	.11
23234 ♂ B.C.	T/T	8.7	43.6	585	52.3	0.9	.22
Standard	N/N	20	26		46		
Rhoades	N/N	20.6 (Yg-Sh)	17.2 (Sh-Wx)		37.8	0.9	.26

The overall recombination from wx to yg is not greatly different but the distribution of crossovers is altered in the 6^9 chromosome. Recombination is reduced in the Yg-C region and increased in the C-Wx region. Since these plants (for the most part) were not heterozygous for the large terminal knob on 9S, there is no apparent reason for the reduction in crossing over in the distal segment.

The position of the distal .6 of 9S with respect to the centromere may be altered by the translocation and might influence recombination in this region. The breakage points of T6-9b according to Longley are 6L.10 and 9S.37. In terms of relative distance from the centromere (based on Longley's pachytene measurements of normal chromosomes) the break in 6L would be 3.68 units from the centromere and the break in 9S, 5.71 units. Thus, in the 6^9 chromosome, the distal part of 9S (including the Wx locus) should be closer to the centromere. An average of three pachytene figures from my stocks gave somewhat different breakpoints: 6L.17 and 9S.46. However, shifting of the point of partner exchange often occurs in heterozygotes and in one figure (which was discarded) both breaks appeared to be adjacent to the centromeres. A comparison of the length of the longer arm of the 6^9 chromosome with the normal 9S should reveal whether the translocated piece is closer to the centromere or more distant. Measurements were made of the arm ratio of the homozygous 6^9 chromosome in 13 pachytene cells. A ratio of 1.6:1 was found:

. The ratio of 9S/6S in a normal strain is 1.3:1. This would indicate that the distal part of 9S is further from the centromere in the translocated chromosome.

A centromere effect, such as that reported by Beadle (1932) in Drosophila, would be expected to cause the greatest change in regions nearest the centromere with a gradual lessening in the effect, rather than a reversal of the effect in the distal region as was found here. Patterson (MNL 32) reported increased C-wx values in homozygous

T4-9$_{5657-2}$ (4L.33-9S.25) and in homozygous T6-9e (6L.17-9L.22). In the second case the break is in 9L so a centromere effect is ruled out. No explanation can be advanced at present for the change in recombination frequencies in the homozygous T6-9b.

Ellen Dempsey

4. Test for pseudoallelism at the A_2 locus.

A total of nine possible mutants (A_2) were obtained among 179,500 seeds from crosses of Gl_{17} $a_2^{Bl\ Mex}$ Bt V_2 / gl_{17} a_2^{St} bt V_2 yy ♀ X gl_{17} a_2^{St} bt Pr v_2 y ♂ (see MNL 34, page 65). The phenotypes of these nine individuals and the results from selfing are shown below:

	Plant phenotype					⊗ Ear
1	Gl	A	Bt	Pr	Y	seg bt and sh, no v; red cob
2	Gl	A	Bt	Pr	y (on same ear)	not seg bt or v
1	Gl	A	Bt	Pr	y	seg bt, no v; red cob
*1	Gl	A	Bt	Pr	y	seg bt, seg v; white cob
1	?	A	Bt	Pr	y	(no germination)
1	gl	A	bt	Pr	y	(hoed out)
*1	gl	A	bt	Pr	y	seg v
1	?	A	bt	Pr	y	(no germination)

The two cases which appear not to be contaminants are non-recombinants for the adjacent markers, one being Gl Bt, the other gl bt. They probably represent mutations of a→A. The reverse mutation rate of the two a alleles used in the experiment has not been tested. This experiment failed to demonstrate intra-cistron recombination.

Ellen Dempsey

5. Evidence for the chiasma theory of metaphase pairing.

On the chiasma theory of metaphase pairing post-diplotene association is due to the presence of chiasmata which arise from prior crossover events. This theory is believed to be generally valid although in some forms, notably Drosophila, other mechanisms are responsible for association of the two homologues until anaphase separation. There is, however, considerable evidence in maize which indicates the essential correctness of this theory. Data of two kinds are available.

The first is purely cytological and comes from the study of plants trisomic for chromosome 6 with and without abnormal 10.

% trivalents		% of trisomic progeny as ♀ parent	
N10 N10	Abn10 N10	N10 N10	Abn10 N10
74%	87%	36%	45%

The argument is clear. Abnormal 10 increases crossing over; this is reflected in an increased number of chiasmata. More chiasmata mean an increase in number of trivalents which in turn leads to a greater number of n+1 megaspores since disjunction of a trivalent usually gives equal numbers of n and n+1 spores.

Data of a different sort comes from studies of plants heterozygous for T6-9b with and without abnormal 10. Plants with abnormal 10 have more genetic crossing over than do N10 N10 sibs; they have more chiasmata as shown by the higher percentage of rings of 4 and by the drastic reduction in trivalent frequency. The cytological observations and genetic data, shown in the following table, are consistent with the theory that chiasmata are essential for metaphase association.

	% rings	% chains	% trivalents	Sh-Wx recomb. in ♂ B. C.
N10 N10	19.4	48.4	32.2	11.5
Abn10 N10	68.8	30.4	0.8	24.0

Ellen Dempsey
M. M. Rhoades

6. Genic interaction with the mutant plastids induced by the iojap gene.

In 1943 I reported that the iojap gene induced plastid mutations which were irreversible. However, Mazoti (1950) found that strains of maize carrying the R allele gave only green progeny when used as the pollen parent onto iojap silks, while strains with the r^r allele gave green and colorless seedlings. Mazoti's results suggested that the expression of the mutant plastids was subject to genic control and that restorer genes existed. This would parallel the finding of restorer genes for male sterile cytoplasm. We have confirmed Mazoti's conclusion that some strains of maize yield only green seedlings while others give varying proportions of whites when crossed onto iojap ears, although it is questionable that the R locus is involved. This past summer ten different lines were used as the pollen parent in crosses with iojap. Five of the ten strains gave only green seedlings while the remaining five gave progenies with both green and white seedlings. The presence of restorer genes in the lines failing to yield white seedlings will be tested this summer in the following manner. If some of the egg cells of the iojap plants possessed

mutant plastids which were restored to normal functioning by one or more restorer genes brought in by the pollen parent, the F_1 plants coming from these zygotes should possess mutant plastids whose expression would be realized in F_2 plants lacking the restorer genes. The ratio of green to white offspring would depend on the number of segregating restorer genes. The selfed F_1 plants which segregated whites in the F_2 would also be crossed as the pollen parent onto lines free of white alleles. None of the F_2's from these outcrosses should segregate for white seedlings since normal plastids were contributed by the egg parent of the P_1 generation. If these results are obtained it follows that irreversible plastid mutations are produced by iojap and that, even though they may be restored to normal activity by genic interaction, their intrinsic mutant quality is retained and becomes evident when the restoring alleles are lost.

M. M. Rhoades

7. Disturbed ratios due to semi-lethality of etched kernels.

Ears segregating for the etched allele, which is 12 units distal to A in chromosome 3, often have a deficiency of homozygous etched kernels. Deviation from the expected percentage varies in different genetic backgrounds; in some, no marked discrepancy is found while in others there is a significant reduction in the number of etched kernels. Tests were made to determine if the deficiency of etched is gametophytic or zygotic in nature. Crosses of a Et/a Et x A Et/a et pollen gave 1 : 1 ratios for the A:a pair so transmission of et pollen is normal. Crosses of A Et/a et by a Et pollen also gave 1 : 1 ratios for A:a so et megaspores are fully viable. However, the crosses of A Et/a et by a et showed that the deficiency of etched kernels is due to the deleterious effect of et on kernel development- i.e., etched acts as a semi-zygotic lethal. Etched kernels may abort early in development.

M. M. Rhoades

8. A test for recombination between the bt_1 and sh_3 alleles in chromosome 5.

Although the recessive mutants bt_1 and sh_3 differ markedly in their effect on kernel development, they are allelic. The compound bt/sh is similar in phenotype to sh homozygotes. The phenotypes produced by the two mutants are so unlike that their allelism was unsuspected for some time and was accidentally revealed through a chance cross of the two mutant strains. Differing as they do in

phenotype, it appeared plausible that they might represent mutations at different sites within the Bt cistron. Intra-cistron recombination between the two presumed mutant sites would produce + + and bt sh chromatids. The former would result in a plump kernel while the latter should yield a defective kernel which might be difficult to distinguish from bt homozygotes. However, plump kernels on an ear segregating for bt and sh would be easily recognized. It would appear that we have here an exceptionally favorable opportunity to test for intra-cistron recombination. Accordingly, hybrids of A_2 sh_3 pr/ a_2 bt_1 Pr constitution were pollinated by a_2 bt_1 pr bv plants. The bv mutant is the needed check on pollen contamination. The 1400 backcrossed ears obtained by carefully controlled hand pollinations gave a population of approximately 500,000 kernels. We have not found the plump kernels expected from recombination and indeed we found no plump kernels at all. This speaks well for our pollinating technique but unfortunately provides no evidence that the Bt_1 locus consists of mutant sites, separable by recombination.

M. M. Rhoades

9. Pollen longevity.

Data from the concluding tests of a series begun in 1957 at Cornell indicate conclusively that corn pollen viability may be retained for varying periods of time under widely different conditions of storage. Pre-storage treatment of the pollen, in addition to temperature and humidity control during storage, have been shown to be critical. Optimum storage conditions have been shown to include the 10° range, 5° either side of 0° C. and a relatively high humidity.

Noteworthy results from two 1960 experiments show: 1) corn pollen viability (as measured by the production of seed) was retained for at least twelve days; 2) the viability was markedly enhanced at a controlled humidity of 75% compared to 25% or 50% at 5°C.

The conclusion is inescapable, and has been confirmed by several demonstrations, that the exchange of pollen among investigators is feasible. The shipment of viable pollen permits at least two applications: 1) the use of pollen at relatively great distances from the site of pollen production; 2) the exchange of genomes without the exchange of cytoplasm.

D. B. Walden

INSTITUTE OF PLANT PRODUCTION
Piešťany Spa, Czechoslovakia

1. The study and the utilization of collections of maize.

The compilation and study of the world collections of maize is the subject of the work of a collective of scientific workers of the institute. This is considered to be of primary importance, because its aim is the evaluation of the economic, botanical, genetic, and morphological characters and properties of Zea mays L. with regard to their further utilization in theoretical and applied research, in practical growing, and in plant production in general. For this reason we evaluate on microparcels the various forms of maize, for which, in the course of one vegetation cycle, we determine 74 indices by means of mechanical and chemical analyses. The sum total of these factors enables us to arrive at conclusions regarding the width of the genetic basis of each form and regarding its adaptability to the conditions existing in this country. Through the determination of the biometric values of the plant organs and of the curves of growth in the various stages of growth, we obtain bases for the calculation of the correlative relations and their mutual effects on the heredity of characters and properties. As our collections of maize are comparatively wide, especially as regards the representation of the various varieties and forms, we are able to draw conclusions regarding the utilization of the favourable properties and characters characterizing each variety or form for the conditions existing in this country. The territory of this country comprises habitats of maize, which differ from one another substantially both geographically and climatically. For this reason special investigation of world collections of maize with regard to the factors of frost resistance, chemical composition, earliness, etc. are of far-reaching significance.

This work also includes the collecting of regional varieties and populations of maize growing on the territory of this country. This enables us to form a real picture of the botanical variability of maize in this country, to obtain valuable starting material for the growing of lines that would be suitable for the conditions of this country, and to obtain indices for the integration of hybrids in the various regions, especially in marginal ones. By means of the above mentioned collecting we obtain a survey of the historical penetration of the various varieties into the territory of this country in the course of their spreading in Europe.

M. Pastorek
L. Říman

2. The investigation of the theory of the combining ability of maize.

Our collective of scientific workers pays special attention to the study of this theory mainly because every correctly selected combination immediately results in an increase of the heterotic effect and so also of the total yield. The basis for this investigation is the study of the world collections of varieties and lines of Zea mays L. On the basis of the evaluation of these collections suitable material for the conditions existing in the country is selected, and this material is cross-bred with male partners that have been selected in advance. The offspring obtained in this way are then tested with regard to various properties and according to the manifold requirements of our plant production in the various microclimatic conditions of Czechoslovakia. These various microclimatic conditions are of especially great importance in this country, since, although Czechoslovakia is not a country covering a large territory, it is most heterogeneous geographically and climatically. This complex work is being done by a large collective of scientific workers in co-operation with practical growers. On the basis of detailed studies a total of 10 microclimatic areas was selected, in which the combinations of offspring are tested and evaluated with regard to the various purposes they are to serve. Theoretically this work follows three main trends:

1) The study of correlations on the basis of the results achieved in the empiric tests.
2) The cytogenetic and microanatomical investigation of the inner structure of the starting material (mainly the morphology of the chromosomes, etc.) as a necessary complement of the correlative studies.
3) Chemico-serological investigations of the starting material as a necessary complement of the correlative studies (mainly in the direction of mutual antigen reactions, etc.).

L. Řiman
M. Pastorek

3. The investigation of pollen sterility in maize.

Considerable attention is being paid to this problem, and the research work follows chiefly the following sectors and directions:

a) the identification of the sources of pollen sterility of various origin, to be achieved by means of a search for new and reliable methods of classification of the various forms of pollen sterility. Special attention is being paid to the new trends of the study of the classification of pollen sterility by means of biochemical and chromatographical analyses.

b) The world collections of lines of maize are evaluated with regard to their capability of stabilizing pollen sterility, or, on the other hand, of renewing pollen fertility with various sources of sterile pollen, for the purpose of their utilization in hybrid combinations.

The results achieved hitherto are utilized, in co-operation with a team of scientific workers and growers, for combining productive hybrids adapted to the climatic conditions of Czechoslovakia.

E. Javorek

4. The study of the methods of improving maize.

In this sector of work several methods of improving maize mainly with material of domestic provenience are investigated and checked. The effectiveness of these methods and the substantiation of their introduction into the practical improvement program are evaluated. The possibility of a suitable synthesis of the elements of several methods of improvement for the purpose of increasing the effectiveness and of shortening the time required for the improvement of lines is being examined.

In a further part of the work data are collected for the critical evaluation of the methods of early testing of lines as methods of predicting the combining ability of the lines prior to their transition to homozygosis, and also the effectiveness of the application of these methods in improvement work is being checked.

Besides this also the possibility of utilizing the results of the examination of the general combining ability for the study of the special combining ability and for the prediction of the likely value and composition of double line hybrids is being investigated and elaborated. These investigations are carried out by a number of scientific workers and growers in Czechoslovakia. The work connected with the complex of the tasks of the study of the methods of maize improvement is carried out in close co-operation and co-ordination with a team of workers investigating the theory of combining ability.

A. Piovarči

5. The improvement of sweet corn and pop corn.

In recent years considerable attention has been paid to research on sweet corn and pop corn and to their special improvement, as the demand of the food-producing industry and of the population has been increasing constantly. Within the scope of the improvement program the improvement of these forms is carried out with special regard to this nutritive value for human consumption.

Sweet corn is grown with special regard to its food value, for canning, etc. A whole series of prospective types has been obtained, especially yellow corn types.

Pop corn is grown with regard to its popping expansion, the fineness of its hulls, and with regard to the general taste qualities of its flakes. Hitherto the improvement work has been carried out primarily with white corn types. Also in this group a number of prospective forms has been obtained.

This improvement program is being pursued in co-ordination with other growing stations, whose work, done in their development centres, is concerned with industrial production.

M. Pastorek

6. A catalogue of factors and genes in maize.

On the basis of the study of the pertinent literature and of theoretical studies, a catalogue of factors and genes of maize is being compiled. In this catalogue the following indices are collected: the international symbols of factors (genes); the original English name; the translation (or explanation) of the original name; the author (who first described a certain type) and the year it was described; chromosome and locus in which a certain gene is found. Besides this there is a compilation of the characteristics of the effects of the various factors and of their genes, their construction, etc. As far as possible also photographic material and other documentation material is being collected in those cases where it is possible to record the activity photographically or schematically.

The purpose of these theoretical and literary studies is the collection and systematization of the results of the present studies of genes and factors of maize, and the adaptation of the results of these studies for the needs of our theoretical and applied research work carried out with maize, and also for the needs of practical growing with various aims.

L. Říman

IOWA STATE UNIVERSITY
Ames, Iowa
Department of Agronomy

1. Reduction of ga pollen contamination in double-cross hybrids made up with one ga ga inbred and 3 Ga^sGa^s inbreds.

Seed contamination of sugary, pop, and waxy endosperm types of corn by pollen of other corns is a serious problem in some seed production areas. This problem may be alleviated by the use of a gametophyte factor which prevents fertilization of Ga^sGa^s genotypes by pollen from ga ga genotypes.

Since new lines isolated from ga ga populations may be used commercially before being converted to Ga^sGa^s, the problem may continually exist. However, where double-cross hybrids are used commercially, one line of the ga ga genotype may be used and the danger of contamination may be reduced materially. Only the Ga^s pollen from a heterozygous single cross Ga^sga is effective on Ga^sGa^s silks. Accordingly, an inbred, ga ga, may be used as one of the parents of a single-cross pollinator in double cross hybrid production.

In case of polygenic inheritance, there is little concern over limiting the functional pollen of the male single cross with a gametophyte factor. However, if a simply inherited character were linked to the ga locus, its transmission to the double-cross would be limited by close linkage.

Prior to 1958, a few reciprocal crosses of popcorn (Ga^sGa^s x Ga^s ga and Ga^sga x Ga^sGa^s) were observed on a limited basis. No evidence was present suggesting differences of any magnitude. However, 12 hybrids of this type were made reciprocally and compared in a split plot design using hybrids as main plots and reciprocals as sub-plots. Measurements made were popping expansion, yield, per cent stand, 100 ear weight, weight per unit volume, plant height, ear height, broken stalks, days from planting to mid silk, and earring.

Two of the crosses involved were 3-way crosses. Accordingly, this seed from the cross of Ga^sGa^s x Ga^sga was produced on an inbred line. Stands were 84% as compared to 93% in the reciprocal cross. This was not surprising but the average stand of the Ga^sGa^s x Ga^sga crosses was consistently higher than the reciprocal type even though the seed was all produced the previous year. No plausible explanation is offered for this difference. Yields were not significantly different when adjusted for stand differences.

Table 1. Means and ranges of 12 popcorn hybrids and their reciprocals for 10 characters.

Character	Type of Cross: Ga^sGa^s x Ga^sga range	Ga^sGa^s x Ga^sga mean	Type of Cross: Ga^sga x Ga^sGa^s range	Ga^sga x Ga^sGa^s mean
Popping expansion (cu.in/Lb)	902-1031	966	910-1001	967
Yield (lbs./acre)*	4228-5121	4706	4402-5179	4832
Stand (%)	81-98	91.5	86-98	94.7
Earring (ears/100 plants)	106-153	120	111-140	123
Ear size (lbs/100 ears)	24.1-31.6	27.4	23.2-31.3	27.1
wt. per 8566 (grams)	154-159	154.8	153-158	154.7
Plant height (feet)	5.9-7.0	6.6	6.1-7.0	6.6
Ear height (feet)**	2.9-3.9	3.6	3.1-4.0	3.7
Broken Stalks (%)	17-39	23	10-40	21
Mid-silk (days)	76-80	78.1	76-80	78.1

* Difference between reciprocals significant at 5% level
** " " " " at 1% level.

Most of the $\underline{Ga^sGa^s}$ lines were isolated from sources which were relatively low eared while lines of the $\underline{ga}$ $\underline{ga}$ genotype were from sources with high ear placement. If factors for low ear placement were associated with the $\underline{Ga^s}$ genotype, selection against $\underline{ga}$ pollen may account for significantly lower ear placement in crosses where the seed parent was of the $\underline{Ga^sGa^s}$ genotype.

The effect on ear height was relatively small and the effect of the direction of the cross on other measurements was essentially negative. Accordingly, use of double crosses of the genotype $\underline{Ga^sGa^s}$ x $\underline{Ga^sga}$, using the $\underline{Ga^sga}$ type as the pollinator, appears feasible to reduce contamination by foreign pollen in seed production blocks until the gametophyte factor can be transferred into new $\underline{ga}$ $\underline{ga}$ lines.

W. I. Thomas*
J. C. Eldredge

*Present Address: Department of Agronomy
Pennsylvania State University
University Park, Pennsylvania

IOWA STATE UNIVERSITY
Ames, Iowa
Department of Genetics

1. Alleles at the vp-9 locus.

Viviparous-nine is a white-albino mutant (white endosperm-albino seedling) that has been placed on chromosome 7 eleven units to the left of gl-1. This mutant is very strongly viviparous, with only an occasionally dormant seed observed. As was indicated last year, positive allele tests based on single segregating F_1 ears were obtained in crosses between pas_{4889} (a white endosperm, pale green seedling mutant) and w_{8657} (a yellow endosperm, albino seedling mutant) and between pas_{4889} and vp_9. This year, numerous crosses involving these three mutants confirmed the allelism of pas_{4889} and vp-9 but failed to confirm that of the pas_{4889} and w_{8657}, nor did w_{8657} prove to be allelic to vp_9.

Last spring, several of the white-albino mutants grown under dim light were analyzed for the accumulation of beta-carotene, zeta-carotene, phytofluene and phytoene. In these tests, it was found that vp_9 and its pas_{4889} allele accumulate zeta-carotene and phytoene. A mutant contributed by Dr. Brawn ($w_{Brawn\ \#2}$), which we had not been able to place and for which no alleles had been found, accumulated the same two carotenoid precursors as vp_9 and in the same relative amounts. Extensive allele tests between these two mutants this past summer have established that they are alleles.

Donald S. Robertson
I. C. Anderson

2. The relationship between the accumulation of carotenoid precursors and vivipary in the white-albino mutants.

The white-albino mutants can be divided into at least two groups: 1) those that have a tendency to germinate prematurely, and 2) those that very rarely if ever germinate prematurely. It has been shown by using A-B translocations (Robertson, Proc. Nat. Acad. Sci. 38: 580-583, 1952) that this tendency to germinate prematurely is independent of the genotype of the endosperm and depends on the genotype of the embryo. Thus, vivipary must be the result of changes in the embryo.

As has been indicated above, several of the white-albino mutants including both viviparous and non-viviparous types have been analyzed for the accumulation of the carotenoid precursors, zeta-carotene, phytofluene, and phytoene. The non-viviparous mutants, lw_1, lw_2, w_{7748}, and cl_1 have very little or none of these compounds. However,

the three viviparous mutants tested accumulated one or more of these. White-3 accumulates all three, vp$_9$ accumulates zeta-carotene and phytoene while vp$_5$ accumulates only phytoene. Normal plants do not accumulate these precursors. Presumedly, they are completely utilized in the production of beta-carotene and related compounds. These results suggest that the accumulation of phytoene or some other related precursor may somehow be related to vivipary. The evidence for this is not conclusive as yet but there are three other observations that give circumstantial support to such an explanation for vivipary.

1) Pastel$_{8686}$, the pale green allele of the viviparous mutant w-3, and pastel$_{4889}$, the pale green allele of vp$_9$, have never been observed to be viviparous, nor have the pale green F_1's between these pastels and their respective viviparous alleles. Both of these pastels accumulate phytoene, and other precursors in the same manner as their viviparous alleles. However, since the pastels do produce some beta-carotene, it is reasonable to expect that these precursors might not accumulate to the level responsible for vivipary in their albino alleles.

2) Although viviparous-2 has not been analyzed for all three precursors, it has been shown to accumulate phytoene. The green mosaic allele of this mutant regularly undergoes mutation back to the normal allele resulting in albino seedlings with streaks of green tissue. Various levels of mutability have been found ranging all the way from only one or two small green spots per leaf to levels where seedlings may have so many spots that approximately a quarter of the total leaf area consists of normal tissue. It has been noticed as a consistent thing for many years that the low mutable stocks have a much higher frequency of viviparous seeds than the high mutable stocks. Because of the presence of more green tissue, the high mutable stocks would be expected to utilize more of the carotene precursors and thus these intermediate compounds would not accumulate to the level responsible for vivipary in the low mutable or stable white lines.

3) An albino mutant that accumulates phytoene also is known in the sunflower. In the summer of 1959, some sunflowers heterozygous for the albino mutant were grown. Normally, in the sunflower there is a short period of after ripening, necessary for the mature seed before they will germinate. However, the heads of some of the plants grown in 1959, which were observed to have come in contact with the damp ground before they were harvested, were found to contain some germinating seeds. In all cases, the germinating seeds produced albino plants. None of the seeds giving normal green plants were observed to have germinated. Thus, it appears that the normal dormancy mechanism in this albino mutant of the sunflower is defective, as it is in the albino viviparous mutants of corn, and that the accumulation of carotene precursors seem to be involved in both instances.

Donald S. Robertson
I. C. Anderson

IOWA STATE UNIVERSITY
Ames, Iowa
Departments of Genetics and Agronomy

1. $\underline{a}_1$--mutable of the En system.

The colorless types arising from $\underline{a}_1^{m(dense)}$:

The original mutable allele, $\underline{a}_1^{m(dense)}$, is recognized by its heavily mutating pattern. From testcrosses of this allele, altered patterns of mutability (timing and frequency changes) are recovered. In addition, a high number of colorless kernels arise. These colorless types do not mutate in the presence of En, i.e. their color potential is lost; and, therefore, a permanent change at the locus has occurred. These are designated $\underline{a}_1^{m(nr)}$ (non-responsive) to distinguish them from $\underline{a}_1^{m(r)}$ (respond) types that have a different origin and are mutable when En is present. En was not detected at the $\underline{a}_1$ locus of these $\underline{a}_1^{m(nr)}$ types. This is in contrast to Dr. Brink's comparable stable colorless type of the $\underline{P}^{vv}$ series that does possess Mp near the P locus.

A changed En - $\underline{En}^{mod.}$:

$\underline{En}^{mod.}$ is differentiated from the normal En in its effect on the $\underline{a}_1^{m(r)}$ allele since it induces a very low rate of mutability. From this $\underline{En}^{mod.}$, however, somatic sectors and germinal mutations of high rates of mutability do occur.

Independent En effect on $\underline{a}_1^{m(fine)}$:

The $\underline{a}_1^{m(fine)}$ mutation is autonomously controlled and is represented by a fine clear mutable pattern. It is stable in that it gives primarily $\underline{a}_1^{m(fine)}$ progeny in outcrosses. The presence of Independent En (Inde.-En) with the $\underline{a}_1^{m(fine)}$ allele results in a very dense pattern--a pattern that is similar to the original autonomous dense allele. In addition to this pattern change, the combination of $\underline{a}_1^{m(fine)}$ and Inde.-En results in a high rate of colorless types, which have been tested and found to be $\underline{a}_1^{m(nr)}$ types. Thus, the presence of Inde.-En causes the $\underline{a}_1^{m(fine)}$ allele to change to a non-responding type at a high rate. It, also, causes the loss of all color potential of the $\underline{a}_1^{m}$ allele. The presence of this additional En with the autonomously mutating $\underline{a}_1^{m(fine)}$ allele results in a higher and often earlier mutability which is in contrast to the characteristic responses of higher dosages of mutators, which cause later and, therefore, lighter patterns.

Peter A. Peterson

2. Relation of centromere associations to knob number.

In studies of pachytene, observations were made of both knob associations and centromere associations. Two families were used, an F_1 of Maiz Chapolote X Tama Knobless Flint (heterozygous for 12 knobs), and an F_1 of a standard genetic line X Tama Knobless Flint (heterozygous for 8 knobs).

