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Mechanical Harvesting of Corn

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Preface

Texas farmers annually plant from 4½ to 5 million acres of corn, from which they harvest about 77 million bushels valued at about $84 million. Most of the corn produced in Texas is harvested by hand. There were approximately 800 corn-picking machines of all types used in Texas in 1947.

Texas farmers grow different types of corn to those grown in the Corn Belt and they prefer to leave the husk on the ears, while the Northern farmer uses a husker to remove the husk. The average yield of corn for Texas is 15.6 bushels per acre, while the average yield in the four Corn Belt states of Ohio, Indiana, Illinois and Iowa was 47.2 bushels for the 5-year period 1943-47. These differences in types, yields and harvesting methods justified experiments to determine the effects of plant characteristics and date of harvest on the machine efficiency and field losses.

Results of experiments conducted from 1943 through 1947 on the mechanical harvesting of two hybrids and two open-pollinated varieties of corn at three different dates are reported in this bulletin.

These studies show that the conventional mechanical corn picker is adaptable for harvesting types of corn grown in Texas if the harvest is made as soon as the moisture in the corn is low enough to permit storage and the machine is properly operated. Some leaves and many stalks will still be green when the corn is ready to harvest.

It appears from these studies that the most outstanding plant characteristic that affects the machine efficiency and the field losses is the percentage of lodged or down stalks. As this percentage increases, the machine efficiency decreases. Also, as the percentage of down stalks increases, the field loss of ear corn increases.

Another important factor that affects the machine efficiency and field losses is the date of harvest. As the harvest is delayed, the machine efficiency decreases; the down stalks increase and the field losses of ear corn increase. Shelled corn losses did not increase when harvest was delayed for 2 months.

The general average machine efficiency in August for all tests was 97.1 percent; the ear corn loss averaged 1.9 percent and the shelled corn loss averaged 1.0 percent.

The general average machine efficiency in September was 92.4 percent; the ear corn loss was 6.4 percent and the shelled corn loss was 1.2 percent.

The general average machine efficiency in October was 87.1 percent; the ear corn loss was 11.8 percent and the shelled corn loss was 1.1 percent.

The condition of the husk on the ear, whether loose or tight, materially influences the percentage of ears totally husked by the machine. The percentage of husked ears is greater where the husk on the ear is light and loose. It is less where the husk is heavy and tight.

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Mechanical Harvesting of Corn

H. P. SMITH, Professor, and J. W. SORENSON, JR., Associate Professor, Department of Agricultural Engineering

Maize or Indian corn is the oldest food crop known in continental North and South America. When Columbus discovered America 456 years ago, he found in Cuba "a sort of grain they call Maiz which was well tosted, bak'd, dry'd and made into flour" (5). Thus, the civilized nations were introduced to a plant which has since become, from the standpoint of total production, the second most important food plant in the world.

Corn is grown in all Texas areas from Texhoma on the north to South Point on the Rio Grande near Brownsville; from the Sabine on the east to El Paso on the west. Only one other crop—cotton—occupies a larger acreage in Texas. The largest acreages of corn are grown in the Blackland Prairie of Central Texas. Of the 254 counties in Texas, only 11 are listed in the 1948 Texas Almanac as producing no corn.

The average annual corn acreage for the 10-year period 1934-43 was 4,985,000 acres, with an average annual production of 77,427,000 bushels, or an average annual yield of 15.6 bushels per acre. The annual value of the crop fluctuates but it was listed at $83,618,000 in 1946.

Most of the corn produced in Texas is harvested by hand. The U. S. Bureau of Agricultural Economics estimated that there were approximately 800 corn-picking machines of all types in use in Texas in 1947.

Farmers growing corn in the long growing season of the South have always harvested the ears with the husk or shuck on them. The main reason for this practice is the prevailing belief that the husk retards weevil damage. Other factors that may have an influence on the practice are: the corn is thoroughly mature and dry by late August, two or more months before frost, and there is no need to remove the husk to permit drying of the kernels. Cotton is also ready for harvest in August and is given priority over corn. Then, too, corn can remain on the stalks in the field, which might be called "natural storage," until after the cotton crop is harvested.

Texas farmers have been slow in using the corn picker for several reasons: (1) Prior to World War II, a relatively plentiful supply

of low-cost labor was available; (2) hand harvesting could be delayed and the smaller acreages harvested at the convenience of the grower; (3) machines could not be obtained during the war years; (4) it has been the general thought that the commonly grown open-pollinated varieties were not suited to machine harvesting; (5) farmers have the impression that the field losses by machine harvesting are too high, and (6) row spacing was not always suitable for efficient machine performance.

Investigations on the mechanical harvesting of corn were begun in 1942 to determine the harvesting characteristics and performance of the conventional type corn picker operating under Texas climatic and farming practices, and the relation of plant characteristics to mechanical harvesting to reduce field losses in harvesting.

In general, the field results of this study can be divided into three parts: (1) plant characteristics prior to harvest, (2) machine performance and (3) effect of machine on the corn ears.

Review of Literature

According to Shedd (7), a few corn picking machines were sold to farmers in the Corn Belt as early as 1904. Manufacturers began to produce both tractor-drawn and tractor mounted corn pickers about 1928.

Young (10) states that the corn picker does its best work when operated early in the season, when the stalks are still tough and the corn is not readily shelled. Most machine operators try to start their pickers as soon as the corn can be stored with a reasonable degree of safety. Carter (1) concluded that if a mechanical picker-husker is to be used, it should be used as soon as the corn is dry enough to crib. Shedd (8) states that timeliness tests showed a steady increase in losses as the season progressed. Hobson and Wileman (2) concluded that one of the advantages of using a mechanical corn picker was the ability to get the corn out of the field earlier during favorable weather and, therefore, in better condition.

Shedd, *et al.* (9), found that field losses increased as the season advanced, and that 3 years' results indicated that the most favorable period for machine harvesting began as soon as the corn was dry enough to crib. Johnston and Meyers (4) concluded that machine harvesting could be started from a week to 10 days earlier than hand husking.

The Sixth Annual Report on Agricultural Research of the Iowa Corn Research Institute (3) reports the field losses in testing five hybrids and one open-pollinated variety as follows: "On Oct. 16, total losses ranged from 1.37 to 2.68 percent of the yield for the five hybrids, and the loss was 6.35 percent for the open-pollinated variety; on Nov. 30, the total losses were 4.27 to 11.80 percent of the yield for the hybrids, and 16.95 percent for the open-pollinated variety."

Varieties and Hybrids

Two open-pollinated varieties and two hybrids were selected to obtain information on various types of corn popular with Texas farmers. The two open-pollinated varieties chosen were Yellow Dent and White Surcropper, and the two hybrids were Texas 8 and Texas 12.

Yellow Dent produces a medium to large ear with fairly heavy husk and large, well dented kernels. The stalk is of average size, bearing ears three to four feet above the ground (Figure 1).

Surcropper produces fairly large ears with a heavy, tight husk that ordinarily extends and closes well over the top of the ear. The kernels are large, firm, hard and white in color. The size and the height of the ears compare closely with Yellow Dent (Figure 2).

Texas 8 has medium size ears with a medium husk which in most cases does not provide a good coverage over the tip of the ears.

Figure 1. Showing comparative growth between Texas 8 on left and Yellow Dent on right, June 17, 1943, 78 days after planting.

Figure 2. Showing comparative growth of Texas 12 on left and Surcropper on right. June 17, 1943, 78 days after planting.

The kernels are yellow, medium in size and usually firm on the cob. The stalks are fairly stiff and slightly smaller in size than the open-pollinated varieties (Figure 1).

Texas 12 produces fairly small ears on a shank that averages longer than the other varieties. The husk is light and loose, giving poor tip coverage to the ears. The kernels are small, yellow in color and quite firmly attached to the cob. The stalk compares with Texas 8 in size but has a greater tendency to break over and lodge (Figure 2).

