# THE INFLUENCE OF ENVIRONMENT ON CERTAIN CONSTITUENTS OF QUALITY AND FOOD VALUE OF HYBRID SWEET CORN AND FIELD CORN

by

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A thesis submitted to the Graduate Faculty of the Virginia Polytechnic Institute in candidacy for the degree of

MASTER OF SCIENCE

in

HORTICULTURE

APPROVED:

Director of Graduate Studies

Dean of Agriculture

APPROVED:

Head of Department

Major Professor

1955

Blacksburg, Virginia

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## ACKNOWLEDGMENTS

The writer wishes to express her appreciation and thanks to all those who assisted in the preparation and presentation of this work. She wishes to give special acknowledgment to Dr. F. S. Andrews, Professor of Horticulture, for his assistance, guidance, interest, and criticism in carrying out the investigation.

Grateful acknowledgment is made to other members of the advisory committee: Dr. W. P. Judkins, Head, Department of Horticulture; Dr. C. I. Rich, Associate Agronomist; and Mrs. Margaret C. Dean, Professor of Home Economics, for their encouragement and assistance in this work.

Appreciation is also expressed to Mr. C. Y. Kramer for his advice on the statistical analysis of the data.

Finally, the author expresses appreciation to her family, especially to her mother, who helped her and encouraged her through her school years.

# V

# INTRODUCTION

Corn has been used primarily as a source of energy in many countries, although it can supply other nutrients. For populations almost wholly dependent on corn for their dietary protein, the protein content of field corn varieties has considerable practical nutritional importance. Since Central American diets tend to be extremely low in fat, and the fat content of corn often constitutes the bulk of fat in the diet, variations of fat content of corn may have direct nutritional significance. The food value of corn is dependent on its chemical composition and its acceptability by the consumer.

Sweet corn is very popular in the United States and Canada, but has not been grown as a commercial crop in Latin American countries where field corn is more widely known.

Field corn or maize and sweet corn are closely related. An accepted theory identifies sweet corn as a mutation from field corn of relatively recent origin (8)[1]; this theory is plausible as it has been demonstrated that sweet corn is really field corn in an arrested state, due to the inability of the kernel to complete the formation of normal starch (16).

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[1]Numbers in parentheses refer to literature cited.

The present study reports the results of work on the influence of plant spacing and soil fertility on the yield components, soluble solids content, and toughness of the pericarp of sweet corn hybrids, and the distribution of protein in hand dissected fractions of sweet corn as compared to the protein content of field corn varieties.

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## REVIEW OF LITERATURE

Much work has been done in connection with the structure of sweet corn kernels and the chemical composition of its parts. The differences in the chemical composition of the various anatomical regions of cereal grains was initiated by Hopkins et. al. (14) in 1903; they worked out the distribution of protein, fat, ash, and carbohydrate in the maize kernel. Later, Earle et. al. (5) reported a study on the differences in chemical composition between component parts of the corn kernel. J. J. C. Hinton (13) reported that 70% of the total protein was found in the endosperm, in which a concentration gradient exists from the outer to the inner layers. Miller and Brimball (17) concluded that kernels with high protein content will invariably have low starch, and kernels with high oil have larger germs than the kernels with low oil content; increased oil content in corn grain was shown to depend primarily upon increased proportion of germ and increased concentration of oil in the germ. These investigators also concluded that variation in total oil percentage was not associated with variation in total protein percentage.

Norden et. al. (19) reported that genetic differences among hybrids were relatively more important in determining protein content than stage of maturity or locational differences in weather and soil type; of these, the supply of soil nitrogen appeared to be the critical factor affecting protein percentage; these workers concluded that nitrogen supplied by the soil is first available to the plant for growth processes related to maximum yield, and excess nitrogen not needed for these processes tends to increase the protein content of the grain. Studying the effect of high rates of nitrogen on corn yield, Eskew and Paden (9) concluded that the average yield in bushel per acre increases as the application of sodium nitrate increases. Doty et. al. (4) found that protein and oil content of the corn grain were influenced by seasonal variations and protein content was also influenced by soil type and location.