It was observed that centromere associations occurred with significantly more frequency in the family with the fewer knobs. (Table I) In this family, knob associations and centromere associations occurred with equal frequency. In the family with 12 knobs, knob associations were 3.54 times as frequent as centromere associations. (Table II)

Table I

family	# of knobs	# of cells	total # of centromere associations	frequency of centromere association
'60-862	12	25	13	52.0%
'60-844	8	25	24	96.0%

$X^2 = 12.578$ $P<0.01$

Table II

family	# of knobs	# of knob associations	# of centromere associations	ratio: knob/ centromere
'60-862	12	46	13	3.54
'60-844	8	25	24	1.04

Sylvia Zvingilas

3. Relation of multiple chromosome associations at diakinesis to knob associations at pachytene.

Using the same crosses as above, pachytene figures of the family having 12 knobs showed significantly more multiple knob associations (3 or more knobs per association) than that with 8 knobs. (Table I)

In diakinesis studies of the same plants, the family with 12 knobs showed fewer single individual bivalents, but more double and multiple bivalent associations. (Table II)

These observations suggest that the knob associations observed at pachytene persist through diakinesis.

Table I (Pachytene)

family	# of knobs	# of associations of 2 knobs	# of associations of 3 or more	total
'60-862	12	21	25	46
'60-844	8	24	1	25

$X^2 = 21.775$ $P<0.005$

Table II (Diakinesis)

family	# of knobs	cells	single bivalents	association of 2 bivalents	associations of 3 or more bivalents
'60-862	12	242	1647	194	106
'60-844	8	243	1777	161	80

For single bivalents, $X^2 = 10.09$ $P<0.025$

Sylvia Zvingilas

ISTITUTO DI GENETICA VEGETALE
UNIVERSITÀ CATTOLICÀ DEL S. CUORE
Piacenza, Italy

and

ISTITUTO DI GENETICA
UNIVERSITÀ DI MILANO
Milano, Italy

1. Defective endosperm factor in maize teosinte derivatives.

The study of such de^t factors has been continued. Other allelism tests have been carried out. However, while no other sure cases of allelism have been found, it seems fairly well established that de^{t13} is not allelic to de^{t25} and to de^{t12}.

The stock segregating de^{t1}, which is known to be linked with su, presents also germless kernels with almost normal endosperm. It is of interest that de^{t1} kernels were defective for endosperm as well as germless. The percentage of the new germless is varying: some ears have about 25% of this condition together with an equivalent percent of the original de^{t1} kernels. Other ears show either only de^{t1} kernels or the new germless. It is not certain whether the new germless is an allelic special condition of de^{t1} or is controlled by another locus. In the first case the situation is similar to that described for de^{t22}, in which its intermediate allele, in heterozygous condition, produces "monohybrid segregation" of about 40% of defectives.

A large scale series of self-pollinations has been completed from ears segregating de^{t1} and de^{t2} in background in which both factors are relatively stable and clearly distinguishable from the normal class. The following results definitively prove that de^{t1} and de^{t2} are located on chromosome 4 and form an example of balanced lethal system:

No. of ears segregating:		
both defectives	one defective	no defective
356	103	5

From such figures, clearly deviating from a 4:4:1 ratio indicating independence, it is also possible to calculate the recombination frequency between de^{t1} and de^{t2}. This turns out to be about 23 percent.

A. Bianchi
A. Morandi

2. Mendelian factors in Italian open pollinated varieties.

In the study of the genetical structure of Italian varieties more extensive data have been obtained, by artificially self-pollinating individual plants of some Italian open-pollinated varieties of commercial field corn. Table I shows the number of plants heterozygous for the recessive characters encountered in scoring the products of such self-pollinations.

Table I. Individuals heterozygous for various recessive mutants in some Italian varieties of maize.

Variety	Ratio	Defective endosperm	Virescent seedling	Yellow seedling	Glossy seedling	Pale green seedling	Dwarf seedling	Striped seedling	Ligueless	Other seed characters	Other seedling characters	Total examined
Locale Valle d'Arena, Potenza	3:1	9	3	2	1	1	1	1		3	2	37
	15:1							1				
Pergola, Pesaro	3:1	7		2		2				2	2	40
	15:1									2	1	
Marano, Vercelli	3:1	5	1	2		1	2		1			23
	15:1	1								1	1	
Sacra Famiglia, Vercelli	3:1	3	3			1	2	3			6	33
	15:1											
Nostrano dell Isola, Vercelli	3:1	3	14			3		1			2	46
	15:1											

A. Bianchi
M. Pozzi

3. Mutagenic activity of ethyl methan sulfonate.

In barley, Heslot et al. (C.R. Séances Acad. Sci., Paris, 1959) have shown that the ethyl methan sulfonate applied to seed is a very powerful mutagen. Some preliminary experiments conducted by means of pollen treatment in maize gave inconclusive results. However, treatments carried out on maize seeds, heterozygous

for alleles of the yg_2 locus, seem clearly to confirm its strong mutagenic action. Somatic sectors, representing losses of the dominant allele (action), provide a criterion of genetic damage.

A first series of data are summarized in Table II.

It may be noted that the EMS not only is a powerful mutagen when applied to maize seed, but also its action tends to persist in cell lineages: while the X ray sectors are reduced by a factor of at least 3, the EMS sectors are only halved passing from the 3rd leaf to the 4th one. The linearity between sector frequency and EMS concentration is very striking.

Table II. Mutagenic action of ethyl methan sulfonate (EMS) as measured by sector frequency of leaves 3 and 4 in maize seedlings of yg_2/Yg_2 genotype (yellow green sectors on green background)

Type of treatment		control (no treatment)	6000 r	EMS 1/100	EMS 1/200	EMS 1/400	EMS 1/800
a) germination %		100	100	44.0	96.0	98.0	96.7
Physiological responses							
b) seedling height in cm.		13.7	13.8	4.1	10.2	12.5	13.6
Genetical response [No. of mutant sectors per leaf.]	3rd leaf	0.4	9.2	Scoring impracticable	21.3	12.4	5.8
	4th leaf	0.0	2.6	"	10.0	6.3	3.4

A. Bianchi
M. Contin

4. Scutellum colour factor in short arm of chromosome 4.

Crosses of TB-4a on A158T reveal that a factor for scutellum colour is present in the segment of the short arm of chromosome 4 that is translocated to the B centromere region, namely the distal 3/4 portion of the arm (the breakage point is proximal to su_1).

Table III. Results of crossing TB-4a on A158T.

No. of ears	No. of kernels			
	small		large	
	coloured scutellum	colourless scutellum	coloured scutellum	colourless scutellum
6	1899	0	369	437

These data suggest that the scutellum locus involved is possibly S_1 of Sprague (1932), whose data showed linkage with su; from the available data it seems also that S_1 is distal to such a marker. It is interesting to note, also, that, among the large kernels, those having a colourless scutellum are slightly heavier than the other ones (mg 0.152 against mg 0.140): this indicates that, as expected, their endosperm is hyperploid, and that such hyperploidy results in larger endosperm.

G. Bellini
E. Ottaviano
A. Ghidoni

MACDONALD COLLEGE
OF
MCGILL UNIVERSITY
Province of Quebec, Canada

1. "Curing" maize of its cytoplasmic male sterility.

Lederberg (Physiol. Rev. 32 : 403-430, 1952) suggested that cytoplasmic male sterility could be the result of an alien virus in the maize plant, and that the male sterility was the symptom of the infection. Many experiments are suggested by this hypothesis. For instance, it is known that the shock of high temperature may inactivate or kill a number of plant viruses and thus rid the plants of their infection. An experiment in which cytoplasmic male sterile maize

seedlings were subjected to heat shocks produced encouraging results in 1959 in the form of four plants apparently "cured" of their cytoplasmic male sterility. The experiment was repeated in 1960 without success. The "cured" plants in 1959 produced abundant pollen and two were detected in time to be selfed. However, no marker genes were present and it is possible that the fertile plants could have arisen in some manner other than as the result of heat shock. For the record it is proposed to record the procedures followed in 1959. Somewhat different equipment and seed stocks were used in 1960!

A flint-dent hybrid which has been consistently sterile with T-cytoplasm was used. Fifty seeds were planted on 3/4 of an inch of sand and covered with a like amount of sand in 4-1/2 x 4-1/2 x 1-1/2 inch cardboard germinating dishes. After planting, the dishes were watered and placed in an incubator at 25°C. for 48 hours. Hot tap water was then added to heat the sand, and the dishes were moved to a laboratory oven set at 45°C. for about 30 hours. The dishes were then removed to a table in a well lighted room and allowed to recover for a few days. The survivors, usually 10 to 20 seedlings per box were transplanted into the field when about 2 to 3 inches high.

From a total of 3100 seeds (62 dishes) run through this cycle, about 120 plants reached the flowering stage in the field and of these 4 shed pollen. Field conditions at flowering time were not those usually associated with the breakdown of cytoplasmic male sterility. The weather was very dry and unusually warm for this region at the time of flowering and many instances of male sterility in ordinarily fertile plants were noted. It is not likely, therefore, that a favorable environment contributed to pollen shedding.

Robert I. Brawn

2. Homozygous variegated pericarp with heterozygous variegated phenotype.

A variegated ear was found in 1959 which was as heavily striped as, and indistinguishable from, heterozygous variegated in the same inbred background, but with the variegated cob of a homozygote. Wood and Brink (P.N.A.S. 42, 1956) have substantiated the earlier observation of Emerson that maize plants heterozygous for variegated pericarp and cob (P^{vv}) and a stable allele (e.g. P^{wr}, colorless pericarp and red cob) bear ears which are more heavily striped than those from homozygous variegated. In the background of inbred Wisconsin 9 this difference is quite clear.

The homozygous variegated plant on which this ear arose was the result of 6 backcrosses of the standard Wisconsin P^{vv} allele into inbred W9 followed by three self-pollinations. Only one ear in a progeny of 8 homozygous ears showed the darker "pseudo-medium variegated" phenotype. The ear had been pollinated with P^{wr} in 1959 prior to its discovery.

A progeny of 32 ears was grown out in 1960 from this ear of which one was red and 31 were variegated confirming the homozygosity of the parent ear. The P^{wr} male parent had only been backcrossed to inbred W9 three times and so it introduced some variability into the background with the result that the expected medium variegated phenotype of the progeny was somewhat more variable than in a highly inbred background. The suggestion of two distinct classes of variegation was nevertheless thought to be present (14 ears with variegated pericarp darker than the other 17). Which class corresponded with the standard medium variegated could not be determined at once.

Robert I. Brawn

3. Blushed pericarp.

The variegated ears in two parallel lines of the ninth backcross of the standard Wisconsin P^{vv} allele into inbred W9 (P^{wr}) were observed to differ in phenotype in 1959. The one line appeared to be darker than the other, the lighter of the two representing typical medium variegated (P^{vv}/P^{wr}). The difference appeared to be due to an overall darkening of the pericarp and not to a change in the number or size of the red stripes although no exact measurements were taken. Within the line with the darker pericarp, one non-variegated ear with a pale orange or blushed pericarp colour was present. This ear had been selfed. In 1960 it produced 7 blushed pericarp and 1 non-blushed or typical colorless pericarp, red cob (P^{wr}/P^{wr}) progeny.

A medium variegated sib ear with the darker phenotype which has been backcrossed the tenth time with inbred W9 was also grown out in 1960. It produced 7 variegated, 7 blushed and two P^{wr} offspring. The variegated ears in this progeny appeared to consist of 4 darker and 3 standard medium variegated ears.

These observations may be explained if we assume a dominant gene for blushed pericarp which segregates independently of the P-locus, and which in combination with P^{vv} causes the overall phenotype of medium variegated to appear darker.

Robert I. Brawn

4. A test for paramutation at the P locus.

An invariable change of the kind reported by Brink for R^{st} and R^{mb} in heterozygotes with R^{r} was not found at the P locus when the standard Wisconsin P^{vv} (variegated pericarp) allele was used in a mating scheme with P^{rr} (red pericarp) similar to that developed by Brink (Genetics 41, 1956).

The heterozygote P^{rr}/P^{vv} was self pollinated and the progeny were grown out and pollinated with homozygous P^{wr} in the same inbred background as the P^{vv} and P^{rr} parent cultures. Four red pericarp F_2 segregates and 2 variegated F_2 segregates were selected and grown out and the progeny examined for deviations from the expected red pericarp and medium variegated pericarp.

Three of the four red F_2 ears proved to be homozygous P^{rr} and produced only red pericarp offspring. One of the red F_2 ears was apparently heterozygous and produced medium variegated and red pericarp offspring. The two variegated F_2 ears were homozygous and produced medium variegated offspring plus a few red pericarp mutants as expected.

All of the red pericarp ears in the 6 cultures were similar in phenotype and the variegated ears were typical medium variegated phenotype for the background used. Thus, there is no evidence of paramutation between these P^{rr} and P^{vv} alleles.

Robert I. Brawn

UNIVERSITY OF MINNESOTA
St. Paul, Minnesota
Department of Agronomy and Plant Genetics

1. Differences in recombination in ♂ and ♀.

Crosses between exotic stocks and 5-9a carrying sh wx gl were backcrossed reciprocally with sh wx gl. Only the results for sh-wx are completed. In all cases, crossing over was higher in the ♂. For crosses with Purple Tama, the averages are 8.9 and 14.7, for Argentine pop, 8.9 and 15.5; and for KYS, 3.1 and 16.4. These large differences were not found in hybrids between the exotics and normal sh wx gl stocks.

C. R. Burnham

2. Linkage relations of teosinte branched (News Letter #33, p. 74).

F_2 data from crosses segregating for br f bm_2, or for f bm and teosinte branched show this gene is probably between f and bm_2. The F_2 data for f bm and teosinte branched (tb) are: F Bm = 216 Tb, 98 tb; F bm = 81 Tb, 8 tb; f Bm = 57 Tb, 6 tb; f bm = 30 Tb, no tb. Using the product method the f-tb recombination is 28.1 and bm-tb is 27.8. The absence of tb plants which are f bm agrees with the conclusion that tb is between these two genes. Crosses between bm tb and f tb plants were made to produce the triple recessive. The character is easily classified even in the presence of brachytic. It produces pollen, but rarely any seed.

3. Progress in producing multiple interchange stocks.

Tests to establish stocks homozygous for the following new combinations will be grown in 1961: 2-1-7, 3-1-7, 6-1-7, 1-2-6, 3-2-6, 4-2-6, 4-2-9, 3-2-4, 1-3-9, 4-3-9, 3-4-8, 1-6-5, 8-10-9, and 8-9-10. Several multiple interchange stocks for rings of 8 have been produced and more are planned for possible use in studies of their effect on segregation for quantitative characters. Progress continues on the crosses planned to produce eventually the ring with 20 chromosomes.

4. Segregation for quantitative characters in crosses with multiple interchange stocks.

For W23 x A188 (1-5-6-7-8 interchange stock) and P39a (1-5-6-7-8) x A188 each with a ring of 10 chromosomes, and for the crosses of normal inbreds, W23 x A188 and P39A x A188, progeny from selfs and backcrosses to both parents were grown in a replicated trial. Notes on silking date, plant height, number of tassel branches, and various ear characters including degree of sterility were taken. A prolonged dry period affected growth and practically eliminated tillering. Preliminary summaries of the data on the various characters show no instance of a sharp segregation into two groups correlated with the presence or absence of the large ring. For the W23 x A188 (010) cross, there was a slight association between number of tassel branches and segregation for high sterility vs. normal fertility. For the P39 (010) x A188 cross, the average heights to the lowest tassel branch were:

For F_2:	010 = 108 cm.,	N = 115
" BC to A188:	" = 121 "	N = 119
" BC to P39:	" = 116 "	N = 133

The differences in F_2 and backcross to P39 are suggestive of an association. The differences are in the direction expected from such an association. This ring of 10 was produced by successive X-ray treatment. The proportion of the five chromosomes covered by this 010 is not known, but it may be relatively small. The multiple interchange stocks being built up by crossing over should be better suited to this type of study. Tests are being continued.

The work with multiple interchange stocks is supported by a Rockefeller Foundation Research Grant.

C. R. Burnham
Paul Yagyu

assisted by

K. Kasha
K. K. Batra
R. Sheehan

5. Notes on the pocket microscope (M.N.L. 34, p. 89).

A few of you may have the "Leitz Taschen Mikroskop" with a magnification of 40X. Our department purchased two in 1935 for $8 each, but they have not been available from Leitz for many years. The company could not be induced to make them again. A company in Italy which makes many Leitz instruments was skeptical that what I described could exist. Finally, among the catalogs and other descriptive material sent by a microscope manufacturer in Tokyo, was one sheet describing "The Midgard" pocket microscope which resembled the Leitz instrument. This instrument, mentioned in last year's News Letter, is approximately 1" in diameter, 2" long, and similar to the Leitz instrument mechanically, but has a somewhat lower magnification, and does not give an image that is quite as satisfactory. It can be improved somewhat by using a metal reamer to enlarge the opening at the lower end of the instrument to let more light in. All that is needed is a narrow rim wide enough to hold the spring. For checking pollen sterility in the field it is a very convenient instrument. Its cost has been $3 each plus $1 postage if by air mail; no duty on shipments received here thus far. The source is:

Nippon Microscope Works Company
35-2 Minamicho
Aoyama, Akasaka
Tokyo, Japan

C. R. Burnham

6. Unpaired spikelet condition in lateral and terminal inflorescences.

Ears with an odd number of kernel rows due to unpaired spikelets were first reported by Hepperly (J. Hered. 1949). This material was studied further by Wilcox (M.S. Thesis, U. of Ill. 1951) and is very probably the source of material reported here. The specific stock used in this study was from an ear having an odd number of kernel rows and was obtained from Funk Brothers Seed Co. in 1958.

Relationship between the unpaired spikelet condition in the ear and tassel was studied by correlating tassel condensation (Anderson, Ann. Mo. Bot. Gard. 1944) with kernel row number for the unpaired pistillate spikelets. The tassel condensation procedure was modified by taking five times the average number of spikelets per node (Anderson used ten times the average number of spikelet pairs per node), since the unpaired spikelet material often had single or odd numbers of spikelets at a node. Spikelet counts were made on 20 nodes per tassel using 295 plants. The central spike rather than the lowermost tassel branch was used since much of the unpaired spikelet material had only a central spike.

A correlation value of 0.189 was obtained between actual and predicted row number. Although this correlation is significant, the modified tassel condensation formula does not appear to be a reliable predictor for kernel row number in this material on an individual plant basis. This essentially agrees with Wilcox who indicated that the ear and tassel do not show a correlation in the number of rudimentary or paired spikelets, but did not give any correlation values. Wilcox also stated that, every time unpaired spikelets were found in the tassel, the ear had unpaired spikelets. This was found to be generally true in the present study; however, several exceptions were found in that some plants had paired spikelets in the tassel and unpaired spikelets in the ear. Furthermore, plants were found that had unpaired spikelets in the tassel and paired spikelets in the ear.

The unpaired spikelet condition develops because one member of the spikelet pair is arrested in its development. Morphological studies on the lateral inflorescence are currently in progress to identify the stage at which this occurs.

Robert W. Briggs
James C. Sentz

7. Centromere activity.

Comparisons of rings of four at metaphase I in corn and in barley show much stronger centromere activity in the chromosomes in corn than in those in barley. In barley as first reported by Hagberg, often only two chromosomes in alternate positions in the ring are orientated toward the two poles. Further studies are needed to determine if these observations offer any clue as to the cause of directed segregation.

O. L. Miller
C. R. Burnham

UNIVERSITY OF MINNESOTA
Minneapolis, Minnesota
Department of Zoology

1. Crossing over and chromosome duplication.

The problem of chromosome duplication in relation to time of crossing over can be approached by use of the 5-6c translocation in maize with which crossovers in the interstitial segments of plants heterozygous for the translocation can be determined by abnormal nucleolar organizer distribution in the quartet stage. The following preliminary results with a small number of plants (het T5-6c, homo In5) indicate that high temperature treatment at 35-38°C during mid-pachytene to diplotene increases the frequency of crossover quartets compared with controls at 22-25°C. The heat treatment presumably is being applied after DNA-histone duplication is complete, although this remains to be verified for maize - probably by radioautography since Feulgen staining of maize PMC's generally is too weak for spectrophotometry. The substantiation of these results by further experimentation with larger numbers would indicate separation of chromosome duplication and crossing over in time, a fact which seems to be contrary to the current views of a majority of microbial geneticists.

	Quartet Type			
Sample (35-38°)	Non-C.O.	C.O.	Total	% C.O. Quartets
A	31	89	120	74
B	21	48	69	68
C	3	13	16	81
D	19	30	49	61
E	11	32	43	74
	85	212	297	71

Sample (22-25°)	Quartet Type: Non-C.O.	C.O.	Total	% C.O. Quartets
A	18	36	54	67
B	73	140	213	66
C	94	155	249	62
	185	331	516	64

Oscar L. Miller, Jr.

UNIVERSITY OF MISSOURI
Columbia, Missouri
Department of Field Crops

1. A small telocentric fragment.

During the course of an attempt to synthesize newer forms of altered abnormal chromosome 10, one B.C.-1 plant was found to possess, in addition to its normal complement, an extremely minute telocentric fragment. This chromosome consists of not more than two discernable chromomeres and thus can easily be mistaken for foreign matter. It is considerably easier to observe at late diakinesis and metaphase I. Unfortunately the origin of this centric fragment is unknown. Inasmuch as the semi-sterile F-1 plant was weak and runty, microsporocytes were not sampled.

A project has been initiated to study the behavior of this fragment chromosome and to determine whether any "major" genes are located in this piece of chromatin.

Gary Y. Kikudome

2. Comparison of two K10 chromosomes.

Cytological examination of plants heterozygous for the Longley-Rhoades type of abnormal chromosome 10 (K10) and for Ting's (K_T 10) type has revealed that the latter is considerably shorter than the former. Furthermore, the knob on K_T 10 is only about a third as large as that in K10. The following diagram should reveal the gross differences between these two forms of abnormal chromosome 10:

In these heterozygotes, the extent of neocentric activity is not unlike that found in K10/k10 plants. Also, preliminary results indicate that K_T10 is incapable of inducing preferential segregation. Thus far, random segregation ratios have been obtained for the loci on the short arm of chromosome 9 which were followed and for R:r of chromosome 10.

Further study is being made to confirm the above results. Should this endeavor confirm the preliminary results, we may need to re-evaluate the relationship between neocentromere formation and preferential segregation.

Gary Y. Kikudome

3. Test of the heterochromatic nature of Ds.

Results thus far obtained do not give positive evidence that Ds is genetically similar to knobs (heterochromatic) in their preferential segregation response to the presence of the abnormal chromosome 10. Examination of about 1500 kernels was made and this number is admittedly too small. More exhaustive tests need be made to determine whether the Ds element can undergo preferential segregation. There is always the possibility that Ds, though heterochromatic, is qualitatively unlike the heterochromatin of the knobs and therefore immune to the actions of the abnormal chromosome 10.

Gary Y. Kikudome

4. Location of new positions of M.

In order to determine the limits within which M may be transposed to new positions and also for the purpose of obtaining stocks with M on certain chromosomes, large numbers of single seed cases which by their appearance may have a newly transposed M, were tested for linkage. M is the mutator factor of the bz^m_2-M mutator system and is roughly equivalent to Ac (MNL 29: 59).

The experiment consisted of crossing bz^m_2 bz^m_2, no M by bz^m_2 bz^m_2, M M to produce F_1 seeds carrying 1 dose of M (large sectors indicating early change of bz^m to Bz). Among large numbers of these are found occasional cases which appear to have 2 doses (many small colored sectors). These presumably have 2 M's (one at the original position and one at a new position). On backcrossing to $bz^m bz^m$, no M, they produced a ratio of 1 two dose:2 one dose:1 which is typical of 2 factors instead of a normal one factor 1:1 ratio.

These cases were all planted and the plants selfed and crossed on a series of waxy marked translocations (the standard chromosome 9 series obtained from E. G. Anderson or a colored aleurone series extracted from the originals). The colored non-waxy F_1 seeds from these crosses were planted and backcrossed to a $\underline{bz}^m$, $\underline{wx}$, no $\underline{M}$ stock. The embryos of the F_1 seeds were all $\underline{Bz}$ $\underline{bz}^m$ and of 4 types with regard to $\underline{M}$ (1) $\underline{M}_1$ $\underline{M}_2$ ($\underline{M}_1$ is the original position, $\underline{M}_2$ the new one) (2) $\underline{M}_1$ (3) $\underline{M}_2$ and (4) no $\underline{M}$. These when grown and backcrossed to $\underline{bz}^m\underline{wx}$ produced ears with $\underline{Bz}$ $\underline{bz}^m$ and $\underline{bz}^m$ $\underline{bz}^m$ seeds the latter of which had either a 1$\underline{M}$ $\underline{M}$:2$\underline{M}$:1 no $\underline{M}$ ratio, a 1$\underline{M}$:1 no $\underline{M}$ ratio, or no $\underline{M}$ at all.

Separation of the $\underline{bz}^m$ $\underline{bz}^m$ seeds from the 1:1 ears for $\underline{Wx}$ and $\underline{M}$ should give evidence for linkage of either $\underline{M}_1$ or $\underline{M}_2$ with each translocation. This was done with as many cases as were available. The results are listed below:

Translocation	Number of cases tested	Cases with Wx-M linkage
1-9c	38	29
1-9(4995)	41	6+1?
2-9b	22	1
3-9c	27	1
4-9g	31	1
5-9c	25	3+2?
6-9b	9	1?
7-9a	45	0
8-9d	23	2+3?
9-10a	7	2
linked to 9	7	1

From the above it may be concluded that the original position of $\underline{M}$ is on the short arm of chromosome number 1, perhaps at the $\underline{P}$ locus but not expressed as $\underline{P}^v$ ($\underline{Mp}$ according to Brink's designation) since the recessive allele $\underline{p}$ is present in this stock. It was also found that the translocation stock 4-9g was segregating for another $\underline{M}$ factor located on chromosome number 4.

The data do not give specific locations of new positions but do show that $\underline{M}$ may be transposed to all but one of the chromosomes in the complement. The number of cases is too small to provide enough information for accurate comparison between chromosomes but it does appear noteworthy that 45 F_1's involving translocation 7-9a failed to show a single case of transposition.

M. G. Nuffer

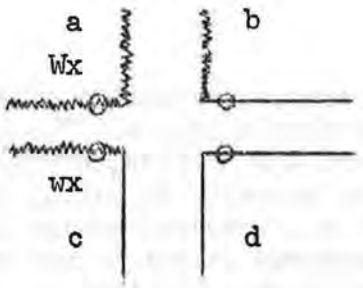
5. Differences in ♀ and ♂ transmission for heterozygotes involving the wx 9 translocation series.

The backcrosses described above were produced from crosses in which the F_1's were used as either ♀ or as ♂ parents, the deciding factor being the presence or absence of r in the F_1. Only the homozygous bz^m seeds were classified for M and Wx hence Wx vs wx counts represent only half of the seed produced and the results may be susceptible to a certain amount of error on this account. However, with this reservation, it is possible to measure transmission of each wx marked translocation through ♀ and ♂ gametes. The results listed below show two things (1) linkage of $bz^m{}_2$ to T 1-9(4995) on the long arm of chromosome number 1 as shown by reduced transmission of bz wx gametes in both female and male. (2) An overall increase in transmission of Wx carrying gametes through the female side.

Frequency of starchy vs waxy seeds from a cross of Twx/N Wx x N wx showing differences when heterozygote is used as female or as male.

Translocation	female			male		
	Wx	wx	Wx/wx	Wx	wx	Wx/wx
1-9c	5573	3270	1.70	1606	1498	1.07
1-9(4995)	1167	389	3.00	5448	2062	2.64
2-9b	1036	727	1.43	1711	1990	.86
3-9c	830	651	1.27	2142	1807	1.19
4-9g	1696	1233	1.38	2267	2327	.97
5-9c	1031	776	1.33	2678	2616	1.02
6-9b				1548	1467	1.08
7-9a	2565	2324	1.10	2083	2148	.97
8-9d	1664	1310	1.27	2364	2428	.97
9-10b				709	745	.95
Totals	15562	10680	1.46	22556	19088	1.18

It is interesting to consider the possible causes of the latter. The two most likely possibilities appear to be (a) that the duplication deficiency products of adjacent disjunction may be differentially viable in the female (inviable in the male) such that the normal Wx carrying chromosome is essential before a deficiency for another chromosome can survive. This seems rather unlikely since the effect is expressed for all 8 of the translocations listed. (b) that nondisjunction occurs such that a 3:1 distribution of the members of the translocation configuration is obtained and that the gametes with extra chromosomes are transmitted through the female but not the male and further that the gametes getting only one chromatid are completely inviable in both. Such behavior would cause an increase in Wx gametes as indicated below.



disjunction product	wx constitution
a b d	Wx
b d c	wx
d c a	Wx wx
c a b	Wx wx

Thus whenever 3:1 distribution occurs 3/4 of the gametes produced carry Wx and this added to the usual equal distribution of gametes from alternate disjunction would increase the frequency of Wx individuals when the heterozygote was the female but not when the male.