Equipment

A conventional Case Model IS two-row pull-type snapper-picker machine was used in making the harvesting tests (Figure 3). The spirally fluted snapping rolls were used without inserting any husking pins in them. The rolls were provided with an adjustment arrangement so that they could be set to run close together or set to run one-fourth to one-half inch apart.

A shield was provided by the manufacturer to be inserted between the housing sections and extend over the upper and outer snapping roll for each row (Figure 4). The purpose of this shield was to deflect the ears and prevent them being caught and pinched by the flights on the snapping rollers.

A change was made in the wagon elevator to save time and labor and to permit the ears to be dropped into a sack. The long

Figure 3. Showing corn picker with long extension wagon elevator in position to convey the harvested corn from the picker to the wagon.

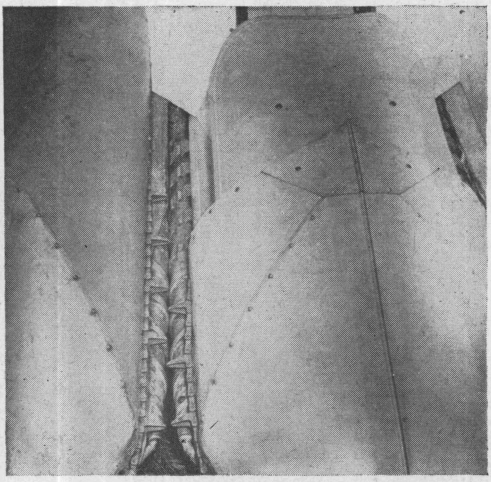

Figure 4. Shields extending over outer snapping rolls were used to prevent the ears from being pinched and to reduce shelled-corn losses.

extension was removed and a special short-hooded end was added to the short section of the wagon elevator which was attached to the machine. A sack-holding attachment was constructed on the end of the hood and a platform mounted on the frame of the picker. Thus, a sack could be attached to the elevator so that the ears dropped into it (Figures 5, 6 and 7). Metal bars attached to the platform extended upward and outward over the tire of the main wheel to hold the sack away from the wheel. The platform supported the weight of the sacked corn. Therefore, the corn was sacked as each test was being made. The sacks were closed with string and tagged for identification. With this arrangement, a series of 64 tests could be harvested, bagged and tagged ready to be transported to the barn in about 3 hours.

The corn picker was pulled by a two-plow-size tractor and operated from the power-take-off.

A Steinlite moisture tester was used to determine the percentages of moisture in the corn before each date of harvest.

The storage samples were placed in wooden bins and sheet iron cans in a small house constructed for use in this study.

Figure 5. Special sacking attachment substituted for extension wagon elevator so that corn could be sacked as harvested. The sack of corn is supported by a small platform.

Plan and Procedure

Four replications with 16-row blocks for each type of corn were used in these tests. Two rows on each side of each block served as guard rows so that lands could be opened around each block before any tests were harvested. Two rows on each side of each block were used as test rows to determine the effect of direction of travel and performance of the machine as may be affected by stalks blown down either with the row or across the row. Therefore, four rows were harvested from each block in August, four rows in September and the last four rows in October. The first two rows harvested off each block were termed the No. 1 tests and the second two rows on the opposite side of the block were termed the No. 2 tests.

Data on the plant characteristics were collected from a sample of 25 plants from each block just prior to the first harvest, which was made during the last two weeks in August.

The percentage of ears showing the presence of or damage by

Figure 6. Showing front and rear views of corn picker in operation and equipped with sacking attachment.

the weevil and the corn ear worm was determined at each date of harvest.

Both the standing and the down or lodged stalks were counted for each two test rows before making each test. Each set of test rows was inspected for any ears that may have fallen on the ground. Such ears were picked up.

The corn picker was then operated over each set of test rows. A stop watch was used to determine the time required to travel the 200 feet which was the length of all test rows. After the harvesting tests were completed, each set of test rows was inspected for ears missed or lost by the machine. These ears were collected, sacked and tagged. They were later shelled and the shelled corn weighed and recorded.

A sample section 20 feet long was marked off and all shelled corn or kernels picked up. This sample was weighed and converted to obtain the loss for the entire 200 feet of the two test rows.

All weights as to losses and yields are shown as shelled corn.

Preharvest Plant Data

Manufacturers of corn harvesting machinery have found that corn growers of the Southwest prefer a machine that snaps the ears from the stalks without removing the husks. They have also

Figure 7. Close-up view of corn picker showing sacking attachment with sack partially filled with corn. Note that a counterbalance weight was necessary to balance the machine over the wheels when the elevator extension was removed.

found that Southwestern corn hybrids and varieties react differently to machine harvesting than those grown in the Corn Belt. Consequently, data on the various plant characteristics were collected to determine, if possible, whether these characteristics have an outstanding influence on the performance of the conventional corn picker, particularly in regard to field losses in the form of ears and shelled corn.

Data were collected on the following plant characteristics and field conditions: (1) the height of the first ear; (2) the diameter of the stalk just below the first ear; (3) the length and diameter of the ear shank; (4) the length and diameter of the ear; (5) the condition of the husk—whether tight or loose; (6) the condition of the kernels on the cob—whether tight or loose; (7) the tip coverage of the ears; (8) the percentage of pendant ears; (9) the percentage of lodged or down stalks; (10) the moisture content of the corn and (11) the growth of grass and weeds.

Height of the first ear. Twenty-five stalks were selected at random and the height of each measured from the ground to the node of the stalk where the ear shank began. Data in Table 1 show that the first ears for Texas 8 and 12 were approximately 35 inches from the ground. The ears on the Yellow Dent and Surcropper stalks were approximately 1 to 2 inches higher, respectively. The data did not indicate that the slight differences in the height of the ears had any significant influence on the performance of the machine in the way of ear and shelled corn losses.

In harvesting the guard rows on the breeding blocks, which were separate from the test blocks, there were some strains that produced stalks 12 to 13 feet in height and bore the ears 6 feet above the ground. When these strains were harvested with the machine, it was necessary to operate the tractor in low gear so the snapping rolls would have time to discharge the extra length and volume of stalk. If the tractor was operated in second gear, the stalks piled up on the machine.

Table 1. Average height of ears, diameter of stalks, length and diameter of ear and shank and number of ears per stalk

Type	Height of Ears, Inches	Diameter of Stalks, Inches	Ear Shank		Ear		No. of Ears per Stalk
			Length, Inches	Diameter, Inches	Length, Inches	Diameter, Inches	
Texas 8	35.0	.76	5.2	.52	6.8	2.1	1.2
Texas 12	35.3	.81	5.6	.53	7.2	2.0	1.3
Surcropper	36.9	.76	4.8	.51	6.8	2.1	1.1
Yellow Dent	36.2	.81	5.2	.59	7.2	2.1	1.0

Diameter of the stalk. Data in Table 1 show that the diameter of Texas 8 and Surcropper stalks averaged .76 inch while Texas 12 and Yellow Dent averaged .81 inch. These differences of .05 inch in the diameter of the stalks for the different varieties did not materially influence the performance of the machine. The data show that the smaller stalks did not lodge or go down as badly as the larger stalks (Table 4).

Length and diameter of the ear shank. The data in Table 1 show that the ear shank was longest for Texas 12, 5.6 inches, and shortest for Surcropper, 4.8 inches. The diameter of the ear shank was smallest for Surcropper, .51 inch and largest for Yellow Dent, .59 inch. The data did not show that these characters had much influence on the performance of the machine.

Length and diameter of the ear. Data are also given in Table 1 on the average length and diameter of the ears for the types of corn studied. The length of the ears for Texas 12 and Yellow Dent averaged slightly longer than those for Texas 8 and Surcropper. Texas 12 has the smallest ears. A careful study of Tables 1 and 12 indicates that the size of the ear may have some influence on shelled corn losses. Texas 12, with the smallest ears, gave slightly higher losses in bushels per acre than the other varieties. It was observed that the corrugations or flights of the snapping rolls had a tendency to pinch and crush more small ears than large ears. The machine appeared to shell corn from more of the butts and tips of the small ears than it did from the larger ears (Figure 17). This is indicated in Table 12, which shows data on the percentages of partially shelled corn.

