

THE EFFECT OF VARIETY, LOCATION, AND RATE OF PLANTING
ON PROTEIN, OIL, AND ASH CONTENT OF CORN GRAIN

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INTRODUCTION

Corn is the grain crop with the largest planted acreage, the largest bushel production, and the greatest farm value in the United States according to Curtis and Earle (7)^{1/}. Over 3 billion bushels of corn are produced annually in the United States of which 88% is used on the farm as food, feed, and seed. Corn has been a major grain crop since its discovery by early white explorers and since that time there has been considerable improvement in quality, yield, disease resistance, lodging resistance, and other agronomic characters through selection and plant breeding. The chemical content of the corn plant was first studied by Hornberger in Germany in 1882 according to Hopper (18) and it was not until 1896 that selection for chemical content of corn grain was started by the Illinois Agricultural Experiment Station (19, 39). Strains were selected for high and low protein content and high and low oil content.

Chemical analysis of corn grain has been expanded since 1896 to include the content of the common mineral elements. Amino acids, vitamins, and other organic compounds utilized in the nutrition of man and animals have also been studied. This work has been expanded to include the effects of environmental and hereditary factors on the chemical content of the corn grain and plant. Some of the factors studied include soil fertility, available moisture, seasonal conditions, cultural practices, maturity, variety, and storage. Since it is evident that these factors are closely related and the effects produced are influenced by the combination and interaction of several factors, the analy-

^{1/} Figures in parenthesis refer to "Literature Cited", p. 29.

sis of one specific effect is almost impossible.

Although chemical analyses will give the total protein, oil, and ash present, they do not give the biological or nutritional value. These must be determined by complex feeding experiments or by biological analyses in the laboratory. According to Mitchell and Villegas (24) only 58% of the total corn protein is of biological value in nutrition.

Although considerable work has been done in other states on the chemical content of corn grain as affected by environmental conditions there is a need for data regarding the chemical content under Oklahoma conditions. The primary objectives of these investigations were to determine the effect of variety, location, and rate of planting on protein, oil, and ash content of corn grain.

REVIEW OF LITERATURE

Composition of the Corn Kernel

The most extensive bibliography of researches bearing on the composition and nutritive value of corn and corn products was published by Keith (22) in 1925. The importance of the chemical content of corn grain and the possibility of increasing the desirable portions of the kernel through breeding and selection have stimulated research during the last 20 years. The National Research Council (27) conducted a nation-wide survey of variation in the chemical composition of corn in 1946. New methods for determining the biological value of corn are being developed to aid in the breeding and selection of superior strains of corn (32).

Corn hybrids of superior yield and adaptability have been developed for the corn growing regions of the United States. However, the chemical quality of these hybrids has been questioned by both research workers and livestock feeders. Morrison (26) stated that the grain of present high yielding strains of corn is appreciably lower in oil content and slightly lower in protein content than previously tested strains. In a feeding test using pigs, Robinson (30) found that hybrids were only 90.4% as valuable as open-pollinated varieties since it required 2.4% more feed for 100 pounds gain using hybrids. However, Schaible (32) in a test using poultry found no difference in feeding value although the hybrids used were 2% lower in protein than the open-pollinated varieties. He concluded that differences in chemical composition were due to differences among hybrids and open-pollinated varieties and not between them. Doty, Bergdoll, and Miles (8) found no significant differences in more than 40 commercial hybrids and open-pollinated

nated varieties of corn. Neal and Bohstedt (28) found very little difference in the composition of corn silage from open-pollinated and hybrid corn.

Composition of the corn kernel has been studied by Hopkins, Smith, and East (17) and Earle, Curtis, and Hubbard (10). They found that the endosperm contains 16% of the ash, 75% of the protein, 15% of the oil, 28% of the sugar, and 98% of the starch of the total kernel. They also found that the germ contains 80% of the ash, 22% of the protein, 84% of the oil, and 70% of the sugar of the total kernel. A review of previous work on protein, oil, and ash will be discussed in the order listed.

Protein Content of Corn

Protein of corn is extremely variable in quality and amount and is affected by many environmental and hereditary factors. Using the results of the Illinois protein experiment, "Student" (36), has calculated the number of genes affecting protein to be 20 to 40 and possibly 200 to 400. East and Jones (11), Hayes and Garber (16), and Sprague (35) have suggested possible improvement in protein content through breeding methods. Woodworth (39) has illustrated the selection possibilities by the production of extremely high and low protein strains of corn. A large portion of the increase in protein consists of zein which, according to Hansen, Brimhall, and Sprague (15), is deficient in both the essential amino acids lysine and tryptophane. They found a significant positive correlation value between zein and the total protein to be 0.923. A negative correlation between zein and glutelin content was found by Showalter and Carr (33). They also found that corn containing 15.7% total protein had a zein content of

8.1% while corn containing 8.0% total protein contained only 2.2% zein.

Glutelin of corn is located in the germ and contains most of the essential amino acids found in corn according to Brunson, Earle, and Curtis (4). Feeding experiments and amino acid analyses by Block and Bolling (3), and Mitchell and Beadle (25) have shown the quality of corn germ protein to be approximately equal to that of animal protein. It has been suggested as a source of protein feed for human beings since it is also rich in thiamine. Corn germ protein was found by Mitchell and Beadle (25) to be 85% as digestible as beef round but with a biological value of 77.6 as compared to 76.9 for the beef round. It was also found that corn germ protein was as digestible as soybean protein which has a biological value of 67.5.

Protein of corn has been found to be very susceptible to environmental influences. The effect of climate was found by Arbuckle and Thies (1), and Weeks and Fergus (37) to be an important factor. A significant negative correlation between protein and rainfall of -0.576 was found by Fraps (13). A higher protein content in dry years was also found by the Illinois Experiment Station (19). Irrigation water was found by Greaves and Nelson (14) to decrease the nitrogen content of the kernel 9%. Although total protein is influenced by climate and location, there was no difference in the amino acid content of white corn grown in Virginia and yellow corn grown in Iowa according to Csonka (6).

Protein content of the corn kernel varies with the stage of development. Zein is almost absent from the immature corn kernel according to Zeleny (40), but is synthesized at a rapid rate as the grain matures. He found also that the globulin and glutelin appear to be

synthesized at a relatively uniform rate throughout the growth period. The simpler amino compounds undergo rapid condensation as the corn approaches maturity. Corn starch is produced after the sugars according to Mangelsdorf (23). He suggests that sweet corn and "brittle" corn are only 88.5% and 62.5% as fully matured as dent corn.

A definite effect of fertilizer on the protein content of corn grain was found by Arbuckle and Thies (1) and on the protein content of corn stover by Wimer (38). Greaves and Nelson (14) found an increase in nitrogen with the addition of barnyard manure. This was thought to be due to the increased bacterial activity which increases the available plant food in the soil. On a phosphorus deficient soil the addition of lime increased nitrogen and calcium content of corn according to Weeks and Fergus (37).

Variety differences in protein content were found by Wimer (38), and Arbuckle and Thies (1). Varietal differences to a lesser extent were found by Weeks and Fergus (37). No differences due to variety were found by Doty, Bergdoll, and Miles (8).

Storage of corn grain resulted in a decrease in solubility of proteins, partial breakdown in true proteins, and a decrease in digestibility according to Jones, Devine, and Gersdorff (21).

Oil Content of Corn

Corn oil, per unit of weight, is the most valuable major product of the corn milling industry according to Brunsen, Earle, and Curtis (4). Only the oil in the germ is commercially extractable. If high oil strains of corn are to be of value, the increase in oil must be largely in the germ. Curtis and Earle (7) and Schaible (32) found that oil content was largely a varietal characteristic. The oil yield

from 100 pounds of moisture free corn was obtained from Illinois 200 and Iowa 939 by Earle, Curtis, and Hubbard (10). The weight of oil recovered was 4.6 pounds for Illinois 200 and 2.9 pounds for Iowa 939.