If one considers the difference between male and female transmission in this experiment (24% or roughly 1/5) and if one attributes this to 3:1 distribution one can see that the frequency of such distribution must be high (since only 3/4 of the non-disjunction events give Wx carrying gametes). This can be calculated as $1/5 + 1/3 \times 1/5 = 4/15$ or 26.7%. In other words, 26.7% of the megasporocytes must undergo unequal distribution, an unexpectedly high figure for non-disjunction in translocations in general.

M. G. Nuffer

UNIVERSITY OF MISSOURI

and

UNITED STATES DEPARTMENT OF AGRICULTURE
Columbia, Missouri

1. The gene action sequence in anthocyanin synthesis.

Previous investigations by various workers have led to the following hypothetical gene action sequence (News Letter 31:138):

(C,R); In; A_1; Bz; A_2---------- anthocyanin

It has been suggested that confirmation of such sequences requires a study of the active synthetic stages. Twenty-day old aleurone tissues of self-fertilized colorless testers, singly recessive for $\underline{a_1}$, $\underline{a_2}$, $\underline{c}$, $\underline{r}$, or $\underline{bz_1}$, were pressed together in pairs, using pieces of distinguishable size, and placed on a complete medium or on agar at 25°C. in test tubes. Pigment was observed in one to two days and was subjected to the standard 10% hydrochloric acid test to confirm that the synthesized pigment was anthocyanin. All possible combinations with $\underline{a_1}$, $\underline{a_2}$, $\underline{c}$, $\underline{r}$, and $\underline{bz_1}$ were made and subjected to the above conditions. Complementary interaction resulting in anthocyanin synthesis was observed in all cases and it was unidirectional without a single exception. Out of every two testers (donor and receiver) combined, consistently only one (the receiver) gave pigment. This suggests that the precursors produced and/or controlled by the donor tester are subsequently used by the receiver to give anthocyanin pigment, since the receiver carries the dominant factor that is lacking in the other, as well as all subsequent factors in the sequence. With this reasoning and observations on all the combinations of the above testers it was determined that the action of $\underline{C}$ precedes $\underline{R}$ ($\underline{c}$ tester develops pigment in the pair of $\underline{c}$ with $\underline{r}$), $\underline{R}$ precedes $\underline{A_1}$, $\underline{A_1}$ precedes $\underline{A_2}$, and $\underline{A_2}$ probably precedes $\underline{Bz_1}$ in the synthesis of the pigment. Aleurone tissue of $\underline{in}$ tester, when subjected to the above conditions, was a strong donor to $\underline{c}$ and $\underline{r}$ testers, but was only a weak donor of the required substrates to $\underline{a_1}$, $\underline{a_2}$, and $\underline{bz_1}$. This quantitative criterion of intensity for $\underline{In}$ suggests its modifying action may follow the action of $\underline{R}$ in the sequence.

The behavior of homozygous $\underline{C^I}$ was interesting. When $\underline{C^I}$ aleurone tissue was combined with the others (i.e. $\underline{a_1}$, $\underline{a_2}$, $\underline{c}$, $\underline{r}$, $\underline{bz_1}$ and $\underline{in}$), $\underline{C^I}$ gave pigment, suggesting that, at the least, the inhibitory action of $\underline{C^I}$ precedes the action of $\underline{C}$. The interaction of $\underline{C^I}$ (presumably an allele of $\underline{C}$) and $\underline{c}$ tester in the production of anthocyanin draws special attention. All these observations establish the following sequence:

C^I, C, R, (In), A_1, A_2, (Bz_1)---- anthocyanin

The position of other known genes ($\underline{C_2}$, $\underline{Bz_2}$) and the modifiers is still to be determined, and attempts to identify accumulated substrates and to demonstrate catalysts are in progress.

G. M. Reddy

2. Endosperm culture.

Non-sugary (wild type) endosperm tissue, cultured last summer, has given continuous growth and pigment synthesis since that time. The medium was modified from that described in MNL 32: 103, substituting 5 gm. of Difco yeast extract for the tomato juice and using

only 20 gm. of sucrose and 8 gm. of agar. Subcultures of a_2, C^I, Pr, and pr were successful, and r tester has shown especially vigorous growth (in some cases as high as a 100-fold increase in volume in about six weeks, without transferring). This growth was not consistent throughout the cultures, of course, but was very significant in some. These observations are in conformity with the studies of Tamaoki and Ullstrup (Bull. Torrey Bot. Club, 1958), except that growth of non-sugary material so far is not limited in our cultures, even after six months. The distinctive phenotypic pigments, dark purple in Pr, dark red in pr, intense (almost black) in in and bronze in bz_1, cultures, are developed. In Pr and pr sub-cultures occasional colorless and pale-colored cell clusters are observed.

E. H. Coe, Jr.
G. M. Reddy

3. Haploid induction.

Properly-marked inducer lines have been recovered from third-generation backcrosses to stock 6 (see MNL 33:77). Although pollen of stock 6 induced as high as 2.35 ± 0.302% haploids in one gl_1 egg parent, a gl_{10}-marked parent that has a field-corn background gave only 0.98 ± 0.138%. The recovered marked lines vary in induction potential, but include individuals giving 1.18 ± 0.414% and 1.09 ± .198% in crosses to gl_{10} (8 haploids in 681 and 30 in 2755, respectively). Seed is available but quite limited in supply.

E. H. Coe, Jr.

4. Anti-inhibitor effect of bz_2: a correction.

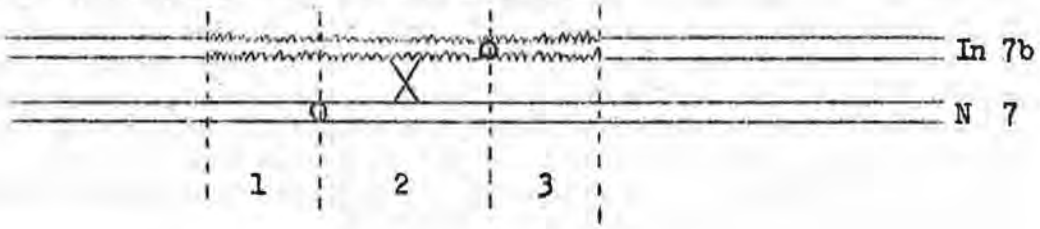
Although the effect was attributed to bz_2, further tests show that bz_2 itself is not involved in suppression of C^I, but that the bz_2 stocks carry a special C allele and an independent modifier. Further tests are in progress.

E. H. Coe, Jr.

5. Non-homologous crossing over.

The occurrence of non-homologous crossing over is suggested by the presence of reciprocal translocations in the progeny of monoploids. However, it is possible that the crossing over occurs between duplicated segments.

Non-homologous pairing is of frequent occurrence in inversion heterozygotes. In the case of pericentric inversions whose break points are of unequal distances from the centromere, non-homologous pairing leads to an interesting situation.



A crossover in region 2 will lead to the formation of a bridge and a fragment at the first anaphase, something which is not normally expected in a pericentric inversion heterozygote.

Limited data have been obtained using In 7b (S. 32 - L. 30) which is diagrammed above. It is difficult to get an unbiased estimate of the frequency of non-homologous pairing, since not all pachytene figures are analysable. However, with this inversion, which is a relatively short one, non-homologous pairing takes place about a third of the time. Three cases of a bridge and fragment were observed out of a total of 352 anaphases. Unfortunately sporocytes of control plants (normal sibs of the In 7b heterozygotes) are not available, so these data are inconclusive, since there is a possibility that the bridges could have arisen from small paracentric inversions which were not detected.

G. G. Doyle

NORTH CAROLINA STATE COLLEGE
Raleigh, North Carolina

1. Epistatic variance for yield in two varieties of corn.

Experiments have been underway at North Carolina State College to obtain estimates of epistatic variance in two open-pollinated varieties, Jarvis and Indian Chief. The genetic material included full-sibs and half-sibs from random inbred parents and non-inbred parents of each variety. The material has been grown in replicated yield tests at two locations for two years, and has given rise to the estimates presented in Table 1.

Table 1. Estimates of genetic variances in two corn varieties (pounds of ear corn per plant)

	Jarvis	Indian Chief
$\sigma_{10}^2 + 1/4\ \sigma_{20}^2 + 1/16\ \sigma_{30}^2 + \ldots$	.00176	.00125
$\sigma_{10}^2 + 1/2\ \sigma_{20}^2 + 1/4\ \sigma_{30}^2 + \ldots$	.00160	.00110
$\sigma_{01}^2 + 1/2\ \sigma_{20}^2 + 1/2\ \sigma_{11}^2 + 1/4\ \sigma_{02}^2 + 3/8\ \sigma_{30}^2 + \ldots$	.00272	-.00048
$\sigma_{01}^2 + 1/2\ \sigma_{20}^2 + \sigma_{11}^2 + \sigma_{02}^2 + 3/4\ \sigma_{30}^2 + \ldots$	.00061	.00070
$\sigma_{20}^2 + 3/4\ \sigma_{30} + \ldots$	-.00064	-.00060

σ_{10}^2 = genetic variance due to additive effects of genes.

σ_{20}^2 = epistatic variance due to additive x additive interaction effects.

σ_{30}^2 = epistatic variance due to additive x additive x additive interaction effects.

σ_{01}^2 = dominance variance due to dominance effects.

σ_{02}^2 = epistatic variance due to dominance x dominance interaction effects.

σ_{11}^2 = epistatic variance due to additive x dominance interaction effects.

The results obtained so far indicate that the additive genetic variance for yield is as large or larger than the dominance variance in both varieties. Estimates of epistatic variance are small and negative, and there is no evidence to date that an appreciable amount of the genotypic variance in yield in these varieties is due to epistasis. However, 83 percent of the lines from Jarvis and 67 percent of the lines from Indian Chief were lost during the process of inbreeding. This resulted in a five percent increase in yield and ear number in both varieties. If genetic variances are less in the reconstituted populations derived from the inbred lines because of changes in gene frequencies due to selection, the additive types of epistasis may be underestimated. Additional experiments are needed whereby the half-sib and full-sib families from non-inbred parents are also obtained from the reconstituted varieties.

S. A. Eberhart
R. H. Moll
H. F. Robinson

2. Full-sib family selection for yield of ear corn in four populations.

A study was conducted in 1959 to compare the progress due to selection in four populations. The test included each cycle of selection (when available) of two varieties, Jarvis and Indian Chief, and two hybrid populations, (NC7 x CI21) F_2 and (NC34 x NC45) F_2. The results are given in Table 1 and show that selection seems to be more effective in the varieties than in the populations derived from crossing inbred lines. It is also apparent that the variety response is much closer to expectation than is the response of the hybrid populations. Since the test was conducted in only one location and year, the results are subject to errors due to genotype x environmental interaction. This material will be studied further over a wider range of environments, and results of additional cycles of selection will be included as they become available.

Table 1. Yield in pounds per plant for each cycle available for test.

Population	Cycle of Selection 0	1	2	3	4	Gain per cycle in percent of mean observed	predicted
Jarvis	.396	.369	.460	.469	---	6.1	6.7
Indian Chief	.399	---	.458	---	---	7.4	5.5
(NC7 x CI21)F_2	.362	---	.386	.400	.398	2.5	9.3
(NC34 x NC45)F_2	.267	---	---	.279	---	1.5	11.5

R. H. Moll
W. A. Compton
H. F. Robinson

UNIVERSITY OF PAVIA
Pavia, Italy
Institute of Genetics

1. Investigations on induced polygenic mutability in maize.

The experiments which were briefly described in Maize Genetics Cooperation News Letter 34 (p. 99-101) and which were intended to study the possibility of increasing through irradiation the genetic variability for quantitative traits in corn have been continued. Subject of this note are the measurements obtained on the R_3 generation grown in summer 1960 at the Agricultural Experiment Station in S. Angelo Lodigiano, in the Po Valley.

Nine different selfed lines were established in 1957 from seed of a single ear of a monoploid stock, HD 173 1375/11, kindly supplied by Professor G. F. Sprague. In the following year three groups of 5 plants (on average) were selfed within each line. The tassels of one group received an X-ray treatment of 1500 r two days before pollen shedding; a second group received a treatment of 3000 r and the third group did not receive any irradiation. Treatments were applied to the tassel cut from the original plant and maintained in tap water up to the time when pollen was collected to fertilize the proper plant. The X-ray machine was operated at 120 KV, 3 mA, 1 mm Al filter.

By selfing a sample of five plants on the average from each treated group within each line the R_2 generation was obtained and sublines started. By selfing a sample of 3 plants within each subline, the R_3 generation was obtained and subsublines established. In 1960 observations were made on about 10 plants per each subsubline of R_3 generation.

The analysis of variance was carried out independently for each treatment according to the hierarchical scheme given in table 1.

Table 1. Analysis of variance and expected components.

Source of variability	df	Variance	Composition
Total	nkmp-1		
between lines	n-1	V_L	$\sigma^2_E + \sigma^2_P + p\,\sigma^2_{SSL} + pm\,\sigma^2_{SL} + kpm\,\sigma^2_L$
between sublines within lines	n(k-1)	V_{SL}	$\sigma^2_E + \sigma^2_P + p\,\sigma^2_{SSL} + pm\,\sigma^2_{SL}$
between subsublines within sublines	(m-1)nk	V_{SSL}	$\sigma^2_E + \sigma^2_P + p\,\sigma^2_{SSL}$
between plants within subsublines	(p-1)nkm	V_P	$\sigma^2_E + \sigma^2_P$

In this table: n = number of lines, k = number of sublines per each line, m = number of subsublines per each subline, p = number of plants per each subsubline, and nkm = total number of plants in the experiment.

Estimates of the portion of variance due to different sources of variability may be obtained:

(1) from the variance due to differences between lines it is possible to identify a portion of variability (σ^2_L) which may be considered as due to differences between the seeds from the same parental ear with which the experiment was started. Since seeds from a monoploid plant were used as starting material this source of variability will give an estimate of variance due to random environmental influence only;

(2) from the variance due to differences between sublines it is possible to identify a portion of variability (σ^2_{SL}) due to the differences between the seeds produced by a single plant, which may be traced to random influences of the treatment on different pollen grains from the same treated tassel;

(3) the variance due to differences between subsublines within sublines enables us to identify a portion of variability (σ^2_{SSL}) traceable to segregation of mutants induced by the treatment and this gives us an estimate of its mutagenic effect. No significant estimate of variance from this source of variability is expected in the untreated material, except for the effects of segregation of spontaneous mutants;

(4) the variance due to differences between plants within subsublines is partly due to the effects of segregation of induced mutants in R_3 families (σ^2_P) and partly to the influence of environment (σ^2_E). In the untreated material the major fraction of the variance is to be attributed to environmental effect with possibly a limited portion due to segregation of spontaneous mutants.

It follows from the above considerations that in studying the effects of X-ray treatments on polygenic mutations in the R_3 generation, only the last two components (3 and 4) are of interest because they may give an estimate of the increase of variability as a consequence of polygenic mutants induced by the treatment. For the time being we will concentrate our attention on these two components only.

At present the analysis has been completed for the following characters:

1) number of internodes below the highest ear
2) total number of internodes in the plant
3) total length (in cm) of the internodes below the highest ear

and the results are given in table 2.

Table 2

Source of variability	control d.f.	control mean squares	1,500 r d.f.	1,500 r mean squares	3,000 r d.f.	3,000 r mean squares
1) Number of internodes below the highest ear						
Between subsublines within lines	59	2.7196	86	3.3728	48	3.0119
Between plants within subsublines	715	1.0477	1071	0.9003	537	1.1817
2) Total number of internodes in the plant						
Between subsublines within sublines	59	2.3873	86	6.1861	48	5.2927
Between plants within subsublines	715	1.4561	1071	1.2991	537	1.7467
3) Total length (in cm) of the internodes below the ear						
Between subsublines within sublines	59	453.1580	86	386.6124	48	563.0394
Between plants within subsublines	715	104.1533	1071	75.0160	537	80.1281

Table 3. Estimates of variance components and relative values

Character	treatment	σ^2_{SSL}*	$\sigma^2_E+\sigma^2_P$	total phenotypic variance	h^2_1	$h^2_2+e^2$
1) number of internodes below the higher ear	control	0.1851	1.0477	1.2328	0.15	0.85
	1500 r	0.3627	0.9003	1.2630	0.29	0.71
	3000 r	0.2163	1.1817	1.3980	0.16	0.84
2) total number of internodes in the plant	control	0.1031	1.4561	1.5592	0.07	0.93
	1500 r	0.5255	1.2991	1.8246	0.29	0.71
	3000 r	0.4191	1.7467	2.1628	0.19	0.81
3) total length of internodes below the ear	control	38.6495	104.1533	142.8028	0.27	0.73
	1500 r	33.5050	75.0160	108.5210	0.31	0.69
	3000 r	57.0817	80.1281	137.2098	0.42	0.58

* p weighted for disproportionate class numbers = 9.03.

The classification of the effects being hierarchical, makes it possible to isolate the genetic component σ^2_{SSL} (see paragraph 3) and to estimate from it the variance increase due to the treatment. In fact,

$$V_{SSL} - V_P = p\sigma^2_{SSL}$$

where σ^2_{SSL} is an estimate of the treated induced genetic variance. Hence the heritability, h^2_1, for each treatment may be computed from the ratio between this estimate and the total phenotypic variance:

$$h^2_1 = \frac{\sigma^2_{SSL}}{\sigma^2_E + \sigma^2_P + \sigma^2_{SSL}}$$

From this experiment it is not possible to estimate separately the environmental and the genetic fractions of variability which add to V_P, the variance between plants within subsublines. Such components would give us the relative estimates e^2 and h^2_2, respectively.

Both estimates of heritability are due partly to fixable effects (D, in terms of Mather notation) and partly to unfixable ones (H), their composition being:

$$h^2_1 = 1/2\ D + 1/16\ H$$

$$h^2_2 = 1/4\ D + 1/8\ H$$

The results of this analysis are given in table 3.

From table 3 it may be seen that h^2_1 values for the plants which received a treatment of 1500 r are in general higher than those for the plants which received no treatment. h^2_1 values for the 3000 r treatment, as obtained from the experiment described, are lower than those of the 1500 r treatment for characters 1 and 2.

This behaviour may be due to a high loss of chromosomes in the 3000 r dose as a consequence of genic and chromosomal lethal mutations. However, the trend is different for character 3 whose genetic variability steadily increases from the controls to the 3000 r group.

Measurements of other quantitative traits were also recorded and their analysis is in progress.

R. E. Scossiroli
D. Palenzona

This work was supported in part by contract 6 L with the Comitato Nazionale per l'Energia Nucleare (C.N.E.N.), Biology Division, Rome and in part by contract 61 U.S. with the I.A.E.A., Vienna.

Errata: The following corrections should be made in the 1960 MNL.

Page 99 bottom--line 2: 9 lines, instead of 8 lines
Lines 6 and 7: X-ray machine operated at 120KV, 3mA, 1mm. Al filter, instead of 230KV, 12 mA, 4mm. Al filter.

THE PENNSYLVANIA STATE UNIVERSITY
University Park, Pennsylvania
Agronomy Department

1. Gene action studies.

Dr. H. Carnahan, former Head, Northeastern Pasture Research Laboratory, USDA, at this Station compared diploid and autotetraploid hybrid prediction procedure in the 17th Alfalfa Improvement Conference: 19-22, 1960. He suggested that in combining diploid single crosses into double crosses the following would be true:

Differences:
Double cross vs. Mean of non-parental single crosses = Epistasis
Mean of parental single crosses vs. Mean of non-parental single crosses = Dominance

In our discussion it was further developed:

Differences:
Double cross vs. Mean of parental single crosses = Non-Additivity

No Differences:
Double cross vs. Mean of parental single crosses = Additivity or Cancelling Effects or Lack of Precision.

A single location, single year split plot test using this technique was planted and harvested at Centre Hall, Pa. in 1960 using early maturing, commercially useful inbred line combinations on hand. The lines involved in the 21 double crosses were: A 495, A 509, CMD 5, MS 1334, Pa 32, Pa 36, PaW 703, R 53, W 37 A, and W 59M. These 10 inbred lines are essentially unrelated, although M 13 is in the background of Pa 32, R 53, and W 59M. No reduction in vigor has been noted in crosses of these lines in this state.

Silking and strong stalks at harvest (resisting a push) were recorded as number of plants (total = 16 per plot) on an appropriate day. Yield was calculated as 56 pound bushels of 15 1/2 percent moisture shelled corn, disregarding possible differences in shelling percentage.

The data in table 1 are presented as examples only. Since a small sample of extremely early germ plasm is dealt with in only one year and one location, no conclusions are drawn at this time.

Table 1. Pa. 1960 Exp. 11. Possible gene action involved in combining single crosses into 21 double crosses.

	Grain Moisture at Harvest	Grain Yield	# Silking 2nd Date	# Silking 3rd Date	# Strong Stalks at Harvest
Number of Hybrids of 21 Showing:					
Additive Gene Action	19	17	0	3	1
Dominance	4	4	15	18	21
Epistasis	2	0	19	16	17
Means					
Double Crosses	28.77%	110.3 bu.	6.05 #	12.98 #	10.79 #
Parental Singles	28.54	113.4	5.24	12.60	10.24
Non-Parental Singles	29.11	110.2	5.19	12.73	11.71
Standard Error $\bar{X}$	.146	.92	.023	.030	.025
"F" Ratios					
Hybrids	6.37**	1.63ns	2.62**	5.13**	3.85**
Components	3.70*	3.87*	4.16*	.43ns	8.90**
Interaction	1.91**	1.53*	2.71**	.95ns	1.24ns
Overall Gene Action Indicated					
Additive Gene Action	X				
Cancelling Effects				X	
Non-Additivity		X	X		X
Dominance	X	X			X
Epistasis			X		X

*,** = Significant at 5% and 1% level, respectively.

G. W. Gorsline
W. I. Thomas

THE PENNSYLVANIA STATE UNIVERSITY
University Park, Pennsylvania
Computation Center

1. A lattice square program for the I.B.M. 650.

The lattice square statistical design is used extensively in field experiments of the corn breeding program of the Agronomy Department, The Pennsylvania State University. A program has been written to automatically compute the analysis of variance using an I.B.M. 650 System with I.A.S. and indexing registers.

Following the notation of the textbook, Experimental Designs, by Cochran and Cox, the program was written for a design with k^2 treatments per replication with $(k+1)/2$ or less replications. The program has a capacity for k as large as 11 and 13 with 6 and 3 replications, respectively. The data cards contain identification for experiment, entry, replicate, row and column with values for up to seven variables. Each observation may have as many as eight digits.

The program reads a parameter card which defines k and r and the variable to be analyzed. Data cards (in any order) are read and processed following the parameter card. The data are left justified automatically to give maximum precision and computation is performed in double precision fixed point arithmetic. A transfer card sends control to a checking routine which determines if all items of data have been entered properly and if so the analysis is completed. In case of errors or omissions, two cards are punched indicating the location in the design of errors or omissions and control is sent to begin a new analysis.

Means and totals for entries adjusted for row and column effects are punched. A console option allows for additional punching of the same unadjusted information.

The analysis of variance output includes sums of squares, degrees of freedom and mean squares for total, replication, unadjusted and adjusted treatment, row, column and residual error. The correct effective error mean square and degrees of freedom are also computed and punched considering the presence or absence of row and/or column effects.

Input, computation and output times required for the analysis of a 5 x 5 and an 8 x 8 lattice square with 3 replicates are 45 and 90 seconds, respectively.

F. Y. Borden
W. I. Thomas
G. W. Gorsline

PENNSYLVANIA STATE UNIVERSITY
University Park, Pennsylvania
Department of Botany and Plant Pathology

1. More disease resistant maize at Penn State--1960.

Last spring we announced (Maize Synthetics for Disease Resistance. Plant Disease Reporter 44: 498-500, 1960) the availability of disease resistant synthetics and early generation inbreds to corn breeders and pathologists desiring seed. The demand for the synthetics cleaned out our departmental supply of some items. Fortunately 3 + pounds of seed of each synthetic is deposited with the National Seed Storage Laboratory, Fort Collins, Colorado.

Since 1957 we have been operating on an "alternate" year basis. The reasons are two; (1) introduction of new material and an enthusiastic crossing program therewith led to a somewhat bewildering amount of work to be evaluated, and (2) there was both a need and desire to develop in a parallel fashion two lots of unrelated material that could be tested against each other in a breeding program.

The following lots represent our first public distribution of breeding material unrelated to last year's offerings.

1. The International Synthetic - A few years ago we set out to develop disease resistant maize with outstanding root systems. Tropical or near tropical inbreds proved to be outstanding for root systems but day length effects, high ear, unusual height, a pronounced conical ear shape, flinty grains and other morphological variations made outcrossing to American material a necessity. (We know now that one such outcrossing or back crossing is adequate. We have seed of selfed S_0 plants from such crosses available for future line breeding). Seed of the original local x tropical crosses was made in the greenhouse and unfortunately the bulk of it was made on the double cross Pa. 602A. It was necessary to diversify this base in the outcrossing. To further dilute this relatedness, seed of these 3-way crosses were pooled and planted in an isolation block and detasseled in 1960. The male parent consisted of S_1 plants of new unrelated crosses made in 1957 and grown for the first time in 1959. These were grouped according to 1959 pollen dates into six maturity classes: (A) 7/10 - 7/20; (B) 7/21 - 7/25; (C) 7/26 - 7/31; (D) 8/1 - 8/5; (E) 8/6 - 8/10 and (F) 8/11 - 8/20. The female portion of the International Synthetic was planted in five rows between C and D. The whole plot was harvested. Some 100 individual ears were selected and passed on to Agronomy for individual ear testing. One hundred-ten ears were selected for bulk seed for the synthetic. For breeders interested in strong root systems this synthetic should act as a source unrelated to the South African-American stiff stalked selection distributed last spring. It should be of the 500-600 maturity classes.

2. The male parent for 1 (above) is available as bulked seed of the different maturity classes mentioned above; A, B, C, D, E, F.

The seed of F is somewhat chaffy due partly to its inherent lateness and partly to local lack of rain from August 7 to September 10. That we have seed at all is the result of a very mild fall with unusually late frosts.

3. Miscellaneous lots to be labelled M-1, M-2, etc.

Certain lots of seed representing local open-pollinated varieties, remnant seed of crosses made for specific purposes, and other specific collections were planted adjacent to the male parent block. These were detasselled, the pollen source was from a mixture of seed A, B, C, D, E, F, planted as male rows.

These miscellaneous lots of 2 - 6 lbs. each, may present some specific traits which are likely to be diffused throughout the more general seed lots previously mentioned.

A. M-1. Top crossed (Turkish flints x WF9 derivatives).

These Turkish flints were obtained from the Plant Introduction Station at Geneva and crossed with WF9 and WF9 derivatives. This lot should offer an opportunity to isolate early lines in the 200-400 maturity classes.

B. Pennsylvania open-pollinated varieties selected at least one season under blight, smut and stalk rot conditions.

M-2. Top crossed 1958 selection from Clarage.
M-3. Top crossed 1959 selection from Clarage.

These two Clarage selections differ chiefly in ear size and length. M-2 has a tendency toward long thin ears whereas M-3 has shorter ears with higher kernel row number.

