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Corn Shelling Percentage Studies

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CONTENTS

SUMMARY

The results of shelling percent studies on corn in Missouri show the following:

1. Determining shelling percent immediately following harvest and without drying resulted in a much lower value (up to 9 percent when the kernel moisture was 35 percent) than when samples were dried to a uniform moisture content of 6 to 8 percent. When kernel and cob moisture was equal the difference among hybrids was lessened. When the kernel moisture content was between 13 and 65 percent the cob moisture was assumed to be considerably higher, and probably caused some discrepancy in estimates of shelling percent.
2. Shelling percentage varied significantly with location and with years. The latter was the most important factor in causing variation, with the range being up to 3.4 percentage points. In general, shelling percent increased as the location was moved from south to north in Missouri.
3. A delay in planting date resulted in a lower shelling percent. The decreases at the different locations were:
   (a) Sikeston, from 83.3 percent for April 20 planting to 76.5 percent for June 20 planting.
   (b) Columbia, from 83.4 percent for April 20 planting to 81.7 percent for June 1 planting.
   (c) Spickard, from 84.2 percent for April 20 planting to 81.3 percent for June 20 planting.
4. Hybrids differ significantly. A large portion of variation in shelling percent can be attributed to hybrids, regardless of whether a double-cross, single-cross, or an inbred line was involved.
5. As the level of applied nitrogen was increased (0, 60, 120, 240 lb/A) the shelling percent increased slightly. The percent was significantly lower at 120 pounds per acre than at 240 pounds per acre. No significant difference existed between applied N rates of 0, 60, or 240 pounds per acre.
6. Over the range of 12,000 to 24,000 plants per acre, shelling percent increased with increase in plant population. Row spacings of 20, 30, and 40 inches resulted in a small significant increase in shelling percent. The values were 82.2, 82.6, and 82.8 percent, respectively.
7. The relationship of shelling percent to cob and kernel characteristics was as follows: a negative correlation with such factors as cob

weight and density, and pressure required to crush a 2-inch section; positive correlations with grain weight and kernel depth.

8. The relationship between shelling percent and test weight is strongly influenced by the environment. Under conditions of low disease incidence (namely cob rot) the *r* value is highly positive. On the other hand, if the environment favors disease organisms, the relationship is strongly negative. This negative expression evidently is a result of lower cob weight caused by cob deterioration under diseased conditions.

In conducting the shelling percent studies reported here, high precision was attained. Coefficients of variation were extremely low and very small differences were statistically significant.

In summary, differences in shelling percent can be attributed to the following factors listed in order of importance: (1) method of determination, (2) years, (3) locations, (4) dates of planting, (5) hybrids, and (6) cultural practices such as nitrogen rates and populations. Method of determination refers to whether shelling percent is determined at a high or low kernel moisture content.

Factors such as temperature, rainfall, drouth stress, and soil type are probably major causes of these differences. However, the importance of each was not determined. This would have required additional, intensive investigations which were beyond the means and scope of these studies.

Corn Shelling Percentage Studies[1]

R. D. Horrocks and M. S. Zuber[2]

INTRODUCTION

During the past decade the method of harvesting corn has rapidly changed from the conventional mechanical picker to the field picker-sheller. Farmers using the picker-sheller are immediately aware of the amount of shelled corn obtained from a given harvested area. Previously the yield estimate was based on unshelled ear corn. In most instances, the grower was never aware of the shelling percent, especially when he marketed or fed the crop on the ear. Only in those cases where he shelled the crop for direct livestock feeding, storage, or marketing was he able to estimate shelling percent.

The importance of being able to obtain a reliable estimate of shelling percent is obvious to those selling or buying corn on an ear basis or to researchers who know that shelling percent is a major component of yield. In both instances a conversion of ear corn to shelled grain must be made. However, the first is of minor importance today.

Research workers are interested in knowing what effect environmental conditions have on shelling percent. In inheritance studies, poor estimates of shelling percent due to the interaction of environmental and genetic factors may lead to invalid conclusions.

The objectives of these studies were to assess the influence of various factors on shelling percent. Many factors were assumed to directly or indirectly affect shelling percent in much the same manner as yield is affected. Some factors may be of greater importance than others.

This publication is an attempt to evaluate all of the shelling percent data accumulated at the Missouri Agricultural Experiment Station during the past two decades. The following factors which effect shelling percent of corn will be evaluated: (a) hybrids, (b) planting dates, (c) years and locations, (d) dates of harvest and time of shelling percent determination, (e) level of applied nitrogen, and (f) populations and row spacings. Also reported is some preliminary information on the association of shelling percentage with several ear and kernel characteristics.

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LITERATURE REVIEW

A thorough review of the literature revealed only a limited number of references on shelling percentages *per se.* Alberts (1) in 1926, Stringfield (5) in 1938, and Kiesselbach (3) in 1950 had the only published papers dealing directly with shelling percent.

The consideration of shelling percent in corn requires an understanding of the relationship between cob and kernel moisture content from the beginning of grain formation to the time when the 12 percent level is reached. Kiesselbach (3), Miles, and Remenga (4) and Hughes and Sprague (2) have reported that the moisture content of the cob and the kernel is approximately equal at about 13 percent or slightly less. On the higher end of the scale equality is reached at 65 percent (3,4). Between 13 and 65 percent kernel moisture, the moisture in the cob is higher than in the kernel (3,4). Above 65 percent the moisture content of the kernels is less than in the cob; below 13 percent approximate equality is attained.

The moisture content of cob corn dried to less than 15 percent moisture can vary considerably in storage depending on atmospheric humidity (4). As moisture is absorbed or released an imbalance in moisture content will occur between the cob and kernel, but equilibrium is soon reached. Miles and Remenga (4) report that these changes result from the relative affinity for moisture of cobs and kernels, and that this affinity changes or even reverses with changes in moisture level.

Miles and Remenga (4) present three reasons why cobs have greater moisture content than kernels between the moisture range of 13 to 65 percent: (a) cobs have a greater affinity for water; (b) dry matter accumulation in the ear ceases at 65 percent moisture in the cob and 45 percent in the grain; and (c) the cob is covered by the kernels thus preventing rapid loss of water.

In addition to the formation above, Hughes and Sprague (2) reported that the ratio of dry weight of cob to dry weight of grain is essentially constant throughout the kernel moisture range from 10 to 40 percent. Other work supports this idea (3,4).

The aforementioned considerations are important in estimating shelling percent. The greater the disparity between moisture content of cob and grain, the more the shelling percent will be distorted. For example, from the results of Miles and Remenga (4) the following is evident. If kernel moisture is less than 13 percent, the cob moisture is approximately equal and the shelling percent is constant for a given hybrid. However, in the kernel moisture range of 13 to 65 percent sizeable discrepancies can result in shelling percent (Fig. 1). From these data it appears that the lowest shelling percent occurs when the kernel