The formation of oil in the kernel starts at an early stage and the nature of the oil progressively changes, becoming more unsaturated in character according to Evans (12). The normal composition of corn oil as reported by Baughman and Jamieson (2) consists of 45.4% oleic acid, 40.9% linolic acid, 7.7% palmitic acid, 3.5% stearic acid, 0.4% arachidic acid, and 0.2% lignoceric acid. The oil content of corn was reported by the Illinois Experiment Station (19) and Doty, Bergdoll, and Miles (8) to be lower during dry years. Published information concerning the effect of other environmental conditions affecting the oil content of corn was not found.

Ash Content of Corn

Information concerning the ash content of corn and the factors that affect it is limited. The ash content of corn was increased by the addition of manure and by irrigation according to Greaves and Nelson (14). Although the ash content of corn grain is high at harvest time, there is a constant decrease as the seed matures when calculated on a dry weight basis according to Evans (12). Maximum ash content is reached in 43 days after silking. Schaible (32) found no difference in the ash content of hybrid and open-pollinated varieties.

MATERIALS AND METHODS

Location and Variety Tests

This study was conducted in 1946 and 1947 in connection with variety tests at seven locations in the corn growing sections of Oklahoma. Two open-pollinated varieties and six hybrids were chosen from the variety test entries to represent the different maturity classes. The two open-pollinated varieties used were Hays Golden and Reid Yellow Dent; medium early and late maturing respectively. The six hybrids used were Indiana 210B and Illinois 751 of early maturity, U.S. 13 of medium early maturity, Illinois 200 of medium late maturity, and Illinois 448 and Texas 12 of late maturity. In 1947 Indiana 210B was replaced by Ohio C-38 of similar maturity.

In 1946 the tests were located in Hughes, Bryan, Garvin, Seminole, LeFlore, and Carter Counties and at the experimental farm at Perkins in Payne County. In 1947 the tests were located in McClain, Garvin, Seminole, Carter, and Tulsa Counties and the experimental farms at Perkins and Stillwater in Payne County. The upland locations were Hughes, LeFlore, Carter, McClain, and Perkins while the others were located on bottomland soils. The tests were planted with a modified two-row corn planter which permitted hand dropping of the seed. The hills were 40 inches apart and each plot contained 20 hills. The row width and cultural practices were those common at each location.

In 1946 a random sample of each plot was taken at time of shelling. These samples were reduced to 150 grams and were not picked or cleaned before analyses. In 1947 a random sample was taken at time of harvest by using the "screwdriver" method. This method involves removing one to two rows of corn from the entire length of 15 to 20

different ears. These samples were then cleaned and hand picked to remove pieces of cob and diseased grain before chemical analyses were made.

The samples were analyzed for protein and oil content in 1946 and for protein, oil, and ash content in 1947. Analyses were made by the Agricultural Chemistry Department, Oklahoma Agricultural and Mechanical College Experiment Station, using the following methods: Nitrogen was run in duplicate by the Kjeldahl-Gunning method on 29 samples, (protein percent = nitrogen x 6.25). Oil or ether extract samples of 2 grams each were dried over night at 105° C and then extracted in a drip extractor for 16 to 24 hours using anhydrous ethyl ether. The loss in weight is calculated as ether extract. Moisture and ash were run in duplicate on 29 samples, dried overnight at 105° C and then ashed in platinum, at a low red heat of 600° C, for about 2 hours or until an essentially carbon free ash remained.

After analyses had been completed, the percentage of protein, oil, and ash were corrected to 15.5% moisture which is the upper limit allowable for No. 2 corn. The data are presented in the Appendix, Tables 12 to 16. The results of the protein, oil, and ash determination were statistically analyzed for each location as a randomized block with three replications. Then the location analyses were combined and analyzed by years. This made a total of 35 analyses by locations and 5 by years. The results are presented in summary tables.

Rate of Planting Test

This study was conducted in 1947 at the experimental farm near Perkins in Payne County. The same eight varieties used in the 1947 variety tests were used in the rate test. The corn was planted in

rows 42 inches apart with the hills 42 inches apart in the row. Each plot consisted of one row 20 hills in length. The plots were thinned to one, two, three, and four plants per hill. Four replications were used. All plots were harvested and weighed separately. The four plots of each variety-rate were composited and a representative sample taken from each at time of shelling. These samples were then cleaned and hand picked to remove pieces of cobs and diseased grain. Chemical analyses were made by the Agricultural Chemistry Department using the same methods outlined above and moisture was corrected to 15.5%. The protein, oil, and ash samples were statistically analyzed separately as a randomized block with four rates and eight varieties.

RESULTS AND DISCUSSION

Protein Content

The average protein content at the seven locations in 1946 varied from 9.28% at Perkins in Payne County to 6.67% in Carter County as shown in Table 1. Both locations were on upland soil of medium to low fertility but were about 160 miles apart. In 1947 the range in protein content at seven locations was from 9.69% at Perkins to 7.30% in Carter County. Although the percent protein was higher in 1947, the high and low locations were the same for both years. Four of the locations tested were the same in both 1946 and 1947 and held the same rank each year.

The average percent protein of seven varieties tested both years shows that Hays Golden, an open-pollinated variety, was highest with 8.49% protein. Illinois 200 was low with 7.66%. Reid Yellow Dent, also an open-pollinated variety, ranked second both years with an average of 8.34% protein. Illinois 448, a hybrid, was third for the two-year average with 8.24% protein. By calculating the total pounds of protein produced each year by each variety, it was found that Hays Golden produced only 175 pounds of protein per acre compared to Illinois 200 with 224 pounds. Reid Yellow Dent produced 201 pounds of protein per acre as compared with 232 pounds for Illinois 448. Texas 12, which ranked fourth in percent protein, produced 243 pounds of protein per acre. The yield of corn in bushels per acre is an important factor in the production of protein by any variety.

A summary of analyses of variance of percent protein in 1946 and 1947 is presented in Tables 2 and 3. Variety differences, as measured by F values, were not significant at any of the test locations in 1946,

Table 1.--Percent protein in corn grain of varieties for each location for 1946 and 1947^{1/}.

| Location | Indiana | Illinois | U.S. 13 | Hays | Illinois | Illinois | Texas | Reid | Average | |
|------------------|---------|--------------------|---------|--------|----------|----------|-------|-------------|---------|------|
| County Fertility | 210B | 751 | | Golden | 200 | 448 | 12 | Yellow Dent | | |
| 1946 | | | | | | | | | | |
| Hughes | Low | 7.42 | 7.62 | 7.99 | 7.78 | 7.38 | 7.70 | 7.36 | 8.24 | 7.69 |
| Bryan | High | 8.32 | 8.75 | 8.50 | 9.14 | 8.49 | 9.29 | 8.46 | 8.82 | 8.72 |
| Garvin | High | 8.54 | 8.54 | 8.71 | 9.37 | 8.28 | 8.95 | 9.30 | 9.29 | 8.87 |
| Seminole | High | 7.44 | 7.64 | 6.90 | 8.97 | 6.88 | 7.95 | 7.98 | 7.72 | 7.69 |
| LeFlore | Low | 7.12 | 7.08 | 7.40 | 7.31 | 7.33 | 7.27 | 6.73 | 7.73 | 7.25 |
| Carter | Low | 6.94 | 6.61 | 6.17 | 6.81 | 6.36 | 6.94 | 6.43 | 7.09 | 6.67 |
| Payne | Medium | 8.71 | 9.04 | 8.64 | 10.01 | 8.92 | 9.61 | 9.81 | 9.51 | 9.28 |
| Upland | | | | | | | | | | |
| Average | | 7.79 | 7.90 | 7.76 | 8.49 | 7.66 | 8.24 | 8.01 | 8.34 | 8.02 |
| 1947 | | | | | | | | | | |
| McClain | Low | 6.84 ^{2/} | 6.79 | 7.04 | 7.82 | 7.53 | 8.28 | 7.96 | 7.60 | 7.48 |
| Garvin | High | 7.47 | 8.08 | 8.33 | 8.06 | 7.61 | 8.36 | 7.99 | 8.55 | 8.06 |
| Seminole | High | 6.86 | 7.66 | 7.17 | 8.43 | 7.25 | 7.98 | 7.71 | 7.89 | 7.62 |
| Carter | Low | 7.10 | 7.72 | 6.94 | 7.99 | 7.48 | 7.59 | 6.34 | 7.27 | 7.30 |
| Tulsa | High | 8.61 | 9.20 | 8.57 | 10.08 | 9.31 | 9.46 | 9.57 | 9.66 | 9.31 |
| Payne | Medium | 9.05 | 9.38 | 9.46 | 9.19 | 9.77 | 9.37 | 9.61 | 10.29 | 9.51 |
| Payne | Medium | 9.22 | 9.38 | 9.30 | 9.68 | 9.73 | 10.17 | 10.37 | 9.63 | 9.69 |
| Upland | | | | | | | | | | |
| Average | | 7.88 | 8.31 | 8.11 | 8.75 | 8.38 | 8.75 | 8.51 | 8.70 | 8.42 |
| 2-Year Average | | 7.83 | 8.10 | 7.93 | 8.62 | 8.02 | 8.50 | 8.26 | 8.52 | 8.22 |