Top crossed:

M-4. Ranker selection - reselected 1959.
M-5. Wright selection - reselected 1959, tall, heavy eared, high kernel row number.
M-6. Bradley selection - reselected 1959, deep kernels, at least 20% plants have red pericarp.
M-7. Roadman - non selected material received in 1960.
M-8. Ullstrup A Synthetic-planted between Ranker and Bradley 1959.
M-9. Ullstrup B Synthetic-planted between Bradley and Clarage 1959.
M8 and M9 should be 1/4 to 1/2 Synthetic. In 1959 we failed to get Ullstrup's Synthetics detasselled.

M-10. Pioneer Synthetic (Early, Medium, Late) seed received in 1955. Only a few plants of each emerged so seed was bulked.
M-11. Dekalb - long eared bronze composite; long ears, long shank, high kernel row number. Top crossing should increase number of yellow and white derivatives.
M-12. U.S.D.A. - double-double. Used to gauge maturity of male (F): 800-900 maturity - seed slightly chaffy like F.

Last spring the big demand was for seed of the Synthetics. We have not received any word of their performance but it is still rather early for anything but disease appraisal.

Three breeders took advantage of our offer of early generation inbreds. We are looking forward to hearing how these turned out.

Our offer of early generation inbreds still stands on the same basis as last year. (We furnish seed, you furnish yield test data when and if you test).

We have early generation disease resistant inbreds of:

(a) WF9 material - varying percentages of Wf9 or C129. Pure line material must be obtained from the originators.
(b) M-14 material - earlier and later than M14.
(c) Os420 material - earlier and later than C1 40.
(d) Tr material - A source of resistance to Helminthosporium maydis. We hope we have improved on its smut and H. turcicum reaction.
(e) Flints of various types - Some of these are 12 and 14 rowed flints of the long fellow-type whereas others are flinty isolations of tropical flint x dent-crosses. Some of these are long-seeded types, quite resistant to disease.

Why have the flints vanished? Are these worth keeping?

P.S. 1. We are interested in maize material with
1. extra wide leaves
2. extra long leaves
3. long and extra long ears
4. any arguments and statements for or against flints. The Pennsylvania Dutch used to raise 6-10 rows flint corn to make corn meal. Any other regional uses?

P.S. 2. If you are interested in any of these offerings, how about sending this department a Postal Money Order for $2.00 to cover the cost of mailing?

C. C. Wernham

2. Aids to the maintenance of $\underline{ys_1}/\underline{ys_1}$ seed stocks.

The $\underline{ys_1}$ phenotype is an iron-deficiency chlorosis. To maintain seed stocks for physiological study, a field plot of $\underline{ys_1}/\underline{ys_1}$ plants was sprayed twice weekly with an aqueous $FeSO_4$ solution containing 500 p.p.m. iron. These plants were visually indistinguishable from normally green maize. Inflorescences developed completely, and ears well-filled with viable grains were produced. Grains derived from inbred iron-sprayed $\underline{ys_1}/\underline{ys_1}$ plants were larger and apparently contained more available iron than grains produced by unsprayed plants. The seedlings from grains of the former required longer to display iron-deficiency symptoms in soil, sand, or solution cultures. At least two completely green leaves were produced by these seedlings on an iron-deficient medium. Seedlings grown from the exiguous grains set on unsprayed $\underline{ys_1}/\underline{ys_1}$ plants produced only chlorotic leaves on a similar substrate.

A report of the investigation demonstrating the interaction of iron and phosphorus metabolism in $\underline{ys_1}/\underline{ys_1}$ and normally green maize has been submitted to the Botanical Gazette.

William D. Bell

3. A new yellow stripe on chromosome 3.

A mutant type having yellow stripes between the main vascular bundles from the seedling stage onward arose in inbred material from the O. P. variety Early Butler at this station. Although expression is variable, classification is usually good and pollen and ears are produced on most plants.

The mutant was crossed to Dr. E. G. Anderson's waxy-marked translocation series involving all chromosomes and F_2 waxy and non-waxy seeds were screened separately. All F_2 populations showed normal 3:1 segregation except those involving the wx 3-9c interchange in which the following data were collected in three families. Non-waxy seeds gave 88 normals : 38 yellow stripes; waxy seeds gave 64 normals : 0 yellow stripes.

These data indicate that the mutant is located very close to the interchange point on chromosome 3, which has been recorded by Dr. Longley as 3L.09. The symbol, $\underline{ys_3}$, has been assigned tentatively to this new mutant.

James E. Wright

UNIVERSITY OF THE PHILIPPINES
College, Laguna, Philippines
College of Agriculture

1. Change of designation of standard lines developed in the Philippines.

The Philippine Corn Improvement Program is considering the use of the letter prefix Ph to indicate inbred lines developed in the Philippines. The program is at present using A which is unfortunate because Minnesota also uses this letter.

Ibarra S. Santos
Flaviano A. Aquilizan

2. Development of sugary-waxy corn (susuwxwx).

Sugary-waxy (susuwxwx) inbred lines are being developed at the University of the Philippines College of Agriculture. Waxy corn has been used as boiled green corn but sweet corn is gaining acceptance. It is expected that sugary-waxy corn will have a special appeal to the Filipinos. On the appearance of the dried kernel, su is epistatic to wx but it is very possible that susuwxwx corn may have something different in taste and endosperm texture from susuWxWx corn when used as boiled green corn.

To produce these sugary-waxy lines, Morong White Glutinous (SuSuwxwx) was crossed to Hawaii Yellow Sweet (susuWxWx). This cross was then selfed. Waxy kernels were selected and planted. From the harvest of selfed S_1 ears there were ears that gave sugary kernels and waxy kernels. The sugary kernels should be of the susuwxwx constitution. The S_1 glutinous kernels were either SuSuwxwx or Susuwxwx. The sugary-waxy kernels were thus derived from the latter.

Almost all these sugary-waxy lines isolated are very weak and poor pollen-producers. Whether this condition can be associated with the susuwxwx genotype or is just a matter of coincidence cannot be stated as of now. It might help to know that both the parent varieties, Morong White Glutinous and Hawaii Yellow Sweet, grow vigorously under Philippine conditions.

Ibarra S. Santos
Amador C. de Mesa
Arturo A. Gomez

3. Waxy corn hybrids utilizing waxy versions of standard U. S. lines.

Several white- and yellow-endosperm waxy corn single crosses were introduced in the early part of 1960 thru Dr. A. M. Brunson. Three-way crosses were made using the introduced single crosses as seed parents and selected high combining local inbred lines as pollen parents. These three-way crosses were tested for yield and other agronomic characters in the 1960 Wet Season. The highest-yielding three-way cross, (wx 33-16 x wx K41) x CG1 yielded 6.9 tons of marketable ears per hectare. CG1 is a local waxy line developed from Central Luzon Glutinous variety. Most of the hybrids outyielded the highest-yielding commercially grown varieties and were more uniform than the latter in maturity but were more susceptible to corn earworm.

Rodolfo M. Payson

4. Resistance to downy mildew disease (Sclerospora philippinensis Weston).

The downy mildew disease (Sclerospora philippinensis Weston) is the most destructive disease of corn in the Philippines. Search for inbreds resistant to the disease has been under investigation since 1956. Since then, outstanding sources of resistance have been identified. Ten yellow and 4 white flint inbred lines were found definitely resistant in three-season tests under epiphytotics of the disease.

In the course of screening resistant inbred lines, a setback in time and the burden of maintaining susceptible segregates has been experienced. This is due to the fact that the causal organism being an obligate parasite cannot be grown in artificial media. In addition, abundant inocula for artificial inoculation can be gathered only when there is a favorable environment for the development of the causal organism. Thus, the efficiency of selecting resistant lines has been largely dependent upon the natural occurrence of the disease.

All the resistant lines obtained so far, unfortunately, are of local origin. Due to lack of genetic diversity among the lines, efforts are being exerted in selecting genetically diverse resistant lines from among newly introduced inbreds and also among lines developed locally from introduced varieties.

Meanwhile, the F_1 between resistant and susceptible inbred lines, their F_2 and F_3, and backcrosses to the resistant and to the susceptible parent are being produced for the study of the mode of inheritance of reaction to the disease.

Flaviano A. Aquilizan
Ibarra S. Santos

5. Restorers found in College Yellow Flint and Eto synthetic (from South America).

In 1958, incorporation of male-sterile cytoplasm in Philippine standard inbred lines was started using F44T, introduced from Florida, U. S. A., as a source of T-sterile cytoplasm. Full and partial restorer lines were isolated. Philippine standard inbreds A104, A105, and A107a fully restored F44T in the single cross combination. After three backcross generations, experimental double-cross hybrids using the derived cyto-sterile inbreds and the natural pollen restorer inbreds were made in the 1960 off-season planting.

The comparative yield trial of these restored and cyto-sterile hybrids and their normal counterparts was done in the 1960 Wet Season (May planting) and 1960-61 Dry Season (October planting). During these seasons' test at College, the restored cyto-sterile Philippine hybrid 1d [(A111T x A113N)(A106T x A107aRf)] exhibited a very acceptable 44% and 66% pollen production in the 1960 Wet Season and 1960-61 Dry Season, respectively.

Degree of pollen restoration in Philippine cyto-sterile hybrids.

Entry 1/	Pollen Fertility 2/ %	
	Wet Season	Dry Season
Philippine Hybrid #1d		
(A106 x A107a)(A111 x A113)	100	100
(A11T x A113N)(A106T x A107aRf)	44	66
Philippine Hybrid #3b		
(A102 x A106)(A112 x A113)	100	100
(A106T x A102N)(A112 x A113)	14	21
Philippine Hybrid #5		
(I83 x A113)(A102 x A103) 3/	100	100
(A102T x A103N)(I83 Rf x A113)	36	51
Philippine Hybrid #7		
(I18 x I80)(A102 x A106) 4/	100	99
(A106T x A102N)(I18 x I80Rf)	19	46
Philippine Hybrid #2		
(L314 x L315)(A200 x A204)	100	100
(L314T x L315N)(A200 x A204)	2	45

1/ - Rf = restorer
T = Texas cytoplasm
N = Normal, Non-restorer

2/ - Includes partially fertile plants

3/ - I83 was derived from Eto - 185-1-#-# obtained from South America through the Rockefeller Foundation

4/ - I80 was derived from Eto-13A-1-#-#-#.

In all cases, higher percentages of pollen restoration were obtained during the Dry Season than during the Wet Season. The low night temperatures in December, when the plants tasseled, probably enhanced the pollen production of the restored sterile hybrids.

Antonio C. Mercado
Cesar C. Jesena, Jr.

PIONEER HI-BRED CORN COMPANY
Johnston, Iowa

1. Continued study of defective WF9 cytoplasm.

Further breeding studies of the apparently defective cytoplasm discovered in an open-pollinated plant of WF9 (Duvick, 1958 Coop News Letter) have indicated that the degree of expression of the aberrant cytoplasm is influenced by the genotype. The original open-pollinated aberrant plant was selfed four times, giving rise to a relatively uniform, viable line of "wsp" phenotype (pale green streaks in the leaves, especially at about the 5 - 7 leaf stage, accompanied by some loss of vigor). In each generation the selfed plant used to propagate the stock also was backcrossed as male to a stock which was originally normal WF9. This has produced a line approaching the general phenotype of the selfed stock in all respects except that no plants have shown any wsp characteristics, and the backcrossed line, although uniform, is considerably more vigorous.

When the wsp line, after four selfs, was crossed reciprocally to four normal inbred lines (Os 420, WF9, M14 and SK2) all crosses with wsp as female showed wsp in some but not all plants of the single cross. The reciprocals in no case had any wsp plants. When the single crosses with wsp as female were backcrossed (as female) to the normal inbred lines, or selfed, wsp plants occurred in the backcross and F_2 progenies, with varying degrees of expression. The progenies involving Os 420 and WF9 showed a much higher percentage of wsp plants than did those involving M14 and SK2, in both the F_1 and the advanced generations. Some wsp plants in the advanced generations of the cross of the wsp line and WF9 greatly exceeded the parent wsp line in degree of expression of wsp. Each of the original F_1 crosses described above was made in duplicate and in all cases the degree of wsp expressed was more similar within progenies involving the same normal inbred line than between progenies involving different inbred lines.

The present plan is to continue backcrossing the four stocks to the respective normal inbreds until four reasonably homozygous stocks, in wsp cytoplasm, are obtained. These will then be used for further genetic studies of effect of the genotype on expression of wsp, as

well as for the perhaps more important study of the permanence of inheritance of this presumed cytoplasmic characteristic. It may be that the relative loss of expression of wsp when M14 and SK2 genotypes are introduced is due to a permanent modification of the wsp cytoplasm, back to normality. The question of non-uniformity of expression in F_1 is also of importance.

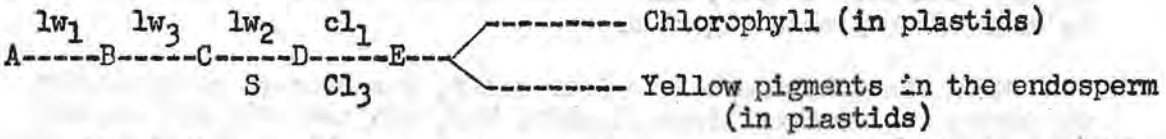
Donald N. Duvick

UNIVERSITY OF POONA
Poona, India

1. Some speculation on the action of lemon-white alleles.

The lemon-white mutants in maize have attracted some attention because of their pleiotropic effect and the detection of suppressors for one of the two effects. The important features of these mutants are as follows: All the natural mutants (at least four cases involving different chromosomes) show a simultaneous effect on both characters. The suppressor effects are specific for the individual mutants.

One can interpret the pleiotropic effect on the basis of interruption at different steps in a chain reaction which subsequently bifurcates to give rise to different end products.



The influence of supressors on only one of the two effects could be due to a difference in their quantitative action and competition for the substrate at the point of bifurcation.

S. H. Tulpule

2. Pachytene chromosomes treated with paradichlorobenzene.

Pretreatment of root tips with paradichlorobenzene gives well spread metaphase plates with shortened chromosomes. The effect on chromosome length was investigated by a study of its action on maize chromosomes at pachytene. The pretreatment consisted of immersing the cut ends of suitable spikes in a saturated aqueous solution of paradichlorobenzene for a definite period and then fixing them in acetic-alcohol. Preliminary results show that: (1) The treatment does not result in any marked increase in the frequency of well spread pachytene configurations. (2) The cells show globules of various sizes resembling the nucleolus in their staining reaction with carmine.

(3) There may be differential contraction of the arms. (4) Significant distortions occur in the cells with advanced prophase stages including apparent extrusion of material from the chromosomes and disturbance at the site of centromeres.

S. H. Tulpule

UNIVERSITY OF PRETORIA

and

TRANSVAAL REGION, DEPARTMENT OF AGRICULTURE
Pretoria, Union of South Africa

1. Aging of pollen and gametic selection in Zea mays, I.

Competition of pollen tube growth is provided by the use of pollen mixtures consisting of equal components from yellow and white sources (M.G.C.N.L. 1958, 1959, 1960). Since the maternal parent is white seeded, as a result of xenia, the ratio of yellow to white seed resulting from the pollination with such mixtures would give an indication which of either Y or y pollen was the most successful in fertilization. In this investigation the effect of aging of pollen mixtures on the relative percentage of yellow and white seed produced was studied. The pollen mixtures used were sufficient to make 20 or more pollinations. The first pollinations were made within an hour of the shedding of the pollen, the balance was then stored for 24 hours in glassine paper bags at room temperature and then the second series of pollinations made. The third series of pollinations followed after 48 hours storage. A perfect set of seed resulted from the first pollination, and although surplus pollen was used, the set of seed after the second pollination was 12% - 30%, whereas after the third pollination only about 30 seeds were produced per ear. This would indicate a high mortality of pollen in the second and third pollinations.

Table 1. Percentage yellow seed on pollinated ears.

Pollen mixture	Immediate pollination	After 24 hours	After 48 hours
1	53	26	16
2	66	32	8
3	57	30	12
4	49	27	9
5	60	27	5
6	78	5	6
7	20	19	2
8	56	3	3
9	79	3	3

Referring to the table, numbers 1 to 5 were pollen mixtures made up from yellow and white single crosses. Numbers 6 to 9 were pollen mixtures made up from yellow and white inbreds. The maternal parent used was a white single cross producing large ears. The tabulated results represent the average percentage of yellow seed produced on the pollinated ears at each period. It is apparent that there is a fair and consistent agreement in the decline of the percentage yellow seed produced by the pollen mixtures with continued aging. It appears that the decline is more marked in the case of pollen mixtures consisting of inbreds (no's. 6-9). The greater decline of the longevity of yellow compared with white pollen must be mainly due to the action of the Y gene. This is confirmed by the fact that the different pollen mixtures must have differed widely with respect to their genic backgrounds. Since, in addition, a reduction in the seed set after 24 hours was observed, other genes must also be involved in this phenomenon. In many maize breeding programs the tassels are bagged a day previous to pollination, and if pollination should start the following day before the shedding of pollen has started actively, it would be expected that gametic selection resulting from the aging of pollen must be of importance. Whether the surviving gametes are also superior with respect to other qualities, only further tests will show.

J. D. J. Hofmeyr
Department of Genetics

2. The effect of silk length on pollen tube competition in Zea mays, L.

In this study pollen mixtures as described previously (M.G.C.N.L. 1958, 1959, 1960) were used. The pollen used in the mixtures was obtained from yellow and white inbreds in order to reduce the genic variability within each component to a minimum. The maternal ears were from a white single cross. Fifty percent of the ears were pollinated according to the usual procedure, but the rest of the ears were cut back through the ear sheath until the tip of the small undeveloped ear was exposed; pollination was then done. The silks of the "normal" and "cut back" ears differed, after the operation, by approximately 6 to 9 inches in length. Hence, in the case of the former the pollen tubes had to cover a much longer distance to affect fertilization than in the latter. The pollen mixtures provided sufficient pollen to make 10 to 20 pollinations. Of the 16 pollen mixtures studied, 8 showed a significant increase of white seed produced on "cut back" ears compared with "normal" ears. In 6 cases, there was no significant difference between the two treatments. It is apparent that in a considerable number of cases the length of the silks may be of significance in pollen tube competition.

J. D. J. Hofmeyr
Department of Genetics

3. Factors influencing the competition of maize pollen in pollen mixtures.

A study was made of some of the factors involved in competition in pollen mixtures (see articles by Hofmeyr and Geerthsen in M. G. C. N. L. 32:129-131 (1958), 33:99 (1959), 34:105 (1960), and this issue).

Firstly, the part played by differential germination and growth of the pollen was studied by conducting two types of experiments. In the one series, after pollination of yy ears by mixtures of equal parts of Y and y pollen, the silks were cut off at different times nl. after 4 1/2, 5, 5 1/2, 6 and 8 hours. The resulting ears were then compared for percentage yellow and white kernels to the control where the silks were not cut. The second series consisted of non-simultaneous pollinations where the one pollen type was used half an hour before or half an hour after the other. The control in this case was simultaneous pollination.

Secondly, the probable effect of extreme environmental conditions on pollen competition was investigated. Pollinations with pollen batches exposed to low temperatures (4-5°C) for 24 hours and to direct sunlight for one hour were compared to the untreated controls.

The following five pollen mixtures were used:

white		yellow
33-16	+	C217 x C56
33-16	+	C217
33-16	+	A413
K64	+	C217
K64	+	C23.

The white female parents were the single crosses E184 x K64r and M155 x K64r.

The results can be summarized as follows:

(1) The preliminary experiments showed that it takes the pollen tubes between 4 and 5 hours to grow a distance of one inch in the silks.

(2) The different pollen mixtures reacted differently to these treatments.

(3) In most cases the result could be explained on the basis of differences in the theoretical frequency distribution curves for speed of growth.

(4) In some mixtures differences in the speed of pollen tube growth were of major importance. For example, the results indicated that the average speed of growth of K64r is higher than that of C217, while there is no significant difference between K64r and C23 in this respect.

(5) Pollen antagonism was observed in some cases. The pollen of the single cross C217 x C56 exhibited a pronounced antagonistic effect on 33-16 pollen. This effect is probably more on the germination than on the growth of the 33-16 pollen.

(6) Exposure to cold and direct sunlight altered the competition in some mixtures. In the case of 33-16 + C217 x C56 both treatments favored the 33-16 pollen, probably by reducing the antagonistic effect. The cold treatment favored K64r in both mixture K64r + C217 and mixture K64r + C23. These two treatments did not alter the competition between 33-16 and A413 significantly.

W. J. van der Walt
Department of Genetics
and Transvaal Region
Department of Agriculture

4. Secondary transpositions of Modulator.

As noted in the M.G.C.N.L. 31:144, limited data suggested that the positional stability of transposed-Modulator might be dependent on its proximity to the P locus.

A study has been undertaken to see if this is in fact the case.

A number of heterozygous light variegated ears were grown and the resulting plants pollinated by a South African inbred, T2, with colorless pericarp. The linkage of tr-Mp and P was determined by observing the proportions of light and medium variegated plants which resulted from the kernels of each ear (a family). A number of pollinated ears from each family was planted the following season and again the linkage relations of P and tr-Mp determined in each case. The crossover value between P and tr-Mp for each family was compared with that of the family from which the parental ear was taken to determine if a secondary transposition of Mp had occurred. A move was considered to have occurred if the new crossover value did not fall within the 95% confidence limits about the parental value, or in cases where this test could not be applied, where P according to the Chi-square distribution was less than .05.

The results obtained for the first groups of families available are as follows:

c.o. between P and tr-Mp in parental family.	% of progeny families showing no moves	moves	no. of families
0	73	27	55
0-5%	72	28	68
5-10%	58	42	33
10-30%	38	62	34

In the case of the families showing 5-10% and 10-30% crossing over, 43% and 39% of the moves, respectively, were to positions closer to the P locus.

Thus, it would appear from the data that transposed-Modulators located at positions close to P on the first chromosome are less likely to undergo further transposition than ones located at a greater distance from P. The data are still too limited to indicate clearly if the direction of move (closer to or farther from P) is also dependent on proximity to P.

Nancy van Schaik
Department of Genetics

5. Uneven development of maize seedlings.

Symptoms very similar to those described by Koehler (Pericarp injuries in seed corn. Bulletin 617, University of Ill. Agric. Exp. Sta.) on maize plants originating from pericarp injured seed, also occur on young maize plants in the main maize growing areas of the Union of South Africa.

During the 1960-61 season three different experiments were planted with seed having different classes of pericarp injuries. These seeds were selected from commercial SA4 (a yellow hybrid) seed, by using the staining technique described by Koehler. Two of these experiments were planted on ground which had been planted with maize many times before and was known to be infected with certain root rotting fungi. The other experiment was done in a greenhouse in unsterilized soil from a maize field where 100% root rot infection had occurred during the previous season.

In all three experiments the plants grew well and plants originating from the different classes of pericarp injured seeds could not be distinguished from plants in the control plots. Thus it was impossible to correlate the Koehler symptoms with pericarp injury.

Under the South African climatic conditions and with the particular microbiological constitution of our soils it seems, therefore, as if pericarp injury of maize seed is not of such paramount importance as described for American conditions. The South African problem therefore calls for further investigation.

J. J. du Toit
Transvaal Region
Department of Agriculture

PURDUE UNIVERSITY
Lafayette, Indiana
Department of Botany and Plant Pathology

1. The Wx/wx Locus.

A. Evidence of a different physical basis for intragenic and intergenic recombination in maize.

Heterozygosity for Dp 9 has been reported by Rhoades in these News Letters (32 and 34) to have a marked suppressive effect on recombination between loci in the short arm of Chromosome 9. Because of this pronounced effect on intergenic recombination it has seemed most desirable to test its effect on intragenic recombination in the Wx/wx locus. If, as some geneticists have suspected, there are different mechanisms for intra-and intergenic recombination, it might be possible to find agents which would affect one type of recombination without affecting the other as markedly or at all.

Accordingly, the heterozygote + + Dp + +/c sh N wx Gl_{15} as received from Rhoades was crossed by c +sh N wx^{90} + gl 15 in the 1960 greenhouse. In the 1960 growing season + + Dp + + gl 15/c + N wx^{90} + was crossed by c sh N wx^{s} gl_{15}. The colored waxy kernels which are crossovers should be + wx^{90} +/c wx^{s} gl_{15} and should nearly all carry Dp 9 (see Rhoades, M. N. L. 32). Such kernels from 3 ears were planted in the greenhouse in the late summer of 1960 together with colorless waxy c wx^{90} +/c wx^{s} gl_{15} kernels from the same ear as a control population. Subsequently, the C wx crossover class from other ears were planted without a corresponding control population. Pollen was collected on all plants, and the plants were pollinated by the c sh N wx^{s} gl_{15} stock, if possible. If such a pollination was not possible, the plant was selfed.

Pollen from all plants has been scored for frequency of $+^{wx}$ pollen grains. The presence of Dp 9 in plants suspected to be carrying it has been checked by the reduction in recombination between sh and gl_{15}. Alternatively, in selfed plants where seedling tests have not been completed yet, the presence of the Dp 9 is revealed by an excess of sh kernels.

Table I gives the pollen analysis data. These data are more heterogeneous than customary in crosses between two wx alleles. Probably the heterogeneity is attributable to the difference in genetic background between plants introduced by the crosses necessary to set up the test. All plants indicated as carrying Dp 9 have been checked for its presence.

The wx^s allele in the tester stock has never been crossed to wx^{90} previously. However, all wx tester stocks seem to contain the same allele which is the one we have designated as wx^c. The expectation, then, in crosses with wx^{90} is for a $+^{wx}$ frequency between 75 x 10^{-5} (1958 Greenhouse) and 102 x 10^{-5} (1960 Field) observed under different growing conditions and in crosses between stocks of somewhat different genetic backgrounds. Because of the small number of plants tested and the heterogeneity of the data it is not possible to decide whether there is any significant difference in $+^{wx}$ frequency between plants heterozygous for Dp 9 and homozygous normal plants. There is an indication that this is so. It is clear, however, that a relatively high frequency of $+^{wx}$ pollen grains can occur in plants heterozygous for Dp 9. In view of the suppressive effect on intergenic recombination of the duplication when heterozygous, it is suggested that the fact that intragenic recombination is little affected is evidence for two different types of recombination.

B. Comparison of $+^{wx}$ frequency estimated by pollen analysis and conventional techniques.

Last year using $+^c$ + + wx^{90} +/+ sh bz wx^{coe} v as both male and female parent in backcrosses to $+^c$ sh bz wx^{coe} v, the frequency of $+^{wx}$ kernels was 72 x 10^{-5} when the F_1 was the female, but only 19 x 10^{-5} when the F_1 was used as the male. The $+^{wx}$ frequency in the pollen of of the F_1 was 90 x 10^{-5}. The detection of the $+^{wx}$ kernels was visual. It was suggested that the disparity between the F_1 as a male and as a female parent was due to a dosage effect when some of the recombinants were not fully functional $+^{wx}$ alleles.

The same type of test has been repeated in 1960. However, each kernel has been tested with the standard KI, I_2 stain. The frequency of $+^{wx}$ pollen grains in the F_1 plants was estimated as 102 x 10^{-5} with an estimated population of 435,000 pollen grains being scanned. The frequency of $+^{wx}$ kernels on the ears is given in Table 2. Of the $+^{wx}$

TABLE I

Frequency of $+^{wx}$ pollen grains in the cross between wx^{s} and wx^{90} in the presence and in the absence of Dp 9. *

$\frac{+\ +\ +^{bz}\ Dp\ wx^{90}\ +}{c\ sh\ +\ N\ wx^{s}\ gl_{15}}$			$\frac{c\ +\ +^{bz}\ N\ wx^{90}\ +}{c\ sh\ +\ N\ wx^{s}\ gl_{15}}$		
	$+ \times 10^{-5}$	Population		$+ \times 10^{-5}$	Population
615A1	33	70,000	616A1	174	62,000
			616A2	90	51,000
617A1	60	66,500	618A1	107	44,000
617A2	41	74,000	618A2	55	42,000
617A3	56	61,000			
611A2	40	108,000	6112A1	61	61,000
			6112A2	82	76,000
6161A2	37	13,500			
6162A1	28	83,000			
6163A1	66	59,000			
6163A8	58	36,000			
6163A9	48	72,500			
6163A11	38	72,000			
6163A12	46	61,000			

* 615A and 616A, 617A and 618A, 6111A and 6112A constitute paired comparisons from the same cross.