Table 2 shows that the percentage of ears which were "nubbins" was slightly higher for Surcropper and Yellow Dent than for Texas 8 and 12.

The data do not show that there was much difference in loss of grain due to size of ear.

Table 2. Average percentage of nubbins in the total number of ears harvested at three dates—1943, 1946 and 1947

Type	August	September	October	Gen. ave.
Texas 8	24.0	26.1	26.6	25.6
Texas 12	25.2	24.9	25.2	25.1
Surcropper	29.4	25.8	26.5	27.2
Yellow Dent	34.1	29.9	30.1	31.3

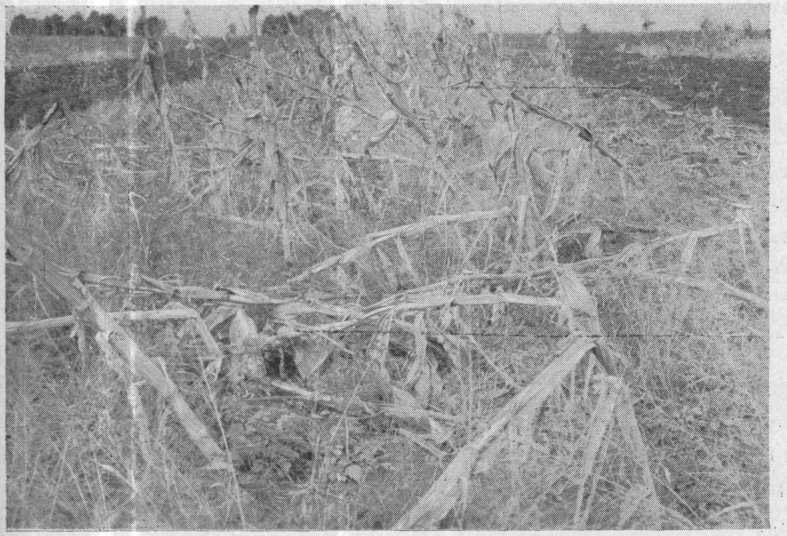

Figure 8. Showing how stalks of Texas 12 had fallen down and lodged in late October 1943.

Condition of the husk. Before making the first harvest in August, the ears on the 25-stalk sample were examined and the condition of the husk was graded as "loose," "medium loose" and "tight." The data in Table 3 show that the husk on the ears of Texas 8 and 12 averaged loose 87 and 92 percent, respectively, while those on Surcropper and Yellow Dent averaged loose on only 22 and 24 percent, respectively. This is a wide range between the open-pollinated varieties and the hybrids. Only 4 percent of the ears of Texas 12 were classed as tight, whereas, Texas 8 was slightly higher with 13 percent. Surcropper and Yellow Dent had 63 and 64 percent tight husk ears, respectively.

Table 3. Average percentage of pendant ears, condition of husk and kernels and the tip coverage of the ears

Type	Pendant ears, percent	Condition of husk on ears			Condition of kernels			Tip coverage of husk on ears		
		Loose	Medium loose	Tight	Loose	Medium loose	Firm	Good	Medium	Poor
Texas 8	50	87	6	13	7	1	92	33	20	47
Texas 12	50	92	4	4	1	0	99	22	17	61
Surcropper	40	22	15	63	4	0	96	64	12	24
Yellow Dent	40	24	12	64	8	0	92	60	12	28

Table 4. Average percentage of stalks lodged or down at three dates of harvest—1943, 1946 and 1947

Type	Number 1 tests				Number 2 tests			
	August	September	October	Gen. ave.	August	September	October	Gen. ave.
Texas 8.....	8.9	15.9	46.1	23.6	11.5	20.3	48.9	26.9
Texas 12.....	10.9	25.5	59.4	31.9	13.4	28.2	57.0	32.9
Surcropper.....	11.3	22.7	53.0	29.0	11.3	27.2	52.7	30.4
Yellow Dent....	17.3	33.8	55.6	35.6	19.8	37.2	57.0	38.0

In harvesting with the machine, it was observed that a high percentage of the ears for Texas 12 were "slip shucked" as they were snapped from the stalk. This is reflected in the data in Table 11 which show the percentage of totally and partially husked ears in a 100-pound sample. The Surcropper variety has a tight, heavy husk and the data show that less ears were totally and partially husked by the machine than was the case for the other three types. These factors are shown in Table 13, which gives the percentage of husks in relation to the percentage of shelled corn and cobs.

Condition of the kernels on the cob. Data in table 3 show that 99 percent of the ears for Texas 12 had firm kernels on the cob. Texas 8 and Yellow Dent had the highest percentage of ears where

Figure 9. Showing how the stalks of Yellow Dent had fallen down and lodged by October 29, 1945.

the kernels were classed as loose, 7 and 8 percent, respectively, Surcropper had only 4 percent of the ears where the kernels were loose on the cob. It is seen in Table 12 that the general average percentage of partially shelled ears was low for Surcropper, 8.0 percent, and high for Yellow Dent, 13.4 percent. Texas 8, which had 7 percent of the ears with loose kernels, averaged 10.2 percent of the ears partially shelled. This shelling was mostly from the tips and butts of the ears (Figure 17). Texas 12 had firm kernels on 99 percent of the ears but the ears were small, and 12.9 percent of the ears were partially shelled.

Tip coverage of the ears. Table 3 shows that the percentage of ears having good tip coverage was low for Texas 8 and 12, 33 and 22 percent, respectively. It also shows that 64 percent of the Surcropper ears and 60 percent of the Yellow Dent ears had good tip coverage. On the other hand, 61 percent of the Texas 12 ears had poor tip coverage. Texas 8 had 47 percent of the ears with poor tip coverage, while Surcropper and Yellow Dent had 24 and 28 percent, respectively, with poor tip coverage.

Pendant ears. The theory has been advanced that when a mechanical corn picker is used to harvest corn where the major portion of the ears are pendant, the tips of the ears are more likely to be pinched and kernels shelled off and lost. Data were collected

Figure 10. Showing lodged and down condition of the stalks of Surcropper on October 29, 1945.

Figure 11. Showing how stalks of Surcropper broke off and collected on the machine when harvest was delayed until October.

on the percentage of pendant ears for each of the four types just before the August harvest. Table 3 shows that 50 percent of the ears of the hybrids and 40 percent of the open-pollinated varieties were pendant. Data on the percentage of pendant ears were not obtained for the September and October harvests. It is reasonable to assume, however, that the percentage of pendant ears increased as the ear shank became thoroughly dry and more brittle. The percentage of pendant ears did not appear to affect the performance of the machine.

Lodged and down stalks. The data in Table 4 show the average percentage of stalks that were classed as lodged or down just before each harvest, and for both No. 1 and 2 directions of travel. Texas 8 had the lowest percentage of down stalks for all harvest dates. The percentage of down stalks ranged fairly even for Texas 12, Yellow Dent and Surcropper, with Surcropper lowest of the three. These differences are shown graphically in Figure 13.

The percentage of down stalks increased later in the season. At the August harvest, Texas 8 and 12 and Surcropper had from 10 to 12 percent down stalks while Yellow Dent had approximately 18 percent. These percentages practically doubled at the September

Table 5. Average moisture content of corn at harvest

Type	August	September	October	Gen. ave.
Texas 8	13.0	11.1	10.2	11.4
Texas 12	16.7	11.5	10.1	12.8
Surcropper	13.7	11.4	10.2	11.7
Yellow Dent	15.0	11.7	8.3	12.0

harvest and the average percentage down at the October harvest was practically double that of September. This can be readily seen in Figure 13.

Figures 8, 9 and 10 show typical field condition of the stalks at harvest.