Ensie (7) studied the relation between plant spacing, rate of maturity, length of ear, plant height and degree of tillering; he concluded that when soil fertility and moisture are brought near optimum certain environmental factors such as temperature and rainfall will affect the corn yield and ear size. Muhr and Rost (18) reported that as population increased, ear size of both sweet and field corn decreased; the yield of field corn was greater than the yield of sweet corn; this was due to an increase in barren stalks in sweet corn as population increased. Thinner stands of sweet corn gave substantially better increases in yield than did field corn of the same population. Under these conditions many stalks of sweet corn produced two or more ears.

Bailey (1), Bowers (2), and Pickett (21) working with sweet corn reported higher yields with close spacing. Pickett (21) states that yield differences due to spacing are almost entirely due to the stand obtained and not to the method of planting; if stands are too heavy, yields of marketable corn will be reduced because of small ear size, even though total yields may be somewhat increased by closer planting.

Nutritional studies of other investigators on the chemical composition of the corn kernels refer to their protein content as the zein and non-zein fractions. Schneider et. al. (23) found that all nitrogen fractions of the whole kernel usually increased when the total nitrogen was increased by breeding or by fertilization of the soil; however, the alcohol-soluble nitrogen-zein increased at the fastest rate. Since zein is a low quality protein the data presented by Schneider et al. (23) indicate that protein of high protein corn has a lower biological value than the protein of low protein corn. These data also indicate that growing corn with high soil nitrogen and selecting for high protein and high oil resulted in an increase in the proportion of germ and a decrease in endosperm, whereas growing corn with low soil nitrogen and selecting for low protein and low oil gave opposite results.

Osborne and Mendel (20) reported that the zein fraction of corn protein is deficient in certain amino acids, tryptophane and lysine, and was found to constitute the major protein of the endosperm and absent from the corn embryo; these workers also showed that corn embryo protein approximated animal protein in nutritive quality. Frey et. al. (10)

concluded that the amount of non-zein protein appears to be a better criterion in the selection for increased tryptophane content in the corn kernel than does the amount of total protein.

VII

## PURPOSE OF EXPERIMENTAL INVESTIGATION

The review of literature indicates some of the research which has been done with the chemical composition of the corn kernels and the influence of environment on yield and other factors, but relatively little data has been presented on the effect of environment as related to varieties on the chemical composition or food value, and on the so-called quality of sweet corn, and the influence of locality on the nutritive value of field corn.

In view of the evidence presented by previous investigators, more information is needed to answer certain questions such as:

1. What effects do spacing and fertilizer treatments have on the nitrogen content, yield, soluble solids content and pericarp toughness of sweet corn hybrids?
2. Are any of the varieties selected more desirable with respect to yield, protein content and quality as determined by soluble solids content and pericarp toughness?
3. Regardless of varieties, what treatments result in a higher total nitrogen content, higher yield and higher soluble solids? Do all varieties respond in the same way?
4. Do early maturing varieties require as much nitrogen or the same spacing as later maturing varieties?

The purpose in undertaking this project is to evaluate the interrelations among factors such as varieties, plant spacing, nitrogen fertilization and yield, total nitrogen content of the component parts of the kernel, percentage of soluble solids, toughness of the pericarp of sweet corn hybrids, and the influence of locality where grown on the total nitrogen content of the component parts of the kernel of field corn varieties.

# VIII

# EXPERIMENTAL METHODS

This experimental investigation consisted of two parts. The experiment conducted at Blacksburg, Virginia, was designed to estimate the influence of soil fertilizer and plant spacing on the yield, soluble solids content, pericarp toughness, and total nitrogen content of the kernel of sweet corn varieties. A supplement to this study consisted of the analysis of three field corn varieties grown in three locations in Central America to determine the influence of locality where grown on the total nitrogen content of (a) corn kernels, and (b) embryos.

## Sweet Corn Used

At Blacksburg, Virginia, three sweet corn hybrids varying in time of maturity were selected, namely, Seneca Arrow (V-1), and Northern Cross (V-2), both early maturing, and Seneca Chief (V-3), a medium late maturing variety.