Table 2. Backcrosses of (wx^{90} x wx^{coe}) with wx^{coe}

Cross	Number of Kernels	Number $+^{wx}$ k.	$+^{wx} \times 10^{-5}$
$\frac{+\ wx^{90}\ +}{bz\ wx^{coe}\ v_1}$ x wx^{coe} v	17,600	14	80
bz wx^{coe} N x $\frac{+\ wx^{90}\ +}{bz\ wx^{coe}\ v}$	51,191	54	105

kernels tested to date, 86 percent carry one or both of the outside markers, and contamination can be excluded as their source (see Table 3). The ear and pollen analyses agree much better than in 1959. Apparently use of the stain is necessary to detect many $+^{wx}$ recombinants particularly when aleurone color is present. Whether or not $+^{wx}$ alleles of less than standard strength are produced by recombination is under investigation.

C. The assortment of outside markers in $+^{wx}$ recombinants.

In the 1960 M. N. L. the assortment of outside markers for the 27 $+^{wx}$ recombinants was given as 2 $+^{bz}$ $+^{v}$, 7 bz v, 6 $+^{bz}$ v, and 12 bz $+^{v}$. Subsequent pollinations of these plants with the bz wx^{coe} v tester showed some of these classifications to be in error since some lightly-colored kernels classified as bz were in actuality $+^{bz}$. The revised classifications are presented in line 1 of Table 3. Also in Table 3 are the classifications of the $+^{wx}$ kernels from the 1960 field which have so far been grown. The data indicate that the order for the wx mutants is bz wx^{c} wx^{90} v.

The same pattern is found in both years, and it is not in accord with expectations if an orthodox crossing-over event between wx^{90} and wx^{coe} gave rise to the $+^{wx}$ gametes. If so, even assuming no interference of this crossover with crossovers between bz and wx or between wx and v, one expects a higher frequency of one cross-over class ($+^{bz}$ v) and lower frequencies of the two parental classes. At the same time, the frequency of crossovers is much higher than in the population of gametes as a whole. This is the "correlation effect" observed so often in such experiments in Neurospora and Aspergillus.

Table 3. Assortment of outside markers in $+^{wx}$ kernels.

Year	$+^{bz}$ $+^{v}$ (P1)	bz v (P2)	$+^{bz}$ v	bz $+^{v}$
1959	4	4	7	1
1960	6	12	24	1

Oliver E. Nelson

2. The brown-midrib mutants of maize.

Several years ago here at Purdue we found that the basis of the bm_1/bm_1 and the bm_2/bm_2 phenotypes was the production by these mutants of lignins which are quite different from that produced by normal plants. These altered lignins are responsible for the midrib color in mutant plants. Later we found that Jorgensen, who isolated the bm_1 mutant, reported that the pigment responsible for the color was either lignin or a pigment indissociably bound to lignin.

Our discovery stimulated a program to attempt to learn something about the biosynthesis and structure of lignin using the mutants as tools as has been done so successfully in Neurospora, E. coli, and other microorganisms. The chemistry of lignin is still poorly understood in spite of much research. Lignin is known to be a polymer of various phenylpropanoid (C6-C3) building blocks (depending on the species). Since this is so, a mutant affecting lignin production could affect either a step in the production of a phenolic building block or a step in the synthesis of the polymer itself.

The current consensus of opinion regarding lignin synthesis (after Freudenburg) is that the only enzymatically mediated step in the synthesis of the polymer itself is a dehydrogenation of the building blocks. The result of this dehydrogenation for a given building block is a radical which can exist in various mesomeric forms. These mesomers can combine at random in all possible combinations to form a disorderly type of polymer. If this view is correct, then the origin of the very different bm_1 and $+^{bm}1$ lignins must be found in different pools of phenolic compounds in which this random polymerization is proceeding. This should be experimentally verifiable, and we are now investigating this point.

The bm_1 and $+^{bm}1$ lignins differ in many ways. In the first place, there is a lower content of Klason lignin in bm_1/bm_1 plants (14 percent) as compared to $+^{bm}/+^{bm}$ plants of roughly comparable genotype which have 21 percent lignin. Alkali lignin from $+^{bm}1$ plants is a light tan amorphous powder which melts at ca 172° C. Alkali bm_1 lignin is a deep reddish-brown paracrystalline substance which chars at 236° C before melting. Oxidative degradation of native lignins with nitrobenzene in an alkaline medium shows a marked deficiency of p-hydroxy-phenyl residues (p-oH cinnamic acid, p-oH benzoic acid, and p-oH benzaldehyde) in bm_1 lignin as compared to $+^{bm}1$ lignin. This reduction has not been determined quantitatively as yet, but there may be only one fourth as much in bm_1 lignin.

The grasses are the only group of plants in which p-hydroxy phenylpropanoid building blocks are incorporated into the lignin polymer. The grasses are also the only group in which added tyrosine will serve as a lignin precursor. It was suspected at first that the block in bm_1 might be in one of the steps between tyrosine and p-oH cinnamyl alcohol

which is apparently the p-oH phenylpropenoid building block. Accordingly tracer experiments were conducted in which both $\underline{bm_1}/\underline{bm_1}$ and $\underline{+^{bm}}/\underline{+^{bm}}$ plants were allowed to take up either UL C^{14} phenylalanine or UL C^{14} tyrosine and then frozen 24 hours later for analysis. Estimation of the specific activity of the isolated alkali lignins indicated that both amino acids were equally good lignin precursors for both $\underline{bm_1}/\underline{bm_1}$ and $\underline{+^{bm}}/\underline{+^{bm}}$ plants. This would appear to rule out the hypothesis suggested above.

If anyone has a brown-midrib mutant which is known not to be 1, 2, 3, or 4, we would be most interested in obtaining it.

Oliver E. Nelson
Joseph Kuc

3. The location of the $\underline{Hm_2}/\underline{hm_2}$ locus.

In the 1951 News Letter (25) we reported a second locus affecting susceptibility to Race I, Helminthosporium carbonum. This locus has now been designated as $\underline{Hm_2}/\underline{hm_2}$ and located on chromosome 9. Its location is probably on the long arm of the chromosome since in a 3-point test (CS) the order of the genes is $\underline{sh}$ $\underline{wx}$ $\underline{hm_2}$ with recombination between $\underline{wx}$ and $\underline{hm_2}$ approximating 25 percent.

The allelic constitution at the $\underline{Hm_2}/\underline{hm_2}$ locus can be determined only in the presence of $\underline{hm_1}/\underline{hm_1}$. The double mutant $\underline{hm_1}/\underline{hm_1}$; $\underline{hm_2}/\underline{hm_2}$ is fully susceptible. Such markedly susceptible inbreds as Pr, Mo. 21a, and K61 are of this genotype. Plants which are $\underline{hm_1}/\underline{hm_1}$; $\underline{Hm_2}/\underline{hm_2}$ or $\underline{Hm_2}/\underline{Hm_2}$ display increasing resistance with time. Seedlings are moderately susceptible and quite large lesions are formed on the leaves attacked by the fungus. The leaves last initiated are highly resistant and only chlorotic flecks develop in response to infection. With artificial inoculations at the flowering stage or later, there is no difficulty in distinguishing $\underline{hm_1}/\underline{hm_1}$; $\underline{hm_2}/\underline{hm_2}$ plants from $\underline{hm_1}/\underline{hm_1}$; $\underline{Hm_2}/\underline{hm_2}$ or $\underline{Hm_2}/\underline{Hm_2}$ plants within ten to fourteen days following penetration by the pathogen. Under natural growing conditions $\underline{hm_1}/\underline{hm_1}$; $\underline{Hm_2}/\underline{Hm_2}$ plants are for practical purposes resistant to infection by the fungus.

The data on the location of $\underline{Hm_2}/\underline{hm_2}$ substantiate those collected earlier from a RS progeny. The F_2 progeny investigated in 1960 was derived from $\left(\frac{\underline{hm_1}\ \underline{Sh}\ \underline{Wx}\ \underline{Hm_2}}{\underline{hm_1}\ \underline{sh}\ \underline{wx}\ \underline{hm_2}}\right)$ ⊗. The data are given in Table I.

TABLE I

$\left(\frac{hm_1}{hm_1}; \frac{Sh\ Wx\ Hm_2}{sh\ wx\ hm_2}\right) \otimes$ Bulked Seed

Kernels Planted	Disease Reaction: Resistant ($Hm_2/?$)	Disease Reaction: Susceptible (hm_2/hm_2)
sh wx	33	49
sh Wx	39	4
Sh wx	30	33
Sh Wx	122	24

Oliver E. Nelson
A. J. Ullstrup

4. Production of diploid eggs by normal diploid maize.

The presence of triploid plants in diploid maize populations has frequently been observed, especially in experimental hybrid tests. It seems logical to theorize that these resulted from diploid (2N) eggs fertilized with normal (1N) pollen. If this is true then pollination of normal 2N plants with 2N pollen from established tetraploids should give rise to a low frequency of plump tetraploid kernels; the other kernels, of course, will be defective triploids. This method would provide an easy, large scale screening technique for detection of 2N eggs and recovery of tetraploid strains for breeding purposes.

In 1958 the above hypothesis was tested on a very small scale and several tetraploids were obtained.

In 1959 ten inbreds and fourteen single crosses were hand pollinated in an isolated field with 2N pollen from tetraploids. Delaying pollination by 4, 7, and 10 days after silking was tried to determine if this would increase the frequency of 2N eggs. The resulting plump kernels from these crosses were unfortunately planted in a Florida winter nursery where poor growing conditions and frost prevented the classification of a majority of the plants. Nevertheless, at least 56 tetraploid plants were obtained among 22 of the 24 crosses.

Classification of only part of the suspect plants prevented an accurate determination of the frequency of 2N eggs. From these limited

data delayed pollination did not appear to increase the frequency of 2N eggs. It was evident, however, based on the number of plump kernels and recovery of tetraploid plants, that the various inbreds and hybrids did differ in frequency of 2N eggs.

In the 1959-60 winter nursery seven single crosses were pollinated with 2N pollen. The plants grown from the plump kernels were classified for ploidy level by selfing and outcrossing them to a diploid tester (See Table below).

Pedigree	Number of gametes tested	Number of plants from plump kernels classified as			Frequency of normal 3N kernels per 1000 gametes	Frequency of 2N eggs per 1000 gametes tested
		2N	3N*	4N		
(H49 x C103) x 4N	2676	6	1	14	.37	5.23
(WF9 x 38-11) x 4N	2593	3	4	9	1.54	3.47
(W22 x Oh28) x 4N	4611	2	8	13	1.73	2.82
(38-11 x Oh43) x 4N	3492	6	3	9	.86	2.58
(Oh51A x Oh28) x 4N	7407	9	18	10	2.43	1.35
(Oh28 x M14) x 4N	3086	6	22	2	7.13	.65
(W22 x Oh51A) x 4N	5152	11	7	3	1.36	.58

* Triploid plants arising only from normal plump kernels.

The crosses ranged in frequency of 2N eggs per 1000 gametes from a low of .58 for Oh28 x M14 to a high of 5.23 for H49 x C103. The possibility of cool weather and poor growing conditions in the winter nursery abnormally increasing these rates will be checked in further tests.

Another interesting result was that some of the plump or normal kernels produced triploid plants. The rate varied, depending on the diploid female, from a low of .37 to a high of 7.13 normal triploid kernels per 1000 gametes. This normal development of some triploid kernels probably explains the occurrence of triploid plants in diploid yield tests. Defective triploid seeds would normally be discarded in cleaning and hand counting of the seed, but these normal triploid seeds would not be detectable. Whether these kernels have a different endosperm constitution to account for their normal development is not known, but will be investigated in future tests.

The production of 2N eggs, even though at a low frequency, by diploid types of maize provides a rapid and efficient method for developing tetraploid populations for breeding purposes. The procedure may be outlined as follows:

1st year: Pollinate diploid types (singles, doubles, synthetics, etc.) with 2N pollen from established tetraploids. Save the plump or normal kernels.

2nd year: Identify the tetraploid plants arising from the plump kernels by selfing and outcrossing to diploid tester (giving 3N defective seeds) or to tetraploid tester (giving 4N kernels).

3rd year: Make backcross with recovered 4N strain onto recurrent diploid parent.

Etc.

A backcross may be completed in two generations, with isolation of tetraploids in each successive backcross. Recovery of tetraploid versions of the diploid recurrent parent should be obtained in successive backcrosses in a manner similar to the expectation in the normal diploid backcrossing procedure, i.e. 75% and 87.5% recovery after the 1st and 2nd backcrosses, respectively.

L. F. Bauman

5. Frequency of mutations of R^{st} to R^{sc} (self-colored aleurone) in $R^{r}R^{st}$ and $R^{st}r^{g}$ heterozygotes.

It has been observed that R^{st} mutates to full self-color (R^{sc}), and that such mutations are more frequent in R^{st} homozygotes (17.0×10^{-4}) than in $R^{st}r^{r}$ heterozygotes (4.9×10^{-4}), (Genetics 45:19-34). Since the rate of mutation of R^{st} to R^{sc} in $R^{st}r^{r}$ heterozygotes reported in the paper cited above was based on a very small population, the test was repeated on a larger scale. In the second test the stability of R^{st} was tested in $R^{st}r^{g}$ heterozygotes with the following result: 14 mutations to R^{sc} were recovered from a population of 19,239 R^{st} gametes, a rate of 7.3×10^{-4}. The difference between this rate and the one first reported (4.9×10^{-4}) is most likely due to the large error involved in the first test because of the small population; however, the possibility of a different effect of r^{r} and r^{g} on R^{st} stability cannot be discounted.

To obtain additional information on the effect of homozygosity and heterozygosity on R^{st} stability a test was made of the frequency of R^{st} to R^{sc} mutations in R^{r} R^{st} heterozygotes. $R^{r}R^{st}$ plants were pollinated with $r^{g}r^{g}$ pollen; the self-colored kernels from this mating were planted in sand in a greenhouse bench and the resulting seedlings scored for plant color. Seedlings from non-mutant self-colored kernels ($R^{r}r^{g}$) had red plant color; seedlings with no plant color (green), presumed mutants, were transplanted into pots in the greenhouse and the resulting plants selfed.

The mutants with self-colored aleurone and green plant color recovered from $R^{r}R^{st}$ heterozygotes could have arisen either from mutations of R^{st} to R^{sc}, or from mutations of R^{r} to R^{g}. It was anticipated, however, that the mutants could be classified as to their source by their phenotypic expression. Many R^{sc} mutants from R^{st} have been isolated and they invariably have given full self-colored kernels when present in only one dose in the endosperm ($R^{sc}rr$). On the other hand, R^{g} mutants from R^{r} give a mottled phenotype when present in a single dose in the endosperm. In addition, R^{sc} mutants are not susceptible to the paramutagenic action of R^{st}, while R^{g} mutants from R^{r} have been shown to be paramutable; therefore, the pigmenting capacity of the R^{g} mutants recovered from $R^{r}R^{st}$ heterozygotes will be further reduced since they will be paramutants.

From the mating $R^{r}R^{st}$ X $r^{g}r^{g}$ 10,175 self-colored kernels were planted, and 74 seedlings were classified as green and transplanted to pots. Selfs were obtained from 63 of these plants and 49 proved to be non-mutant, i.e. R^{st}. Ten verified mutants segregated 3:1 on the selfed ears for fully self-colored and colorless kernels and were therefore considered to be R^{sc} mutations from R^{st}. The rate of mutation of R^{st} to R^{sc}, after adjustment of the total number of kernels planted for the death of 11 presumed mutants (63/74) and for percent germination (96.7), was 11.9×10^{-4}. This mutation rate falls about mid-way between the rate obtained from $R^{st}r^{g}$ heterozygotes (7.3×10^{-4}) and the one previously reported for R^{st} homozygotes (17.0×10^{-4}). The mutation rates of R^{st} to R^{sc}, as measured in various R locus combinations, are summarized below.

R locus Combinations	Frequency of R^{st} to R^{sc} Mutations	Rate X 10^{-4}
$R^{st}R^{st}$	34/19,920	17.0
$R^{st}r^{r}$	1/ 2,055	4.9
$R^{st}r^{g}$	14/19,239	7.3
R^{r} R^{st}	10/ 8,378	11.9

R. B. Ashman

6. A stippled - self-colored ($R^{g}R^{st}$) compound allele.

Four mutants with no plant color (green) were recovered from the above matings that did not segregate the phenotypes expected from either R^{sc} mutants from R^{st} or R^{g} mutants from R^{r}. The selfed ears carrying these four exceptional mutants segregated the expected 1/4 colorless kernels, but the colored class of kernels was made up of both self-colored and stippled kernels. Progeny tests of the self-colored and

stippled kernels from the four exceptional ears indicate that the self-colored, stippled, and colorless aleurone phenotypes resulted from the segregation of two R locus alleles only--one conditioning colorless aleurone (r^g), and the other a compound allele conditioning both self-colored and stippled aleurone (R^gR^{st}). The self-colored aleurone component of the compound allele gave a phenotype characteristic of a paramutant R^g allele. The stippled component gave a phenotype characteristic of R^{st} (light), a pheontype that results from the loss of a modifier carried on the R^{st} chromosome about 6 crossover units distal to the R locus. R^gR^{st}/r^rr^r endosperms resulting from pollinating r^rr^r ears with R^gR^{st}/R^gR^{st} pollen clearly show the R^{st} (light) phenotype superimposed on the very light mottled phenotype characteristic of one dose of a paramutant R^g. It would appear that in R^rR^{st} heterozygotes a genetic change is possible that incorporates the seed color component of both R^r and R^{st} together on the same chromosome, but excludes the plant color component of R^r and a distal modifier carried on the R^{st} chromosome. The frequency of such genetic changes in the above test was 4/8378 R^r gametes tested, a rate of 4.8×10^{-4}. The possibility of compound alleles occurring at the R locus has been suggested by Stadler (Science 120:811-819), and Brink has reported a stippled-Navajo ($R^{st}R^{nj}$) compound allele (Maize News Letter 34:122).

R. B. Ashman

S. K. C. G. COLLEGE
Parlakhemundi, Ganjam
Orissa, India

1. A study of abnormal nucleolar behaviour in meiocytes of maize induced by various agents and its relation to the course of meiosis.

The nucleolus is an organelle intimately associated with the synthesis of RNA and proteins. Hence, any change in the appearance or behaviour of the nucleolus might well be a reflection of the change in the metabolism of these compounds or their organization within this organelle. It is believed that the RNA/DNA ratio is an important factor controlling the mitotic or meiotic pattern of cell division and the normal progress of meiosis. (Sinha, MNL 34; Science, 1959; Ph.D. thesis, Indiana U., 1960). This leads us to the further belief that the nucleolus may be involved in the control of the pattern of cell division and the regulation of meiosis.

One of the ways to test this belief is to note simultaneously different types of nucleolar abnormalities in meiocytes and any

associated change in the course of meiosis. A series of experiments are being undertaken to determine (1) the behaviour of the nucleolus in meiocytes subjected to treatment with various chemicals known to affect mitosis or suspected to affect meiosis and (2) any change in the course of meiosis correlated with any abnormal nucleolar behaviour.

Some preliminary observations in plants treated with different phenolic compounds and RNA (MNL 34) are presented below.

(a) Decrease in the size of the nucleolus:- In plants treated with 0.1M phenol an appreciable fraction of meiocytes appear to have relatively smaller primary nucleoli at diakinesis. However, the course of meiosis appears quite normal.

A similar observation in a limited number of meiocytes of asynaptic maize plants may be of some interest, if confirmed.

(b) Secondary nucleolus:- A small secondary nucleolus is found associated with the large primary nucleolus in a great number of meiocytes of plants treated with 0.1M phenol. Cells with this abnormality may or may not show abnormal division in the form of asynapsis or desynapsis of chromosome segments.

(c) Nucleolus-like bodies associated with chromosomes:- In plants treated with RNA, small nucleolus-like bodies are found associated with certain chromosomes. The maximum number of such bodies found in a cell so far is 4. These bodies are of the same size or smaller than the secondary nucleoli. This nucleolar condition does not appear to be associated with any abnormality of meiosis.

(d) Chromatin bodies not associated with chromosomes:- In plants treated with 0.1M phenol most of the meiocytes are found to contain several small granules stainable with aceto-carmine and lying scattered in the nuclear sap. These bodies are smaller than the secondary nucleoli or the nucleolus-like bodies associated with chromosomes. The maximum number of these bodies has been found to be 20, per cell. Meiocytes showing this condition also exhibit partial asynapsis or desynapsis of chromosomes.

(e) "Persistent" nucleoli:- This condition as reported by Sampayo (MNL 33) and Miller (MNL 34) has been observed in a few cells of plants treated with RNA. No abnormality in the course of meiosis is, however, evident.

Further work is in progress.

S. K. Sinha

SOUS-DIRECTION DE LA RECHERCHE AGRONOMIQUE
ET DE L'ENSEIGNEMENT
Rabat - Morocco

1. Location of a gene for susceptibility to Puccinia sorghi.

The Moroccan inbred line, MR 368, has been found to be very susceptible to the leaf rust, Puccinia sorghi. Crosses with normally resistant inbred lines have been made and F_2 segregations studied. The results obtained indicated that this susceptibility is due to a single recessive gene (X^2 value # 1.5 and P value # 0.25), named provisionally rp_x.

By crosses with Maize Cooperative Stocks, linkage relations have been established with some genes of chromosome II. The following data have been obtained:

Genes XY	Phase	XY	Xy	xY	xy	Total	Recombination
Rp_x Lg_1	RS	326	155	141	3	625	14
Rp_x Gl_2	RS	291	190	134	10	625	22
Rp_x B	CS	414	67	81	63	625	42
Lg_1 Gl_2	CS	387	80	38	120	625	19
Lg_1 B	RS	354	113	141	17	625	36

According to these data, the rp_x gene seems to be located on the short arm of chromosome II, probably near ws_3. Crosses with the ws_3 lg_1 gl_2 stock have been also made and the F_2 progenies will be studied this year; a three point test (rp_x ws_3 lg_1) will be elaborated.

Seeds of the susceptible inbred are available for eventual allelism tests with the known dominant factors for rust resistance.

A. Cornu

2. Location of floury-endosperm-2 (fl_2).

A fl_2 stock (from Dr. H. H. Kramer) has been crossed with Cooperative stocks (marker genes and A-B chromosome translocations). We obtained a positive result with TB-9 b (as female parent). Consequently,

this gene fl_2 is probably located on the short arm of chromosome IX. Further studies are foreseen in order to determine this location more precisely.

A. Cornu

UNIVERSITY OF TEXAS
Austin, Texas
Genetics Foundation

1. Substitution of a Tripsacum chromosome segment for a portion of the corn genome.

As a result of an interchange a segment from a Tripsacum chromosome was substituted for the distal half of the short arm of corn chromosome 2 in plants whose chromosomes were apparently otherwise unaltered corn chromosomes. Plants both heterozygous and homozygous for the substitution have been obtained. Genetic tests have indicated that the Tripsacum segment carries Lg_1 and Gl_2, and tests are underway to determine whether a Ws_3 locus is also present. Cytological and genetic evidence seem to support the view that the Tripsacum segment has remained intact (or nearly so) as derived from Tripsacum.

Heterozygous plants were indistinguishable from normal corn in gross appearance, but homozygous plants were characteristically short and stocky with stiff leaves and very few tassel branches, and silks which were usually split for an appreciable distance back from the tip. Both heterozygous and homozygous plants differed significantly from normal corn of the same stocks (at the five percent level in t tests) in having narrower leaves and a tendency to be proterogynous. Homozygous plants differed from heterozygous and normal plants in that these homozygous plants were shorter (had fewer nodes), had fewer tassel branches, a smaller number of rows of ovules and a smaller number of ovules per row.

Pollen carrying the substitution appeared normal and functioned in fertilization in direct competition with pollen of normal constitution with a frequency of about 40 percent.

It appears that adequate substitutes may exist in a Tripsacum chromosome region for those loci essential to the normal development and reproduction of corn which are located in the distal half of its chromosome 2.

Marjorie P. Maguire

2. High transmission frequency of a Tripsacum chromosome in a hyperploid maize stock.

A 21 chromosome stock was obtained in a third backcross to corn generation of a corn-Tripsacum hybrid. The extra chromosome was about the length of corn chromosome 10 and its short arm, which carried a small terminal knob, had approximately half the length of the long arm. This extra chromosome never showed any tendency to synapse with any of the corn chromosomes and always appeared as a univalent at pachytene, diakinesis and metaphase I. Seven of 13 plants carried this chromosome. Five of the seven 21 chromosome plants had only defective pollen, and these were out-crossed, producing progenies totalling 62 plants, 56 of which contained the extra chromosome. The other 2 of the seven 21 chromosome plants had 40 percent to 50 percent normal appearing pollen, and these were selfed. In a total of 12 plants obtained from these selfings eight contained 21 chromosomes, one 20 chromosomes and three 22 chromosomes with the extra chromosome of the previous generation present in duplicate and always forming a bivalent at pachytene, diakinesis and metaphase. All ears produced on plants carrying extra chromosomes appeared to have reduced ovule fertility. Most 21 chromosome plants had completely defective pollen, but again two had normal appearing pollen, and two had about half normal appearing pollen. The pollen of the three 22 chromosome plants was about 65, 80 and 95 percent normal in appearance. Pollen of 20 chromosome segregants appeared normal.

Although more data are needed, it appears that presence of the extra chromosome singly usually inhibits the production of normal pollen while its presence in duplicate may not effect pollen production, or may effect it to a much lesser degree. Pollen which carries the extra chromosome not only functions but competes with some measure of success against 10 chromosome pollen.

The apparent high transmission frequency of the extra chromosome through the egg (75 to 80 percent) is of particular interest, and megasporogenesis will be studied. It is not known whether differential viability of 10 and 11 chromosome eggs may be a factor in plants of the peculiar constitution involved in these studies or whether there is a tendency for 11 chromosome megaspores to occupy the functional position. In microsporocytes the extra chromosome usually lags at metaphase and anaphase I. It may divide in either meiotic division and frequently fails to be included in a nucleus at telophase.

Possible effects on quantitative characters of the chromosome derived from Tripsacum when present singly and in duplicate are being studied, and genetic tests have been initiated for presence on the chromosome of loci common to corn.

Marjorie P. Maguire

WEST AFRICAN MAIZE RESEARCH UNIT
Moor Plantation
Ibadan, Nigeria

A number of articles were received from the West African Maize Research Unit. Since they are too lengthy for publication in full, the titles and summaries are given below. The complete articles will be kept in our files and may be obtained on request.

1. Analysis and discussion of 4 variety trials grown at Ibadan 1957-1958.

The four trials had a rather consistent standard error of 313 lb/acre (per plot). This is satisfactory to detect differences between the varieties of approx. 250 lb/acre. Three groups of varieties with very different residual variabilities are present. Therefore three variance components were considered in the calculation of the analysis of variance. Mexico 1 is the most variable treatment. Mexico 7, Mexico 13 and local form the medium variable group. Year and season main effects and their interactions were not shown to be significant. Some differences between varieties within both least variable groups are significant. Mexico 5 and Trinidad are the highest yielders. The interaction of varieties with seasons is most pronounced for Mexico 7, Mexico 13 and local. The "within trials" error is 128 lb/acre; the "between trials" error is 277 lb/acre. This indicates the advantage of a further repetition of trials in preference to an additional replication within trials.

C. L. M. Van Eijnatten

2. Report on a yield trial with varietal crosses.

Forty-one varieties were topcrossed to three very different tester varieties with a view to a determination of their combining ability on a varietal level. The varieties EAFRO 237 and EAFRO 231 (WAMRU Acquisitions 772 and 766) ranked highest, follwed by Sicaragua Br. 155 Trinidad and Br. 149 Trinidad (WAMRU Acquisition 40, 1017 and 265). The presence of a high variety x tester interaction was indicated.