^{1/} Each figure represents the average of three replications.

^{2/} Indiana 210B was replaced by Ohio C-38 in 1947.

Table 2.--Summary of analyses of variance of percentage of protein in corn at each location and all locations in 1946.

| County | Location Fertility | Source | D.F. | M.S. | F values | | | | | |
|-----------------|-----------------------|-----------|------------------|---------|------------|----------------|----------------|--------|------|------|
| | | | | | Calculated | Required 5% | Required 1% | | | |
| Hughes | Low | Variety | 7 | 0.2925 | 2.06 | 2.77 | 4.28 | | | |
| | | Error | 14 | 0.1420 | | | | | | |
| Bryan | High | Variety | 7 | 0.3614 | 1.30 | 2.77 | 4.28 | | | |
| | | Error | 14 | 0.2783 | | | | | | |
| Garvin | High | Variety | 7 | 0.5156 | 1.87 | 2.77 | 4.28 | | | |
| | | Error | 14 | 0.2743 | | | | | | |
| Seminole | High | Variety | 7 | 1.3450 | 2.48 | 2.77 | 4.28 | | | |
| | | Error | 14 | 0.5427 | | | | | | |
| LeFlore | Low | Variety | 7 | 0.2498 | 1.23 | 2.77 | 4.28 | | | |
| | | Error | 14 | 0.2028 | | | | | | |
| Carter | Low | Variety | 7 | 0.3179 | 1.73 | 2.77 | 4.28 | | | |
| | | Error | 14 | 0.1831 | | | | | | |
| Payne Upland | Medium | Variety | 7 | 0.8101 | 2.28 | 2.84 | 4.44 | | | |
| | | Error | 13 ^{1/} | 0.3556 | | | | | | |
| All Locations | | Locations | 6 | 26.7000 | 43.20** | 2.85 | 4.46 | | | |
| | | Error (a) | 14 | 0.6180 | | | | | | |
| | | Variety | 7 | 1.9040 | | | | 5.75** | 2.24 | 3.10 |
| | | V x L | 42 | 0.3310 | | | | 1.19 | 1.51 | 1.79 |
| | | Error (b) | 97 | 0.2766 | | | | | | |

^{1/} Three degrees of freedom lost due to adjustment for missing data according to the method given by Snedecor (34).

** Indicates that the F value exceeds the value required for significance at the 1% level.

Table 3.—Summary of analyses of variance of percentage of protein in corn at each location and all locations in 1947.

| Location County | Fertility | Source | D.F. | M.S. | F values | | |
|---------------------|-----------|-----------|------------------|---------|------------|----------------|----------------|
| | | | | | Calculated | Required 5% | Required 1% |
| McClain | Medium | Variety | 7 | 0.8921 | 4.61** | 2.77 | 4.28 |
| | | Error | 14 | 0.1935 | | | |
| Garvin | High | Variety | 7 | 0.4101 | 2.69 | 2.77 | 4.28 |
| | | Error | 14 | 0.1527 | | | |
| Seminole | High | Variety | 7 | 0.7673 | 6.23** | 3.01 | 4.88 |
| | | Error | 11 ^{1/} | 0.1232 | | | |
| Carter | Low | Variety | 7 | 0.7944 | 1.77 | 2.77 | 4.28 |
| | | Error | 14 | 0.4493 | | | |
| Tulsa | High | Variety | 7 | 0.7962 | 5.18** | 2.77 | 4.28 |
| | | Error | 14 | 0.1536 | | | |
| Payne Bottomland | Medium | Variety | 7 | 0.4421 | 1.74 | 2.77 | 4.28 |
| | | Error | 14 | 0.2541 | | | |
| Payne Upland | Medium | Variety | 7 | 0.4951 | 3.00* | 2.77 | 4.28 |
| | | Error | 14 | 0.1649 | | | |
| All Locations | | Location | 6 | 25.9470 | 48.30** | 2.85 | 4.46 |
| | | Error (a) | 14 | 0.5372 | | | |
| | | Variety | 7 | 2.0877 | 9.66** | 2.24 | 3.10 |
| | | V x L | 42 | 0.4183 | 1.94** | 1.52 | 1.80 |
| | | Error (b) | 95 | 0.2159 | | | |

^{1/} Three degrees of freedom lost due to adjustment for missing data according to the method given by Snedecor (34).

* Indicates that the F value exceeds the value required for significance at the 5% level.

** Indicates that the F value exceeds the value required for significance at the 1% level.

although three were near the 5% level of significance. When all the 1946 locations were analyzed together, both location and variety differences were significant at the 1% level. This significance was probably due to the large increase in degrees of freedom when all locations were combined and analyzed together. The variety x location interaction was not significant.

Significant variety differences at the 1% level were obtained at three locations in 1947 and one was significant at the 5% level. An analysis of all locations in 1947 showed location, variety, and variety x location differences to be significant at the 1% level. Since variety x location differences were significant, it was apparent that all varieties did not react the same at all locations in 1947.

Seven of the varieties were planted in both 1946 and 1947. Four locations were the same each year. These seven varieties and four locations were analyzed for both years to see if the effect of years was significant. A summary of this analysis is presented in Table 4. Locations were significantly different at the 1% level with none of the other main effects or interactions showing significance. However, data for two years are not sufficient for accuracy in testing differences due to years.

The percent protein for eight varieties planted at four rates is presented in Table 5. An average of all rates for each variety showed Illinois 448 and Texas 12 to be the highest and Ohio C-38 the lowest in protein. The highest protein content was obtained from plots that were thinned to one plant per hill. There were no apparent differences in protein content between two, three, and four plants per hill. Hays Golden and Reid Yellow Dent showed the largest decrease in protein

Table 4.—Analyses of variance of the protein and oil content of seven varieties at the same four locations in 1946 and 1947.

| Source | D.F. | M.S. | F values | | |
|-------------------------|------|---------|------------|------------------------|------|
| | | | Calculated | Required 5% 1% | |
| Protein 1946 and 1947 | | | | | |
| Years | 1 | 0.2672 | 0.21 | 4.05 | 7.21 |
| Locations | 3 | 51.2981 | 41.21** | 2.81 | 4.24 |
| Varieties | 6 | 2.6109 | 2.10 | 2.31 | 3.44 |
| V x L | 18 | 0.6010 | 0.37 | 2.22 | 3.13 |
| V x Y | 6 | 0.4619 | 0.28 | 2.66 | 4.01 |
| Y x L | 3 | 4.3081 | 2.63 | 3.16 | 5.09 |
| Y x L x V | 18 | 1.6393 | | | |
| Error (a) ^{1/} | 45 | 1.2449 | | | |
| Error (b) | 111 | 0.0311 | | | |
| Oil 1946 and 1947 | | | | | |
| Years | 1 | 0.5395 | 3.08 | 4.05 | 7.21 |
| Locations | 3 | 5.1089 | 29.19** | 2.81 | 4.24 |
| Varieties | 6 | 1.9734 | 11.28** | 2.31 | 3.44 |
| V x L | 18 | 0.0666 | 0.28 | 2.22 | 3.13 |
| V x Y | 6 | 0.0862 | 0.36 | 2.66 | 4.01 |
| Y x L | 3 | 0.6054 | 2.51 | 3.16 | 5.09 |
| Y x L x V | 18 | 0.2414 | | | |
| Error (a) ^{1/} | 45 | 0.1750 | | | |
| Error (b) | 109 | 0.0763 | | | |

^{1/} Error (a) was obtained by adding the degrees of freedom and sums of squares of V x L, V x Y, Y x L, and Y x L x V, and was used to test the main sources of variation.