## Field Corn Used

The field corn varieties Papaloapan, Venezuela 3, and Rocamex 520-C were grown in Central America in cooperation with the Proyecto Cooperativo Centroamericano in the following locations: Santa Cruz Porrillo (L-1), and San Andres (L-2) Experiment Stations in El Salvador; and Panama (L-3). One hundred gram samples of three replicates of each variety were sent to us from each location through the facilities of the Rockefeller Foundation, Mexico City, D. F.

Soil

The soil in the experiment at Blacksburg, Virginia, had been planted in rye grass and soybeans in the previous year. The soil was plowed with a tractor, harrowed thoroughly and disked. The previous cover crop of a grass and a legume evidently contributed to the nitrate content of the soil. In the past two years the rainfall had been low and probably delayed the conversion of organic nitrogen to nitrate.

Plot Size and Arrangement

At Blacksburg, Virginia, plots consisted of two rows 3 feet apart 16 feet long; each plot was separated by a guard row, and arranged in a randomized split-split plot design as given in Table I. The plot arrangement consisted of three treatments using three varieties replicated three times.

Treatments

The three sweet corn hybrids were planted on May 25, 1954. The seed was planted 6, 9, and 12 inches apart in rows 3 feet apart. The spacing is designated throughout this report as S-6, S-9, and S-12. The plants were later thinned to one plant per hill. A basic application of 2-12-12 fertilizer was applied to all plots at the rate of 700 lbs. per acre, broadcast before planting. Nitrogen in the form of nitrate of soda was applied as a side-dressing when the plants were about one-third grown at the following rates:

Table 1

<u>Split-Split Plot Design for Sweet Corn</u>

In the design below:

V-1 - Seneca Arrow
V-2 - Northern Cross
V-3 - Seneca Chief

S-1 - Close spacing, 6 inches
S-2 - Conventional spacing, 9 inches
S-3 - Wide spacing, 12 inches

F-1 - 14 lbs. N
F-2 - 64 lbs. N
F-3 - 114 lbs. N

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $V_2S_3F_3$ | $V_2S_3F_2$ | $V_2S_3F_1$ | $V_2S_1F_2$ | $V_2S_1F_1$ | $V_2S_1F_3$ | $V_2S_2F_1$ | $V_2S_2F_3$ | $V_2S_2F_2$ |
| Rep. I | $V_1S_{\underset{1}{2}}F_3$ | $V_1S_{\underset{1}{2}}F_1$ | $V_1S_{\underset{1}{2}}F_2$ | $V_1S_3F_2$ | $V_1S_3F_3$ | $V_1S_3F_1$ | $V_1S_2F_2$ | $V_1S_2F_3$ | $V_1S_2F_1$ |
| | $V_3S_3F_3$ | $V_3S_3F_1$ | $V_3S_3F_2$ | $V_3S_2F_2$ | $V_3S_2F_3$ | $V_3S_2F_1$ | $V_3S_1F_1$ | $V_3S_1F_3$ | $V_3S_1F_2$ |
| | $V_1S_1F_1$ | $V_1S_1F_2$ | $V_1S_1F_3$ | $V_1S_2F_1$ | $V_1S_2F_3$ | $V_1S_2F_2$ | $V_1S_3F_3$ | $V_1S_3F_1$ | $V_1S_3F_2$ |
| Rep. II | $V_2S_3F_2$ | $V_2S_3F_1$ | $V_2S_3F_3$ | $V_2S_1F_3$ | $V_2S_1F_1$ | $V_2S_1F_2$ | $V_2S_2F_2$ | $V_2S_2F_3$ | $V_2S_2F_1$ |
| | $V_3S_2F_2$ | $V_3S_2F_3$ | $V_3S_2F_1$ | $V_3S_3F_3$ | $V_3S_3F_1$ | $V_3S_3F_2$ | $V_3S_1F_3$ | $V_3S_1F_1$ | $V_3S_1F_2$ |
| | $V_3S_1F_3$ | $V_3S_1F_1$ | $V_3S_1F_2$ | $V_3S_3F_1$ | $V_3S_3F_2$ | $V_3S_3F_3$ | $V_3S_2F_3$ | $V_3S_2F_1$ | $V_3S_2F_2$ |
| Rep. III | $V_2S_3F_2$ | $V_2S_3F_3$ | $V_2S_3F_1$ | $V_2S_1F_1$ | $V_2S_1F_2$ | $V_2S_1F_3$ | $V_2S_2F_1$ | $V_2S_2F_3$ | $V_2S_2F_2$ |
| | $V_1S_2F_2$ | $V_1S_2F_1$ | $V_1S_2F_3$ | $V_1S_1F_3$ | $V_1S_1F_2$ | $V_1S_1F_1$ | $V_1S_3F_2$ | $V_1S_3F_3$ | $V_1S_3F_1$ |