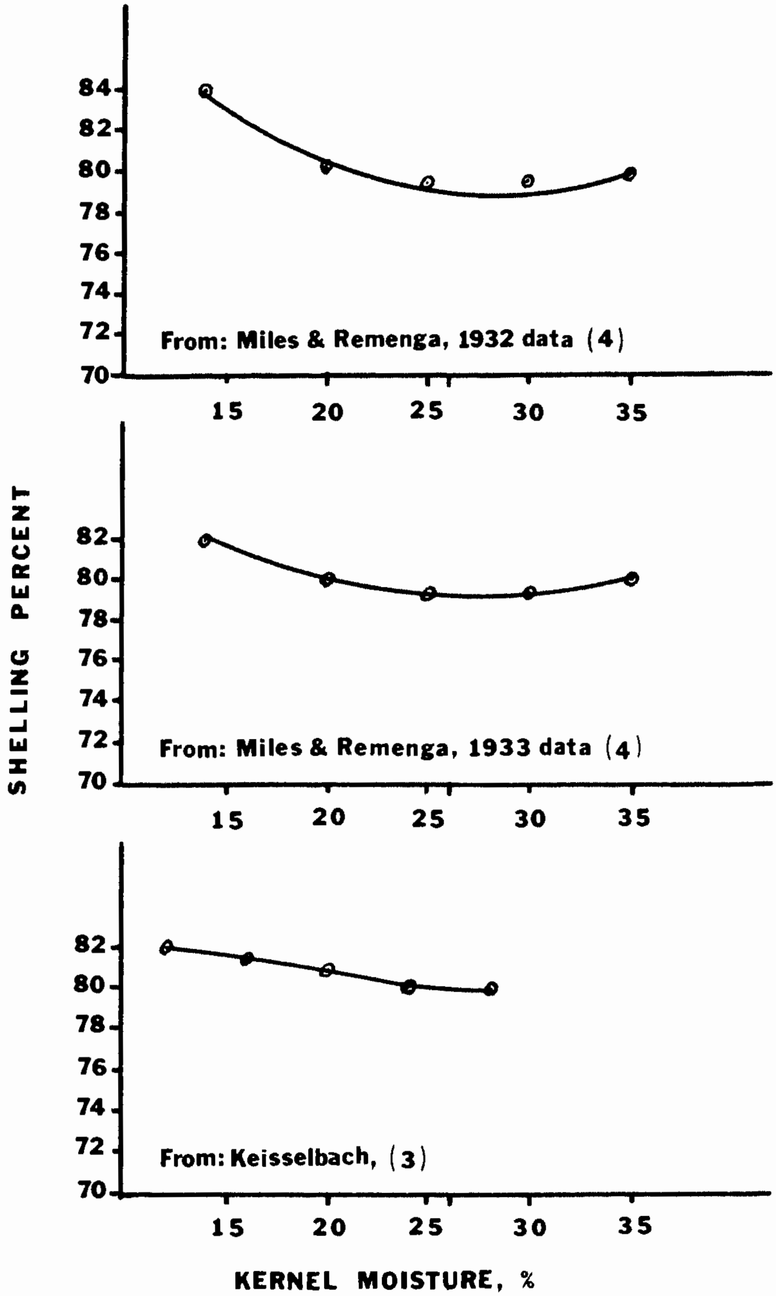

Fig. 1—Relationship between shelling percent and kernel moisture.

moisture is between 25 and 30 percent, the range in which the largest difference occurs between kernel and cob moisture.

Hybrids. The variation in shelling percent for hybrids or varieties has been reported to vary from 81.5 to 88.2 percent (5). From these data (5) it was reported that the shelling percent was slightly higher for hybrids compared with varieties. Based on a very large number of ears from many hybrids, Hughes and Sprague (2) used an average shelling percent of 82.7 percent in preparing their ear-corn-to-shelled-corn conversion tables. Miles and Remenga (4) found that among varieties cob moistures differ considerably in the interval where kernel moisture ranges from 16 to 55 percent. They also suggest that the relationship between cob and kernel moisture may vary from year to year among varieties. They indicate that this variation could account for the major differences in shelling percentage among varieties or hybrids.

Time of Harvest. The effect of harvesting at various stages of maturity on shelling percent has been reported by Albert (1) and Kiesselbach (3). Albert (1) used the varieties 'Golden Glow' in 1919 and 'Murdock' in 1920 with essentially identical results. Five stages of maturity (early milk, late milk, dough, beginning glaze, and full dent) were used: the shelling percents ranged from 25 to 85 percent. Kiesselbach (3), who used the variety 'Nebraska White Prize', reported the shelling percentages ranged from 47 (6 weeks prior to maturity) to 83 at maturity. Maturity was defined as the point when the kernel reached 34 percent moisture. Over the three-year period the shelling percentages varied considerably at three, four, five, and six weeks before maturity, but were approximately equal at maturity and one and two weeks prior to maturity.

Further Work. Despite the few published references to shelling percent, corn researchers have not ignored this area. Many have collected shelling percent data which have remained unpublished or have been published as part of other corn performance records. This is an attempt to summarize a portion of these data collected at the Missouri Agricultural Experiment Station.

MATERIALS AND METHODS

During the past 15 years numerous data on shelling percent have been obtained at the Missouri Agricultural Experiment Station. Several experiments were conducted with the specific objective of determining the relationship of various factors with shelling percent. In other instances, information on shelling percent was incidental to the main objective of a particular study.

Unless otherwise noted, shelling percentages in these studies were determined on ear corn dried to about 7 to 10 percent moisture. The cobs were collected for each sample and the amount of shelled corn was determined by subtracting the cob weight from the original sample weight. Determining the amount of shelled corn by difference was found to be more precise than using the weight of the shelled corn *per se.* The reduction in precision by using weight of shelled corn was apparently due to the loss of kernels when shelling.

RESULTS

Hybrids

Numerous data have been collected on the variation in shelling percent of corn hybrids. In 1962 shelling percent was determined for 52 hybrids tested near Tarkio. The procedure for determining these percentages was to shell each of the four replications for each hybrid directly after harvesting with no prior drying of the sample. The shelling percent data for each hybrid are shown in Table 1. The shelling

Table 1. Shelling percent for 52 hybrids grown at Tarkio, Missouri in 1962.

Hybrid	Shelling Percent	Moisture Percent	Hybrid	Shelling Percent	Moisture Percent
Mo 447W*	77.0	19.2	U.S. 619W*	82.6	18.0
Mo. 1035	78.7	16.7	MFA 2120	82.7	17.0
Maygold 29X	79.8	16.5	Cargill 310	82.7	15.5
Mo. 4078W*	80.5	17.1	Cargill 285	82.8	16.5
Kansas 1639	80.5	16.7	Iowa 4376	83.0	15.5
Mo 843	80.6	17.5	MFA 212	83.1	15.6
Mo 880	81.1	15.9	Maygold WX85	83.1	15.9
AEA 801	81.4	13.9	United Hagie 3H56	83.1	18.0
Kansas 1859	81.4	17.6	Maygold 48	83.1	15.9
Mo 1007	81.6	16.6	MFA 3210	83.2	15.4
DeKalb 633	81.6	16.9	Cargill S440	83.3	16.3
US 523W*	81.6	17.3	DeKalb 3X0	83.4	16.5
Mo 1034	81.7	16.8	DeKalb 3X1	83.4	14.7
DeKalb 3X5	81.8	14.6	DeKalb 805	83.5	16.6
DeKalb 661	82.0	14.5	IA 5043	83.8	16.1
DeKalb 640	82.1	17.0	Pioneer 321	83.9	16.7
AA 366W*	82.2	17.4	MFA K6	84.0	17.0
DeKalb 854	82.2	15.0	Pioneer 3304	84.2	17.1
United Hagie 160	82.3	22.4	Maygold 58X	84.4	16.9
Mo 1017	82.3	17.3	Pioneer 3359	84.8	15.4
Mo 1020	82.3	17.2	Corn King 418	84.8	15.6
Maygold 37	82.4	17.2	Pioneer 314	84.8	16.2
IA 5118	82.4	16.3	US 13	84.9	16.2
Mo 1023	82.4	16.5	Pioneer X6028	85.2	16.4
Mo 4080W*	82.4	17.2	DeKalb 831	85.2	16.3
Cargill 340	82.6	16.6	United Hagie 158	85.6	15.7

*White hybrid

percent ranged from 77.0 to 85.6 percent for the 52 hybrids. Differences between hybrids were significant at the 1 percent level. Distribution of shelling percent for the 52 hybrids is presented in Table 2.

Table 2. Frequency distribution of shelling percent for 52 hybrids.

Range in Shelling %	Number of Hybrids in Range
77.0 - 78.9	2
79.0 - 80.9	4
81.0 - 82.9	25
83.0 - 84.9	18
85.0 - 86.9	3

The correlation (r = -0.27) between grain moisture at harvest and shelling percent was negative and non-significant. Although the correlation was not significant, it indicated that shelling percent data might be affected by differences in moisture content of the grain and therefore, for comparative purposes all samples should be dried to a uniform moisture content. These observations prompted the research discussed in a later section on methods of determining shelling percent.

Other data were collected over a period of years on the effect of hybrids on shelling percent (Tables 3, 4, 5, and 6). Table 3 summarizes data on eight hybrids over three locations with a total of 15 years of experiment. Table 4 shows the average shelling percent of three of the same hybrids over a period of 4 years and 13 locations. Table 5 presents 11 other hybrids (some are the same as in Tables 3 and 4) in two different years. Tables 4 and 5 indicate that only a small difference was required for significance between hybrids in shelling percent in these experiments. The reason for the large difference between the low and high percent in Table 5 is due to the pipe corn (Mo Pipe 4) that was included. This hybrid has up to 10 percent more cob than regular hybrids.