It was observed that more of the Surcropper stalks broke and collected on the center divider and outside gatherers at the October harvest than for either of the other types (Figures 11 and 12). It appears, therefore, that when the Surcropper stalks become thoroughly dry, there is also a tendency for them to break easily at the nodes or joints. This characteristic apparently had some influence on the ear corn loss as this was highest for Surcropper, particularly at the October harvest (Table 9).

The data show that the percentage of down stalks affected the

Figure 12. Stalks of Texas 8 did not break off and collect on the machine, as did Surcropper at the October harvest.

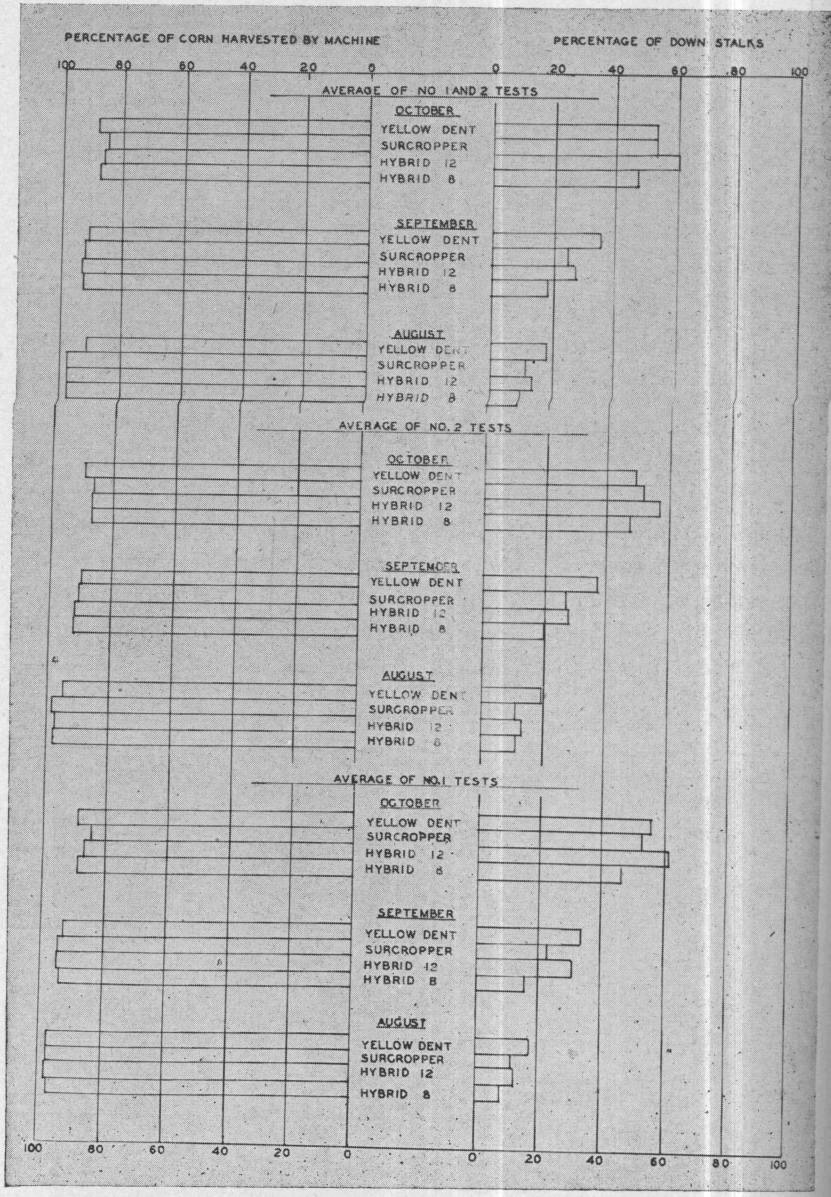

Figure 13. Chart showing relation between the percentage of corn harvested by the corn picker and the percentage of down stalks. Note that as the percentage of down stalks increases for the later dates, the percentage of corn harvested by the machine drops. Hybrids 8 and 12 above are officially Texas 8 and 12, respectively.

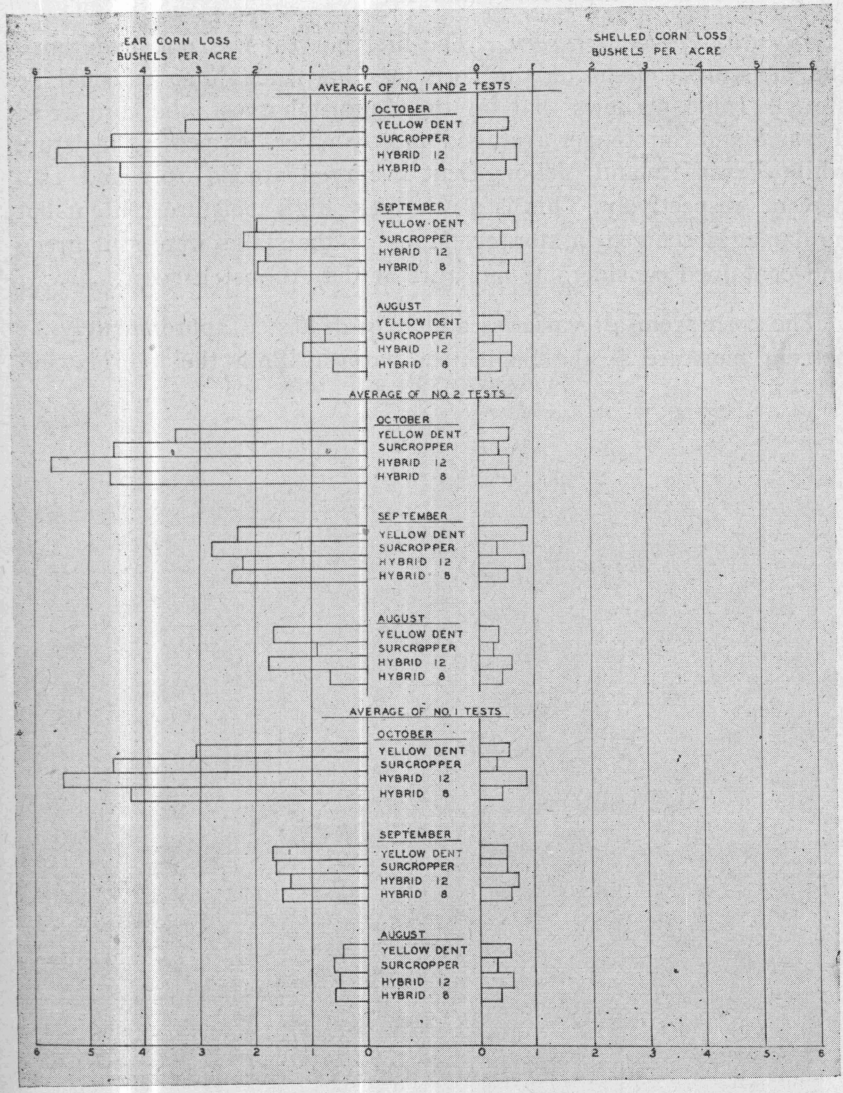

Figure 14. Chart showing bushels of corn lost as ear and shelled corn by the corn picker for four types when harvested at monthly intervals from August to October. Note that the loss of ear corn is in direct relation to the percentage of down stalks shown in Figure 13. Hybrids 8 and 12 above are officially Texas 8 and 12, respectively.

performance of the machine and indicated that this characteristic materially affected the amount of ear corn lost. This relation can be clearly seen in Figures 13 and 14.

Moisture content of corn. The first harvest was not made until the moisture content of the corn was low enough so it could be stored. Table 5 shows that, at the August harvest, the corn from Texas 8 and Surcropper averaged approximately 13 percent moisture while Texas 12 and Yellow Dent averaged around 16.7 and 15.0 percent, respectively. This is a relatively high moisture content but no damage occurred in storage. Many of the stalks were still green and contained considerable moisture at the August harvest.