F-1 14 lbs. N/A broadcast, no side-dressing.

F-2 14 lbs. N/A broadcast, plus 50 lbs. N side-dressing

F-3 14 lbs. N/A broadcast, plus 100 lbs. N side-dressing.

Shallow cultivation was practiced to control weeds, and artificial irrigation was applied three times because of low rainfall.

Pollination

At least six ears per plot were selfed, and six ears of certain plots were cross-pollinated. After pollination the silks were covered with paper bags and tagged properly. The purpose of hand pollination was to be sure that pollen from other varieties and other treatments did not fall on the silks being pollinated, and also to determine whether or not cross-pollination influenced the factors studied.

Self and cross pollination took place on the following dates: Northern Cross, July 20 and 21; Seneca Arrow, July 23 to 27; and Seneca Chief, July 27 to 29, 1954.

Determination of Maturity

The stage of maturity of sweet corn was determined by the number of days after silking, by pressure required to puncture the pericarp or toughness, and by determining the total soluble solids content. The number of days after silking was found to be a good measure for determining the approximate stage of maturity if accompanied by other tests.

## Plant Characteristics

As a means of measuring the influence of plant spacing and fertilizer treatments on the plant and its growth response to environment, certain plant characteristics were studied including height to the tassel and to the first ear, and number of shoots per plant.

The height of five plants per plot and the number of shoots per plant per plot were obtained on stalks taken at random at time of harvest. Height of stalk was measured from ground at base of the stalk to base of tassel. The height of first ear was taken from the same stalks as those utilized for total height and was measured from ground to attachment of first ear.

## Harvesting

The first and second crops were harvested on the following dates: Northern Cross, August 9 and 14; Seneca Arrow, August 12 and 20; and Seneca Chief, August 19 and 23, 1954. At harvest the yield data, which included the total number and weight of marketable ears, the number and weight of total ears, and the weight of individual ears both unhusked and husked was recorded.

## Methods of Sampling and Analysis

For each determination made in the laboratory 4 to 5 ears from each plot of self-pollinated and certain cross-pollinated plants were taken at random. The samples were brought in within 1/2 to 1 hour after harvesting; the toughness of the pericarp and the percent of total soluble solids were determined immediately after the samples were brought in.

Another set of ears were chilled in ice water and kept in a refrigerator at 2° C. until analyzed for total nitrogen content.

(a) Puncture Tests. The pericarp toughness was determined with a standard push-pull gauge with a plunger 1/24 inch in diameter; by puncturing an average of 20 kernels from the middle portion of each of 4 to 5 ears the error introduced by taking measurements from the tip or butt end of the cob was avoided. The pressure required to puncture the pericarp was measured in grams. An average of these measurements is given in Table 9.

(b) Soluble Solids. From the same set of ears, 25 grams of kernels were taken to determine the percentage of soluble solids with a Baush and Lomb Juice Refractometer which gave accurate readings of .1 percent. Corrections for temperature were made. The average of these readings is given in Table 10.