Data in Table 6 present average shelling percent (1956-1958) for 11 double-cross hybrids and their single cross parents. The shelling percent range for the double-cross hybrids was from 74.6 (Mo Pipe 4) to 83.3 (US 13) and 71.8 (K10 x Ky49) to 84.9 (Ky 27 x Ky49) for the single-cross parents.

In general these data show that shelling percent among hybrids varies by four to five percentage points when averaged over several years. If data from only one year and a large number of hybrids is considered the range is approximately seven percentage points.

Table 3. Shelling percentage for 8 hybrids at three Missouri locations.

Hybrid	Sikeston (5-year average)	Columbia (5-year average)	Spickard (5-year average)	Mean
Kansas 1639	78.0	80.2	80.8	79.7
Dixie 22	79.9	81.3	82.2	81.1
Mo 804	79.6	81.1	82.4	81.0
US 523W*	80.4	82.6	83.4	82.1
Iowa 4570	80.9	82.6	83.9	82.5
Iowa 4376	81.5	83.7	84.5	83.2
US 13	80.9	82.8	83.8	82.5
Dixie 33	81.9	83.8	84.6	83.4
Mean	80.4	82.3	83.2	82.0
LSD (.01)	0.8	0.6	0.7	
CV (%)	2.32	1.83	2.06	

*White hybrid

Table 4. Shelling percentage for 3 hybrids (average of 4 years and 13 locations).

Hybrid	Shelling Percent
US 523W	82.9
US 13	83.7
Iowa 4376	84.1
Mean	83.6
LSD (.01)	0.4

*White hybrid

Table 5. Shelling percentage of 11 hybrids (Method Study)

Hybrid	Shelling Percent (1960)	(1969)	Mean
Mo. Pipe 4	78.7	79.7	79.2
Mo 843	84.4	82.0	83.2
Mo 4060AW	84.8	----	----
DeKalb XL45	----	83.3	----
Iowa 4376	86.4	----	----
US 13	86.5	83.7	85.1
US 523W	86.6	----	----
PAG 454	87.1	----	----
Dixie 33	87.4	84.4	85.9
Pioneer 3306	----	84.4	----
PAG SX29	----	84.8	----
Mean	85.2	83.2	84.2
LSD (.01)	0.4	0.6	

Table 6. Shelling percentages for 11 double-cross hybrids and their single-cross parents.

Double Cross Hybrids	Single Cross Parents	Shelling Percent Double Cross	Shelling Percent Single Cross
Mo. Pipe 4		74.6	
	K10 x Ky49		71.8
	Mo8W x Mo9W		73.6
Mo 407W		78.6	
	K55 x H28		78.9
	k41 x K6		81.8
Mo 843		79.5	
	B10 x C103		77.2
	WF9 x Oh7A		83.0
Mo 880[1]		80.4	
	K148 x Mo5		80.3
	WF9 x 38-11		83.6
Oh C92[1]		81.5	
	Oh07 x Hy		83.4
Mo 804		81.4	
	C17 x K4		81.1
	38-11 x CI21E		81.7
AEA 904W		81.6	
	K64 x Mo 22		81.8
	T111 x T115		82.4
Kan 1639[1]		81.6	
	K148 x K150		80.0
Mo 880A		82.5	
	Mo3 x CI21E		81.7
	Mo10 x T202		83.1
US 523W		82.5	
	K55 x K64		81.5
	Ky27 x Ky49		84.9
US 13[1]		83.3	
	L317 x Hy		83.1
Mean		80.7	80.8

[1]These hybrids have the common seed parent (WF9 x 38-11).

Date of Planting

Date-of-planting studies have been conducted for a period years at three locations: Sikeston, in southeast Missouri; Columbia, in central Missouri; and Spickard, in north Missouri. Eight hybrids representing four maturity groups were planted on five dates at each of the locations. The initial planting dates were April 1 at Sikeston and April 20 at Columbia and Spickard. The remaining dates were at 20-day intervals at each location. Another study was conducted at Columbia with the same hybrids with only three planting dates: April 20, May 20, and June 20.

Although the hybrids differed in shelling percent, this discussion will be based on the average of all hybrids. Hybrid difference was presented and discussed in the previous section. Detailed data appear in Appendix Tables I, II, and III.

The effects of planting date on shelling percent are shown in Figure 2 for three locations (two tests at Columbia). Shelling percent gradually decreased after the second planting date at Sikeston, Columbia (2-year average), and Spickard with the lowest values occuring June 20. The results of the second Columbia study (5-year average) show the same trend until the last date, at which time the shelling percent was higher than on the previous date. However, it should be noted that the over-all trend is similar in each case.

The analysis of variance showed the interaction of planting date by years to be significant (P=.01) for each location, except for the 2-year Columbia study (Table 7). These results also indicate that the planting date x hybrid interaction was significant only at Spickard. Over-all, at the more southern locations, years made the major contribution to the variation. At Spickard, planting dates and hybrids were major causes of variation. This is probably related to the better distribution of rainfall and lower temperatures at the north Missouri location.

Years and Locations

Three hybrids representing different maturity groups were grown at 13 locations for the 4-year period 1957 to 1960. The hybrids were (a) Iowa 4376, with a relative maturity of 90 days; (b) US 13, 115 days; and (c) US 523W, 125 days. These data were collected as part of the Missouri hybrid corn evaluation program.

During the four-year period the grain moisture at harvest ranged from 15.6 to 21.3 percent, and shelling percent from 81.6 to 85.3 percent. The correlation coefficient for yield versus shelling percent was significant at the one percent level ($r = 0.72$).

The analysis of variance for shelling percent is presented in Table 8. This analysis indicates that the major variation in shelling percent can

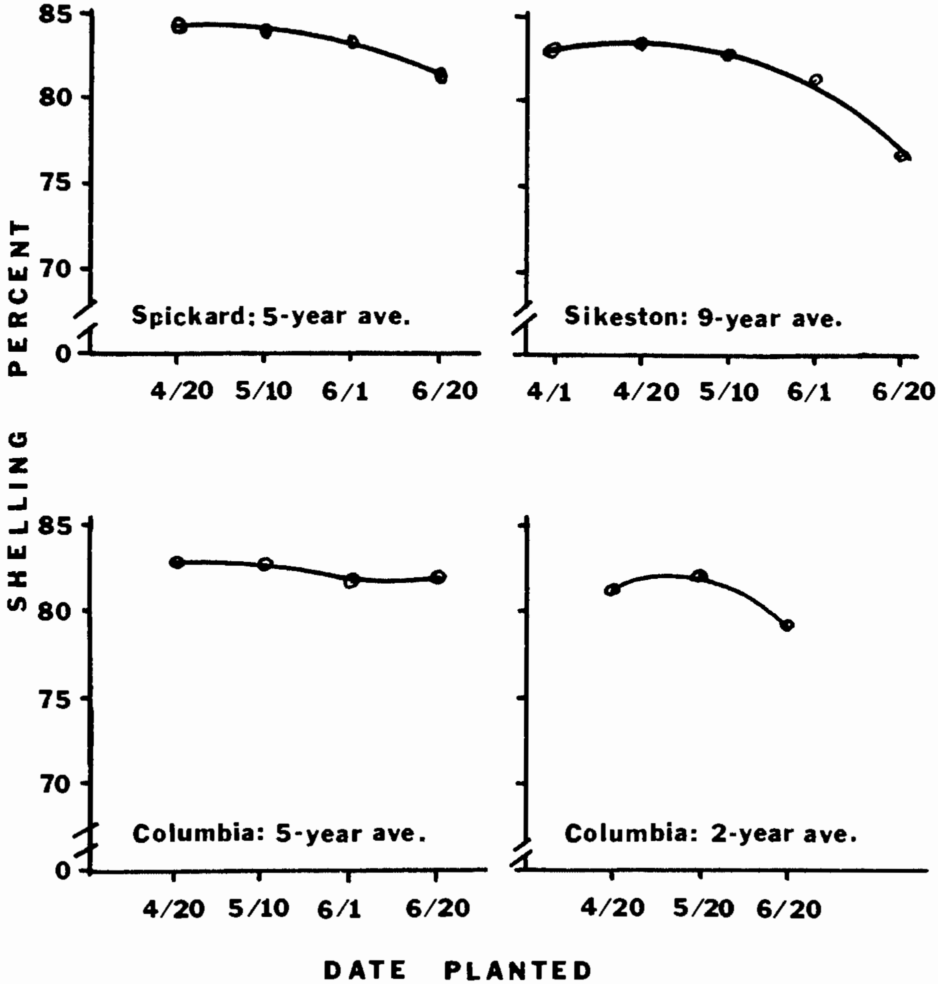

Fig. 2. Relationship between shelling percent and planting date.