The corn from all varieties and hybrids tested approximately 11 percent moisture at the September harvest. Both the hybrids and

Figure 15. Above, tall Johnson grass practically hiding the stalks of corn and the man before harvest. Below, the plot after the machine had been used to harvest the corn.

Surcropper tested approximately 10 percent at the October harvest while Yellow Dent tested 8.3 percent.

Grass and weeds. It should be pointed out that grass and weeds mature in September and October. The field in 1943 was practically free of tall grass and large weeds in August, but when the September tests were made the grass was knee-high and Johnson grass and pigweeds waist-high. By October, if Johnson grass was very thick, it was often difficult to follow the rows of corn. These conditions are shown in Figure 15. Some trouble was given by tall Johnson grass wrapping around the snapping rolls. On the whole, it was surprising how well the machine picked the corn from stalks practically hidden by grass and weeds.

Machine Performance

In these studies, the performance or efficiency of the machine was determined by calculating the percentage of the corn that was harvested by the machine. All data shown are on a shelled corn basis.

Rate of travel. A stop watch was used to check the time required to travel the 200 feet used in all the tests. To avoid possible effects of speed, an effort was made in harvesting all the tests to operate the tractor, as nearly as possible, at the same speed. The data in Table 6 show that there were slight variations in the rate of travel for the different types, harvest dates and directions of travel, but the general average rate of travel for all tests was 2.6 miles per hour. It is, therefore, apparent that the rate of travel did not have much effect on the performance of the machine. It can be assumed, however, that high rates of travel will materially increase ear corn losses.

Yield of corn. As the performance of the machine is based on the amount of the corn harvested, the yield data are given in

Table 6. Average rate of travel in miles per hour in harvesting tests

Type	Number 1 tests				Number 2 tests			
	August	September	October	Gen. ave.	August	September	October	Gen. ave.
Texas 8.....	2.6	2.7	2.4	2.6	2.6	2.8	2.3	2.6
Texas 12.....	2.5	2.8	2.4	2.6	2.6	2.8	2.4	2.6
Surcropper.....	2.6	2.7	2.4	2.6	2.6	2.7	2.3	2.6
Yellow Dent....	2.7	2.7	2.3	2.6	2.7	2.7	2.3	2.6

Table 7. Average yield of corn, including that harvested and lost by machine, at three dates—1943, 1946 and 1947*

Type	Number 1 tests							
	August		September		October		Gen. ave.	
	Lbs. per test	Bu. per acre	Lbs. per test	Bu. per acre	Lbs. per test	Bu. per acre	Lbs. per test	Bu. per acre
Texas 8	64.1	37.4	62.3	36.4	66.1	39.1	64.2	37.7
Texas 12	72.4	42.2	69.6	40.6	73.0	43.8	71.7	42.2
Surcropper	66.3	38.7	68.1	39.7	59.4	35.2	64.6	37.9
Yellow Dent	62.7	36.6	63.9	37.2	61.5	36.4	62.7	36.8
	Number 2 tests							
Texas 8	67.1	39.1	63.4	38.1	66.8	39.0	66.4	38.7
Texas 12	71.0	41.4	71.0	41.5	70.8	41.9	70.9	41.6
Surcropper	68.8	40.1	62.4	36.4	63.0	37.5	64.7	38.0
Yellow Dent	62.9	36.7	61.0	35.5	62.5	37.2	62.1	36.5

*Data for 1945 were included in the October date.

Table 7. Texas 12 gave an average yield of approximately 42 bushels per acre for the 3-year period. This was approximately 10 percent above the average yield obtained for Texas 8 and the open-pollinated varieties. Yellow Dent gave the lowest yield with an average of about 36.5 bushels per acre. These yields include both the corn harvested and that lost by the machine. The difference in yield was not enough to have much effect on the efficiency of the machine.

Machine efficiency. The data in Table 8 show the average percentage of corn harvested by the machine for each of the varieties and hybrids when harvested in August, September and October. This is also shown graphically in Figure 13. There is a greater difference in the efficiency of the machine for the different dates of harvest than there is between the types of corn at any one date.

The machine harvested a slightly higher percentage of the corn in the No. 1 tests than the No. 2 tests. This difference in the direction of travel can be attributed largely to stalks being blown across the rows so that they were in position to be run over and mashed down more for the No. 2 tests than for the No. 1 tests. This is particularly true for the October harvest. At the later harvests, when a large

percentage of the stalks were down, it was necessary to swing the hitch so that the inside tractor wheel ran in the second middle from the first row being harvested to prevent the tractor drive wheel from running over stalks leaning across the middle between rows.

It is seen in Table 8 that in August the machine harvested an average of better than 97 percent of the corn for both the hybrids and the varieties in the No. 1 tests, and slightly less than 97 percent for the No. 2 tests. These differences are shown for each of the three dates of harvest.

Table 8. Average percentage of corn harvested by machine at three dates —1943, 1946 and 1947

Type	Number 1 tests				Number 2 tests			
	August	September	October	Gen. ave.	August	September	October	Gen. ave.
Texas 8.....	97.5	94.0	88.4	93.3	97.4	91.6	86.8	92.0
Texas 12.....	97.7	94.4	86.3	92.8	96.8	91.3	86.7	91.6
Surcropper.....	97.3	94.1	84.2	91.9	97.6	90.2	86.0	91.3
Yellow Dent....	97.3	92.8	88.6	92.9	94.9	89.2	89.0	91.0

As may be expected, there was less variation in the efficiency of the machine in harvesting each of the four types of corn in August, when the stalks were in good condition, than in September and October, when the stalks had badly lodged and were dry and brittle (Table 8 and Figure 13). The machine efficiency varied directly with the percentage of down stalks.

Ear corn lost by machine. The data in Table 9 and Figure 14 show the average loss of ear corn in bushels per acre and as percentage of the yield when harvested at monthly intervals from August to October. Both values are given because there may be some who are interested in the bushels per acre lost by the machine, while others may be interested in the percentage of the yield lost.

The data show that the average loss in August was less than 1 bushel and less than 2 percent of the yield. This is true for both directions of travel.

The loss increased in September to slightly less than 2 bushels per acre for the No. 1 tests and to slightly more than 2 bushels per acre for the No. 2 tests. The loss of 2 bushels per acre does not appear to be great, but when expressed in percentage of yield, the loss is more impressive. The loss ranged in September from 4.1 percent for Texas 12 and 6.2 percent for Yellow Dent for the No. 1 tests. The loss was greater for the No. 2 tests and ranged from

Table 9. Average ear corn lost in bushels per acre by machine and percentage of yield at three dates—1943, 1946 and 1947

Type	Number 1 tests							
	August		September		October		Gen. ave.	
	Bu. per acre	Per-cent	Bu. per acre	Per cent	Bu. per acre	Per-cent	Bu. per acre	Per-cent
Texas 8.....	.6	1.6	1.5	4.2	4.2	5.4	2.1	3.7
Texas 12.....	.5	1.1	1.4	4.1	5.4	12.4	2.4	5.9
Surcropper.....	.6	1.9	1.6	5.2	4.6	15.0	2.3	7.4
Yellow Dent....	.4	1.4	1.7	6.2	3.1	10.1	1.7	5.9
	Number 2 tests							
Texas 8.....	.6	1.7	2.4	6.9	4.6	11.9	2.6	6.8
Texas 12.....	1.8	1.9	2.2	6.9	5.7	13.1	3.2	7.3
Surcropper.....	.9	1.9	2.8	9.1	4.6	13.2	2.7	8.0
Yellow Dent....	1.7	4.2	2.3	8.7	3.4	10.5	2.5	7.8

6.9 percent for the two hybrids to 8.7 for Yellow Dent and 9.1 percent for Surcropper. Losses up to 4 percent may be accepted but losses amounting to 8 and 9 percent become excessive.