C. L. M. Van Eijnatten

3. S_1 - selection of inbred lines in the variety Mexico 5.

Fifty first stage inbred lines were developed from the variety Rocamex 520-C (Mexico 5) and topcrossed to the source variety for a determination of their combining ability. Twelve of these lines were selected for further work on basis of the yielding performance of their topcrosses. The range of variation in yields was limited for two trials with a low average yield level (1000-1300 lb/acre). It averaged 1551 lb/acre for the higher yielding trials, although a tendency was observed that the range decreased with increasing yield level.

C. L. M. Van Eijnatten

4. Quantitative and qualitative tests of four maize varieties.

Two experiments were conducted in 1959 with four maize varieties. One experiment was performed in an attempt to find, according to the traditional method of food extraction, the proportion of food material in the grains. The other experiment was conducted to determine taste preferences for the four maize varieties. Processing and cooking of "Eko" and "Akamu" were done by students of a local girls' secondary school. Lagos White gave the highest proportion of food material. EAFRO 231 came second, Mexico 5 third and Sicaragua last. The results obtained from two types of food prepared were invariably similar. Lagos White was significantly superior in taste both in "Eko" and "Akamu" to other varieties, followed by EAFRO 231 and Sicaragua. A large proportion of food material was lost through hand grinding and it was presumed that 26-37% of food could be saved by the use of a milling machine.

P. M. Chinwuba
N. N. Okparanta

5. Early and late testing for combining ability of inbreds developed from the maize variety Mexico 5.

The performances in yield trials of S1 and S4 topcrosses of inbred lines of maize derived from the variety Mexico 5 were compared. The better combining S1 - lines did not necessarily give rise to good combining S4 lines. Comparisons of S4 - topcrosses originating from the same S1 - line showed that remarkable differences (up to six times the standard error of a mean) existed between those derivatives. It is suggested that an early test for combining ability in this variety is not the best procedure to derive desirable and good combining inbred lines.

C. L. M. Van Eijnatten

UNIVERSITY OF WISCONSIN
Madison, Wisconsin

1. Occurrence of paramutation during endosperm development.

Following Brink's (PNAS 45:819) demonstration that the change of R^r to the paramutant form ($R^{r'}$) does not directly involve zygotene pairing of R^r and R^{st} (stippled aleurone), attempts have been made to demonstrate directly that the alteration occurs in somatic cells. Ashman (Genetics 45:18) derived near-colorless mutants from stippled or R^rR^{st} plants (designated by r^gI or r^rI) which retained the paramutagenic property of R^{st}. Weyers found that the pigment-producing action of the standard R^r allele was not detectably altered in the $R^r/r^rI/r^rI$ endosperms immediately resulting from r^rI/r^rI ♀ X R^rR^r ♂ matings. The present experiment confirms this observation. It is found, however, that if the R allele tested in a comparable way is already a paramutant (R') then its pigment-producing action is further reduced in $R'/r^rI/r^rI$ and $R'/r^gI/r^gI$ endosperms.

Demonstration of this effect of the near-colorless paramutagenic alleles requires the use of R' paramutants which initially have been only slightly reduced in pigment-producing action. The source of R' paramutants for the experiment was, therefore, $R^{scl}R^g$ heterozygotes. The R^{scl} alleles involved were self colored mutants from light stippled which had previously been characterized as being weakly paramutagenic. The R^g allele is a green plant color mutant derived from the standard R^r allele.

The following crosses were made:

W22 ♀♀ parents		W22 ♂♂ parents
r^rI_3/r^g		$R^{scl}134/R^g5$
r^r/r^gI_4	X	$R^{scl}99/R^g5$
r^r/r^g		R^g5/R^g5

The r^r and r^g colorless alleles involved in the female parents are nonparamutagenic, while r^rI_3 and r^gI_4 are near-colorless, paramutagenic alleles, with red and green seedling color, respectively.

Single pollen collections were taken from male plants and used to pollinate one ear in each of the three pistillate parents. The resulting kernels were evaluated for level of aleurone pigmentation by separation of the $R^g/-/-$ kernels into classes ranging from 1 (colorless) to 6 (darkly mottled) and 7 (self colored). Kernels were scored individually

for aleurone pigmentation, germinated in order, and the genotype of the endosperm was determined from the seedling color. For examples, in matings involving $\underline{r}^{r}I_3/\underline{r}^{g}$ ♀, the kernels giving red seedlings = $\underline{R}^{g\prime}/\underline{r}^{r}I/\underline{r}^{r}I$ and those giving green seedlings = $\underline{R}^{g\prime}/\underline{r}^{g}/\underline{r}^{g}$. Heterofertilization does not interfere with this classification, since all male parents are homozygous for the green seedling character ($\underline{R}^{scl}$ alleles are $\underline{R}^{g}$, in Emerson's terminology).

The mean aleurone color scores for the "red" and "green" classes on each ear are based on 50 kernels scored. Table 1 contains these individual class mean values averaged over the number of plants tested, and also the mean difference between "red" and "green" classes per kernel scored.

The full results, of which Table 1 is a summary, are regular. For each of the staminate parents, the difference between classes on individual ears of matings involving $\underline{r}^{r}I/\underline{r}^{g}$ ♀ and $\underline{r}^{r}/\underline{r}^{g}I$ ♀ are in the same direction. The combination involving $\underline{R}^{g\prime}$ with the paramutagenic allele contributed by the female parent is the least pigmented. In the case of the $\underline{R}^{g}5/\underline{R}^{g}5$ staminate parent this difference is extremely small, and is significant only in the case of $\underline{r}^{r}I/\underline{r}^{g}$ ♀ X $\underline{R}^{g}5/\underline{R}^{g}5$ crosses. Even here the observed difference represents a relative displacement of only 18 kernels of the 250 kernels scored for each endosperm genotype, and therefore does not clearly represent a paramutagenic effect of the $\underline{r}^{r}I$ allele.

In contrast the difference between classes is non-significant in all matings involving the $\underline{r}^{r}/\underline{r}^{g}$ pistillate parent.

The reduction in pigmentation level observed for $\underline{R}^{g\prime}/\underline{r}^{r}I/\underline{r}^{r}I$ and $\underline{R}^{g\prime}/\underline{r}^{g}I/\underline{r}^{g}I$ endosperm kernels relative to their respective controls is clearly a consequence of the paramutagenic action of the near-colorless alleles ($\underline{r}^{r}I$ and $\underline{r}^{g}I$). Since it is known that $\underline{R}^{r}$ paramutants from heterozygotes with weakly paramutagenic $\underline{R}^{sc}$ alleles may be further reduced in pigment-producing action if made heterozygous with stippled, the effect observed here may rightly be termed paramutation. It follows, therefore, that the paramutagenic effect of these near-colorless alleles can be manifested in the immediate endosperm phenotype. By extrapolation it appears likely that this secondary alteration of the $\underline{R}^{g\prime}$ paramutants is progressive, and begins as soon as the paramutable $\underline{R}^{g\prime}$ and paramutagenic near-colorless alleles become associated in a common nucleus following fertilization.

The immediate paramutagenic effect of the near-colorless alleles is not detected if the $\underline{R}^{r}$ or $\underline{R}^{g}$ alleles are non-paramutants. There is, therefore, a "threshold" for the effect.

Some $\underline{R}^{sc}$ alleles (mutants from stippled) are non-paramutagenic when standard $\underline{R}^{r}/\underline{R}^{sc}$ heterozygotes are tested in the usual way. Heterozygotes of 3 of these $\underline{R}^{sc}$ alleles with $\underline{R}^{g}5$ were also tested in this

Table 1. Occurrence of paramutation during endosperm development. Mean aleurone color scores for R^{g}'/-/- kernels.

Staminate parent	Number of ♂ plants tested	Pistillate parent(1)	Mean aleurone color scores/kernel(2) "red"(3)	"green"(3)	Mean difference between classes per kernel (red - green)	Significance(4)
$R^{scl_{134}}/R^{g5}$	6	$r^{r}I/r^{g}$	4.883	5.226	-0.343	**
	6	$r^{r}/r^{g}I$	5.303	4.856	+0.447	*
$M^{c}757$	6	r^{r}/r^{g}	5.198	5.170	+0.028	-
$R^{scl_{99}}/R^{g5}$	4	$r^{r}I/r^{g}$	4.535	4.935	-0.40	*
	4	$r^{r}/r^{g}I$	4.330	3.965	+0.365	**
$M^{c}751$	4	r^{r}/r^{g}	4.685	4.750	-0.065	-
R^{g5}/R^{g5}	5	$r^{r}I/r^{g}$	5.888	5.960	-0.072	*
	5	$r^{r}/r^{g}I$	5.940	5.884	+0.056	-
W 761	5	r^{r}/r^{g}	5.968	5.94	+0.028	-

(1) r^{r} and r^{g} are colorless, non-paramutagenic alleles, while $r^{r}I$ and $r^{g}I$ denote red plant color, near-colorless aleurone, paramutagenic, and green plant color, near-colorless aleurone, paramutagenic, alleles, respectively.

(2) The total number of kernels upon which these mean values are based is given by n X 50 where n is the number of ♂ plants tested.

(3) "red" signifies the class of kernels giving red seedlings on germination and hence of $R^{g}r^{r}r^{r}$ endosperm genotype, and "green" signifies the alternate relation.

(4) * Significant at P = 0.05, ** significant at P = 0.01.

experiment. There is no evidence of an immediate effect of the paramutagenic alleles on $\underline{R}^{g}$ from this source, so that there is no evidence of a subliminal alteration of $\underline{R}^{g}$ in these heterozygotes with non-paramutagenic $\underline{R}^{sc}$ alleles.

K. S. McWhirter

2. Mutation of a self colored allele to a Navajo pattern.

A mutation study involving 98 self colored R alleles (designated R^{sc} from R^{st}, or R^{scl} from light stippled) derived by mutation from stippled was begun in 1959. The object was to study the mutation spectrum of R^{sc} alleles, and to determine whether mutability was related to the paramutagenic action of the allele.

Eighteen independent mutants from R^{sc} alleles were established, of which 10 were based upon the selection of mutant kernels which were initially completely colorless. The progeny tests show, however, that only one of these is a completely colorless mutant. Three are near-colorless, 3 are weakly pigmented (diffuse patches) and 3 are "pale spotted," dosage-dependent alleles.

From 8 presumed mutant kernels which initially showed some pigmentation of the aleurone, 3 weakly pigmented mutants, one "pale spotted" and 3 dosage-dependent self colored alleles were obtained. (The R^{sc} parent alleles are dosage-independent.) The remaining pigmented mutant kernel had the Navajo phenotype, and its descendants gave the Navajo pattern. This mutant was derived from the cross $R^{scl-134}R^{scl-134}$ ♀ X $r^{r}r^{r}$ ♂, and its origin by contamination is excluded. As expected, it is associated with green plant and seedling color (all R^{sc} alleles are R^{g} in Emerson's terminology).

No reverse mutations to a stippled allele were found, although the "near-colorless" and weakly pigmented alleles phenotypically resemble the $r^{g}I$ alleles which Ashman (Genetics 45:18) obtained directly from stippled by mutation.

The over-all mutation rate was low; considering all mutants it was $18/1,150,746 = 0.15 \times 10^{-4}$.

There is no indication in the present data of a relation between the paramutagenic action of R^{sc} alleles and mutability of these alleles. The number of mutants recovered is insufficient, however, to provide an adequate test of this question.

K. S. McWhirter

3. Phenotypes of presumed mutant kernels from stippled in relation to germinal transmissibility.

Ashman's (Genetics 45:19) studies of the mutation of stippled to self colored demonstrated two points:

a) An approximately 50% concordance between a self colored endosperm phenotype of the mutant kernel and transmissibility of self colored to offspring.

b) A mutation frequency in homozygotes of stippled about four times greater than that in heterozygotes of stippled with r. This is termed the "heterozygote effect" here.

Subsequently J. Kermicle found that kernels with the phenotype, stippled aleurone-colored scutellum, frequently gave mutant self colored progeny. It was also observed that all proven self colored mutants from stippled had a colored scutellum.

These observations prompted a study of the concordance of kernel phenotype with germinal mutation of stippled to self colored.

Kernels from the crosses

W22 $\underline{R}^{st}$(light) $\underline{R}^{st}$(light) ♀♀ X W22 $\underline{r}^{r}\underline{r}^{r}$ ♂♂

(referred to subsequently as the homozygote)

and W22 $\underline{R}^{st}/\underline{r}^{g}$ ♀♀ X W22 $\underline{r}^{g}\underline{r}^{g}$ ♂♂

W22 $\underline{R}^{st}$(light) K10/$\underline{r}^{g}$ ♀♀ X W22 $\underline{r}^{r}\underline{r}^{r}$ ♂♂

(collectively referred to as heterozygotes)

were classified into one or other of the classes of kernel phenotypes listed in Table 1. The non-parental kernel types were subsequently progeny tested. The results of the progeny test, in which only the ear genotype was determined, are included in Table 1.

The data show that, irrespective of the aleurone phenotype, there is a high concordance of germinal mutation of stippled to self colored with presence of the colored scutellum phenotype. Kernels of class 4 (mosaic scutellum) probably represent mutations occurring in early sporophyte development. A small proportion of class 3 (stippled aleurone-colored scutellum) kernels regularly give non-mutant progeny. It follows from this result that some proportion of the germinal mutants from this class of kernel may be attributed to very early somatic mutations. The germinal mutations to self colored obtained from class 5 kernels (stippled aleurone-colorless scutellum) are clearly a consequence of somatic mutation later in sporophyte development.

An explanation of the remaining classes of kernels occurring on stippled ears may be made as follows:

Table 1. Concordance of germinal mutation of stippled to self colored with the phenotype of presumed mutant kernels.

Class	Phenotype of the presumed mutant kernels	Origin(1)	Number of presumed mutant kernels tested(2)	Progeny test result (ear classified only) Mutant ($R^{sc}r$)	Non mutant $R^{st}r$	Mosaic
1	Colored aleurone colored scutellum	Homozygote	38	38	-	-
		Heterozygotes	4	4	-	-
2	Colored aleurone colorless scutellum	Homozygote	22	-	22	-
		Heterozygotes	16	3	13	-
3	Stippled aleurone colored scutellum	Homozygote	14	12	2	-
		Heterozygotes	12	10	2	-
4	Stippled aleurone mosaic scutellum	Homozygote	18	5	13	-
5	Stippled aleurone colorless scutellum	(3)	757	3	753	1(4)

(1) "Homozygote" and "heterozygotes" refer the kernels to origin from the crosses listed in the text.

(2) 2 proven contaminants and 4 kernels not tested were omitted from the tabulation.

(3) All these kernels were from the crosses R^{scl}/R^{st}(light) K X $r^r r^r$

R^r/R^{st}(light) K X $r^r r^r$

R^{st}(light) K/r^g X $r^r r^r$

(4) Sectored ear bearing a patch of 18 R^{scl} kernels and 10 colorless kernels, remaining kernels were R^{st}(light) or colorless.

Class 1 kernels: colored aleurone-colored scutellum

These are invariably germinally transmissible and the majority probably represent instances in which the megaspore is mutant. Mutations occurring early in the development of the megagametophyte could also give rise to this kernel phenotype.

Class 2 and class 3 kernels

These may be interpreted as the reciprocal types expected if the mutation of stippled to self colored occurs during development of the megagametophyte. The embryo sac would therefore contain a mixture of mutant and nonmutant haploid nuclei. Disposition of a mutant nucleus to function in the egg, or in the development of the endosperm would result in kernels with the class 3 and class 2 phenotypes, respectively.

The relative frequencies of these kernel phenotypes are in the relation expected on this interpretation. There are several ways of deriving a class 2 type (mutant endosperm, non-mutant egg), whereas class 3 kernels (non-mutant endosperm, mutant egg) presumably can be obtained in only one way. More definitive support for this interpretation comes from a study of the relative frequencies of these types of kernels following mutation in the pollen grain (see the following note by J. Kermicle).

The high concordance of the colored scutellum phenotype with germinal mutation to self colored shows that this scutellum pigmentation is an effect of the R^{sc} allele. This conclusion is confirmed by the subsequent inheritance of the character. Colored scutellum was found to be completely associated with the self colored aleurone, green plant, color complex in a backcross test involving 3126 kernels from the cross W22 $r^g r^g$ ♀♀ X W22 $R^{sc} R^r$ ♂♂. The $R^r R^r$ stock in W22 background has a colorless scutellum. The only apparent exceptions to the parental types proved to be the result of heterofertilization when progeny tested. The colored scutellum character in these stocks, therefore, is not the same as that earlier described by Sprague (1932, U.S.D.A. Tech. Bull. 292).

The mutation rates calculated from these data and the appropriate significance tests are contained in Table 2. These show that, when comparison is made of the frequencies of mutant kernel types in homozygote and heterozygotes, there is a difference with respect to only one class, namely the colored aleurone-colored scutellum kernels. It follows from the above interpretation of the origin of this class of kernels that the "heterozygote effect" observed by Ashman is manifest only in terms of the mutations occurring during meiosis. Since kernels of classes 2 and 3 are interpreted as the consequences of mutation occurring during embryo sac development, a "heterozygote effect" on the mutability of stippled is not to be expected at this stage, and was not observed.

Table 2. Mutation rates and significance tests for the data in Table 1.

A. In the homozygote, cross $\underline{R}^{st}$(light) $\underline{R}^{st}$(light) ♀♀ X $\underline{r}^{r}\underline{r}^{r}$ ♂♂

Class of presumed mutant kernel	Mutants ($\underline{R}^{sc}/\underline{r}^{r}$)	Total kernels (corrected)	Mutation frequency X 10^{-4}
1. Colored aleurone (class 2 + class 3)	38	13,414	28.3
2. Stippled aleurone colored scutellum (class 3)	12	14,308	8.38
3. All classes 1, 2 and 3	50	13,575	36.8
4. Stippled aleurone mosaic scutellum (class 4)	5	4,266	11.75

B. In the heterozygote, pooled data from the crosses $\underline{R}^{st}\underline{r}^{g}$ ♀♀ X $\underline{r}^{g}\underline{r}^{g}$ ♂♂ and $\underline{R}^{st}$(light) $\underline{K}/\underline{r}^{g}$ ♀♀ X $\underline{r}^{r}\underline{r}^{r}$ ♂♂

Class of presumed mutant kernel	Mutants ($\underline{R}^{sc}/\underline{r}^{r}$)	Total kernels (corrected)	Mutation frequency X 10^{-4}
1. Colored aleurone (class 2 + 3)	7	7,425	9.4
2. Stippled aleurone colored scutellum (class 3)	10	7,796	12.8
3. All classes 1, 2 and 3	17	7,560	22.5

Significance tests: 1) Frequencies of colored aleurone kernels which give mutant progeny differ significantly at P = 0.01 in homozygote and heterozygote.

2) Frequencies of class 3 mutants (stippled aleurone-colored scutellum kernels), and of class 2 kernels (colored aleurone, colorless scutellum) which give non-mutant progeny, do not differ at P = 0.2 in homozygote and heterozygote.

These data also provide some evidence showing lack of association of mutation of stippled to self colored with distal crossing over. Thirteen self colored mutants (9 in the present study and 4 previously) from the cross W22 R^{st}(light) K10/r^g ♀♀ X W22 $r^r r^r$ ♂♂ were all R^{sc1}K10/r^r in constitution (i.e., noncrossovers). However, only those mutants derived from colored aleurone, colored scutellum kernels legitimately test for an association with distal crossing over. Only three mutants had this origin, and all three were noncrossovers.

K. S. McWhirter

4. Mutation of stippled (R^{st}) to self-colored (R^{sc}) aleurone during microsporogenesis.

This investigation was prompted by the following two observations made in studies of mutation of R^{st} to R^{sc} in $R^{st}R^{st}$♀♀. In the first place, a large portion, perhaps half, of the self-colored kernels on stippled ears prove to be non-germinal (Ashman, Genetics 45:19; and McWhirter, accompanying report). The second point is the frequent occurrence of kernels with stippled aleurone and colored scutellum (the latter is a characteristic of the R^{sc} phenotype) which turn out, in fact, to be germinally transmissible self-colored mutants. The present experiment was undertaken to test the supposition that the two classes described above arise from mutation in the haploid gametophyte. Since, in the case of microsporogenesis, a single mitosis (the second nuclear division in the male gametophyte) gives rise to the two sperm which participate in double fertilization, one would expect the two reciprocal classes in equal frequencies from matings on colorless plants in which $R^{st}R^{st}$ was the male parent.

The categories and respective frequencies of mutants arising from the mating $r^r r^r$; Y Y x $R^{st}R^{st}$; y y are given in the following table. The recessive marker y was utilized in the male parent in order to identify pollen contaminants. All presumed mutants were grown out and then tested by pollination with $r^r r^r$; y y.

Mutation of R^{st} to R^{sc} in $r^r r^r$♀ x $R^{st}R^{st}$♂ matings

Kernel phenotype of presumed mutant	Classification by breeding test	Number of mutants	Number of * R^{st} gametes tested	Mutation rate (X 10^{-4})
Colored aleurone	R^{st}	15	2,831	53.0
	R^{sc}	27	2,831	95.4
Colored scutellum (R^{st} aleurone)	R^{st}	1	3,640	2.75
	R^{sc}	13	3,640	35.7

* Initial population = 3,640. Corrected in computation where progeny were not obtained from mutant kernels.

It is apparent from the data that R^{sc} mutations are frequent when $R^{st}R^{st}$ is employed as staminate parent. Since the R^{sc} aleurone-R^{st} embryo combination and the reciprocal class, R^{st} aleurone-R^{sc} embryo, occur with frequencies of similar order, the hypothesis concerning the gametophytic origin of the types is upheld. An additional point of interest is that it is possible in this material to determine directly the mutation rate for a particular mitotic division. The frequency with which the second nuclear division of the male gametophyte gives rise to two daughter nuclei only one of which is mutant, is obtained by pooling the two classes which represent discordance between the two tissues, embryo and endosperm. In this case the rate is $\frac{15 + 13}{(2831 + 3640)/2} = 86.5 \times 10^{-4}$.

J. Kermicle

5. Differential induction of paramutation at R locus.

The earlier work in this laboratory showed that certain R^r and R^g alleles undergo weak and variable paramutation when they are made heterozygous with R^{st}, which is known to be a strong and uniform paramutagenic allele. On the other hand, some R^{sc} (self colored) mutants from stippled and R^{mb} alleles are weakly and variably paramutagenic. One explanation for such variability is that the plants in question are actually chimeras, in which paramutation of R^r or R^g has proceeded to various levels in different parts of the individual. An attempt is being made to see if this hypothesis is valid, by separating and testing paramutated R^r and R^g alleles, as well as R^{sc} alleles, from within the same plant.

The material in the present study includes (1) R^rR^{st} combinations in which the R^r alleles used showed, in previous studies, different grades of paramutation, (2) R^rR^{sc} combinations in which R^{sc} showed different grades of paramutagenicity and (3) R^gR^{st} and R^rR^{mb} combinations in which R^g showed variable changes in pigment-producing action and R^{mb} showed variable paramutagenic action. The method consists in collecting pollen lots from side branches of the tassel of the plants to be tested and then pollinating plants of r^gr^g constitution (Inbred W22). From the resulting ears, 100 $R^{r'}r^gr^g$ or $R^{g'}r^gr^g$ kernels ($R^{r'}$ and $R^{g'}$ designate paramutants of R^r and R^g alleles, respectively) were scored for intensity of pigment by matching them with a standard set of kernels defining 11 classes.

The following table is a sample of data from plants in which differences in paramutation of R^r in different tassel branches could be detected. The scores from two ears pollinated by the pollen from the same tassel branch did not differ widely, and so the observed differences cannot be attributed to the r^gr^g ♀♀ parents. One

Differential induction of paramutation at $\underline{R}^r$ locus

Family	Genotype of ♂ parent	Position of the branch on tassel	Mean score of $R^{r'}r^g r^g$ kernels
(52-10)-6	$\underline{R}^r\underline{R}^{st}$	Basal	4.54
		Central	7.87
		Top	3.97
(52-11)-1	$\underline{R}^r\underline{R}^{st}$	Basal	6.54
		Central	3.04
		Top	5.96
(52-12)-8	$\underline{R}^r\underline{R}^{st}$	Basal	7.81
		Central	5.09
		Top	2.14
(52-18)-5	$\underline{R}^r\underline{R}^{sc}$	Basal	6.65
		Central	10.91
		Top	4.94
M^c772-1	$\underline{R}^r\underline{R}^{sc}$	Basal	6.11
		Central	3.23
		Top	5.63

interesting case ((52-18)-5) was where in the central branch no paramutation of $\underline{R}^r$ has occurred, while in both basal and top branches it occurred to some degree. The present data do not indicate any simple relationship between differential paramutation of $\underline{R}^r$ and symmetry of the tassel. In some cases the $\underline{R}^{r'}$ alleles from weakly affected branches showed a considerable range of variability. Matings are being planned to test whether the observed differences are heritable and to study the concurrent changes in both alleles of heterozygotes, particularly in $\underline{R}^r\underline{R}^{sc}$ combinations.

These results are in agreement with those previously obtained by H. B. Cooper, Jr. referred to briefly by Brink (Quart. Rev. Biol. 35:120-137).

G. R. K. Sastry

6. A non-paramutable, non-paramutagenic R^r allele.

Among a collection of R alleles from various geographic sources presently being introduced into the W22 inbred line, are several which give self-color in Rrr aleurone. This behavior is in contrast to that of the majority of the R alleles which are darkly mottled in Rrr

kernels, but is comparable to that of all self-colored mutants (R^{sc}) obtained from the pattern alleles, R^{st} and R^{mb}. In a preliminary test conducted in 1959, these same self-colored alleles were shown to be insensitive to the paramutagenic action of the R^{st} allele in $R^{sc}R^{st}$ heterozygotes. Two of these alleles, designated R^{g} Bolivia 1160 and R^{r} Ecuador 1172, were included in a 1960 test for paramutagenic action in heterozygotes with R alleles of contrasting plant color, known from previous trials to be paramutable. Results from testcross matings of these heterozygotes show that the R^{g} Bolivia 1160 allele is definitely paramutagenic, and is thus in this respect also, comparable to the majority of self-colored mutants from R^{st} or R^{mb}. The R^{r} Ecuador, however, showed no paramutagenic action. It is the only R allele giving red seedlings and anthers thus far found, that is apparently both non-paramutable and non-paramutagenic. In this respect it resembles certain self-colored mutants from stippled or marbled but differs from them in giving plant color. The latter characteristic would appear to exclude mutation from R^{st} or R^{mb} as the origin of R^{r} Ecuador 1172.

Derek Styles

UNIVERSITY OF WISCONSIN
Madison, Wisconsin

and

HARROW RESEARCH STATION
Harrow, Ontario, Canada

1. Note on the transposition of Modulator from the variegated pericarp allele.

The P^{vv} allele has been postulated by Brink and Nilan (Genetics 37: 519-544, 1952) to be a compound structure, one component of which is P^{RR}, the top dominant in the multiple allelic series at the P locus on the short arm of chromosome 1, and the other component a genetic element, which suppresses the pigment-producing capacity of P^{RR}, termed Modulator (Mp). The medium variegated phenotype which comprises numerous red stripes of various sizes on a colorless background was assumed to result from the transposition of Modulator from the P locus to a position elsewhere in the genome, thus restoring the normal pigment-producing action of P^{RR}. Progeny tests showed that another phenotype called light variegated often accompanies the mutation to self-red. This variegated phenotype was found to differ from medium variegated in possessing an additional Modulator at some position in the genome other than the P locus.

Van Schaik (Genetics 44: 725-737) studied the sites to which Modulator is transposed when the element is removed from the P locus in the mutation of variegated to red pericarp. The criterion used to identify the transposed Modulator was the capacity of this element to change the pericarp phenotype from medium to light variegated. She found that 64 percent of the new positions of Modulator showed linkage with P, and 29 percent of the transposed Modulators showed no recombination with the P locus.