Table 7. Analysis of variance for shelling percent and test weight at three Missouri locations. (Date-of-Planting Studies, 1960-1964)

	Shelling Percent						Test Weight					
	Sikeston		Columbia		Spickard		Sikeston		Columbia		Spickard	
Source	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Date of Planting (D)	4	1551.89**	3	52.19**	3	259.64**	4	890.20**	3	120.48**	3	1346.89**
Hybrids (H)	7	153.91**	7	130.69**	7	137.54**	7	182.39**	7	98.97**	7	186.06**
Years (Y)	4	1146.68**	4	381.85**	4	61.03**	4	348.70**	4	65.28**	4	220.51**
D x H	28	10.74**	21	2.67^{ns}	21	5.41*	28	5.05**	21	6.15**	21	12.96**
D x Y	16	83.02**	12	21.57**	12	51.38**	16	31.32**	12	15.82**	12	209.13**
H x Y	28	11.19**	28	15.90**	28	7.44**	28	7.20**	28	2.93**	28	7.73**
D x H x Y	112	6.29**	84	4.76**	84	3.63^{ns}	112	3.18**	84	3.13**	84	7.80**
Error	597	3.49	477	2.26	447	2.93	597	1.42	477	1.30	477	2.27

be accounted for by years and locations. As discussed in the previous section, years were found to be major contributors of variation in shelling percent, especially in central and southern Missouri. Hybrids appear to be of lesser importance, but do show significant variation. The hybrid x year and the hybrid x location interactions were not significant, indicating that despite the variation in shelling percent caused by year or location, the responses of the hybrids were similar.

Table 8. Analysis of variance for shelling percent of three hybrids grown at 13 locations (1957-60).

Source	df	Mean Square
Hybrids	2	16.99**
Years	3	75.28**
Locations	12	19.61**
Hybrids x Years	6	1.36
Hybrids x Locations	24	0.68
Years x Locations	36	6.97**
Error	72	0.82

**Significant at 1% level

Table 7 indicates that the largest contributor to variation at the Columbia location was years. The date-of-planting x year and hybrid x year interactions were significant at all three locations.

Table 9 shows the effect of location on shelling percent, and Table 10 indicates the shelling percent deviation from year to year. The range in shelling percent was 3.7 percent for locations and 3.4 percent for years.

Table 11 presents further information on the average shelling percent of eight hybrids at three locations over a number of years. The range in shelling percent was 7.9 percent at Sikeston, 4.0 percent at Columbia, and 1.5 percent at Spickard. Not only was the shelling percent range smaller at the more northern Missouri locations, but the actual shelling percent also increased by what appears to be a significant margin as the plot location was moved from south to north. The amount of variation in shelling percent also decreased from south to north locations in Missouri.

Table 9. Average shelling percent and moisture content for three hybrids grown at 13 Missouri locations (1957-1960)

Location	Shelling Percent	Grain Moisture At Harvest
Tarkio	85.0	20.0
Spickard	84.1	21.3
Kirksville	84.1	20.5
Clarence	82.6	20.8
Higginsville	81.2	17.1
Marshall	83.8	17.5
Columbia	83.0	15.6
Washington	85.3	18.1
Moscow Mills	84.7	19.9
Pierce City	83.9	16.4
Summersville	83.1	18.2
Ellington	81.6	17.2
Sikeston	84.6	16.8
Mean	83.6	18.4
LSD (.01)	0.8	

Table 10. The effect of years on shelling percent of three hybrids at 13 locations in Missouri.

Year	Shelling Percent	Grain Moisture at Harvest
1957	83.7	18.2
1958	85.3	19.4
1959	81.9	19.4
1960	83.7	19.2
Mean	83.6	
LSD (.01)	0.4	

Table 11. The effect of years on shelling percent of eight hybrids at three Missouri locations.

	Shelling Percent		
Year	Sikeston	Columbia	Spickard
1955	81.1	----	----
1957	82.3	----	----
1958	84.9	----	----
1959	80.2	----	----
1960	83.9	81.0	82.9
1961	81.7	83.9	83.9
1962	80.9	83.7	82.8
1963	78.6	79.9	84.0
1964	77.0	82.9	82.5
Mean	81.2	82.3	83.2

Method of Determination

In response to the possibility that the time at which the shelling percent is determined can be of significance the following study was conducted.

Two methods of determining shelling percent were compared on each of three harvest dates. Under method I, shelling percent was determined immediately after harvest; under method II, it was determined after drying the sample in a forced-air dryer at 40-60 C to a uniform moisture content before shelling. The harvest dates at which these comparisons were made were September 15, October 15, and November 15. Moisture and shelling percent determinations for method I were made immediately after harvest and for method II after the corn had been dried to approximately 6 percent.

The experimental design consisted of a randomized complete block with six replications. Each hybrid was planted in a plot consisting of six rows with 15 plants spaced one foot apart in the row. The six-row plot allowed for sampling of one row for each of the two methods on each of the three harvest dates. Data were collected in 1960 and in 1968.

Data on the effect of harvest date and method of determining shelling percent are presented in Tables 12 through 15. Determining shelling percent at harvest time, on the average, gives an estimate that is 5 to 6 percentage points lower than after drying. As the time of harvest is delayed from September 15 to November 15 the difference decreases.

These data tend to support the information already presented showing the relationship of moisture content and shelling percent (2, 3, 4). Wide discrepancies result when the grain moisture content is above 25 percent. The 1968 data show that after the second date-of-harvest the shelling percent as determined in method II decreases. However, this should not be considered significant since the authors feel that this probably resulted from discrepancies in the drying procedure; namely,

Table 12. Average shelling percent and grain moisture content for the 2 methods of determining shelling percent at each of 3 dates, 1960.

Dates of Harvest	Method			
	At Harvest (I)		After drying 2 weeks (II)	
	Shelling	Moisture	Shelling	Moisture
	%	%	%	%
September 15	75.4	36.3	84.4	7.1
October 15	79.7	20.9	84.5	7.4
November 15	82.6	17.9	86.9	4.3
Mean	79.2	25.0	85.3	6.3

Table 13. Average shelling percent and grain moisture content for two methods of determining shelling percent at each of three dates, 1968.

Dates of Harvest	Method: At Harvest (I) Shelling	At Harvest (I) Moisture	After drying 2 weeks (II) Shelling	After drying 2 weeks (II) Moisture
	%	%	%	%
September 15	75.6	39.9	82.6	Less
October 15	79.1	30.1	85.1	Than
November 15	80.2	21.0	81.8	6
				Percent
Mean	78.3	30.0	83.2	

Table 14. Average shelling percent and grain moisture content for the 2 methods of determining shelling percent for 7 hybrids, 1960.

Hybrids	Method of Determining Shelling Percent: At harvest Shelling	At harvest Moisture	After drying 2 weeks Shelling	After drying 2 weeks Moisture
	%	%	%	%
Mo 4060AW	78.2	23.2	84.8	6.1
Mo Pipe 4	70.9	27.7	78.7	6.5
Dixie 33	81.7	29.0	87.4	6.5
US 523W	80.7	25.6	86.6	6.4
Mo 843	77.7	25.2	84.4	6.4
Iowa 4376	82.0	20.0	86.4	5.8
PAG 454	81.7	27.4	87.1	6.2
Mean	79.3	25.1	85.2	6.2

Table 15.. Average shelling percent and grain moisture content for the two methods of determining shelling percent for 7 hybrids, 1968.

Hybrids	Method: At harvest Shelling	At harvest Moisture	After drying 2 weeks Shelling	After drying 2 weeks Moisture
	%	%	%	%
Mo Pipe 4	71.6	34.3	79.7	Less
Dixie 33	79.2	33.4	84.4	than
DeKalb XL45	80.0	26.3	83.3	6
US 13	80.3	27.4	83.7	Percent
Mo 843	76.2	30.4	82.0	
PAG SX29	81.4	29.9	84.8	
Pioneer 3306	79.3	30.2	84.4	
Mean	87.3		83.2	

the fact that the dried corn was at a higher moisture content after drying on October 15 than the other two dates.