The losses in bushels per acre for the October harvest increased to 5.4 bushels for Texas 12 for the No. 1 tests, and to 5.7 bushels for the No. 2 tests. When expressed in percentage of the yield, this was 12.4 and 13.1 percent, respectively. For the No. 1 tests, Texas 8 was low with 5.4 percent loss, while Surcropper was high with 15.0 percent loss. For the No. 2 tests, there was not such a wide difference in loss between the types as Yellow Dent was low with 10.5 percent and Surcropper was high with 13.2 percent. These losses are excessive and it would not be profitable to use a corn picker when such high losses are sustained.

Figures 13 and 14 show there is a direct relation between the ear corn loss, the percentage of down stalks and the machine efficiency. That is, as the percentage of down stalks increases, the machine efficiency decreases.

Shelled corn lost by the machine. The corn lost by the machine as shelled corn was the kernels shelled from the ears as they were snapped from the stalk or caught and pinched by the snapping rolls. The data in Table 10, as in Table 9, show the loss in bushels per acre and the percentage of the yield.

Table 10 and Figure 14 show that the shelled corn losses were fairly consistent for both the hybrids and the varieties when harvested in August, September and October. Texas 12, which had the smallest ears and the poorest tip coverage, and Yellow Dent, which had many ears with loose kernels, gave an over-all loss of .7 bushels per acre, or approximately 1.4 percent of the yield. Surcropper, which had larger ears with well covered tips, gave an average loss of about .4 bushels per acre, or .7 percent of the yield. The shelled corn loss for Texas 8 averaged 1.0 percent of the yield.

Careful operation of the machine. The performance or efficiency of the machine and the field losses can be materially affected by careless operation. No machine will give its best performance unless it is carefully and skillfully operated and properly adjusted.

Effect of Date of Harvest

It has been pointed out in the foregoing discussion of machine performance that there were differences in the machine efficiency and the ear corn loss when harvests were made at monthly intervals from August to October. Even so, it should be emphasized that the date at which the harvests were made had a material influence on the machine efficiency and the corn lost by the machine.

Table 10. Average shelled corn lost by machine in bushels per acre and percentage of yields at three dates of harvest—1943, 1946 and 1947

Type	Number 1 tests							
	August		September		October		Gen. ave.	
	Bu. per acre	Per-cent	Bu. per acre	Per-cent	Bu. per acre	Per-cent	Bu. per acre	Per-cent
Texas 8	.4	.9	.5	1.1	.4	1.0	.4	1.0
Texas 12	.6	1.1	.7	1.5	.8	1.4	.7	1.3
Surcropper	.3	.8	.5	.7	.3	.8	.4	.8
Yellow Dent	.5	1.6	.5	1.1	.5	1.2	.5	1.3
	Number 2 tests							
Texas 8	.4	.9	.5	1.0	.6	1.2	.5	1.0
Texas 12	.6	1.2	.9	1.9	.6	1.2	.7	1.4
Surcropper	.2	.5	.3	.7	.3	.8	.3	.6
Yellow Dent	.3	.9	.8	2.1	.5	1.3	.6	1.4

When the corn first becomes dry enough to harvest in August, a higher percentage of the stalks are standing upright, and they have not become dry and brittle (Table 4). Consequently, the machine can harvest a higher percentage of the corn (Table 8 and Figure 13) and the field losses of ear corn are lower (Table 9 and Figure 14).

As the late summer and early fall months are usually dry and hot in the vicinity of College Station, the stalks dry out and become very brittle. They may not be as brittle early in the morning but harvesting cannot be confined to a few hours each morning when there is a large acreage of corn. The stalks soon deterioriate because of these climatic conditions. Some will break and lodge. Many stalks may be partially down due to high winds which accompany rainstorms that occur during the growing season. When stalks are blown down after they have reached three or four feet in height, they never entirely straighten up.

By the middle of September, the stalks have become so dry and brittle that they break easily. If harvest is delayed until October, it can be expected that in most years at least 50 percent of the stalks for most varieties will be lodged or down (Table 4). Where fields are badly infested with Johnson grass, the tall grass creates a problem of keeping the machine lined up with the rows (Figure 15).

Therefore, the data show clearly that to obtain the highest machine efficiency and the lowest field loss of corn, harvesting should be done as soon as the moisture in the kernels is about 14 percent, which is low enough to permit storage.

McCune (6) stated in his thesis on the "Effect of Date of Harvest on the Efficiency of Mechanical Corn Harvesting in Texas," that a comparison of the field losses on successive harvest dates shows a steady increase in the total amount of corn lost from August up to November for each type of corn tested.

Effect of Machine on Corn Ears

A 100-pound sample was taken from each block after harvest and analyzed to determine the effect of the machine on the ears. Data were collected on the number and percentage of ears totally and partially husked and shelled. The husks were removed from the ears and weighed. The ears were shelled and the weights of the shelled corn and the cobs and waste determined. The percentages of shelled corn, husks, cobs and waste were calculated from these weights. The percentage of shelled corn thus obtained, was used to calculate the acre yield on a shelled corn basis.

Table 11. Average percentage of ears totally and partially husked by machine at three dates—1943, 1946 and 1947*

Type	August		September		October		Gen. average	
	Totally	Partially	Totally	Partially	Totally	Partially	Totally	Partially
Texas 8	26.8	8.5	20.6	12.1	20.0	11.2	22.5	10.6
Texas 12	50.1	6.8	35.8	9.6	36.4	10.9	40.8	9.1
Surcropper	19.3	3.9	15.4	7.5	17.5	7.3	17.4	6.2
Yellow Dent	29.0	9.1	21.6	10.8	25.3	11.2	25.3	10.4

*100-pound sample of machine-harvested corn.

Ears totally and partially husked by machine. The data in Table 11 show the average percentage of ears in a 100-pound sample that were totally and partially husked by the machine in the harvesting process. Texas 12 had a high percentage of the ears totally husked for each of the harvests (Figure 16). The general average of totally husked ears for Texas 12 on the three dates, was 40.8 percent. Surcropper gave the lowest percentage of totally husked ears for each harvest, with a general average of 17.5 percent. The general average for the percentage of totally husked ears for Texas 8 and Yellow Dent was 22.5 and 25.3 percent, respectively. An examination of the stalks and the ears after harvest revealed

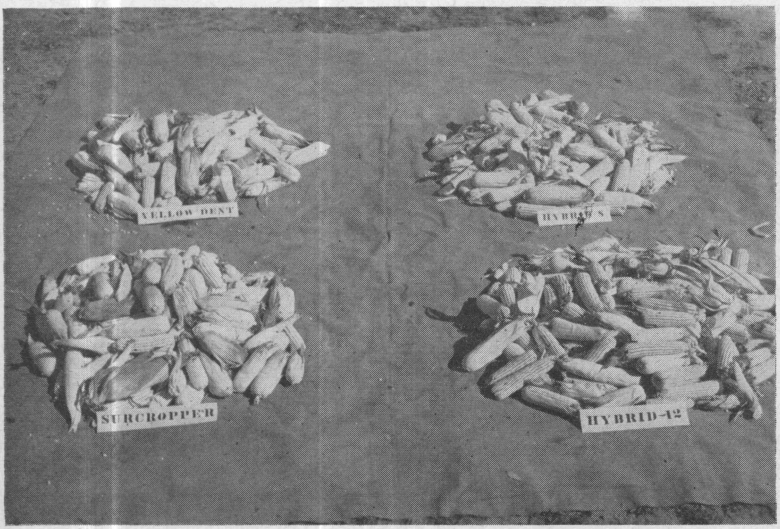

Figure 16. Samples of mechanically harvested corn and amount of husk removed from ears of each of the four types when harvested in September. Note that more ears of Texas 12 are husked than the other three types.