(c) Total Nitrogen Determination. In the preparation of samples for chemical analyses, the ears of sweet corn were taken out of the refrigerator where they had remained between 8 to 10 days, the kernels dissected with the aid of dissecting knives and a magnifier illuminator. These embryos and a set of kernels were weighed and dried in an air oven for 24 hours at 60-65° C. The dried samples were cooled in a desiccator, and reweighed. A micro-Wiley mill with 40 mesh screen was used to grind the kernels; as the embryos were very oily they were macerated in a mortar. All samples were kept in sealed containers. The chemical analysis for total nitrogen was done according to the micro-Kjeldahl-Nessler method.

A sample of field corn grown in Central America was dissected, weighed, and dried. This set of embryos and another set of kernels were ground and analyzed according to the same methods described for sweet corn. The average readings of two separate determinations of the total nitrogen of whole kernels and embryos of field corn are given in Tables 13 and 14 respectively.

(d) Statistical Analysis. Analysis of variance of the sweet corn data obtained was done in two separate tables. It was necessary to eliminate Rep. I in one case, and variety 1, Seneca Arrow, in another.

Analysis of the field corn data was done according to the randomized block experiment since there were only two variables to be considered. It will be noticed in Tables 13 and 14 that in the second variety, Venezuela 3, there was a missing sample which reduced the number of degrees of freedom by 1 in the analysis of variance of the same variety.

# IX

# RESULTS

## YIELD

### (a) Number of Ears

In Tables 2 and 3 the total number of ears per plot and the number of marketable ears per plot are given respectively.

The variety Seneca Chief obtained a higher total yield than the varieties Northern Cross and Seneca Arrow, but this difference was not statistically significant. Seneca Chief also obtained a higher number of total marketable ears per plot than Northern Cross and Seneca Arrow; this difference was significant at the 5% level.

Spacing treatments did affect the yield components; higher yields resulted when plants of all varieties were grown 6 inches apart.

The fertilizer treatments did not affect the yield of any of the varieties studied.

### (b) Weight of Ears

The average of three replicates of the total weight of ears of sweet corn per plot is given in Table 4. The total weight of ears of Seneca Chief was higher than the total weight of ears of Northern Cross; this difference was significant at the 5% level.

Spacing treatments definitely affected the weight of total ears; this was significantly higher at 6 inches than at 9 and 12 inches of spac-

Table 2

Influence of Plant Spacing and Nitrogen Fertilizer on the Yield of Hybrid Sweet Corn

**Average of three replicates of number of marketable ears of sweet corn per plot. (Size plot, 6' x 16')**

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 71.0 | 73.7 | 48.3 | 64.3 | 62.3 | 41.7 | 52.0 | 52.0 | 71.3 | 72.3 | 65.3 | 69.6 |
| 50 | 66.0 | 59.7 | 54.0 | 59.9 | 60.7 | 50.0 | 50.3 | 53.6 | 75.3 | 70.3 | 65.7 | 70.4 |
| 100 | 75.0 | 56.7 | 57.0 | 62.9 | 63.7 | 44.0 | 45.0 | 50.9 | 71.7 | 66.7 | 60.7 | 66.3 |
| Ave. | 70.7 | 63.4 | 53.1 | 62.4 | 62.2 | 45.2 | 49.1 | 52.2 | 72.8 | 69.8 | 63.9 | 68.8 |

**Replicates II and III (varieties 1,2 and 3)**

| Source | F. ratio |
|---|---|
| Spacings | 40.88** |
| Varieties x spacings | 6.38* |

**Replicates I, II and III (varieties 2 and 3)**

| Source | F. ratio |
|---|---|
| Spacings | 23.34** |
| Varieties x spacings | 8.13* |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates
* Significant at the 5% level
** Significant at the 1% level