** Indicates that the F value exceeds the value required for significance at the 1% level.

Table 5.--Percent of protein, oil, and ash in corn grain for eight varieties and four rates at Perkins, Oklahoma in 1947.

| Plants Per Hill | Ohio C-38 | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent | Average |
|--------------------|--------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|---------|
| Percent Protein | | | | | | | | | |
| 1 | 9.80 | 10.18 | 10.00 | 11.02 | 10.41 | 10.67 | 10.38 | 10.45 | 10.36 |
| 2 | 9.12 | 9.40 | 9.48 | 9.87 | 9.85 | 10.42 | 9.99 | 9.17 | 9.66 |
| 3 | 8.93 | 9.21 | 9.33 | 9.70 | 9.54 | 10.65 | 9.90 | 9.51 | 9.59 |
| 4 | 8.96 | 9.31 | 9.39 | 9.33 | 9.46 | 10.94 | 9.95 | 9.88 | 9.65 |
| Average | 9.20 | 9.53 | 9.55 | 9.98 | 9.82 | 10.67 | 10.06 | 9.75 | 9.81 |
| Percent Oil | | | | | | | | | |
| 1 | 3.65 | 3.63 | 4.13 | 3.82 | 3.56 | 3.81 | 3.90 | 2.40 | 3.61 |
| 2 | 3.47 | 3.61 | 3.48 | 3.71 | 3.69 | 4.13 | 3.85 | 2.81 | 3.59 |
| 3 | 3.12 | 3.73 | 3.16 | 3.54 | 3.53 | 3.57 | 3.74 | 2.26 | 3.33 |
| 4 | 3.47 | 3.47 | 3.09 | 3.44 | 3.37 | 3.29 | 3.66 | 2.79 | 3.32 |
| Average | 3.43 | 3.61 | 3.47 | 3.63 | 3.54 | 3.70 | 3.79 | 2.57 | 3.46 |
| Percent Ash | | | | | | | | | |
| 1 | 1.30 | 1.18 | 1.18 | 1.06 | 1.04 | 1.22 | 1.28 | 1.10 | 1.17 |
| 2 | 1.31 | 1.42 | 1.14 | 1.08 | 1.11 | 1.40 | 1.17 | 1.06 | 1.21 |
| 3 | 1.23 | 1.30 | 1.11 | 1.05 | 1.05 | 1.18 | 1.20 | 1.33 | 1.18 |
| 4 | 1.09 | 1.25 | 1.23 | 1.13 | 1.04 | 1.05 | 1.18 | 1.14 | 1.14 |
| Average | 1.23 | 1.29 | 1.17 | 1.08 | 1.06 | 1.21 | 1.21 | 1.16 | 1.18 |

content between one and two plants per hill. The analysis of variance for the protein content of corn as affected by variety and rate is presented in Table 6. Both variety and rate were found to be significant at the 1% level. The results of these tests indicate that differences in protein content of both hybrids and varieties may be affected by location, variety, and rate of planting. They also indicate that location and rate of planting may produce greater differences than those differences due to hybrids and varieties.

Oil Content

In 1947 Garvin County corn had the highest average oil content with 4.22% while Tulsa County corn was low with 3.53% (Table 7). Both locations were on bottomland of high fertility. The second high location was McClain County corn with 4.05% oil. In 1946 corn from the highly fertile location in Bryan County was highest with 4.51% oil. The medium fertility location at Perkins in Payne County was lowest with 3.43%. This indicates a negative correlation between protein and oil content on upland soils. Four of the locations were the same for 1946 and 1947. Of these four locations, Garvin County corn was highest in oil both years and Payne County corn was lowest.

The average oil content of each of the seven varieties tested in 1946 and 1947 shows that Illinois 448 was the highest with 4.15% oil. The lowest in oil content was U.S. 13 which had 3.58%. The total pounds of oil produced per acre each year was calculated. It was found that Illinois 448 produced 122 pounds per acre while U. S. 13 and Texas 12 produced 113 and 129 pounds respectively. The total pounds of oil produced per acre by Hays Golden and Reid Yellow Dent were 83 and 92 pounds respectively. These results indicate that the

Table 6.--Summary of analyses of variance of percentage of protein, oil, and ash in corn for rate of planting test on Payne County Upland in 1947.

| Percent | Source | D.F. | M.S. | F values | | |
|---------|---------|------------------|--------|------------|------------------------|------|
| | | | | Calculated | Required 5% 1% | |
| Protein | Variety | 7 | 0.7710 | 10.71** | 2.49 | 3.65 |
| | Rate | 3 | 1.0630 | 14.76** | 3.07 | 4.87 |
| | Error | 21 | 0.0720 | | | |
| Oil | Variety | 7 | 0.5848 | 11.33** | 2.52 | 3.71 |
| | Rate | 3 | 0.2041 | 3.96* | 3.10 | 4.94 |
| | Error | 20 ^{1/} | 0.0516 | | | |
| Ash | Variety | 7 | 0.0235 | 2.79* | 2.52 | 3.71 |
| | Rate | 3 | 0.0072 | 0.85 | 3.10 | 4.94 |
| | Error | 20 ^{1/} | 0.0084 | | | |

^{1/} One degree of freedom lost due to adjustment for missing data according to the method given by Snedecor (34).

* Indicates that the F value exceeds the value required for significance at the 5% level.

** Indicates that the F value exceeds the value required for significance at the 1% level.

Table 7.--Percent oil in corn grain of varieties for each location for 1946 and 1947 ^{1/}.

| Location County Fertility | Indiana 210B | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent | Average |
|------------------------------|--------------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|---------|
| 1946 | | | | | | | | | |
| Hughes Low | 3.64 | 3.02 | 3.13 | 3.66 | 3.87 | 4.47 | 4.20 | 3.74 | 3.71 |
| Bryan High | 4.09 | 4.11 | 4.33 | 4.67 | 4.59 | 4.83 | 4.94 | 4.50 | 4.51 |
| Garvin High | 4.22 | 3.99 | 3.94 | 4.68 | 4.40 | 4.80 | 4.68 | 4.38 | 4.39 |
| Seminole High | 4.30 | 3.64 | 3.85 | 4.20 | 4.39 | 4.94 | 4.50 | 4.00 | 4.23 |
| LeFlore Low | 3.72 | 3.00 | 3.37 | 3.93 | 4.02 | 4.45 | 4.81 | 4.29 | 3.95 |
| Carter Low | 3.95 | 3.62 | 3.63 | 4.31 | 3.87 | 4.50 | 4.17 | 3.93 | 4.00 |
| Payne Medium | 3.60 | 3.27 | 2.79 | 3.36 | 3.52 | 3.67 | 3.75 | 3.48 | 3.43 |
| Upland | | | | | | | | | |
| Average | 3.93 | 3.52 | 3.58 | 4.12 | 4.09 | 4.52 | 4.44 | 4.05 | 4.03 |
| 1947 | | | | | | | | | |
| McClain Low | 3.37 ^{2/} | 3.99 | 3.63 | 4.27 | 3.94 | 4.64 | 4.65 | 3.91 | 4.05 |
| Garvin High | 3.82 | 4.14 | 3.93 | 4.50 | 4.23 | 4.64 | 4.50 | 4.04 | 4.22 |
| Seminole High | 3.65 | 3.58 | 3.44 | 3.81 | 4.10 | 4.20 | 3.98 | 3.61 | 3.80 |
| Carter Low | 3.54 | 3.71 | 3.41 | 3.91 | 3.91 | 4.30 | 4.20 | 3.82 | 3.85 |
| Tulsa High | 3.11 | 3.47 | 3.60 | 3.40 | 3.35 | 3.83 | 3.90 | 3.54 | 3.53 |
| Payne Medium | 3.48 | 3.23 | 3.61 | 4.35 | 4.00 | 3.55 | 3.51 | 3.10 | 3.60 |
| Payne Medium | 3.17 | 3.43 | 3.42 | 3.60 | 3.64 | 3.86 | 3.77 | 3.42 | 3.54 |
| Upland | | | | | | | | | |
| Average | 3.45 | 3.65 | 3.58 | 3.98 | 3.88 | 4.15 | 4.07 | 3.64 | 3.80 |
| 2-Year Average | 3.69 | 3.59 | 3.58 | 4.05 | 3.99 | 4.33 | 4.25 | 3.84 | 3.91 |