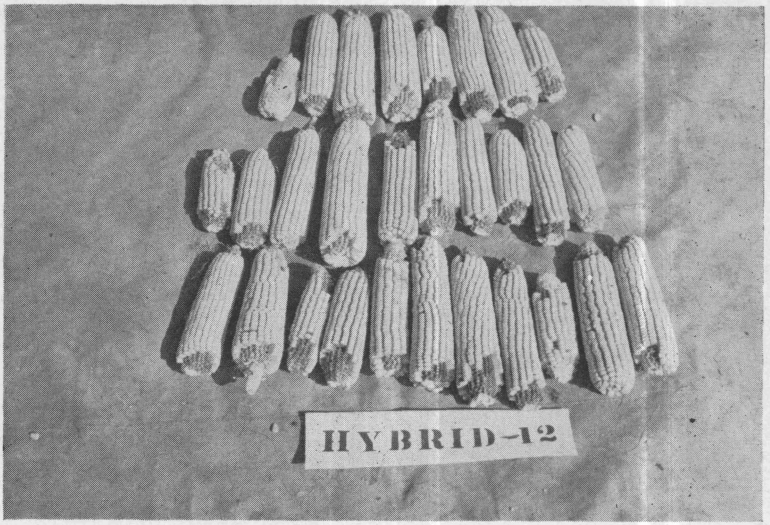

Figure 17. Sample of Texas 12 ears showing how kernels were shelled from the butts and tips of the ears when harvested with the corn picker.

that a high percentage of the ears totally husked were "slip shucked" by the machine. All the husk for the ear remained attached to the stalk. This was particularly true for Texas 12.

The percentage of ears partially husked increased slightly at later harvests. The general average percentage of partially husked ears for Surcropper, Texas 12, Texas 8 and Yellow Dent was 6.2, 9.1, 10.6 and 10.4 percent, respectively.

The removal of the husks by the machine is reflected in the weight of the husks removed by hand from the 100-pound sample (Table 13). Texas 12, which had a high percentage of totally husked ears, had a low amount of husks. Surcropper, with a low percentage of totally husked ears, had the largest amount of husks.

Ears partially shelled by machine. Most of the shelled corn loss resulted from ears being partially shelled (Table 12). Very seldom was an ear completely shelled by the snapping rolls. Most of the kernels of shelled corn found on the ground after using the corn picker were from the butts and tips of the ears, as shown in Figure 17. Occasionally an ear resting momentarily on the snapping rolls had kernels shelled from one side but the ear fell into the conveyor before it was completely shelled.

The percentage of ears partially shelled followed about the same pattern for both the hybrids and the varieties as the percentage

Table 12. Average percentage of ears partially shelled by machine at three dates—1943, 1946 and 1947*

Type	August	September	October	Gen. ave.
Texas 8	6.4	11.7	12.6	10.2
Texas 12	11.3	12.5	14.0	12.9
Surcropper	5.5	9.3	9.1	8.0
Yellow Dent	10.7	12.4	17.0	13.4

*100-pound sample of machine-harvested corn.

of totally husked ears. That is, Texas 12 with its small ears, light, loose husk gave a high percentage of partially shelled ears as it did totally husked ears (Tables 11 and 12).

The percentage of partially shelled ears increased 1 or 2 percent at later harvest. For August, September and October, the average partially shelled ears for Texas 12 was 11.3, 12.5 and 14.0 percent, respectively.

The Surcropper variety produces an ear larger in diameter than is produced by Texas 12 (Table 1). Surcropper also has a thick, heavy husk. This variety had the lowest percentage of ears partially shelled. The average percentage of partially shelled ears for the three harvests for Surcropper was 5.5, 9.3 and 9.1 percent, respectively

Yellow Dent, which had loose kernels on 8 percent of the ears (Table 3), gave the highest general average percentage of partially shelled ears, 13.4. Texas 8 had a general average of 10.2 percent.

Percent of shelled corn, husks and cobs. It was found in the four types of corn used in these studies that the average percentage of shelled corn in unhusked machine harvested ear corn was 77.3, 78.5, 74.0 and 75.4, respectively, for Texas 8, Texas 12, Surcropper and Yellow Dent (Table 13). Texas 12 gave the highest percentage of shelled corn and had the highest percentage of totally husked ears. Table 13 shows only 4.2 percent of husks in the total sample.

Table 13. Average percentage of shelled corn, husks, cobs and waste

Type	Shelled corn, Percent	Husks, Percent	Cobs and waste, Percent
Texas 8	77.3	5.6	17.1
Texas 12	78.5	4.2	17.3
Surcropper	74.0	8.8	17.2
Yellow Dent	75.4	6.6	18.0

On the other hand, Surcropper shows a low of 74.0 percent shelled corn and a high of 8.8 percent husks in the sample. Texas 8 had 77.3 percent shelled corn and 5.6 percent husks. Yellow Dent had 75.4 shelled corn and 6.6 percent husks.

The percentage of cobs in the samples for the hybrids and the varieties varied less than 1 percent.

Therefore, the effect of the machine on the removal of the husks and the partial shelling of the ears will definitely affect the percentage of shelled corn (Table 13).

Use of the Husker and Sheller Attachments

Husking and shelling attachments are not generally used on corn pickers when harvesting corn in Texas. Most farmers prefer to leave the husk on the ears as they feel it offers some protection against weevil damage. Then, too, there is a market demand for a limited quantity of husks for domestic uses.

Sheller attachments are not used as most of the corn is marketed by the grower as ear corn.

Husker attachment. A husker attachment was used to a limited extent in these studies to determine the ability of the attachment to husk varieties of corn commonly grown in Texas. The picker-

Figure 18. Rear view of corn picker equipped with husking attachment.

husker combination (Figure 18) was used to harvest the guard rows on the corn breeding blocks and several acres of production corn which were separate from the test blocks. It was observed that

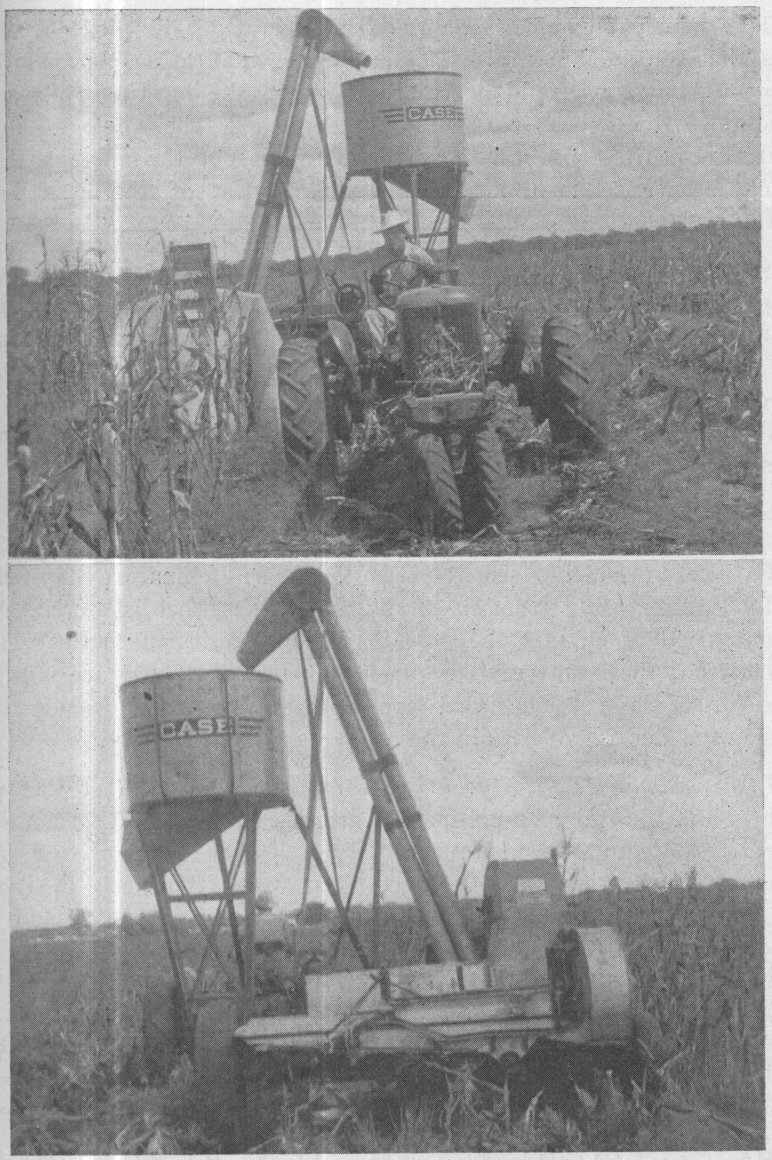

Figure 19. Front and rear views of corn picker equipped with sheller attachment. After the corn is snapped from the stalks, it passes through the sheller and is shelled and the shelled corn is elevated to the grain tank. The husks and cobs are dropped on the ground.

varieties and strains having a light, loose husk had a small percentage of ears that were not well husked. Varieties and strains having a tight, heavy husk were poorly husked by the machine. Husking pins were used in all the husking rolls.