Table 3

**<u>Influence of Plant Spacing and Nitrogen Fertilizer on the Number of Marketable Ears of Hybrid Sweet Corn</u>**

Average of three replicates of number of marketable ears of sweet corn per plot. (Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 29.0 | 34.7 | 22.3 | 28.9 | 41.0 | 25.3 | 29.0 | 31.8 | 47.7 | 47.8 | 45.3 | 46.9 |
| 50 | 30.0 | 27.3 | 22.0 | 26.4 | 46.3 | 31.7 | 29.7 | 35.9 | 51.0 | 45.7 | 46.0 | 47.6 |
| 100 | 36.0 | 27.0 | 28.3 | 30.4 | 45.3 | 34.3 | 27.8 | 35.8 | 48.7 | 43.3 | 43.0 | 45.0 |
| Ave. | 31.7 | 29.7 | 24.2 | 28.5 | 44.2 | 30.4 | 28.8 | 34.5 | 49.1 | 45.6 | 44.8 | 46.5 |

Replicates II and III (varieties 1, 2 and 3)

| <u>Source</u> | <u>F. ratio</u> |
|---|---|
| Varieties | 19.92* |
| Spacings | 30.24** |
| Varieties x spacings | 4.54* |

Replicates I, II and III (varieties 2 and 3)

| <u>Source</u> | <u>F. ratio</u> |
|---|---|
| Varieties | 22.53* |
| Spacings | 30.96** |
| Varieties x spacings | 10.15** |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots
[2]Average of two replicates
* Significant at 5% level
** Significant at 1% level

Table 4

Influence of Plant Spacing and Nitrogen Fertilization on the Total Weight of Ears of Hybrid Sweet Corn

Average total weight in lbs. of ears of sweet corn per plot, three replicates.
(Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 27.5 | 33.7 | 22.9 | 28.0 | 33.9 | 22.2 | 24.9 | 27.0 | 34.1 | 34.5 | 33.1 | 33.9 |
| 50 | 29.0 | 27.6 | 24.8 | 27.1 | 36.1 | 27.9 | 27.2 | 30.4 | 36.4 | 33.5 | 32.3 | 34.1 |
| 100 | 32.7 | 26.3 | 26.3 | 28.4 | 35.7 | 36.6 | 23.7 | 32.0 | 33.6 | 32.3 | 30.2 | 32.0 |
| Ave. | 29.7 | 29.2 | 24.7 | 27.9 | 35.2 | 28.9 | 25.3 | 29.8 | 34.7 | 33.4 | 31.9 | 33.3 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Spacings | 54.75** |
| Varieties x spacings | 11.83** |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 20.66* |
| Spacings | 30.63** |
| Varieties x spacings | 14.06** |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots
[2]Average of two replicates
* Significant at 5% level
** Significant at 1% level

ing. A highly significant interaction between varieties and spacings is also indicated in Table 4. Two varieties obtained the highest total weight in pounds when grown 6 inches apart; however, Seneca Arrow showed no difference in total weight of ears when grown 6 or 9 inches apart. The total weight of sweet corn ears per plot did not vary under the different nitrogen fertilizer levels.

The average total weight of marketable ears per plot is given in Table 5. The weight of marketable ears was significantly higher at 6 inches of spacing than at 9 and 12 inches.

Although no significant differences between varieties were observed, Seneca Chief had the tendency to give lower weight of ears per plot than Northern Cross and Seneca Arrow. Interaction between varieties and spacings which was significant at the 5% level is interpreted as follows: Seneca Chief and Northern Cross gave higher total weights of marketable ears per plot when grown at 6 inches of spacing than at 9 and 12 inches. This was not the case of variety Seneca Arrow which gave the highest total weight of marketable ears when grown at 9 inches of spacing. The lowest total weight of marketable ears of the three varieties was obtained with 12 inches of spacing.

(c) Weight of Individual Ears

Tables 6 and 7 give the weight of individual unhusked and husked ears of sweet corn.