^{1/} Each figure represents the average of three replications.

^{2/} Indiana 210B was replaced by Ohio C-38 in 1947.

hybrids tested are as high in oil content as the open-pollinated varieties and produce considerably more oil per acre.

A summary of analyses of variance for percent oil in 1946 and 1947 is presented in Tables 8 and 9. In both 1946 and 1947 there were four locations at which highly significant differences among varieties were obtained while other locations showed no variety significance. This indicates that the effect of location on the oil content of a particular variety was very definite. When all of the locations for each year were analyzed, both locations and varieties showed high significance. The lack of significance in varieties x locations indicates the uniform reaction of varieties at all locations. An analysis of four locations for both years presented in Table 4 shows no significant difference in years but does show highly significant differences in both varieties and locations.

The percent oil in eight varieties planted at four rates is presented in Table 5. An average of each variety for all rates showed Texas 12 to be the highest with 3.79% oil. Illinois 448 was next and Ohio C-38 was lowest with 3.43%. There was very little difference between the four planting rates. The analysis of variance presented in Table 6 shows variety differences to be highly significant. Differences in rate were significant at the 5% level. The results of these tests indicate the need for further study of the effect of planting rate on the oil content of corn.

Ash Content

The ash content of corn was analyzed in 1947. The average percent ash for eight varieties at seven locations is presented in Table 10. The Payne County bottomland location was considerably higher in ash

Table 8.—Summary of analyses of variance of percent of oil in corn at each location and all locations in 1946.

| County | Location Fertility | Source | D.F. | M.S. | F values | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|-----------------------|-----------|------------------|--------|------------|----------------|----------------|-----------------|--------|-----------|------|--------|---------|------|------|-----------|------------------|--------|-----------------|--------|-----------|------|--------|-----------|------|--------|-----------|------------------|--------|-----------------|--------|-----------|------|--------|-----------|------|--------|-----------|------------------|--------|-----------------|--------|-----------|------|--------|-----------|------|--------|-----------|------------------|--------|-----------------|--------|-----------|------|--------|-----------|------|--------|-----------|------------------|--------|-----------------|--------|-----------|------|--------|-----------|------|--------|-----------|------------------|--------|---------------|--|-----------|------|--------|-----------|------|--------|-----------|----|--------|---------|------|--------|-----------|------|--------|-------|----|--------|------|------|------|-----------|
| | | | | | Calculated | Required 5% | Required 1% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hughes | Low | Variety | 7 | 0.7142 | 9.48** | 2.77 | 4.28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 14 | 0.0753 | | | | Bryan | High | Variety | 7 | 0.2966 | 4.47** | 2.77 | 4.28 | Error | 14 | 0.0664 | Garvin | High | Variety | 7 | 0.3119 | 1.55 | 2.77 | 4.28 | Error | 14 | 0.2011 | Seminole | High | Variety | 7 | 0.4963 | 1.00 | 2.77 | 4.28 | Error | 14 | 0.4942 | LeFlore | Low | Variety | 7 | 1.0320 | 16.69** | 2.77 | 4.28 | Error | 14 | 0.0668 | Carter | Low | Variety | 7 | 0.2903 | 4.48** | 2.77 | 4.28 | Error | 14 | 0.0648 | Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | Error | 13 ^{1/} | 0.1541 | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | 0.74 | 1.51 | 1.79 | Error (b) |
| Bryan | High | Variety | 7 | 0.2966 | 4.47** | 2.77 | 4.28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 14 | 0.0664 | | | | Garvin | High | Variety | 7 | 0.3119 | 1.55 | 2.77 | 4.28 | Error | 14 | 0.2011 | Seminole | High | Variety | 7 | 0.4963 | 1.00 | 2.77 | 4.28 | Error | 14 | 0.4942 | LeFlore | Low | Variety | 7 | 1.0320 | 16.69** | 2.77 | 4.28 | Error | 14 | 0.0668 | Carter | Low | Variety | 7 | 0.2903 | 4.48** | 2.77 | 4.28 | Error | 14 | 0.0648 | Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | Error | 13 ^{1/} | 0.1541 | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | |
| Garvin | High | Variety | 7 | 0.3119 | 1.55 | 2.77 | 4.28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 14 | 0.2011 | | | | Seminole | High | Variety | 7 | 0.4963 | 1.00 | 2.77 | 4.28 | Error | 14 | 0.4942 | LeFlore | Low | Variety | 7 | 1.0320 | 16.69** | 2.77 | 4.28 | Error | 14 | 0.0668 | Carter | Low | Variety | 7 | 0.2903 | 4.48** | 2.77 | 4.28 | Error | 14 | 0.0648 | Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | Error | 13 ^{1/} | 0.1541 | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | | | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | |
| Seminole | High | Variety | 7 | 0.4963 | 1.00 | 2.77 | 4.28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 14 | 0.4942 | | | | LeFlore | Low | Variety | 7 | 1.0320 | 16.69** | 2.77 | 4.28 | Error | 14 | 0.0668 | Carter | Low | Variety | 7 | 0.2903 | 4.48** | 2.77 | 4.28 | Error | 14 | 0.0648 | Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | Error | 13 ^{1/} | 0.1541 | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | | | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LeFlore | Low | Variety | 7 | 1.0320 | 16.69** | 2.77 | 4.28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 14 | 0.0668 | | | | Carter | Low | Variety | 7 | 0.2903 | 4.48** | 2.77 | 4.28 | Error | 14 | 0.0648 | Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | Error | 13 ^{1/} | 0.1541 | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | | | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Carter | Low | Variety | 7 | 0.2903 | 4.48** | 2.77 | 4.28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 14 | 0.0648 | | | | Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | Error | 13 ^{1/} | 0.1541 | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | | | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Payne Upland | Medium | Variety | 7 | 0.2782 | 1.80 | 2.84 | 4.44 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error | 13 ^{1/} | 0.1541 | | | | All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | Error (a) | 14 | 0.1381 | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | | | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| All Locations | | Locations | 6 | 3.4480 | 24.97** | 2.85 | 4.46 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error (a) | 14 | 0.1381 | | | | | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | V x L | 42 | 0.1229 | | | 0.74 | 1.51 | 1.79 | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Variety | 7 | 2.6820 | 21.82** | 2.24 | 3.10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | V x L | 42 | 0.1229 | | | | | | 0.74 | 1.51 | 1.79 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Error (b) | 97 | 0.1660 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

^{1/} Three degrees of freedom lost due to adjustment for missing data according to the method given by Snedecor (34).