The principal trouble encountered in operating the picker-husker was that long, empty husks, extending several inches beyond the short nubbin ear, would be caught between the husking rolls and feed down to the ear part and jam and choke the whole husking unit. Frequent stops had to be made to cut out the nubbins. The machine operated without trouble where most of the ears were well developed.

Sheller attachment. The picker-sheller combination (Figure 19) was used in 1944 to pick and shell several acres of corn where many of the ears were not thoroughly dry. Many such ears passed through the sheller without being completely shelled. The picker-sheller was used to harvest a field of corn where all the ears were completely dry. Under these conditions, no ears passed out without being shelled.

Insect Damage in Field and Storage

Farmers producing corn under Southern climatic conditions suffer severe losses from insect damage when corn is stored. An examination of ears in the field at various stages of maturity revealed that the corn weevil is often found in ears that are still in the "milk stage." The corn ear worm also causes considerable damage to the tips of ears in the early stages of maturity.

Insect damage in the field. A sample of 100 ears for the two hybrid and the two open-pollinated varieties were carefully examined during 1946 and 1947 at each harvest for the presence of and damage by the corn weevil and corn ear worm. The data in Table 14 show for the August harvest that Texas 8 and 12 had 29 and 37

Table 14. Average percentage of ears infested with weevil at different dates of harvest and ears showing damage by ear worm

Type	Ears infested with weevils in field									Ears showing damage by ear worm		
	August			September			October					
	1946	1947	Ave.	1946	1947	Ave.	1946	1947	Ave.	1946	1947	Ave.
Texas 8	29	10	20	78	43	60	79	34	56	46	86	66
Texas 12	37	6	22	85	41	63	83	35	59	35	95	65
Surcropper	6	3	4	33	7	20	47	11	29	44	76	60
Yellow Dent	.....	4	.....	.....	13	.....	.....	11	.....	.....	89	.....

percent, respectively, of the ears infested with weevils. Only 6 percent of the Surcropper ears were infested. Because of poor stands, Yellow Dent was not included in the tests in 1946. The percentage of the ears infested with weevils in August 1947 was low for each of the hybrids and the varieties (Table 14).

In August 1946, Texas 8 and 12 had 46 and 35 percent, respectively, of the ears damaged by the corn ear worm while Surcropper had 44 percent.

The data in Table 14 show that in September 1946, Texas 8 and 12 had 78 and 85 percent, respectively, of the ears infested with weevils. These percentages did not materially change by October. Surcropper had only 33 percent of the ears infested in September. This increased to 47 percent by October. The percentage of ears infested by weevils in 1947 was not as high as in 1946.

The percentage of ears damaged by the corn ear worm was higher in 1947 than in 1946 (Table 14). The damage was less for Surcropper, 76 percent, than for Texas 8 and 12 which had 86 and 93 percent damaged ears, respectively.

Thus, it is seen from these data that both weevil infestation and corn ear worm damage varies from year to year and with the type of corn. These data indicate that a good tip coverage of the ear has a retarding effect on both the weevil and the corn ear worm, as Surcropper, which had a high percentage of the ears with a good tip coverage (Table 3), had the lowest percentage of ears infested with weevils and ear worms.

It should be emphasized that corn should be harvested early, stored and treated to prevent further damage from insects.

Insect damage in storage. Samples of the machine harvested ear corn of each type were stored in open bins for observation on weevil damage. Samples of shelled corn were stored in open cans for observation on insect damage.

An examination in the spring of the stored ear and shelled corn revealed that weevil damage was much higher for the hybrids than for the open-pollinated varieties. Little difference could be found in the amount of weevil damage when the husked and unhusked ears were examined. It was observed, however, that the weevils generally began working near the butt of the ear and progressed toward the tip.

When ear corn is stored in bins under Texas climatic conditions, a high percentage of the ears will be completely eaten up by March

or April of the following spring. It should, therefore, be placed in tight bins so that it can be treated soon after storage to kill the weevils and protect the corn.

Texas corn growers store very little shelled corn. Seed breeders, however, shell their seed corn as soon after harvest as possible, then store it in bags and treat the lot for protection.

When shelled corn was stored in open cans, weevils did not become very active until March. The cool temperature of the winter months retarded their activity. In 1946, the cans of shelled corn were checked in early April. It was found that weevil activity was causing the corn to heat. Checks showed that the temperature of the Texas 12 can of shelled corn rose approximately 10 percent. Texas 8 rose about 8 percent. Surcropper and Yellow Dent rose only about 2 or 3 percent.

The corn stored in November 1946 showed very little weevil activity by April 1947. March remained cool with temperatures below normal and this probably retarded weevil activity.

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Summary

Studies were made from 1943 to 1947 on the harvesting characteristics at three different dates of two hybrids and two open-pollinated varieties of corn. The corn was grown on the Yahola Clay and Miller sandy loams soils of the Brazos River Valley near College Station. The corn was planted with conventional two-row tractor-mounted planters. It was harvested with a conventional two-row pull-type snapper-picker mounted on pneumatic rubber tires.

The two hybrids and two varieties of corn were planted in 16 randomized 16-row blocks and replicated 4 times. In each block there were 4 guard rows and 4 rows for each of the 3 dates of harvest.

The harvests were made the latter parts of August, September and October.

The most outstanding plant characteristic that influenced machine efficiency and ear and shelled corn losses was the lodging, dryness and brittleness of the stalks.

The average percentage of lodged or down stalks for all types increased with later harvest dates. The average percentage of down stalks in August, September and October was 12.1, 24.5 and 54.5 percent, respectively.

The machine efficiency decreased as the season advanced. The machine efficiency for the August harvest was 97.1 percent, for the September harvest, 92.4 percent, and for the October harvest 87.1 percent.

The average percentage of ear corn lost by the machine increased as the season advanced. The loss ranged from approximately 1.9 percent in August to 11.4 percent in October.

The average percentage of shelled corn loss for both the hybrids and varieties and for all tests did not increase as the season advanced. The loss was approximately 1.0 percent for all three dates of harvest.

There appears to be a direct relation between the machine efficiency on one hand and the ear corn loss and the percentage of lodged and down stalks on the other.

There was less variation or differences in the efficiency of the machine in harvesting each of the four types of corn in August, when the stalks were in good condition, than in September and October, when the stalks had lodged badly and were dry and brittle.

Stalks of the Surcropper variety broke off and collected on the machine at the October harvest.

The percentage of totally husked ears varied more between types of corn than dates of harvest. Texas 12, which has a light, loose husk, had a general average of 40.8 percent totally husked ears, while Surcropper, which has a heavy, tight husk, had only 17.4 percent of the ears totally husked by the machine.

Texas 12, with its small ears and light, loose husk, and Yellow Dent, with many ears having loose kernels, gave the highest percentage of partially shelled ears. Surcropper, which has a heavy, tight husk, had the lowest percentage of partially shelled ears.

The percentage of shelled corn obtained from machine harvested ear corn varied between types of corn in direct relation to the percentage of totally husked and partially shelled ears. Texas 12 was high while Surcropper was low.

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