Table 5

**Influence of Plant Spacing and Nitrogen Fertilization on the Weight of Marketable Ears of Hybrid Sweet Corn**

Average of three replicates of the weight in lbs. of marketable ears of sweet corn per plot. (Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 14.7 | 17.4 | 15.6 | 15.9 | 24.6 | 15.6 | 18.0 | 19.4 | 25.5 | 24.8 | 25.1 | 25.1 |
| 50 | 16.1 | 16.4 | 14.3 | 15.6 | 30.1 | 21.0 | 18.9 | 23.3 | 26.8 | 24.3 | 24.6 | 25.2 |
| 100 | 18.2 | 16.2 | 14.9 | 16.4 | 28.1 | 19.5 | 15.1 | 20.9 | 25.1 | 23.9 | 23.8 | 24.3 |
| Ave. | 16.3 | 16.7 | 14.9 | 15.9 | 27.6 | 18.7 | 17.3 | 21.2 | 25.8 | 24.3 | 24.5 | 24.9 |

Replicates II and III (varieties 1, 2, and 3)

| Source | F. ratio |
|---|---|
| Spacings | 15.63** |
| Varieties x spacings | 5.63* |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Spacings | 13.77** |
| Varieties x spacings | 7.85* |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots
[2]Average of two replicates
* Significant at 5% level
** Significant at 1% level

Table 6

Influence of Plant Spacing and Nitrogen Fertilization on the Weight of Unhusked Ears of Hybrid Sweet Corn

Average weight in lbs. of unhusked individual ears of sweet corn, three replicates

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | .50 | .60 | .56 | .55 | .61 | .62 | .65 | .63 | .54 | .52 | .55 | .54 |
| 50 | .52 | .60 | .56 | .56 | .64 | .66 | .64 | .65 | .52 | .53 | .53 | .53 |
| 100 | .51 | .60 | .52 | .54 | .61 | .66 | .60 | .62 | .52 | .55 | .55 | .53 |
| Ave. | .51 | .60 | .55 | .55 | .62 | .65 | .63 | .63 | .53 | .53 | .54 | .53 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 21.50* |
| Spacings | 6.75* |
| Varieties x spacings | 5.00* |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Spacings | 8.50* |
| Varieties x spacings | 5.00* |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates
* Significant at the 5% level
** Significant at the 1% level

Table 7

**Influence of Plant Spacing and Nitrogen Fertilization on the Weight of Husked Ears of Hybrid Sweet Corn**

Average weight in lbs. of husked individual ears of sweet corn, three replicates

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | .41 | .45 | .43 | .43 | .47 | .47 | .51 | .48 | .38 | .39 | .39 | .39 |
| 50 | .44 | .46 | .41 | .44 | .47 | .48 | .49 | .48 | .39 | .38 | .39 | .39 |
| 100 | .44 | .45 | .39 | .43 | .46 | .46 | .49 | .47 | .37 | .39 | .40 | .39 |
| Ave. | .43 | .45 | .41 | .43 | .47 | .47 | .50 | .48 | .38 | .39 | .39 | .39 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 43.5000* |
| Varieties x spacings | 4.5556* |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 110.2000** |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates.
*Significant at the 5% level
**Significant at the 1% level

The weight of individual unhusked and husked ears of Northern Cross was significantly higher than the weight of individual ears of the other two varieties. Interaction between varieties and spacings of the weight of individual ears shows the inconsistency with which different varieties responded to spacing treatments.

PLANT CHARACTERISTICS

(a) Height of Sweet Corn Plants

The heights of sweet corn plants to the tassel and first ear were measured but the results are not given in table form. No significant differences as a result of treatment were observed. This is further evidence that nitrogen was probably not the limiting factor in any treatments.

(b) Number of Shoots

The average number of shoots or tillers per plant is given in Table 8. The variety Seneca Chief gave a higher number of shoots than Northern Cross and Seneca Arrow. A highly significant difference due to spacing resulted in greater number of shoots when the plants were grown 12 inches apart; the number of shoots was decreased as the spacing between plants was reduced. No significant differences due to nitrogen fertilizer levels were observed.