Table 16 indicates that the responses to methods, hybrids, and dates were similar each year; and method was the major contributor of variation.

Table 16. Analysis of variance for shelling percent in the method-date-of-harvest study, Columbia, Mo.

Source of Variation	df		Mean Square	
	1960	1968	1960	1968
Hybrids (H)	7	6	398.71**	234.24**
Methods (M)	1	1	2566.06**	1523.43**
Dates (D)	2	2	564.89**	191.82**
H x M	7	6	9.69**	26.50**
H x D	14	12	3.35	4.55
M x D	2	2	158.44**	175.91**
H x M x D	14	6	4.19	1.60
Error	235	205	1.40	3.09

**Significant differences exist at the 1% level.

Effect of Nitrogen Levels

Shelling percent was determined for 30 hybrids, consisting of 11 double crosses and 19 single crosses, grown at four levels of nitrogen over a three-year period. The results are in Table 17. There were significant differences at the 1 percent level due to hybrids, nitrogen levels, and years. Only one of the interactions, nitrogen x years was significant (Table 18). The range in shelling percent for the four levels of applied nitrogen was 80.3 to 81.3. The highest shelling percent occurred at the highest N level.

In this study the differences associated with years and hybrids appeared to be more important than differences between levels of applied nitrogen.

Population and Row Spacing

Shelling percent data were collected from a hybrid x population x spacing study during the three-year period, 1966-1968. These data were from four locations: (1) North Missouri Center (Grundy County), (2) Southwest Center (Lawrence County), (3) Bradford Farm (Boone County), and (4) the Delta Center (Pemiscot County).

Analysis of variance at the sites indicates that hybrids contributed the majority of the variation at all locations except the Delta Center

Table 17. Average shelling percent for 11 double-crossed hybrids and their single cross parents grown at 4 levels of applied nitrogen for the 3-year period of 1956 to 1958.

Double Cross Hybrids	Single Cross Parents	NITROGEN (Applied)			
		None	60 lbs.	120 lbs.	240 lbs.
Mo 804		82.1	80.6	81.4	81.3
	CI7 x K4	81.4	81.1	80.9	81.0
	38-11 x CI21E	81.2	82.5	81.6	81.5
US 13		83.4	83.0	83.1	83.7
	WF9 x 31-11	82.2	83.4	84.6	84.0
	L317 x HY	83.0	83.3	83.2	82.9
Kan 1639		81.4	82.0	81.2	81.6
	K148 x K150	79.7	79.3	80.9	79.9
US 523W		82.0	83.2	81.1	83.6
	K55 x K64	83.0	81.1	78.9	82.4
	Ky 27 x Ky 49	86.1	83.3	84.6	85.5
AES 904W		80.2	82.8	81.4	81.9
	K64 x Mo22	81.5	80.6	82.6	82.5
	T111 x T115	82.7	82.8	82.0	82.1
Mo 800A		83.2	81.9	82.7	82.1
	Mo 10 x T202	84.3	82.5	83.8	81.7
	Mo 3 x CI21E	81.5	82.4	80.7	82.2
Mo 4047W		79.3	78.4	77.9	78.9
	K55 x H28	80.3	79.5	75.5	80.3
	K41 x K6	80.9	81.8	82.0	82.6
Oh C92*		77.0	83.5	82.1	83.5
	OH97 x Hy	85.0	84.4	79.5	84.7
Mo 843		80.3	80.2	76.9	80.7
	WF9 x Oh7A	82.1	82.7	83.5	83.8
	B10 x C103	76.6	76.6	77.2	78.4
Mo 880*		80.9	80.2	78.6	82.0
	K148 x Mo5	79.3	80.3	80.2	81.5
Mo Pipe 4		74.0	74.3	75.0	75.2
	Mo8W x Mo9W	73.4	72.9	74.5	73.5
	K10 x Ky49	72.0	70.2	71.4	73.7
	Mean	80.7	80.7	80.3	81.3

*These hybrids have the common seed parent WF9 x 38-11.

Table 18. Shelling percent as affected by the interaction of N level and years for the period 1956 to 1958.

Years	Nitrogen (Applied)			
	None	60 lbs.	120 lbs.	240 lbs.
1956	83.0	81.6	82.9	83.0
1957	79.4	78.8	78.6	79.0
1958	79.8	81.7	79.3	81.8
Mean	80.7	80.7	80.3	81.3

*These values represent the averages within each year and N level of the hybrids shown in Table 17.

(Table 19). Significant differences (P = .01) existed between years and populations within a location. Row spacing (20", 30", and 40") resulted in significant differences (P = 0.5) at all locations except the Bradford Farm. The hybrid x spacing interaction was non-significant; thus the average values for 20", 30", and 40" row widths are presented (Table 20). The year x hybrid interaction was significant at all locations; the year x spacing was significant only at the Bradford Farm (P = .01). All other interactions were non-significant. Detailed information is presented in Appendix Tables IV, V, VI, and VII.

Table 19. Analysis of variance for shelling percent for 3 hybrids grown three years at three locations in a population x row spacing study.

	Spickard		Mt. Vernon		Columbia		Portageville	
Source	df	MS	df	MS	df	MS	df	MS
Years (Y)	2	0.87**[1]	1	6.66**	2	13.17**	2	30.33**
Hybrids (H)	2	29.89**	2	22.10**	2	32.60**	2	32.75**
Spacing (S)	2	0.38*	2	0.29*	2	0.27	2	2.18*
Population (P)	3	0.76**	3	0.39**	3	1.46**	3	0.60
Y x H	4	2.50**	2	0.68**	4	1.91**	4	2.52**
Y x S	4	0.23	2	0.05	4	0.70**	4	0.27
Y x P	6	0.18	3	0.04	6	0.25	6	0.23
H x S	4	0.06	4	0.15	4	0.16	4	0.14
H x P	6	0.08	6	0.15	6	0.36	6	0.35
S x P	6	0.11	6	0.17	6	0.21	6	0.11
Y x H x S	8	0.25	4	0.01	8	0.13	8	0.11
Y x H x P	12	0.10	6	0.12	12	0.28	12	0.48
Y x S x P	12	0.11	6	0.09	12	0.23	12	0.20
H x S x P	12	0.11	12	0.05	12	0.13	12	0.42
Y x H x S x P	24	0.14	12	0.14	24	0.18	24	0.62
Error	324	0.10	144	0.09	324	0.18	216	0.64
Total	431		215		431		323	

[1]All mean squares are to be multiplied by the factor 10^{-3}.

Table 20. Average differences in shelling percent attributed to row spacing, at four Missouri locations, 1966-1968.

	Row Width		
Location	20"	30"	40"
Spickard	82.3	83.2	83.3
Columbia	83.8	83.6	83.9
Mt. Vernon	82.5	82.8	82.8
Portageville	80.0	80.6	80.9
Mean	82.2	82.6	82.8

Table 21 shows the influence of plant population on shelling percent at four Missouri locations. Generally, these data indicate that as the population increases, the shelling percent also increases, at least within the limits of this experiment. As populations increase above 24,000 plants per acre, one would expect the incidence of poorly filled ears to increase and thus shelling percent to decrease.

Table 21. Differences in shelling percent attributed to population, 1966-1968.

	Shelling Percent				
Population	North Missouri Center	Southwest Center	Bradford Farm	Delta Center	Mean
12M	82.8	82.4	83.4	80.1	82.2
16M	83.0	82.7	83.5	80.7	82.5
20M	83.4	82.8	84.0	80.5	82.7
24M	83.3	83.4	84.2	80.7	82.9
Mean	83.1	82.7	83.8	80.4	82.5

Shelling Percent and Various Ear and Kernel Characteristics.

A preliminary study was conducted to determine if a relationship exists between shelling percent and certain ear and kernel characters. The study was conducted with 360 inbred lines of corn. The 12 measurements listed in Table 22 are the averages for two ears selected from each inbred line. When the 360 lines were grouped by kernel color, 180 had yellow endosperm and 189 had white endosperm. When grouped by cob color, 120 were red, 9 pink, and 240 white. Correlation coefficients were computed for the 12 ear and cob characters versus shelling percent within each kernel and cob color classification. The results are shown in Table 22.