** Indicates that the F value exceeds the value required for significance at the 1% level.

Table 9.--Summary of analyses of variance of percent of oil in corn at each location and all locations in 1947.

| Location County | Fertility | Source | D.F. | M.S. | F values | | |
|---------------------|-----------|-----------|------------------|--------|------------|----------------|----------------|
| | | | | | Calculated | Required 5% | Required 1% |
| McClain | Medium | Variety | 7 | 0.6137 | 4.39** | 2.77 | 4.28 |
| | | Error | 14 | 0.1395 | | | |
| Garvin | High | Variety | 7 | 0.2632 | 1.98 | 2.77 | 4.28 |
| | | Error | 14 | 0.1329 | | | |
| Seminole | High | Variety | 7 ^{1/} | 0.2246 | 7.02** | 3.01 | 4.88 |
| | | Error | 11 ^{1/} | 0.0320 | | | |
| Carter | Low | Variety | 7 | 0.2760 | 8.41** | 2.77 | 4.28 |
| | | Error | 14 | 0.0328 | | | |
| Tulsa | High | Variety | 7 | 0.1950 | 1.97 | 2.77 | 4.28 |
| | | Error | 14 | 0.0988 | | | |
| Payne Bottomland | Medium | Variety | 7 | 0.4837 | 5.36** | 2.77 | 4.28 |
| | | Error | 14 | 0.0902 | | | |
| Payne Upland | Medium | Variety | 7 | 0.1487 | 2.40 | 2.77 | 4.28 |
| | | Error | 14 | 0.0619 | | | |
| All Locations | | Locations | 6 | 1.7087 | 21.20** | 2.85 | 4.46 |
| | | Error (a) | 14 | 0.0806 | | | |
| | | Variety | 7 | 1.3622 | 9.67** | 2.24 | 3.10 |
| | | V x L | 42 | 0.1409 | 1.17 | 1.52 | 1.80 |
| | | Error (b) | 95 | 0.0855 | | | |

^{1/} Three degrees of freedom lost due to adjustment for missing data according to the method given by Snedecor (34).

** Indicates that the F value exceeds the value required for significance at the 1% level.

Table 10.--Percentage of ash in corn grain for eight varieties at seven locations in 1947.

| Location County Fertility | Ohio C-38 | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent | Average |
|------------------------------|--------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|---------|
| McClain Low | 1.16 | 1.23 | 1.09 | 1.27 | 1.06 | 1.16 | 1.12 | 1.18 | 1.16 |
| Garvin High | 1.02 | 1.03 | 1.00 | 1.12 | 0.93 | 0.88 | 1.19 | 1.14 | 1.04 |
| Seminole High | 1.14 | 1.24 | 1.12 | 1.21 | 1.06 | 1.11 | 1.15 | 1.24 | 1.16 |
| Carter Low | 1.23 | 1.24 | 1.09 | 1.20 | 1.11 | 1.08 | 1.06 | 1.08 | 1.14 |
| Tulsa High | 1.35 | 1.13 | 1.27 | 1.27 | 1.22 | 1.27 | 1.23 | 1.12 | 1.23 |
| Payne Medium | 1.46 | 1.45 | 1.34 | 1.30 | 1.32 | 1.31 | 1.26 | 1.35 | 1.35 |
| Payne Medium | 1.31 | 1.19 | 1.24 | 1.08 | 1.13 | 1.10 | 1.20 | 1.17 | 1.18 |
| Upland | | | | | | | | | |
| Average | 1.24 | 1.22 | 1.16 | 1.21 | 1.12 | 1.13 | 1.17 | 1.19 | 1.18 |

content than the other locations. It contained 1.35% ash compared with a low ash content of 1.04% for Garvin County. Ohio C-38, the earliest hybrid in the test, was the highest in ash content with 1.24%. The lowest was Illinois 200 with 1.12% ash. The ash content, for both varieties and locations, does not vary as much as the protein and oil content.

The summary of analyses of variance for percent ash in 1947 is presented in Table 11. Only Carter County showed a significant difference at the 1% level. It was the only low fertility test location in 1947. The two Payne County locations of medium fertility showed significance at the 5% level. When all the locations were analyzed together, location and variety x location interaction showed high significance. Differences in varieties were significant at the 5% level.

The percent ash in eight varieties planted at four rates is presented in Table 5. The early varieties are somewhat higher in ash than the late varieties. The analysis of variance presented in Table 6 shows varieties to be significant at the 5% level with no significant differences due to rates.

Data for one year indicate a definite effect of location on the ash content of corn and very little effect due to variety and rate of planting.

Table 11.—Summary of analyses of variance of percentage of ash in corn at each location and all locations in 1947.

| Location County | Fertility | Source | D.F. | M.S. | F values | | |
|---------------------|-----------|-----------|------------------|--------|------------|----------------|----------------|
| | | | | | Calculated | Required 5% | Required 1% |
| McClain | Medium | Variety | 7 | 0.0150 | 2.53 | 2.77 | 4.28 |
| | | Error | 14 | 0.0059 | | | |
| Garvin | High | Variety | 7 | 0.0336 | 2.29 | 2.77 | 4.28 |
| | | Error | 14 | 0.0147 | | | |
| Seminole | High | Variety | 7 | 0.0134 | 2.27 | 3.01 | 4.88 |
| | | Error | 11 ^{1/} | 0.0059 | | | |
| Carter | Low | Variety | 7 | 0.0155 | 4.84** | 2.77 | 4.28 |
| | | Error | 14 | 0.0032 | | | |
| Tulsa | High | Variety | 7 | 0.0174 | 2.41 | 2.77 | 4.28 |
| | | Error | 14 | 0.0072 | | | |
| Payne Bottomland | Medium | Variety | 7 | 0.0150 | 2.78* | 2.77 | 4.28 |
| | | Error | 14 | 0.0054 | | | |
| Payne Upland | Medium | Variety | 7 | 0.0174 | 3.34* | 2.77 | 4.28 |
| | | Error | 14 | 0.0052 | | | |
| All Locations | | Location | 6 | 0.2203 | 23.95** | 2.85 | 4.46 |
| | | Error (a) | 14 | 0.0092 | | | |
| | | Variety | 7 | 0.0367 | 2.43* | 2.24 | 3.10 |
| | | V x L | 42 | 0.0151 | 2.22** | 1.52 | 1.80 |
| | | Error (b) | 95 | 0.0068 | | | |

^{1/} Three degrees of freedom lost due to adjustment for missing data according to the method given by Snedecor (34).

* Indicates that the F value exceeds the value required for significance at the 5% level.

** Indicates that the F value exceeds the value required for significance at the 1% level.

SUMMARY AND CONCLUSIONS

Studies were conducted to determine the effect of variety, location, and rate of planting on protein, oil, and ash content of corn grain. The eight varieties tested in 1946 were Indiana 210B, Illinois 751, U.S. 13, Hays Golden, Illinois 200, Illinois 448, Texas 12, and Reid Yellow Dent. These varieties range from early to late maturity. Indiana 210B was replaced by Ohio C-38 in the 1947 variety and rate of planting tests. In 1946 the tests were located in Hughes, Bryan, Garvin, Seminole, LeFlore, Carter, and Payne Counties. In 1947 the tests were located in McClain, Garvin, Seminole, Carter, Tulsa, and Payne Counties. The rate of planting test was located at Perkins in Payne County. The rates of planting used were one, two, three, and four plants per hill. Samples were analyzed for protein and oil content in 1946 and for protein, oil, and ash content in 1947. These results were statistically analyzed for each location in 1946 and 1947.

The average of the two open-pollinated varieties was slightly higher than the six hybrids in percent protein but considerably lower in total pounds of protein produced per acre.

The hybrids tested were as high in oil content as the open-pollinated varieties and considerably higher in total pounds of oil produced per acre.

The effect of different locations on the protein, oil, and ash content of corn grain was generally greater than the effect due to different varieties.

The number of plants per acre has more effect on the protein content of corn than on the oil content. It has no apparent effect on

the ash content.

The ash content of corn grain is affected considerably by location but only slightly affected by variety, and rate of planting.

The effect of two different seasons on the protein, oil, and ash content of corn grain was not significant.