While conducting another study on the light variegated phenotype, more information on the transposition of Modulator from the P locus was obtained. Independently occurring mutations from medium to light variegated were assembled from mutants on medium variegated ears. These mutants, which were heterozygous for variegated pericarp and hemizygous for transposed Modulator, were crossed to colorless pericarp inbred strains. Progenies were then grown out, and the variegated ears were harvested and classified for pericarp color.

The results of testing for recombination between P and transposed Mp are presented in Table 1. Of the 17 families tested, each representing an independent mutation to light variegated, 7 or 41 percent showed linkage of P and Mp, and 2 or 12 percent showed no recombination between P and Mp. These findings indicate that when Mp is

Table 1. Percentage of medium variegated segregates among the testcross offspring of independent, newly arisen light variegateds.

Family Number	Number Var. ears	Number Med. Var.	Percent Med. Var.
T13	84	33	39.3*
T14	73	36	49.3*
T15	59	2	3.4+
T16	85	1	1.2+
T18	70	42	60.0*
T21	96	47	49.0*
T24	84	45	53.6*
T28	71	30	42.3*
T30	33	6	18.2+
T31	37	17	46.0*
T34	58	29	50.0*
T35	28	13	46.4*
T36	47	0	0.0+
T39	13	4	30.8*
T41	75	10	13.3+
T42	62	2	3.2+
T44	70	0	0.0+

* Not significantly different from 50 percent ($P > .05$).
+ Differs very significantly from 50 percent ($P < .01$).

transposed from P to another site in the genome, the new site is very frequently located within 50 crossover units on either side of the P locus. These data also indicate that transposed Mp may not be as frequently linked with P as the data presented by Van Schaik indicated. In particular, the number of families showing no recombination between P and Mp was much lower in the data presented here.

G. H. Clark

UNIVERSITY OF ZAGREB
Zagreb, Yugoslavia
Department of Plant Breeding and Genetics

1. Percentage of inbred lines with chlorophyll deficient seedlings in the first generation after selfing of some Yugoslav varieties of maize.

The frequency of inbred lines with chlorophyll deficient seedlings: white (w), luteus (l), virescent (v), virescent luteus (v l) and virescent white (v w), which have developed in the first year after selfing of plants in some Yugoslav varieties, has been studied. For that purpose 7 yellow flint, 4 white flint, 11 yellow dent and 5 white dent varieties have been investigated. Some of these have been improved through individual selection.

The percentage of chlorophyll deficient inbred lines was much greater from unimproved varieties. In flint maize it varied from 25.7% to 33.5% and in dent maize from 22.3% to 31.3%.

From improved varieties the variation was as follows: in flints from 2.8% to 5% and in dents from 2.1% to 5.9%. In flints and in dents the percentage of chlorophyll deficient inbreds in the first generation of selfing increased in the following order: white; white, virescent-white; white, luteus; white, luteus, virescent; white, luteus, virescent-white.

The data are given in the tables appearing on the next two pages.

A. Tavčar

Percentage of inbred lines with chlorophyll deficient seedlings in first generation after selfing of some Yugoslav varieties of maize.

No.	Variety	Number of rows M	Percentage of inbred lines with w	w, l	w, l, v	w, vw	w, l, vw	Total
I.	Flint - a) yellow:							
1.	Long fellow-Lepoglava	8.4	4.1	5.3	6.5	4.3	7.2	27.4
2.	Long fellow-Lepoglava (improved)	8.1	0.3	0.6	0.7	0.4	0.8	2.8
3.	Early yellow-Medjimurje	13.7	5.3	4.1	4.8	3.3	8.2	25.7
4.	Early yellow-Maksimir	14.2	5.7	5.4	6.0	4.3	6.2	27.6
5.	Early yellow-Maksimir (improved)	14.7	0.4	0.7	0.7	0.6	0.9	3.3
6.	Yellow - Pirot	12.5	5.8	6.7	7.6	4.2	8.5	32.8
7.	Cinquantino	17.1	3.6	5.6	7.3	4.5	8.1	29.1
	b) white:							
8.	Long fellow-white Zaječar	9.3	3.8	4.7	7.2	5.6	7.4	28.7
9.	Long fellow-Zaječar (improved)	8.4	0.6	0.8	1.2	0.9	1.3	4.8
10.	White - Pirot	12.5	5.1	6.6	7.2	6.4	8.2	33.5
11.	White - Pirot (improved)	14.1	0.5	1.0	1.4	0.7	1.4	5.0
	Total flints: M		3.20	3.77	4.60	3.20	5.29	

w = white
l = luteus
v = virescent
v l = virescent luteus
v w = virescent white

Percentage of inbred lines with chlorophyll deficient seedlings in first generation after selfing of some Yugoslav varieties of maize.

No.	Variety	Number of rows	Percentage of inbred lines with					
		M	w	w, l	w, l, v	w, vw	w, l, vw	Total
II.	Dent - a) yellow:							
12.	Early yellow-Maksimir	15.2	2.6	3.7	5.4	4.5	6.1	22.3
13.	Early yellow-Maksimir (improved)	16.1	0.2	0.4	0.5	0.5	0.8	2.4
14.	Early yellow-Osijek	13.3	4.8	5.3	6.2	5.4	6.4	28.1
15.	Early yellow-Osijek (improved)	12.4	0.5	1.2	1.3	0.7	1.6	5.3
16.	Early yellow-Horgoš	13.8	4.2	5.6	6.2	4.8	7.1	27.9
17.	Early yellow-Horgoš (improved)	12.3	0.6	0.8	1.3	0.9	1.4	5.9
18.	Yellow-Bajša	14.8	4.2	5.3	7.1	4.6	8.2	29.4
19.	Yellow-Ruma (improved)	14.4	0.3	0.6	0.7	0.5	0.8	2.9
20.	Yellow-Novi Sad (improved)	16.5	0.2	0.3	0.5	0.4	0.7	2.1
21.	Yellow-Belje (improved)	16.2	0.4	0.5	0.6	0.4	0.7	2.6
22.	Yellow - Šid	18.3	5.2	5.8	6.4	5.7	7.3	30.4
	b) white:							
23.	White - Bankut (improved)	12.9	0.5	0.8	0.9	0.6	1.1	3.9
24.	White - Požega	14.2	3.6	4.4	6.5	4.2	7.1	25.8
25.	White - Horgoš (improved)	15.4	0.3	0.5	0.8	0.4	1.2	3.2
26.	White - Mastadont	15.1	5.4	6.2	6.9	5.5	7.3	31.3
27.	White - Šid	18.3	3.5	4.6	5.8	4.5	6.6	25.0
	Total dents: M		2.28	2.87	3.57	2.72	4.02	

w = white
l = luteus
v = virescent
v l = virescent luteus
v w = virescent white

2. The frequency of mutations from colourless to coloured pericarp in inbred lines.

The frequency of mutations from colourless to coloured pericarp: orange, red and variegata in inbred lines during 15 years of selfing of some Yugoslav varieties of maize has been studied. For that purpose inbred lines from 6 yellow flints, 5 white flints, 7 yellow dents and 4 white dents extracted from some varieties have been used. The mutation rate has been calculated per 10,000 plants. The rate of mutation from colourless to coloured increased in the following order: variegated, orange, red. There is no significant difference in the percentage of mutations from flint types and dent types but there are some small differences in the total mutation rates in yellow flints.

All investigated flints and dents have produced orange mutants, but not all of them have given variegated pericarp.

Frequency of mutations from colourless to coloured pericarp in inbred lines during 15 years of selfing of some Yugoslav varieties of maize.

No.	Variety	Mutation rate per 10,000 plants from colourless to: orange	red	variegata	Total
	I. Flints - a) yellow				
1.	Long fellow-Lepoglava	0.6	0.8	-	1.4
2.	Early - Medjimurje	0.3	0.7	0.1	1.1
3.	Early - Maksimir	0.2	-	0.1	0.3
4.	Yellow - Pirot	0.4	0.5	-	0.9
5.	Yellow - Djakovo	0.3	0.6	0.2	1.1
6.	Cinquantino	0.2	0.4	-	0.6
	Total Yellow flints: M	0.33	0.5	0.06	
	b) white				
7.	Long fellow - Zaječar	0.3	0.4	0.2	0.9
8.	White - Djakovo	0.4	0.7	0.1	1.2
9.	White - Pirot	0.3	0.8	0.2	1.3
10.	White - Knin	0.5	0.7	0.3	1.5
11.	White - Kruševac	0.4	0.9	-	1.3
	Total White flints: M	0.38	0.7	0.16	
	Total Flints: M	0.35	0.59	0.09	

Frequency of mutations from colourless to coloured pericarp in inbred lines during 15 years of selfing of some Yugoslav varieties of maize.

No.	Variety	Mutation rate per 10,000 plants from colourless to: orange	red	variegata	Total
	II. Dents - a) yellow				
12.	Early dent - Maksimir	0.2	0.8	0.2	1.2
13.	Early dent - Osijek	0.6	0.7	-	1.3
14.	Early dent-Horgoš	0.4	0.6	0.2	1.2
15.	Yellow - Bajša	0.5	0.8	-	1.3
16.	Yellow - Belje	0.3	0.9	0.2	1.4
17.	Yellow - Novi Sad	0.4	0.6	-	1.0
18.	Yellow - Šid	0.6	0.9	0.1	1.6
	Total Yellow dents: M	0.43	0.75	0.01	
	b) white				
19.	Early white - Horgoš	0.4	0.6	-	1.0
20.	White - Požega	0.3	0.7	-	1.0
21.	White - Zaječar	0.2	0.5	0.1	0.8
22.	Mastadont	0.4	0.7	0.1	1.2
	Total white dents: M	0.32	0.62	0.05	
	Total dents: M	0.37	0.65	0.09	

A. Tavčar

3. Number of knobs and B-chromosomes in some Yugoslav varieties of maize.

The number of chromosome knobs and the number of B-chromosomes have been investigated in 7 yellow flint, 5 white flint, 6 yellow dent and 3 white dent varieties collected in different regions of Yugoslavia. In the table are the data for maturity rate of the different varieties, and the number of knobs on chromosomes and the number of B-chromosomes. In the flints the number of knobs varied from 0 to 4 and the number of B-chromosomes from 0 to 2. Only in 6 of the 12 flint varieties were B-chromosomes found. The dent varieties have a higher number of chromosome knobs. It varies from 2 to 14. In one and the same variety the difference between the lowest and highest number of knobs is usually 2 and only in the varieties with the highest number of knobs is there a difference of 5 knobs.

Number of knobs and B-chromosomes in some Yugoslav varieties of maize.

No.	Variety	Maturity rate days	Number of knobs	Number of B-chromosomes
	I. Flints: a) yellow			
1.	Cinquantino	140	0-2	-
2.	Long fellow - Lepoglava	142	0-2	0-1
3.	Early - Maksimir	142	1-3	0-2
4.	Yellow - Zaječar	143	2-3	-
5.	Yellow-Djakovo	143	1-2	0-1
6.	Yellow - Medjimurje	145	1-3	0-1
7.	Yellow - Pirot	143	2-3	-
	b) white			
8.	Long fellow-Zaječar	143	2-4	0-1
9.	White-Knin	141	1-2	-
10.	White - Kruševac	142	2-3	-
11.	White - Djakovo	143	1-3	-
12.	White - Pirot	144	2-3	0-1
	II. Dents: a) yellow			
13.	Early dent - Horgoš	133	3-5	0-1
14.	Early dent - Osijek	137	3-4	-
15.	Early dent - Maksimir	137	2-4	-
16.	Yellow - Bajša	145	5-7	0-1
17.	Yellow - Ruma	146	5-8	-
18.	Yellow - Šid	152	7-12	-
	b) white			
19.	Early - Horgoš	137	3-5	0-1
20.	White - Požega	138	3-6	0-1
21.	Mastadont	153	9-14	-

A. Tavčar

Addendum:

GOVERNMENT COLLEGE, ROHTAK
Punjab, India

1. Tassel ear induction by loss of apical dominance.

During the summer of 1960, while working in the Maize Breeding program of the Rockefeller Foundation in coordination with the Indian Agricultural Research Institute, Pusa, New-Delhi, we noticed certain after effects on the corn borer (Chilo) attacked plants. The chief observation was the loss, by severe injury to the main growing point, of the stem under acute cases of borer damage, very often resulting in tillering. These tillers usually matured relatively late, probably due to the age effect, but there was also a predominance of tassel ear formation. It is this second part of the observation which attracted special attention.

The tillering appears to be caused by a shift in the apical dominance phenomenon as a result of a physiological upset in hormonal balance, which in turn might also cause tassel ear development. The following lines of work on this project are being pursued:

(a) Anatomical differences in gross organization of tissues and internal structures of both the main stem tips of plants and the meristematic apical tips of induced tillers are being compared with the meristematic structure of a genetically controlled tassel ear type and normally tillering material.

(b) The bioassay of growth substances in all four types of material and graphic representation with Rf values for comparisons are being carried out in order to correlate the artificial changes with the truly genetic type.

(c) The probable biochemical differences in terms of growth promoting and growth inhibiting substances as measured by peaks which indicate concentrations of substances and by Rf values, are being considered. The arrangement and equipment for detailed chromatographic spotting and identification of biochemicals involved are lacking.

(d) Artificial injury to normal plants will be compared with corn borer injury in order to ascertain indirectly that no toxic or toxin like substances are involved that might have caused tassel ear development after borer injury.

(e) Studies on physiological genetic effects of photoperiodism on tassel ear induction have been undertaken.

(f) The physiologically induced tassel ear, as well as the genic type, may represent reversions needed for survival and their significance as a possible stage in the evolutionary line is being explored.

(g) If possible, the above mentioned tests will also be carried out in different races of maize that have been thought by the Wellhausen group in Mexico to be involved in the evolutionary development of modern maize.

B. S. Sidhu

2. Preliminary investigations on the endogenous growth substances in Hc _ and hc hc coleoptile.

It was felt that the horn-like outgrowth(s) on the subterminal tip of the coleoptile described in M. N. L. 34 (page 25) may be controlled by internal growth regulating substances. The oat mesocotyl bioassay method standardized by Nitsch (Pl. Physiol. 31:94-111. 1956) was used to determine the auxin production and breakdown in hc as compared to normal coleoptiles. The attempt was made to explain this single gene-controlled proliferation on the coleoptile tip through variations in concentrations of growth substances during the growth period.

In one experiment normal green (W_3 _ Hc Hc), normal albino (w_3 w_3 Hc Hc), hc green (W_3 _ hc hc), and hc albino (w_3 w_3 hc hc) coleoptiles were fixed in methanol one week after the seeds were placed in the germinator. Histograms with Rf values on the ordinate and total length of oat mesocotyl sections on the abscissa indicate two broad regions of growth peaks, i.e. at Rf .05-.10 and .20-.25, and one region of inhibitor action, i.e. at Rf .65-1.0 in all four types of material. The only apparent difference seems to be a slightly greater quantity of growth substances in the green than in the albino type of both normal and horn-like coleoptiles.

In another bioassay test green normal and green hc coleoptile tips after two weeks of seed soaking in the germinator, i.e. at a stage when the first leaf was about to emerge and the coleoptile had reached maximum length, were similarly bioassayed and histogrammed and a suggestion of differential peaks is shown at this stage. Complete absence of inhibitor action in hc's as compared to a slight amount still persisting in normals was observed.

Higher concentrations of growth promotors and inhibitors in green coleoptiles, i.e. both Hc and hc, may be attributed to photosynthetic activity and/or to the pleiotropic nature of the complicated W_3 _ gene. An early destruction or quick translocation of inhibitors in hc coleoptiles may be responsible for the length of hc gene controlled horns.

The data at hand as yet are inconclusive with regard to the biochemical and genetic complications of this study.

This work was completed in the Department of Plant Breeding of Cornell University and formed part of the Ph.D. thesis work.

B. S. Sidhu

III. STOCKS AVAILABLE AND WANTED

A. Wanted:

O. E. Nelson, Purdue University:
brown-midrib mutants other than $\underline{bm_1}$, $\underline{bm_2}$, $\underline{bm_3}$, $\underline{bm_4}$.

D. S. Robertson, Iowa State University:
chalky-white albino mutants with white or pale yellow endosperm
chalky-white albino mutants with yellow endosperm
pale green or zebra mutants with white or pale yellow endosperm
white endosperm mutants other than $\underline{y_1}$.

C. C. Wernham, Pennsylvania State University:
maize with extra long or wide leaves
maize with extra long ears

B. Available:

E. H. Coe, Jr.:
haploid-inducer stocks; see contribution from University of Missouri and USDA.

G. Y. Kikudome, University of Missouri:
$\underline{yg_2}$ $\underline{c}$ $\underline{sh_1}$ $\underline{wx}$ $\underline{K^L}$ 9S/K^S 9S.

C. S. Levings, D. E. Alexander:
tetraploid genetic stocks; see contribution from Agronomy Department, University of Illinois.

C. C. Wernham:
disease resistant maize; see contribution from Departments of Botany and Plant Pathology, Pennsylvania State University.

IV. REPORT ON MAIZE COOPERATIVE

Work of the past summer was concentrated primarily on stocks of Chromosomes 1, 7, 8, 9, and 10. Extensive intercrosses were made among various stocks for the purpose of deriving new multiple tester combinations. Many of these crosses will also be of value for further linkage studies, and would be particularly useful to those individuals responsible for mapping specific chromosomes. Numerous intercrosses of stocks of the remaining chromosomes (Chromosomes 2-6) were made in 1959. In many cases gene combinations not listed in the accompanying catalogue of stocks are available as segregating progenies.

Our stock collection includes about 150 chromosome rearrangements which are marked with closely-linked endosperm or seedling genes. Most of these were grown last summer to obtain fresh seed. In many cases alternatively-marked versions of individual translocations have been saved (e.g., both $\underline{Ws}\ \underline{gl_1}\ T_{7\text{-}9c}$ and $\underline{wx}\ \underline{Gl_1}\ T_{7\text{-}9c}$).

An additional extensive series of reciprocal translocations from E. G. Anderson's collection was grown at Urbana last summer. Dr. Anderson very generously devoted several weeks during the pollinating season to examining pollen and increasing seed supplies of this material. These stocks are now in excellent condition and have been added to the Maize Cooperative collection. Other large series of translocations from the Cal Tech collection are being grown by Dr. H. H. Kramer at Purdue University and by Dr. D. S. Robertson at Iowa State University to obtain new seed supplies. Dr. C. R. Burnham is increasing the inversion stocks.

Some 200 families segregating for untested, newly-acquired seedling traits were also grown. Most of these represented progenies from self-pollination of Canadian and northern U. S. varieties. Mutant segregants were crossed out to Corn Belt inbred lines and are being re-extracted in the current Florida generation. These will be allele-tested among themselves and with similar known traits. In the process of growing these progenies, a number of mature-plant traits have also been noted. Several hundred additional endosperm or seedling traits remain to be tested.

Dr. Johnie N. Jenkins, formerly at Purdue University, joined the staff of our Agronomy Department last June. He is assisting part-time with the work of the Maize Cooperative.

We again urge that you submit seed samples of any useful traits or gene combinations not yet represented in our collection. It is especially important that you do this whenever you cease active work with particular stocks in order that we may have seed of good viability for continued maintenance.

The following listing of Maize Cooperative stocks includes the more useful combinations now available. Seed requests should be sent to the Botany Department, University of Illinois, Urbana, Illinois.

Chromosome 1

ad_1 an_1 bm_2

ad_1 Kn

an_1 Kn bm_2

as

br_1 Vg

Hm

Kn

Kn Ts_6

lw_1

necrotic 8147-31

p^{CR}

p^{CW}

p^{MO}

p^{RR} ad_1 an_1

p^{RR} ad_1 bm_2

p^{RR} an_1 gs_1 bm_2

p^{RR} br_1 f_1 an_1 gs_1 bm_2

p^{RR} br_1 f_1 gs_1 bm_2

p^{VV}

p^{WR} bm_2

p^{WR} gs_1 bm_2

p^{WW} br_1 f_1 bm_2

p^{WW} br_1 f_1 an_1 gs_1 bm_2

p^{WW} hm br_1 f_1

Chromosome 1 (continued)

sr_1 p^{WR} an_1 bm_2

sr_1 p^{WR} an_1 gs_1 bm_2

sr_1 zb_4 p^{WW}

ts_2 p^{WW} br_1 bm_2

Ts_6

v_{19} bm_2

Vg

Vg an_1 bm_2

vp_5

vp_8

zb_4 ms_{17} p^{WW}

zb_4 p^{WW} bm_2

zb_4 p^{WW} br_1

zb_4 ts_2 p^{WW}

Chromosome 2

al lg_1

al lg_1 gl_2 B sk

al lg_1 gl_2 b sk

ba_2

fl_1

lg_1 gl_2 B

lg_1 gl_2 b

lg_1 gl_2 b fl_1 v_4

Chromosome 2 (continued)

lg_1 gl_2 b fl_1 v_4 Ch

lg_1 gl_2 B gs_2

lg_1 gl_2 b gs_2 v_4

lg_1 gl_2 b gs_2 v_4 Ch

lg_1 gl_2 B sk v_4

lg_1 gl_2 b sk v_4

lg_1 gl_2 b sk fl_1 v_4

lg_1 gl_2 B v_4

lg_1 gl_2 b v_4

lg_1 gl_2 b v_4 Ch

lg_1 gs_2 b v_4

ws_3 lg_1 gl_2 B

ws_3 lg_1 gl_2 b

ws_3 lg_1 gl_2 b fl_1 v_4

ws_3 lg_1 gl_2 B sk

ws_3 lg_1 gl_2 b sk

Chromosome 3

A_1 ga_7; A_2 C R

A_1 sh_2; A_2 C R

A^d-3l; A_2 C R

A^d-3l sh_2; A2 C R

a^p et; A_2 C R Dt_1

a_1; A_2 C R B Pl dt_1

Chromosome 3 (continued)

a_1 et; A_2 C R Dt_1

a_1 sh_2; A_2 C R Dt_1

a_1 sh_2 et; A_2 C R Dt_1

a_1^{st} sh_2; A_2 C R Dt_1

a_1^{st} et; A_2 C R Dt_1

a_{x-1}; A_2 C R

a_{x-3}; A_2 C R

a_{x-3} et; A_2 C R

an_2 = allele of d_1

ba_1

Cg

cr_1

d_1

d_1 Cg

d_1 gl_6

d_1 gl_6 Lg_3

d_1 lg_2

d_1 Lg_3

d_1 Lg_3 Rg

d_1 pg_2

d_1 Rg

d_1 rt

d_1 ts_4 lg_2

d_1 ts_4 lg_2 a_1; A_2 C R Dt_1

Chromosome 3 (continued)

d_2

gl_6

gl_6 lg_2 a_1 et; A_2 C R Dt_1

gl_6 Lg_3

gl_6 Rg

gl_6 v_{17}

gl_6 v_{17} lg_2

gl_7

lg_2 A_1^b et; A_2 C R Dt_1

lg_2 a_1 et; A_2 C R Dt_1

lg_2 a_1 sh_2 et; A_2 C R Dt_1

lg_2 a_1^{st} et; A_2 C R Dt_1

lg_2 a_1^{st} sh_2; A_2 C R Dt_1

lg_2 pm

Lg_3

Lg_3 Rg

pg_2

pm

ra_2

ra_2 gl_6 lg_2

ra_2 lg_2 pm

ra_2 Rg

ra_2 Rg lg_2

Rg

Chromosome 3 (continued)

rt; A_1 A_2 C R

ts_4 na_1

v_{17}

vp_1

Primary trisomic 3

Chromosome 4

bm_3

bt_2

$de_{(1 \text{ or } 16?)}$

$\frac{Ga_1\ Su_1}{ga_1\ su_1}$

gl_3

j_2

j_2 gl_3

la su_1 gl_3

la su_1 Tu gl_3

lo Su_1

lo su_1

lw_4; lw_3

o_1

sp_1 su_1

st

su_1 bm_3

Chromosome 4 (continued)

su_1 gl_3

su_1 gl_4

su_1 j_2 gl_3

su_1 o_1

su_1 ra_3

su_1 Tu

su_1 Tu gl_3

su_1 zb_6

su_1 zb_6 gl_3

su_1 zb_6 Tu

su_1^{am}

Ts_5

Ts_5 st

Ts_5 su_1

Tu gl_3

v_8

Chromosome 5

a_2; A_1 C R

a_2 bm_1 bt_1 bv_1 pr; A_1 C R

a_2 bm_1 pr v_2; A_1 C R

a_2 bm_1 pr ys_1; A_1 C R

a_2 bt_1 pr; A_1 C R

a_2 bt_1 pr ys_1; A_1 C R

Chromosome 5 (continued)

a_2 pr; A_1 C R

ae

bm_1 pr; A_1 A_2 C R

bm_1 pr v_2; A_1 A_2 C R

bm_1 pr ys_1; A_1 A_2 C R

bm_1 pr ys_1 v_2; A_1 A_2 C R

bm_1 yg_1

bt_1 pr; A_1 A_2 C R

$\frac{Ga\ Bt_1}{ga\ bt_1}$

gl_5

gl_8

gl_{17} a_2 bt_1 v_2; A_1 C R

gl_{17} v_2

intensifier of pr closely linked to bt_1

lw_2

lw_3; lw_4

na_2

na_2 pr

pr; A_1 A_2 C R

pr ys_1; A_1 A_2 C R

sh^{fl} = "sh_4"

"sh_3" = allele of bt_1

tn

Chromosome 5 (continued)

v_3 pr; A_1 A_2 C R

v_{12}

vp_2 gl_8

vp_2 pr; A_1 A_2 C R

vp_7

vp_7 pr; A_1 A_2 C R

Chromosome 6

at = allele of si_1

po Y_1 pl

po y_1 pl

Pt

si_1 Y_1 Pl

si_1 Y_1 pl

si_1 y_1 pl

y_1 l_{10}

Y_1 $ms_{(1?)}$

y_1 $ms_{(1?)}$

Y_1 pb_4 pl

y_1 pb_4 Pl

y_1 pb_4 pl

Y_1 pg_{11}; wx pg_{12}

y_1 pg_{11}; wx pg_{12}

y_1 Pl Bh

Chromosome 6 (continued)

y_1 pl Bh

Y_1 Pl sm py; A_1 A_2 b P^{RR}

Y_1 pl su_2

y_1 pl su_2

Y_1 Pl; seg w_1

Y_1 pl; seg w_1

y_1 Pl; seg w_1

y_1 pl; seg w_1

"male sterile-silky" = allele of si_1

"orobanche" (seedling)

"ragged" (seedling)

"white 8522" (seedling)

"white 8896" (seedling)

Chromosome 7

bd

Bn_1

g_2

gl_1 ij bd

gl_1 sl Bn_1

Hs

ij

in; pr A_1 A_2 C R

o_2

Chromosome 7 (continued)

o_2 gl_1 sl

o_2 gl_1 sl Bn_1

o_2 ra_1 gl_1

o_2 ra_1 gl_1 ij

o_2 ra_1 gl_1 Tp_1

o_2 v_5 gl_1; seg ra_1

o_2 v_5 ra_1 gl_1

o_2 v_5 ra_1 gl_1 Hs

o_2 v_5 ra_1 gl_1 Tp_1

ra_1 gl_1

Tp_1

v_5 gl_1 Tp_1

va_1

vp_9 gl_1; wx

Chromosome 8

v_{16} j_1

v_{16} ms_8 j_1

v_{16} ms_8 j_1; l_1

"necrotic 6697" (seedling)

"sienna 7748" (seedling)

Chromosome 9

au_1 au_2

Chromosome 9 (continued)