Among the yellow endosperm inbred lines shelling percent was positively correlated with (1) kernel row number, (2) weight of ear, (3) weight of grain, (4) diameter of ear, and (5) depth of kernel. Negative correlations were found between shelling percent and (1) weight of cob, (2) weight of 2" cob section, (3) density of a 2" cob section, and (4) crushing pressure of a 2" cob section.

In the white endosperm inbred lines shelling percent was positively correlated only with depth of kernel. Negative correlations were found between shelling percent and (1) weight of grain, (2) diameter of cob, (3) weight of 2" section, (4) density of 2" section, (5) water displacement of 2" section, (6) crushing pressure of 2" cob section, and (7) diameter of ear.

The only reversal in correlation coefficient that was statistically significant between yellow and white endosperm inbred lines, was the

Table 22. Correlation Coefficients between shelling percent and various ear and kernel characters for 369 inbred lines when grouped by kernel and cob color.

Shelling % VS	Kernel Color		Cob Color		
	Yellow	White	Red	Pink	White
Ear length	-.16*	-.03	-.18	-.33	-.04
Kernel row No.	.23**	-.08	.30**	-.56	-.04
Weight ear	.34**	-.13	.25**	.20	-.01
Weight cob	-.37**	-.68**	-.31**	-.80**	-.67**
Weight grain	.47**	.10	.38**	.46	.22*
Diameter cob	.01	-.48**	-.17	-.43	-.33**
Weight of 2'' cob section	-.44**	-.71**	-.35**	-.88**	-.67**
Density of 2'' cob section	-.35**	-.55**	-.37**	-.84**	-.49**
Water displacement of 2'' section	-.19*	-.56**	-.17**	-.84**	-.50**
Crushing pressure of 2'' cob section	-.30**	-.60**	-.21*	-.87**	-.61**
Diameter of ear	.33**	-.29**	.15	----	-.08
Depth of kernel	.54**	.35**	.53**	.23	.43**
Number of observations	180	189	120	9	240

*Significant at 5% level

**Significant at 1% level

one for shelling percent and diameter of ear. The *r* values were 0.33 and -0.29, respectively.

In general, most of the measurements involving cobs were negatively correlated with shelling percent regardless of endosperm color.

Since a relationship existed between shelling percent and certain ear and cob characters for the 360 inbred lines studied, a question arises as to whether the data would represent a random sample from a population. Therefore the authors suggest that this should be considered as preliminary work and the results should not be extrapolated to the whole corn population.

Relationship of Shelling Percent and Test Weight

Preliminary data had indicated that as shelling percent increased, test weight also increased. However, in examining the data it sometimes appeared that a negative relationship might exist. In view of this, simple correlation coefficients were determined for shelling percent and test weight per bushel for all data in the date-of-planting studies and the hybrid x spacing x population studies, The *r* values are presented in Tables 23 and 24 for the two studies.

The data from the date-of-planting studies show a strong positive correlation between shelling percent and test weight for the hybrids at Spickard and Sikeston, and essentially no relationship at Columbia. The *r* values for years were highly varied. The trend for planting date appears to be a negative relationship at the earlier dates and a strongly positive one at the last planting date.

Data in Table 24 indicate that the relationship between shelling percent and test weight for the specific conditions is generally negative. However, considerable variation and shifting of position exist among locations for any given factor, thus suggesting that the relationship is influenced significantly by the environmental conditions. We suggest that the moisture conditions of the soil and atmosphere are important as they tend to influence cob deterioration; i.e., as conditions favor the fungi that cause cob rot the relationship between shelling percent and test weight could be highly negative due to the loss in weight of the cob.

To support this we cite the following relationships: The pressure in pounds per square inch (psi) required to crush a 2-inch section of cob is highly correlated with the physical condition of that cob. As cob rot increases, the psi required for crushing decreases. When shelling percent is correlated with this measurement of cob strength the relationship is strongly negative. For example, from the hybrid x spacing x population study of the Columbia data this correlation showed an *r* value of -0.52 in 1967 and -0.88 in 1968. The mean cob crushing values were 1204 psi

Table 23. Simple correlation coefficients (r) for shelling percent on test weight as affected by various factors, Date-of-planting studies, 1960-1964.

Hybrids	Location Spickard	Columbia	Sikeston
	(80)[1]	(80)[1]	(100)[1]
Ia 4376	.37	.02	.70
Ia 4570	.36	.19	.79
Kan 1639	.49	.21	.54
US 13	.41	.18	.68
US 523W	.69	.08	.68
Mo 804	.65	.38	.62
Dixie 22	.57	.13	.71
Dixie 33	.76	.32	.74
Years	(128)[1]	(128)[1]	(160)[1]
1960	.02	-.22	.31
1961	.27	-.06	.33
1962	.19	-.19	.41
1963		-.29	.59
1964	.70	-.33	.57
Planting Date	(160)[1]	(160)[1]	(160)[1]
April 1	--	--	-.28
April 20	-.19	-.02	-.02
May 10	-.10	-.12	.13
June 1	-.13	-.08	.24
June 20	.52	-.12	.42
Total Over Location	(640)[1]	(640)[1]	(800)[1]
	.40	-.03	.52

[1]Number of cases

Table 24. Simple correlation coefficients (r) for shelling percent on test weight as effected by various factors, Hybrid x Population x Spacing Studies, 1966-1968.

	Location			
	Spickard	Columbia	Mt. Vernon	Portageville
Hybrids	(144)[1]	(144)[1]	(72)[1]	(108)[1]
Pio. 3306	.45	-.06	-.32	0.44
MFA 2222	-.03	-.10	.28	0.50
DeKalb XL65A	-.22	-.48	.12	0.23
Populations	(108)[1]	(108)[1]	(54)[1]	(81)[1]
12M	-.40	-.57	-.49	-.16
16M	-.15	-.44	-.68	.02
20M	-.10	-.54	-.61	.17
24M	-.11	-.47	-.54	.21
Spacings	(144)[1]	(144)[1]	(72)[1]	(108)[1]
20 in.	-.16	-.40	-.57	-0.07
30 in.	-.24	-.52	-.57	0.09
40 in.	-.18	-.52	-.57	0.12
Year	(144)[1]	(144)[1]	(108)[1]	(108)[1]
1966	-.02	-.39	-.58	.33
1967	-.40	-.39	-.54	-.48
1968	-.18	-.54	----	.28
Total over Location	(432)[1]	(432)[1]	(216)[1]	(324)[1]
	-.15	-.46	-.53	0.07

[1]Number of cases

and 856 psi for 1967 and 1968, respectively. Data from this study at other locations are similar, Table 25.

These data suggest a varied relationship between shelling percent and test weight. They suggest that it is strongly influenced by cob quality and that further work is needed to clarify the role of environmental factors in this relationship.

Table 25. r values showing relationship of shelling percent and cob crushing psi, hybrid x spacing x population studies.

Location	Year	r value	Mean cob Crushing (psi)
Spickard	1967	-0.55	1799
	1968	-0.76	810
Columbia	1967	-0.52	1204
	1968	-0.88	856
Mt. Vernon	1967	-0.73	1351
Portageville	1967	-0.54	1223

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Appendix I. Shelling percent as affected by various factors, Spickard, Mo. (Date-of-Planting).