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A P P E N D I X

Table 12.—Percentage of protein in corn grain for eight varieties at seven locations in 1946.

| Location County | Fertility | Repli- cation | Indiana 210B | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent |
|--------------------|-----------|------------------|-----------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|
| Hughes | Low | A | 8.01 | 7.16 | 8.13 | 8.04 | 7.22 | 7.34 | 7.67 | 8.10 |
| | | B | 6.77 | 7.73 | 8.00 | 7.49 | 7.64 | 7.50 | 7.22 | 7.99 |
| | | C | 7.48 | 7.97 | 7.85 | 7.82 | 7.29 | 8.26 | 7.18 | 8.62 |
| Bryan | High | A | 8.70 | 8.62 | 9.06 | 9.87 | 8.35 | 9.98 | 8.98 | 8.33 |
| | | B | 8.59 | 9.53 | 8.92 | 8.57 | 9.12 | 8.93 | 8.50 | 9.06 |
| | | C | 7.67 | 8.10 | 7.53 | 8.97 | 7.99 | 8.97 | 7.89 | 9.06 |
| Garvin | High | A | 8.00 | 8.22 | 9.29 | 9.55 | 8.23 | 9.52 | 9.89 | 9.00 |
| | | B | 9.20 | 8.47 | 8.36 | 9.50 | 7.57 | 8.81 | 8.98 | 9.51 |
| | | C | 8.42 | 8.94 | 8.48 | 9.05 | 9.05 | 8.53 | 9.04 | 9.36 |
| Seminole | High | A | 7.85 | 8.34 | 6.90 | 8.18 | 6.52 | 8.39 | 8.74 | 9.05 |
| | | B | 7.72 | 7.46 | 6.86 | 9.98 | 7.95 | 8.61 | 7.20 | 7.49 |
| | | C | 6.76 | 7.13 | 6.94 | 8.76 | 6.17 | 6.84 | 7.99 | 6.61 |
| LeFlore | Low | A | 7.22 | 6.97 | 7.76 | 7.79 | 8.19 | 7.25 | 6.78 | 7.72 |
| | | B | 6.88 | 7.23 | 7.31 | 7.73 | 7.34 | 7.00 | 7.22 | 8.25 |
| | | C | 7.28 | 7.05 | 7.13 | 6.46 | 6.47 | 7.57 | 6.19 | 7.23 |
| Carter | Low | A | 6.78 | 6.38 | 6.16 | 6.63 | 5.73 | 6.92 | 7.17 | 7.30 |
| | | B | 7.38 | 7.14 | 6.69 | 6.71 | 6.68 | 7.14 | 6.28 | 6.84 |
| | | C | 6.66 | 6.31 | 5.66 | 7.08 | 6.67 | 6.75 | 5.85 | 7.12 |
| Payne Upland | Medium | A | 8.44 | 8.28 | 8.97 | 9.99 | 8.95 | 10.07 | 10.24 | 9.54 |
| | | B | 8.88 | 9.41 | 9.21 | 9.46 | 8.84 | 9.95 | 9.08 | 9.57 |
| | | C | 8.81 | 9.43 | 7.74 | 10.57 | 8.97 | 8.80 | 10.11 | 9.42 |

Table 13.—Percentage of protein in corn grain for eight varieties at seven locations in 1947.

| Location County | Fertility | Repli- cation | Ohio C-38 | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent |
|---------------------|-----------|------------------|--------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|
| McClain | Medium | A | 6.91 | 6.51 | 6.97 | 7.80 | 6.96 | 7.84 | 7.28 | 8.03 |
| | | B | 6.95 | 6.71 | 7.29 | 7.71 | 8.52 | 8.90 | 8.77 | 7.60 |
| | | C | 6.67 | 7.15 | 6.85 | 7.95 | 7.11 | 8.10 | 7.83 | 7.18 |
| Garvin | High | A | 8.01 | 8.34 | 8.44 | 7.84 | 7.36 | 8.59 | 8.23 | 8.59 |
| | | B | 7.30 | 7.95 | 7.85 | 8.46 | 7.80 | 8.52 | 8.58 | 8.68 |
| | | C | 7.11 | 7.94 | 8.70 | 7.89 | 7.67 | 7.98 | 7.16 | 8.38 |
| Seminole | High | A | 7.31 | 8.45 | 7.75 | 8.84 | 7.71 | 8.79 | 7.93 | 8.06 |
| | | B | 6.76 | 7.90 | 6.74 | 8.31 | 7.20 | 7.56 | 7.61 | 8.07 |
| | | C | 6.51 | 6.62 | 7.02 | 8.15 | 6.84 | 7.60 | 7.58 | 7.53 |
| Carter | Low | A | 6.92 | 8.20 | 6.97 | 8.17 | 6.92 | 7.90 | 5.56 | 8.28 |
| | | B | 7.60 | 6.77 | 6.63 | 7.12 | 7.47 | 7.15 | 6.63 | 7.21 |
| | | C | 6.79 | 8.19 | 7.21 | 8.68 | 8.05 | 7.71 | 6.84 | 6.32 |
| Tulsa | High | A | 8.70 | 9.40 | 8.70 | 9.64 | 9.32 | 9.53 | 10.00 | 9.04 |
| | | B | 8.55 | 9.12 | 8.80 | 10.86 | 9.37 | 9.98 | 9.94 | 10.39 |
| | | C | 8.57 | 9.09 | 8.21 | 9.74 | 9.23 | 8.88 | 8.77 | 9.54 |
| Payne Bottomland | Medium | A | 9.05 | 9.34 | 9.22 | 8.71 | 9.33 | 9.59 | 8.96 | 10.78 |
| | | B | 9.58 | 8.94 | 9.33 | 10.04 | 10.04 | 9.28 | 9.65 | 10.09 |
| | | C | 8.53 | 9.85 | 9.83 | 8.81 | 9.93 | 9.25 | 10.23 | 9.99 |
| Payne Upland | Medium | A | 8.95 | 9.63 | 8.88 | 9.52 | 9.61 | 9.71 | 10.38 | 10.22 |
| | | B | 8.99 | 9.23 | 9.10 | 9.72 | 9.78 | 10.56 | 10.74 | 9.48 |
| | | C | 9.75 | 9.27 | 9.92 | 9.80 | 9.81 | 10.24 | 9.98 | 9.20 |

Table 14.--Percentage of oil in corn grain for eight varieties at seven locations in 1946.

| Location County | Fertility | Repli- cation | Indiana 210B | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent |
|--------------------|-----------|------------------|-----------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|
| Hughes | Low | A | 3.16 | 2.87 | 3.42 | 3.53 | 3.76 | 4.42 | 3.84 | 3.69 |
| | | B | 3.41 | 3.24 | 2.99 | 3.67 | 3.63 | 4.36 | 4.18 | 3.61 |
| | | C | 4.35 | 2.94 | 2.97 | 3.77 | 4.21 | 4.62 | 4.58 | 3.91 |
| Bryan | High | A | 4.17 | 4.24 | 3.81 | 4.45 | 4.54 | 4.84 | 5.08 | 4.44 |
| | | B | 3.91 | 4.15 | 4.78 | 5.14 | 4.68 | 4.80 | 5.02 | 4.05 |
| | | C | 4.19 | 3.93 | 4.41 | 4.43 | 4.56 | 4.84 | 4.73 | 5.00 |
| Garvin | High | A | 4.01 | 4.20 | 3.86 | 4.29 | 4.53 | 5.08 | 5.15 | 4.41 |
| | | B | 4.89 | 3.93 | 4.02 | 4.34 | 3.86 | 4.79 | 4.79 | 4.26 |
| | | C | 3.75 | 3.83 | 3.95 | 5.42 | 4.82 | 4.52 | 4.10 | 4.48 |
| Seminole | High | A | 3.93 | 3.42 | 3.80 | 4.14 | 4.38 | 4.20 | 3.93 | 4.08 |
| | | B | 4.99 | 3.24 | 3.93 | 4.40 | 5.13 | 5.56 | 4.86 | 3.81 |
| | | C | 3.99 | 4.26 | 3.81 | 4.07 | 3.66 | 5.07 | 4.70 | 4.12 |
| LeFlore | Low | A | 3.60 | 3.33 | 3.35 | 4.33 | 4.03 | 4.25 | 4.86 | 4.15 |
| | | B | 3.70 | 2.52 | 3.26 | 3.46 | 4.06 | 4.51 | 4.73 | 4.55 |
| | | C | 3.85 | 3.14 | 3.51 | 4.00 | 3.96 | 4.59 | 4.84 | 4.18 |
| Carter | Low | A | 3.84 | 3.66 | 3.52 | 4.49 | 3.83 | 4.37 | 3.87 | 3.98 |
| | | B | 4.27 | 3.70 | 3.78 | 4.27 | 3.95 | 4.44 | 3.95 | 3.57 |
| | | C | 3.74 | 3.51 | 3.60 | 4.18 | 3.82 | 4.69 | 4.68 | 4.24 |
| Payne Upland | Medium | A | 3.25 | 3.30 | 2.88 | 3.11 | 3.70 | 2.99 | 4.02 | 3.38 |
| | | B | 3.87 | 2.94 | 2.47 | 3.56 | 3.93 | 4.13 | 3.84 | 3.26 |
| | | C | 3.68 | 3.56 | 3.01 | 3.41 | 2.94 | 3.90 | 3.40 | 3.80 |