Bf_1

bk_2 ms_{20}

bk_2 Wc

bm_4

bp Wx; P^{RR}

C Ds wx

C sh_1 wx; A_1 A_2 R

c sh_1 wx; A_1 A_2 R

c sh_1 wx gl_{15}; A_1 A_2 R

C wx; A_1 A_2 R

c wx; A_1 A_2 R

c wx bk_2; A_1 A_2 R

Dt_1 (See Chromosome 3 stocks)

gl_{15} bm_4

I Ds Wx

I wx; A_1 A_2 R Pr B pl

I wx; A_1 A_2 R pr B pl

K^L9 C sh_1 wx; A_1 A_2 R

l_7

ms_2

ms_2 sh_1; A_1 A_2 C R

ms_{20}

sh_1 wx d_3

sh_1 wx l_7

Chromosome 9 (continued)

sh_1 wx pg_{12}; y pg_{11} pl

sh_1 wx v_1

wx ar

wx Bf_1

wx bk_2

wx d_3

wx da_1; A_1 A_2 C R

wx g_4

wx l_6

wx pg_{12}; Y pg_{11} pl

wx pg_{12}; y pg_{11}

wx^a

yg_2 c sh_1 wx; A_1 A_2 R

yg_2 C sh_1 bz wx; A_1 A_2 R

Primary trisomic 9

Chromosome 10

a_3

a_3 g_1

bf_2

du_1

g_1

g_1 l_2

g_1 r^g; A_1 A_2 C

Chromosome 10 (continued)

g_1 r^{ch}

g_1 R sr_2

g_1 r sr_2

gl_9

l_1; v_{16} ms_8 j_1

l_1; w_1

li g_1 R; A_1 A_2 C

li g_1 r; A_1 A_2 C

li g_1 r; A_1 A_2 C;
carries abnormal 10

nl_1 g_1 R; A_1 A_2 C

Og R; A_1 A_2 C B Pl

r abnormal 10

R^g sr_2

r^r sr_2

R^r:Boone; A_1 A_2 C

R^{mb}; A_1 A_2 C

R^{nj}; A_1 A_2 C

R^{st}; A_1 A_2 C

v_{18}

w_2

zn

"oil yellow" (seedling and plant)

Primary trisomic 10

Unplaced genes

cl

ct

de_{17}

dv

dy

el

fl_2

gl_{11}

gl_{12}

gl_{14}

gl_{16}

gl_g

h

l_3

mn

ms_5

ms_6

ms_7

ms_9

ms_{10}

ms_{11}

ms_{12}

ms_{13}

ms_{14}

Unplaced genes (continued)

Mt

New Starchy

rd

Rs_1

rs_2

"sh_5"

tw_1

tw_2

v_{13}

va_2

vp_6

wi

ws_1 ws_2

zb_1

zb_2

zb_3

Multiple gene stocks

A_1 A_2 C R^r Pr B Pl

A_1 A_2 C R^g Pr B Pl

A_1 A_2 C R^g Pr B pl lg_1 y

A_1 A_2 C R Pr

A_1 A_2 C R Pr wx

A_1 A_2 C R Pr wx gl_1

Multiple gene stocks (continued)

A_1 A_2 C R Pr wx y

A_1 A_2 C R pr

A_1 A_2 C R pr su_1

A_1 A_2 C R pr su_1 y wx

A_1 A_2 C R pr y gl_1

A_1 A_2 C R pr y wx

A_1 A_2 C R pr y wx gl_1

A_1 A_2 c R Pr su_1

A_1 A_2 c R Pr y wx

A_1 A_2 c R Pr y sh_1 wx

A_1 A_2 C r Pr su_1

A_1 A_2 C r Pr su_1 y g_1

A_1 A_2 C r Pr y wx

A_1 A_2 C r Pr y sh_1 wx

bm_2 lg_1 a_1 su_1 pr y_1 gl_1 j_1 wx g_1

colored scutellum

lg_1 su_1 bm_2 y_1 gl_1 j_1

su_1 y_1 wx a_1 A_2 C R^g pr

y_1 su_1 ra_1 gl_1

y_1 wx gl_1

Popcorns

Amber Pearl

Argentine

Black Beauty

Hulless

Ladyfinger

Ohio Yellow

Red

South American

Strawberry

Supergold

Tom Thumb

White Rice

Exotics and Varieties

Black Mexican Sweet Corn (with B chromosomes)

Black Mexican Sweet Corn (without B chromosomes)

Gourdseed

Maiz chapolote

Papago Flour Corn

Parker's Flint

Tama Flint

Zapaluta chica

Chromosome rearrangements

The following rearrangements are being maintained primarily for use in determining the chromosome locations of new traits. All are marked with closely-linked endosperm or seedling traits.

The cytological positions of Inv 2a were determined by Dr. Morgan; those of Inv 9a were determined by Dr. Li. The indicated interchange points of the reciprocal translocations are taken from published work of Dr. Longley.

Inversions

lg_1 or gl_2 Inv 2a (also available with Ch)	2S.7; 2L.8
wx Inv 9a	9S.7; 9L.9

Reciprocal translocations

wx 1-9c	1S.48; 9L.22
wx 1-9 4995	1L.19; 9S.20
wx 2-9b	2S.18; 9L.22
wx 3-9c	3L.09; 9L.12
wx 3-9 5775	3L.09; 9S.24
wx 4-9b	4L.90; 9L.29
wx 4-9 5657	4L.33; 9S.25
wx 4-9g	4S.27; 9L.27
wx 5-9a	5L.69; 9S.17
wx 5-9c	5S.07; 9L.10
wx 5-9 4817	5L.06; 9S.07
wx 5-9 5614	5L.09: 9L.06
wx 6-9a	6S.79: 9L.40
wx, y 6-9b	6L.10; 9S.37
wx 6-9 4505	6L.13; 9 cent
wx 6-9 4778	6S.80; 9L.30

Reciprocal translocations (continued)

wx 7-9a	7L.63; 9S.07
wx or gl_1 7-9 4363	7 cent; 9 cent
wx 8-9d	8L.09; 9S.16
wx 8-9 6673	8L.35; 9S.31
wx 9-10b	9S.13; 10S.40
su_1 1-4a (also available with P^{RR})	1L.51; 4S.69
su_1 1-4d (also available with P^{RR})	1L.27; 4L.30
su_1 4-5j	4L.21; 5L.36
su_1, y 4-6a	4L.37; 6L.43
su_1 4-8a	4S.59; 8L.19
su_1, R 4-10b	4L.15; 10L.60
y 1-6c (also available with P^{RR})	1S.25; 6L.27
gl_2 2-3c	2S.46; 3S.52
gl_2 2-3 5304	2S.62; 3L.29
gl_2 2-6b	2S.69; 6L.49
gl_2, R 2-10b	2S.50; 10L.75
gl_1 6-7 4545	6L.25; 7S.73

Stocks of A-B chromosome translocations

B-1a	1L.2	Proximal to Hm
B-1b	1S.05	
B-3a	3L.1	
B-4a	4S.25	Proximal to su_1
B-7b	7L.3	Proximal to ra_1
B-9a	9L.5	
B-9b	9S.4	Between C and wx; close to wx
B-10a	10L.35	Proximal to g_1

Earl B. Patterson

V. RECENT MAIZE PUBLICATIONS

Ashman, R. B. Modification of expression and mutability of stippled aleurone ($\underline{R}^{st}$) in maize. Diss. Abstr. 19: 2720. 1959. (Abstr.)

_____. Stippled aleurone in maize. Genetics 45: 19-34. 1960.

Bauman, L. F. Evidence of non-allelic gene interaction in determining yield, ear height, and kernel row number in corn. Agron. J. 51: 531-534. 1959.

_____. Relative yields of first (apical) and second ears of semi-prolific southern corn hybrids. Agron. J. 52: 220-222. 1960.

_____. Environmental interactions with prolific hybrids. Proc. 14th Hybrid Corn Industry-Research Conference: 53-59. 1960.

Bernardo, F. A., I. S. Santos, and F. A. Aquilizan. Fifty years of corn improvement in the U. P. College of Agriculture. Philippine Agriculturist Golden Jubilee Supplement 43: 98-117. 1960.

Bianchi, A. Mitosis in the tapetum of maize anthers. Caryologia 12: 338-340. 1959.

Bianchi, A., G. Mariani, and P. Uberti. Endosperm and seedling mutations induced in maize, following X-irradiation and diepoxybutane treatment of mature pollen. Genetics 45: 976. 1960. (Abstr.)

Brink, R. A. Paramutation and chromosome organization. Quart. Rev. Biol. 35: 120-137. 1960.

Brink, R. A., M. Blackwood and N. K. Notani. Effects of structural changes in the long arm of chromosome 10 in maize on paramutation of the $\underline{R}^{r}$ factor. Science 131: 1317. 1960. (Abstr.)

Brink, R. A., D. F. Brown, J. Kermicle, and W. H. Weyers. Locus dependence of the paramutant R phenotype in maize. Genetics 45: 1297-1312. 1960.

Brink, R. A. and W. H. Weyers. Effect of an abnormal knob-carrying chromosome 10 on paramutation of $\underline{R}^{r}$ in maize. Genetics 45: 1445-1455. 1960.

Brown, D. F. and R. A. Brink. Paramutagenic action of paramutant $\underline{R}^{r}$ and $\underline{R}^{g}$ alleles in maize. Genetics 45: 1313-1316. 1960.

Candia, Z. and D. Barnes. Field infestation of maize by Sitophilus oryzae L. Agric. Tec. Mex. 1959-1960 (9): 9-10. 1959-60.

Casselman, T. W., J. L. Schmidt, and W. G. Lovely. Corn topping, its effect on field drying and harvesting. USDA Agricultural Research, ARS-42-44. 1-15. 1960.

Cherry, J., H. A. Lund, and E. B. Earley. Effect of gibberellic acid on growth and yield of corn. Agron. J. 52: 167-171. 1960.

Coe, E. H. The pattern of origination of conversion-type inheritance at the B locus in maize. Genetics 45: 981-982. 1960. (Abstr.)

Cornu, A. The distribution of the effect of heterosis on ten of the principal anatomical, physiological, or cultural characteristics of maize. Bull. Soc. Sci. Nat. Phys. Maroc. 37: 89-103. 1957.

Cruz, D. L., D. V. Banaag, M. B. Seguerra, and M. T. Ricaforte. Abstract bibliography of corn, 1946-1955. Agric. Coll., Laguna. 1958.

Diaz Robles, J. C. Study of sodium α,β-dichloroisobutyrate as a gametocide for maize. Rev. Assoc. Ind. Agron., Montevideo 30: 34-37. 1959.

Duvick, D. N. Genetic and environmental interactions with cytoplasmic pollen sterility of corn. Proc. 14th Ann. Hybrid Corn Industry-Research Conference: 42-52. 1959.

Emmerling, M. H. The mutational behavior of the R^r:Jana allele in Zea mays. Genetics 45: 763-770. 1960.

Everett, H. L. Effect of cytoplasms and an Rf gene in maize. Agron. J. 52: 215-217. 1960.

Faludi, B., A. F. Daniel, and G. Kelemen. Increased photosensitivity of leaf pigments and its relation to the respiratory system in albino mutants of corn. Physiol. Plant. 13: 227-236. 1960.

Fleming, A. A., G. M. Kozelnicky, and E. B. Browne. Cytoplasmic effects on agronomic characters in a double-cross maize hybrid. Agron. J. 52: 112-115. 1960.

Foley, D. C. The response of corn to inoculation with Diplodia zeae and Gibberella zeae. Phytopath. 50: 146-150. 1960.

Galeev, G. S. The method of producing interline hybrids with pollen-sterile maternal plants. Rep. Agric. Sci. 1959 (6): 43-54. 1959.

Gardner, C. O. and Lonnquist, J. H. Linkage and the degree of dominance of genes controlling quantitative characters in maize. Agron. J. 51: 524-528. 1959.

Gaur, B. K. and N. K. Notani. Effect of gibberellic acid on the radiation-stunted seedling of maize. Int. J. Radiation Biol. 2: 257-259. 1960.

Giesbrecht, J. The inheritance of time of silking and pollen shedding in maize. Canad. J. Genet. Cyt. 1: 329-338. 1959.

_____. The inheritance of maturity in maize. Canad. J. Pl. Sci. 40: 490-499. 1960.

Goring, H. Studies of the fertilization process in Z. mays L. with radioactive phosphorus. Naturwiss. 47: 142. 1960.

Gorsline, G. W. A graphical "regression selection" technique for maturity-related characters in field corn. Agron. J. 52: 581-584. 1960.

Gorter, G. J. M. A. Breeding maize for resistance to streak. Euphytica, Wageningen 8: 234-240. 1959.

Grafius, J. E. Does overdominance exist for yield in corn? Agron. J. 52: 361. 1960.

Graner, E. A. The probable position of gene Y-7 in chromosome 7 of maize. An. Esc. Agric. Queiroz 14-15: 81-89. 1957-58.

Greenblatt, I. M. The genetic composition of twin mutations in medium variegated pericarp of maize. Diss. Abstr. 20: 1977. 1960. (Abstr.)

Griliches, Z. Hybrid corn and the economics of innovation. Science 132: 275-281. 1960.

Guthrie, W. D., F. F. Dicke, and C. R. Neiswander. Leaf and sheath feeding resistance to the European corn borer in eight inbred lines of dent corn. Res. Bull. Ohio Agric. Exp. Sta. No. 860. 1960.

Gwynn, G. R. Relation between means and components of genotypic variance in biparental progenies of a variety of maize. Diss. Abstr. 20: 37. 1959. (Abstr.)

Hadzinov, M. I. The method of breeding sterile hybrids. Kukuruza 1959 (4): 19-23. 1959.

Hanson, J. B., R. H. Hageman, and M. E. Fisher. The association of carbohydrases with the mitochondria of corn scutellum. Agron. J. 52: 49-53. 1960.

Hulea, A. Maize wilt caused by Fusarium sp. Probl. Agric., Bucaresti 11: 31-37. 1959.

Ibrahim, M. A. A survey of chromosome knobs in maize varieties. Genetics 45: 811-817. 1960.

Jensen, S. D. Combining ability of unselected inbred lines of corn from incomplete diallel and top-cross tests. Diss. Abstr. 20: 839. 1959. (Abstr.)

Jermoljev, E., M. Stanek, and I. Ujevic. A study of the possibilities of ascertaining the resistance of maize varieties to the causal agent of maize smut, U. zeae (Beckm.) Unger, by serological methods. Sborn. csl. Akad. zemed. Ved: Rada rostlinna Vyroba 33: 1067-1078. 1960.

Jones, D. F. The genotype as the sum of plasmatype and chromotype. Amer. Nat. 94: 181-184. 1960.

Jones, D. F., H. Stinson, and U. Khoo. Plasmatypes of maize as evidence of cytoplasmic diversity and continuity within a species. Science 131: 1318. 1960. (Abstr.)

Kedrova-Zihman, L. V. and V. E. Bormotov. Intensity of respiration of maize ovaries under different conditions of crossing. Bull. Inst. Biol. Acad. Sci. White Russ. SSR 1956 (2): 222-227. 1957.

Kiesselbach, T. A. Performance of advanced generation corn hybrids. Agron. J. 52: 29-33. 1960.

Kolesnikov, S. M. The question of the nature of heterosis in interline maize hybrids. Sci. Mem. Kisinev Univ. 28: 111-122. 1958.

Kramer, H. H. and A. J. Ullstrup. Preliminary evaluation of exotic maize germ plasm. Agron. J. 51: 687-689. 1959.

Kreizinger, J. D. Diepoxybutane as a chemical mutagen in Zea mays. Genetics 45: 143-154. 1960.

Kuperman, F. M., I. Ja. Mar'Jahina, and A. I. Bajsugurova. The diagnosis of male sterility in maize. Kukuruza 1959 (5): 16-18. 1959.

Kurtz, E. B., J. L. Liverman and H. Tucker. Some problems concerning fossil and modern corn pollen. Bull. Torrey Bot. Club 87: 85-94. 1960.

Lebedeff, G. A. Further studies on the inheritance of loose pericarp in corn. Jour. Hered. 51: 15-18. 1960.

Lebedeva, Z. V. The effect of supplementary pollination with foreign pollen on the depressive action of inbreeding in maize. Proc. Acad. Sci. USSR 126: 1096-1099. 1959.

Le Conte, J. A contribution to the genetic study of resistance in maize to rust (Puccinia polysora) and some practical results obtained at Dahomey. Riz et Rizic. 5: 98-116. 1959.

Longwell, A. and M. Mota. The distribution of cellular matter during meiosis. Endeavour 19: 100-107. 1960.

Lonnquist, J. H. Modifying double-cross hybrid corn performance through convergent improvement. Agron. J. 52: 226-229. 1960.

Maguire, M. P. A study of pachytene chromosome pairing in a corn-Tripsacum hybrid derivative. Genetics 45: 651-664. 1960.

_____. A study of homology between terminal portion of Zea chromosome 2 and a segment derived from Tripsacum. Genetics 45: 195-209. 1960.

_____. Relative positions of chromosomes at pachytene in diploid and hyperploid stocks. Genetics 45: 999. 1960. (Abstr.)

_____. The relation of reduplication, recombination, synapsis and chromosome coiling. Genet. Res. Camb. 1: 487-488. 1960.

_____. Pachytene pairing failure in corn in two inbred lines and their hybrid. Genetics 46: 135-142. 1961.

Malinowski, E., H. Bankowska and M. Biurkowska. Heterosis in maize (Zea mays). I. Correlation phenomena between vigorous growth and time of flowering in F_2. II. Fixing vigorous growth. Bull. Acad. Polon. Sci. 8: 23-27, 29-33. 1960.

Manoliu, M. and T. Craciun. Observations on the phenomenon of xenia in maize. Probl. Agric., Bucuresti 10: 25-33. 1958.

Mayes, M. Factors affecting seed set with restricted pollination in corn Zea mays, L. Diss. Abstr. 20: 1120-1121. 1959. (Abstr.)

Miller, C. O. A kinetin-like compound in maize. Proc. Nat. Acad. Sci. 47: 170-174. 1961.

Moll, R. H. Quantitative genetics in corn and the implications to breeding methodology. Proc. 14th Hybrid Corn Industry-Research Conference: 139-144. 1960.

Moll, R. H., H. F. Robinson, and C. C. Cockerham. Genetic variability in the advanced generation of the cross of open-pollinated varieties of corn. Agron. J. 52: 171-173. 1960.

Mostovoj, K. The lability of pollen sterility in maize. Sborn. csl. Akad. zemed. Ved: Rada rostlinna Vyroba 32: 1625-1636. 1959.

Nickerson, N. H. Studies involving sustained treatment of maize with gibberellic acid II: Responses of plants carrying certain tassel-modifying genes. Ann. Mo. Bot. Garden 47: 243-261. 1960.

_____. Sustained treatment with gibberellic acid of maize plants carrying one of the dominant genes Teopod and Corn-grass. Amer. J. Bot. 47: 809-815. 1960.

Nickerson, N. H. and T. N. Embler. Studies involving sustained treatment of maize with gibberellic acid I: Further notes on responses of races. Ann. Mo. Bot. Garden 47: 227-242. 1960.

Orton, E. R. Jr. Reconstitution of the variegated pericarp allele in maize by return of Modulator to the P locus. Diss. Abstr. 20: 4250. 1960. (Abstr.)

Peters, D. C., M. S. Zuber, and V. Fergason. Preliminary evidence of resistance of high amylose corn to the Angoumois grain moth. J. Econ. Entom. 53: 573-574. 1960.

Peterson, P. A. The pale green mutable system in maize. Genetics 45: 115-133. 1960.

_____. Mutable gene control in maize. Genetics 45: 1005. 1960. (Abstr.)

Poncova, J. Experiments on extending the viability of maize pollen by preservation. Sborn. csl. Akad. zemed. Ved: Rada rostlinna Vyroba 32: 1637-1650. 1959.

Portjanko, V. F. The response of maize to short days depending on plant age and spectral composition of light. Phys. Pl. 6: 622-624. 1959.

Rabson, R. and G. D. Novelli. The incorporation of leucine-C^{14} into protein by a cell-free preparation from maize kernels. Proc. Nat. Acad. Sci. 46: 484-487. 1960.

Richardson, D. L. Pericarp thickness in popcorn. Agron. J. 52: 77-81. 1960.

Říman, L. The state of the problem of heterogeneous pollination in plants. Cs. Biol. (Prague) 2: 166-170. 1958.

_____. Monoploids (haploids) in maize (Zea mays L.). Polnohospodárstvo (Bratislava) 7 (9): 715-726. 1960.

_____. I. National seminary on the genetics, plant improvement, agrotechnique, and pathology of maize. Rostlinná výroba (Prague) 10: 1447-1454. 1960.

Robinson, H. F., C. C. Cockerham, and R. H. Moll. Studies on estimation of dominance variance and effects of linkage bias. Biometrical Genetics. Pp. 171-177, 196. 1960.

Robinson, H. F. and R. H. Moll. Implications of environmental effects on genotypes in relation to breeding. Proc. 14th Hybrid Corn Industry-Research Conference: 24-31. 1960.

Santos, I. S. Effect of seed treatment with maleic hydrazide on germination and seedling growth of corn. Philippine Agriculturist 44: 134-145. 1960.

Santos, I. S., F. A. Bernardo, and N. Marcos-Tepora. Performance of yellow-endosperm synthetic corn varieties. Philippine Agriculturist 43: 260-270. 1959.

Santos, I. S. and B. L. Lit. The efficiency of the 4 x 4 Latin square for testing grain and stover yields of corn. Philippine Agriculturist 44: 218-222. 1960.

Sarma, M. S. Studies on the origin of the non-crossover derivatives from the $\underline{A}^{b}$ complexes in maize. Diss. Abstr. 20: 1551. 1959. (Abstr.)

Sawada, Y. Physiological and morphological studies on pollen grains. XVIII Nitrogen metabolism of maize pollen. Bot. Mag. Tokyo 73: 252-257. 1960.

Scedrina, R. N. Studying the fertilization process in maize, employing different methods of pollination. Agrobiology 1959 (2): 193-197. 1959.

Schwartz, D. Analysis of a highly mutable gene in maize. A molecular model for gene instability. Genetics 45: 1141-1152. 1960.

_____. Electrophoretic and immunochemical studies with endosperm proteins of maize mutants. Genetics 45: 1419-1428. 1960.

_____. Genetic studies on mutant enzymes in maize: synthesis of hybrid enzymes by heterozygotes. Proc. Nat. Acad. Sci. 46: 1210-1215. 1960.

Shank, D. B. and M. W. Adams. Environmental variability within inbred lines and single crosses of maize. J. Genetics 57: 119-126. 1960.

Sidorov, F. F. and S. V. Zubkova. Cold resistance of maize. Rep. Agric. Sci. 1959 (6): 55-60. 1959.

Singh, B. and R. L. Paliwal. Studies on a luxuriant form of teosinte and its hybrids with maize. Agra Univ. J. Res. 9: 137-146. 1960.

Singh, R. D. Evaluation of second cycle inbreds of maize by different types of related and unrelated testers. Indian J. Genet. 18: 199-205. 1958.

Singleton, O. V. and M. S. Zuber. 1959 Missouri hybrid corn yield trials. Missouri Agr. Exp. Sta. Bul. 744. 1960.

Singleton, W. R. Epistasis--what is it? J. Hered. 50: 261-263. 1959.

Sinha, S. K. The study of meiosis as a gene-controlled phenomenon--a statement of approach and review. Symp. on "Advancing Frontiers of Life Sciences," National Institute of Sciences, India. Silver Jubilee Vol. 3. 1960-61. (Abstr.)

_____. Studies of a gene controlling meiosis in maize--I. Cytogenetic studies. Proc. 48th Indian Science Congress, Part 3: 315. 1961. (Abstr.)

Smith, R. C. Influence of upward water translocation on uptake of ions in corn plants. Amer. Jour. Bot. 47: 724-728. 1960.

Sowell, W. F., A. J. Ohlrogge, and O. E. Nelson, Jr. Growth and fruiting of compact and Hy normal corn types under a high population stress. Agron. J. 53: 25-28. 1961.

Sposojevic, V. Mutant gene rt in maize. Arh. poljopr. Nauk. 12: 35-51. 1959.

Sprague, G. F., W. A. Russell, and L. H. Penny. Mutations affecting quantitative traits in selfed progeny of doubled monoploid maize stocks. Genetics 45: 855-865. 1960.

Stein, O. L. and D. M. Steffensen. The activity of x-rayed apical meristems: a genetic and morphogenetic analysis in Zea mays. Z. VererbLehre 90: 483-502. 1959.

Straus, J. Maize endosperm tissue grown in vitro. III. Development of a synthetic medium. Amer. Jour. Bot. 47: 641-647. 1960.

Tandler, C. J. An alkali-formaldehyde squash technic for plant cytology and cytochemistry. Stain Tech. 34: 234-236. 1959.

Thomas, W. I. and J. C. Eldredge. Simultaneous conversion of inbred lines of corn to cytoplasmic male sterility and pollen restoration. Agron. J. 52: 716-717. 1960.

Thomas, W. I., J. C. Eldredge and F. F. Dicke. Resistance in popcorn to European corn borer leaf feeding. Agron. J. 52: 299. 1960.

Thomas, W. I., G. W. Gorsline, G. W. Korman, J. L. Ragland, and C. C. Wernham. Pennsylvania corn performance studies 1959. Progress Report 220, Pennsylvania State University. 1960.

Thompson, D. L. and J. O. Rawlings. Evaluation of four testers of different ear heights in corn. Agron. J. 52: 617-621. 1960.

Ting, Y. C. Cytological observations on two tropical forms of Tripsacum. Bot. Mus. Leafl. Harv. 19: 97-107. 1960.

Ustinova, E. I. A study of male sterility in maize. Proc. Acad. Sci. USSR 127: 689-692. 1959.

Ventura, Y. Inheritance studies of the cold test reaction of Zea mays. Diss. Abstr. 20: 1985-1986. 1960. (Abstr.)

Vettel, F. K. and F. Walther. The influence of raised temperatures at the seedling and young-plant stage on the development of maize (Z. mays L.). Z. Pflanzenz. 41: 326-342. 1959.

Walden, D. B. Preliminary studies on longevity of corn pollen and related physiological factors. Diss. Abstr. 20: 3488-3489. 1960. (Abstr.)

Walden, D. B. and H. L. Everett. A quantitative method for the in vivo measurement of the viability of corn pollen. Crop. Sci. 1 (1): 21-25. 1961.

Wang, M.-H., C.-L. Su, and W.-C. Chen. Biological investigations into the viability of maize pollen, the receptivity of the stigmas and flowering. Act. Agric. sin. 10: 121-128. 1959.

Weyers, W. H. The paramutagenic action of the marbled allele in maize. Diss. Abstr. 20: 3932. 1959. (Abstr.)

Wiser, W. J., H. H. Kramer, and A. J. Ullstrup. Evaluating inbred lines of corn for resistance to Diplodia ear rot. Agron. J. 52: 624-627. 1960.

Woodstock, L. W. and F. Skoog. Relationships between growth rates and nucleic acid contents in the roots of inbred lines of corn. Amer. Jour. Bot. 47: 713-716. 1960.

Zuber, M. S., W. L. Deatherage, M. M. MacMasters, and V. L. Fergason. A report on the lack of correlation between the amylose content of pollen and endosperm in maize. Agron. J. 52: 411-412. 1960.

Zuber, M. S., W. L. Deatherage, C. O. Grogan, and M. M. MacMasters. Chemical composition of kernel fractions of corn samples varying in amylose content. Agron. J. 52: 572-575. 1960.

Zuber, M. S., C. O. Grogan, V. L. Fergason, W. L. Deatherage, and M. M. MacMasters. Some observed secondary effects of high-amylose genes in maize. Cereal Chemistry 37: 212-217. 1960.

Zuber, M. S., C. O. Grogan, and O. V. Singleton. Rate of planting studies with prolific and single ear corn hybrids. Missouri Agr. Exp. Sta. Res. Bul. 737. 1960.

Zuber, M. S., O. V. Singleton and P. J. Loesch. Report of 1959 Missouri cooperative corn investigations. Field Crops Misc. Report No. 8. 1960.