Year	Hybrid	April 20	May 10	June 1	June 20	Mean
		Planting Date				
1960	Ia 4376	84.2	84.1	83.7	82.1	83.5
	Ia 4570	82.9	83.6	83.5	81.8	82.9
	Kan 1639	81.0	80.6	80.8	80.8	80.7
	US 13	83.2	83.5	83.0	82.5	83.0
	US 523W	81.5	83.1	83.6	81.9	82.5
	Mo 804	83.4	81.8	82.7	81.1	82.2
	Dixie 22	83.2	83.5	83.2	79.5	82.3
	Dixie 33	85.5	85.2	86.2	83.9	85.2
	Average	83.1	83.2	83.3	81.7	82.8
1961	Ia 4376	83.7	85.3	85.5	82.2	84.2
	Ia 4570	84.5	86.0	85.1	83.0	84.7
	Kan 1639	82.1	81.9	82.4	80.9	81.8
	US 13	83.4	85.1	83.3	83.7	83.9
	US 523W	86.4	85.0	85.5	82.4	84.8
	Mo 804	85.2	84.3	82.9	81.7	83.5
	Dixie 22	85.6	84.5	82.9	78.0	82.7
	Dixie 37	86.6	86.7	84.7	82.9	85.2
	Average	84.7	84.9	84.0	81.9	83.9
1962	Ia 4276	85.5	85.5	85.1	82.3	84.6
	IA 4570	84.2	83.8	81.0	81.1	82.5
	Kan 1639	80.5	79.2	80.5	79.2	79.9
	US 13	85.1	86.2	85.6	81.8	84.7
	US 523W	84.0	81.9	84.0	83.1	83.3
	Mo 804	82.4	82.1	82.5	81.2	82.1
	Dixie 22	82.7	81.0	81.5	79.6	81.2
	Dixie 37	85.6	84.0	84.2	80.6	83.6
	Average	83.8	83.0	83.1	81.1	82.7
1963	Ia 4276	84.6	85.7	84.8	85.2	85.1
	Ia 4570	85.5	84.8	84.6	84.8	84.9
	Kan 1639	81.2	81.5	80.0	82.7	81.4
	US 13	84.5	85.0	82.7	84.5	84.2
	US 523W	84.4	84.1	82.1	84.8	83.9
	Mo 804	84.8	82.7	82.1	82.1	82.9
	Dixie 22	83.7	83.2	83.8	83.7	83.6
	Dixie 37	85.3	86.1	85.0	85.4	85.5
	Average	84.3	84.1	83.1	84.1	83.9
1964	Ia 4376	85.7	86.9	84.6	81.5	84.7
	Ia 4570	85.7	85.5	84.7	81.8	84.4
	Kan 1639	80.9	81.6	80.8	76.3	79.9
	US 13	84.5	83.8	84.3	78.4	82.8
	US 523W	86.2	85.8	82.0	75.4	82.4
	Mo 804	82.9	83.2	82.6	75.2	81.0
	Dixie 22	82.4	83.2	82.1	75.5	80.8
	Dixie 33	85.9	86.6	84.5	77.1	83.5
	Average	84.3	84.6	83.2	77.6	82.4

Appendix II. Shelling percent as affected by various factors, Columbia, Mo. (Date-of-Planting).

Year	Hybrid	Planting Date				
		April 20	May 10	June 1	June 20	Mean
1960	Ia 4376	82.2	83.2	80.9	81.0	81.8
	Ia 4570	81.7	81.4	80.2	82.2	81.4
	Kan 1639	79.9	80.6	78.5	79.3	79.6
	US 13	82.8	82.3	79.7	82.6	81.9
	US 523W	81.8	81.2	79.4	81.7	81.0
	Mo 804	79.4	80.3	78.4	79.6	79.4
	Dixie 22	80.2	79.4	80.6	79.1	79.8
	Dixie 33	83.0	83.1	82.0	83.2	82.8
	Average	81.4	81.4	80.0	81.1	81.0
1961	Ia 4376	85.2	83.1	83.9	81.7	83.5
	Ia 4570	84.4	84.3	83.0	81.7	83.3
	Kan 1639	82.6	83.3	80.8	80.1	81.7
	US 13	85.9	85.0	84.3	84.2	84.9
	US 523W	85.4	85.5	84.7	83.4	84.8
	Mo 804	84.3	83.1	83.0	81.9	83.1
	Dixie 22	83.5	84.3	83.2	81.6	83.2
	Dixie 33	86.8	86.6	85.6	85.4	86.1
	Average	84.8	84.4	83.6	82.5	83.8
1962	Ia 4376	83.7	84.6	84.8	85.2	84.6
	Ia 4570	81.7	82.9	81.0	82.8	82.1
	Kan 1639	81.0	81.0	82.6	80.1	81.2
	US 13	82.9	84.5	85.0	84.6	84.3
	US 523W	83.6	83.4	86.0	84.2	84.3
	Mo 804	83.9	82.6	85.6	82.8	83.7
	Dixie 22	83.5	84.1	83.6	83.8	83.8
	Dixie 33	86.2	86.1	86.3	82.4	85.3
	Average	83.3	83.7	84.4	83.2	83.7
1963	Ia 4376	85.0	84.0	83.5	82.1	83.7
	Ia 4570	83.2	81.4	81.8	82.2	82.1
	Kan 1639	80.0	75.9	76.6	77.9	77.6
	US 13	83.1	78.7	78.6	80.4	80.2
	US 523W	80.6	82.0	75.7	79.9	79.6
	Mo 804	76.9	78.8	75.1	79.4	77.5
	Dixie 22	77.5	79.8	75.0	79.5	77.9
	Dixie 33	82.5	82.5	75.1	81.5	80.4
	Average	81.1	80.4	77.7	80.3	79.9
1964	Ia 4376	84.0	85.6	84.2	85.2	84.8
	Ia 4570	83.3	84.8	82.4	83.9	83.6
	Kan 1639	81.3	81.6	80.5	79.7	80.7
	US 13	83.7	82.9	81.2	82.1	82.5
	US 523W	84.2	83.6	82.4	82.8	83.2
	Mo 804	82.4	81.1	81.5	81.3	81.6
	Dixie 22	82.4	82.1	82.0	79.9	81.6
	Dixie 33	84.6	84.5	84.1	83.6	84.2
	Average	83.2	83.3	82.3	82.3	82.8

Appendix III. Shelling percent as affected by various factors, Sikeston, Mo. (Date-of-Planting).

Year	Hybrid	Planting Date					
		April 1	April 20	May 10	June 1	June 20	Mean
1960	Ia 4376	86.1	86.4	86.1	84.8	83.3	85.4
	Ia 4570	85.1	85.9	85.7	83.5	81.2	84.3
	Kan 1639	81.8	85.2	83.5	81.1	78.4	82.0
	US 13	85.2	86.1	86.5	84.4	82.3	84.9
	US 523W	84.3	84.6	85.3	82.5	80.2	83.4
	Mo 804	84.9	83.3	84.1	81.7	79.5	82.7
	Dixie 22	84.8	84.5	83.5	82.0	79.2	82.8
	Dixie 33	87.0	86.4	86.3	84.9	82.4	85.4
	Average	84.9	85.3	85.1	83.2	80.8	83.9
1961	Ia 4376	83.9	83.8	84.3	82.3	78.9	82.7
	Ia 4570	83.9	84.0	84.2	84.4	81.4	83.6
	Kan 1639	80.0	82.5	80.9	87.7	73.6	79.0
	US 13	83.7	84.9	83.0	81.6	79.7	82.6
	US 523W	83.1	84.1	80.9	81.0	78.0	81.4
	Mo 804	82.3	82.9	80.7	79.8	76.4	80.4
	Dixie 22	80.6	83.3	80.3	74.6	75.2	79.8
	Dixie 33	85.4	87.2	80.8	82.7	79.6	83.2
	Average	82.9	84.2	82.0	81.2	77.9	81.6
1962	Ia 4376	82.7	81.2	82.9	80.2	77.7	80.9
	Ia 4570	82.9	81.2	82.6	78.7	76.0	80.3
	Kan 1639	79.1	80.0	78.9	77.0	75.9	78.2
	US 13	84.3	82.4	84.2	81.2	77.9	82.0
	US 523W	80.9	81.4	81.4	79.8	78.9	80.5
	Mo 804	81.6	81.1	82.4	79.1	78.3	80.5
	Dixie 22	82.3	82.2	81.7	80.6	77.7	80.9
	Dixie 33	85.2	85.6	83.1	80.5	79.5	82.8
	Average	82.4	81.9	82.2	79.7	77.7	80.8
1963	Ia 4376	83.0	83.4	82.5	81.0	67.3	79.4
	Ia 4570	82.9	83.3	82.9	79.5	64.5	78.6
	Kan 1637	77.6	80.2	78.6	76.0	66.7	75.8
	US 13	81.3	82.9	82.5	79.5	67.9	78.8
	US 523W	81.7	80.5	81.0	79.5	73.1	79.2
	Mo 804	82.2	81.4	79.4	74.6	70.6	77.7
	Dixie 22	80.4	80.8	80.7	76.4	72.7	78.2
	Dixie 33	82.8	83.1	82.2	79.0	73.1	80.1
	Average	81.5	82.0	81.2	78.2	69.5	78.5
1964	Ia 4376	82.6	81.2	81.5	77.1	72.5	79.0
	Ia 4570	81.0	82.3	81.3	76.8	67.9	77.9
	Kan 1637	75.5	76.6	78.5	72.5	70.1	74.6
	US 13	78.9	81.2	79.7	71.0	68.2	75.8
	US 523W	79.7	79.8	78.8	78.0	71.4	77.6
	Mo 804	78.7	80.1	79.7	71.9	71.4	76.4
	Dixie 22	78.9	79.2	79.6	76.8	72.3	77.4
	Dixie 33	81.7	81.2	79.5	76.5	69.0	77.6
	Average	79.6	80.2	79.8	75.1	70.4	77.0

Appendix IV. Shelling percent as influenced by various factors, Spickard, Mo. (Pop.-Spac.-Hybrid).