Table 15.--Percentage of oil in corn grain for eight varieties at seven locations in 1947.

| Location County | Fertility | Repli- cation | Ohio C-38 | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent |
|---------------------|-----------|------------------|--------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|
| McClain | Low | A | 3.27 | 4.33 | 3.61 | 4.03 | 4.50 | 4.58 | 4.50 | 3.92 |
| | | B | 3.37 | 4.49 | 3.79 | 4.25 | 3.45 | 4.96 | 4.65 | 3.81 |
| | | C | 3.47 | 3.16 | 3.49 | 4.53 | 3.86 | 4.37 | 4.81 | 3.99 |
| Garvin | High | A | 3.74 | 4.13 | 3.93 | 4.44 | 4.21 | 4.45 | 3.85 | 4.26 |
| | | B | 4.06 | 4.53 | 3.78 | 4.12 | 4.24 | 4.60 | 4.63 | 4.35 |
| | | C | 3.67 | 3.76 | 4.07 | 4.95 | 4.23 | 4.87 | 5.01 | 3.52 |
| Seminole | High | A | 3.77 | 3.61 | 3.52 | 3.48 | 4.18 | 4.12 | 3.87 | 3.48 |
| | | B | 3.64 | 3.43 | 3.28 | 3.99 | 3.97 | 4.23 | 3.93 | 3.79 |
| | | C | 3.54 | 3.69 | 3.51 | 3.95 | 4.15 | 4.25 | 4.15 | 3.56 |
| Carter | Low | A | 3.63 | 3.89 | 3.39 | 4.19 | 3.99 | 4.26 | 4.36 | 3.90 |
| | | B | 3.45 | 3.48 | 3.29 | 3.50 | 4.10 | 4.43 | 4.02 | 3.75 |
| | | C | 3.53 | 3.77 | 3.55 | 4.05 | 3.64 | 4.21 | 4.22 | 3.81 |
| Tulsa | High | A | 2.92 | 3.51 | 3.96 | 2.77 | 3.62 | 3.84 | 4.14 | 3.35 |
| | | B | 2.98 | 3.48 | 3.24 | 3.57 | 3.06 | 3.93 | 3.94 | 3.63 |
| | | C | 3.44 | 3.43 | 3.59 | 3.85 | 3.38 | 3.71 | 3.62 | 3.65 |
| Payne Bottomland | Medium | A | 3.62 | 3.64 | 3.84 | 4.46 | 4.02 | 4.03 | 3.80 | 3.23 |
| | | B | 3.08 | 3.42 | 3.14 | 4.54 | 4.16 | 3.37 | 3.28 | 3.19 |
| | | C | 3.75 | 2.64 | 3.84 | 4.05 | 3.81 | 3.26 | 3.44 | 2.88 |
| Payne Upland | Medium | A | 3.26 | 3.40 | 3.36 | 3.89 | 3.63 | 3.66 | 3.89 | 3.53 |
| | | B | 2.83 | 3.52 | 3.77 | 3.74 | 3.52 | 3.83 | 3.82 | 3.43 |
| | | C | 3.42 | 3.38 | 3.13 | 3.16 | 3.77 | 4.10 | 3.60 | 3.31 |

Table 16.--Percentage of ash in corn grain for eight varieties at seven locations in 1947.

| Location County | Fertility | Repli- cation | Ohio C-38 | Illinois 751 | U.S. 13 | Hays Golden | Illinois 200 | Illinois 448 | Texas 12 | Reid Yellow Dent |
|---------------------|-----------|------------------|--------------|-----------------|---------|----------------|-----------------|-----------------|-------------|---------------------|
| McClain | Medium | A | 1.10 | 1.16 | 1.10 | 1.28 | 1.13 | 1.16 | 1.11 | 1.25 |
| | | B | 1.16 | 1.36 | 1.04 | 1.29 | 1.14 | 1.24 | 1.15 | 1.11 |
| | | C | 1.22 | 1.17 | 1.12 | 1.24 | 0.90 | 1.09 | 1.10 | 1.18 |
| Garvin | High | A | 1.07 | 1.02 | 1.20 | 0.91 | 0.91 | 0.90 | 1.10 | 1.12 |
| | | B | 1.05 | 1.09 | 0.85 | 1.14 | 1.06 | 0.85 | 1.27 | 1.22 |
| | | C | 0.95 | 0.99 | 0.95 | 1.31 | 0.82 | 0.89 | 1.20 | 1.08 |
| Seminole | High | A | 1.27 | 1.25 | 1.16 | 1.21 | 1.03 | 1.19 | 1.15 | 1.15 |
| | | B | 1.17 | 1.32 | 1.09 | 1.25 | 1.13 | 1.08 | 1.17 | 1.31 |
| | | C | 0.99 | 1.16 | 1.12 | 1.18 | 1.01 | 1.07 | 1.12 | 1.27 |
| Carter | Low | A | 1.24 | 1.28 | 1.16 | 1.22 | 1.16 | 1.18 | 1.01 | 1.13 |
| | | B | 1.22 | 1.25 | 1.12 | 1.20 | 1.04 | 0.97 | 1.08 | 1.06 |
| | | C | 1.23 | 1.18 | 0.99 | 1.17 | 1.13 | 1.10 | 1.10 | 1.06 |
| Tulsa | High | A | 1.31 | 1.20 | 1.44 | 1.20 | 1.21 | 1.27 | 1.19 | 1.06 |
| | | B | 1.39 | 1.05 | 1.17 | 1.25 | 1.31 | 1.27 | 1.31 | 1.16 |
| | | C | 1.36 | 1.15 | 1.20 | 1.36 | 1.15 | 1.27 | 1.19 | 1.15 |
| Payne Bottomland | Medium | A | 1.53 | 1.45 | 1.27 | 1.35 | 1.31 | 1.23 | 1.24 | 1.47 |
| | | B | 1.42 | 1.48 | 1.34 | 1.37 | 1.33 | 1.32 | 1.27 | 1.30 |
| | | C | 1.44 | 1.42 | 1.42 | 1.18 | 1.33 | 1.39 | 1.28 | 1.29 |
| Payne Upland | Medium | A | 1.34 | 1.19 | 1.24 | 1.05 | 1.05 | 1.10 | 1.18 | 1.17 |
| | | B | 1.12 | 1.16 | 1.25 | 1.04 | 1.15 | 0.96 | 1.20 | 1.11 |
| | | C | 1.48 | 1.23 | 1.23 | 1.15 | 1.18 | 1.25 | 1.22 | 1.24 |

Typist: Elizabeth Hobbs Chessmore