			Population				
Year	Hybrid	Spacing (in.)	12M	16M	20M	24M	Mean
1966	Pioneer 3306	20	84.1	84.1	82.8	82.2	83.3
		30	83.1	83.5	83.9	82.8	83.3
		40	83.0	82.1	84.6	82.8	83.1
	MFA 2222	20	82.4	82.4	83.4	82.4	82.7
		30	81.2	81.9	82.1	81.4	81.7
		40	81.5	82.0	82.9	81.9	82.1
	DeKalb XL65A	20	83.0	83.5	85.1	85.4	84.3
		30	85.1	84.5	85.3	85.3	85.1
		40	84.6	85.3	84.5	84.3	84.7
	Average		83.1	83.3	83.8	83.2	83.4
1967	Pioneer 3306	20	82.5	82.6	83.3	83.6	83.0
		30	83.3	83.2	84.1	83.9	83.6
		40	83.3	83.6	83.8	83.8	83.6
	MFA 2222	20	80.2	79.9	81.8	81.2	80.8
		30	79.9	81.2	81.9	81.7	81.2
		40	82.1	81.8	81.2	82.2	81.8
	DeKalb XL65A	20	82.8	83.5	84.1	83.7	83.5
		30	83.5	84.0	84.2	84.1	84.0
		40	84.2	84.4	84.2	83.8	84.2
	Average		82.4	82.7	83.1	83.1	82.8
1968	Pioneer	20	81.7	82.4	82.0	82.7	82.2
		30	82.4	81.7	82.2	81.9	82.1
		40	82.4	82.7	82.2	82.2	82.4
	MFA 2222	20	80.7	81.2	81.4	82.4	81.4
		30	82.2	81.6	82.1	83.0	82.1
		40	82.0	82.6	82.4	82.3	82.3
	DeKalb XL65A	20	85.1	85.4	85.4	86.3	85.6
		30	85.3	84.8	86.0	85.1	85.3
		40	85.0	85.0	85.6	85.9	85.4
	Average		82.9	83.0	83.2	83.5	83.2

Appendix V. Shelling percent as affected by various factors, Columbia, Missouri. (Pop.-Hybrid-Spac.).

Year	Hybrid	Spacing	Population				
		(in.)	12M	16M	20M	24M	Mean
1966	Pioneer 3306	20	83.8	83.8	82.8	83.5	83.4
		30	81.8	83.0	83.4	83.2	82.8
		40	83.0	82.5	82.6	82.8	82.7
	MFA 2222	20	81.4	81.2	81.7	82.4	81.6
		30	81.1	81.8	81.8	81.8	81.6
		40	81.4	82.0	81.0	81.8	81.6
	DeKalb XL65A	20	83.5	82.6	83.1	84.8	83.5
		30	83.6	83.3	83.8	81.8	83.1
		40	83.6	84.2	84.8	83.6	84.0
	Average		82.6	82.7	82.8	82.8	82.7
1967	Pioneer 3306	20	84.8	83.2	85.6	85.2	84.7
		30	84.3	83.9	83.4	83.0	83.6
		40	83.6	84.5	83.3	82.9	83.6
	MFA 2222	20	81.0	82.4	84.2	85.0	83.1
		30	81.8	83.6	81.4	83.0	82.4
		40	81.8	82.0	83.3	83.6	82.6
	DeKalb XL65A	20	84.8	84.2	87.6	86.1	85.6
		30	84.7	82.8	86.2	86.2	85.0
		40	84.8	85.3	86.2	86.6	85.7
	Average		83.5	83.6	84.5	84.6	84.0
1968	Pioneer 3306	20	83.4	83.9	84.2	84.6	84.0
		30	83.9	84.4	85.0	85.4	84.6
		40	85.1	84.6	85.3	85.6	85.2
	MFA 2222	20	81.6	81.6	82.3	82.4	82.0
		30	82.1	82.2	82.6	83.1	82.5
		40	82.2	82.4	82.8	83.2	82.6
	DeKalb XL65A	20	86.2	86.3	86.0	87.1	86.4
		30	86.8	86.4	87.2	87.0	86.8
		40	86.4	86.8	87.3	87.2	86.9
	Average		84.2	84.3	84.7	85.0	84.6

Appendix VI. Shelling percent as affected by various factors, Mt. Vernon, Mo. (Pop.-Spac.-Hybrid).

Year	Hybrid	Spacing (in.)	Population 12M	16M	20M	24M	Mean
1966	Pioneer 3306	20	82.6	83.2	81.6	80.2	81.9
		30	82.3	81.6	83.2	82.8	82.4
		40	82.2	82.2	82.6	82.3	82.3
	MFA 2222	20	79.3	80.6	80.5	81.0	80.4
		30	81.0	81.0	80.3	81.5	81.0
		40	79.8	80.6	81.0	81.6	80.8
	DeKalb XL65A	20	83.0	83.5	83.6	84.8	83.7
		30	83.5	83.2	83.2	84.3	83.6
		40	83.5	83.0	83.5	84.3	83.6
	Average		81.9	82.1	82.1	82.5	82.2
1967	Pioneer 3306	20	82.1	83.8	83.2	83.6	83.2
		30	83.3	83.6	84.2	83.6	83.6
		40	83.7	84.2	83.9	84.2	84.0
	MFA 2222	20	80.1	81.4	79.8	81.2	80.6
		30	80.6	80.9	82.5	81.6	81.4
		40	81.4	81.1	81.4	81.2	81.2
	DeKalb XL65A	20	84.8	85.4	85.4	85.2	85.2
		30	84.6	84.3	85.3	85.6	85.0
		40	85.1	85.2	85.4	85.6	85.3
	Average		82.8	83.3	83.4	83.5	83.3

Appendix VII. Shelling percent as affected by various factors, Portageville, Mo. (Pop.-Hybrid-Spac.).

Year	Hybrid	Spacing (in.)	Population 12M	16M	20M	24M	Mean
1966	Pioneer 3306	20	79.0	79.5	80.0	77.6	79.0
		30	78.8	80.5	81.1	79.0	79.8
		40	79.5	81.8	80.8	78.5	80.2
	MFA 2222	20	78.1	75.5	75.8	76.6	76.5
		30	77.3	78.6	74.0	78.3	77.5
		40	77.5	78.3	80.5	77.1	78.4
	DeKalb XL65A	20	76.8	79.8	81.6	78.8	79.2
		30	78.6	81.6	80.5	81.8	80.6
		40	80.6	80.3	75.8	83.1	80.0
	Average		78.5	79.6	78.9	79.0	79.0
1967	Pioneer 3306	20	83.1	82.5	81.1	80.8	81.8
		30	81.9	82.6	82.9	82.6	82.5
		40	82.4	82.9	83.3	83.0	82.9
	MFA 2222	20	78.5	79.9	80.3	81.1	80.0
		30	79.9	81.4	81.3	81.1	80.9
		40	80.3	81.1	81.1	81.9	81.1
	DeKalb XL65A	20	82.7	82.3	83.2	84.2	83.1
		30	83.2	83.4	84.7	84.4	83.9
		40	83.3	84.3	84.6	84.7	84.2
	Average		81.9	82.2	82.5	82.6	82.3
1968	Pioneer 3306	20	78.9	80.3	77.7	80.3	79.3
		30	78.7	79.5	78.9	79.5	79.2
		40	79.7	79.0	79.9	80.0	79.7
	MFA 2222	20	77.3	77.8	78.2	77.8	77.8
		30	78.1	78.2	78.2	78.7	78.3
		40	79.6	78.6	77.7	78.2	78.5
	DeKalb XL65A	20	83.7	82.2	83.1	82.8	83.0
		30	83.2	82.9	82.5	82.4	82.8
		40	81.4	83.2	83.3	83.6	82.9
	Average		80.1	80.2	80.0	80.4	80.2