Table 8

**Influence of Plant Spacing and Nitrogen Fertilization on the Number of Shoots per Plant of Hybrid Sweet Corn**

Average number of shoots per plant per plot, three replicates. (Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | .48 | 1.50 | 1.69 | 1.22 | .61 | 1.59 | 2.15 | 1.45 | 1.02 | 1.87 | 2.45 | 1.78 |
| 50 | .34 | 1.34 | 1.39 | 1.02 | .79 | 1.73 | 1.98 | 1.50 | 1.03 | 1.89 | 2.59 | 1.84 |
| 100 | .58 | 1.17 | 1.53 | 1.09 | .79 | 1.53 | 1.71 | 1.34 | .88 | 1.82 | 1.73 | 1.48 |
| Ave. | .47 | 1.33 | 1.54 | 1.11 | .73 | 1.62 | 1.95 | 1.43 | .98 | 1.86 | 2.26 | 1.70 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 38.835* |
| Spacings | 57.245** |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Spacings | 45.335** |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates.
*Significant at the 5% level.
**Significant at the 1% level.

## QUALITY CHARACTERISTICS

### (a) Toughness of the Pericarp

The toughness of the pericarp of sweet corn as influenced by plant spacing and nitrogen fertility is given in Table 9.

There was a significant difference between varieties, Northern Cross being the toughest, but not much difference between the toughness of Seneca Chief and Seneca Arrow was observed. Plant spacing and nitrogen fertilizer did not affect the toughness of the pericarp.

### (b) Soluble Solids Content

Table 10 shows the influence of plant spacing and nitrogen fertilizer on the percentage of total soluble solids of sweet corn ears per plot. Seneca Arrow had a higher total soluble solids content than Seneca Chief or Northern Cross. Plant spacing and nitrogen fertilizer did not affect the percentage of total soluble solids. There was no significant interaction between the factors studied.

## NITROGEN

### (a) Total Nitrogen of Whole Kernels and Embryos of Sweet Corn

Table 11 shows the average percentage of total nitrogen of whole kernels of the sweet corn varieties.

Kernels of Northern Cross contained the highest percentage of total nitrogen and kernels of Seneca Chief the lowest values for total nitrogen.

Table 9

**Influence of Plant Spacing and Nitrogen Fertilizer on the Toughness of the Pericarp of Hybrid Sweet Corn**

Average of three replicates of the toughness of the pericarp of sweet corn ears per plot as measured by puncture tests. (Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 214.0 | 204.7 | 232.7 | 217.1 | 298.0 | 296.3 | 326.0 | 306.8 | 225.0 | 220.0 | 216.0 | 220.3 |
| 50 | 215.0 | 207.0 | 205.0 | 209.0 | 314.0 | 295.7 | 291.7 | 300.4 | 235.3 | 231.3 | 246.7 | 237.8 |
| 100 | 224.0 | 223.3 | 203.0 | 216.8 | 300.7 | 316.7 | 301.7 | 306.3 | 246.0 | 213.0 | 233.7 | 230.9 |
| Ave. | 217.7 | 211.7 | 213.6 | 214.3 | 304.2 | 302.9 | 306.4 | 304.5 | 235.4 | 221.4 | 232.1 | 229.7 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 51.44* |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 52.57* |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates
* Significant at the 5% level
** Significant at the 1% level

Table 10

**The Influence of Plant Spacing and Nitrogen Fertilization on the Soluble Solids Content of Hybrid Sweet Corn**

Average of three replicates of the percentage of soluble solids of sweet corn ears per plot based on refractometer readings

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 20.74 | 20.15 | 21.25 | 20.71 | 19.24 | 18.85 | 20.00 | 19.36 | 20.81 | 20.04 | 20.56 | 20.47 |
| 50 | 23.09 | 21.10 | 20.28 | 21.49 | 19.00 | 19.12 | 18.68 | 18.93 | 20.41 | 20.47 | 22.26 | 21.04 |
| 100 | 21.02 | 22.25 | 19.60 | 20.95 | 19.34 | 18.72 | 19.03 | 19.03 | 20.02 | 19.81 | 20.06 | 19.96 |
| Ave. | 21.61 | 21.16 | 20.37 | 21.04 | 19.19 | 18.89 | 19.23 | 19.10 | 20.41 | 20.10 | 20.96 | 20.49 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 222.5637** |
| Replicates | 62.8247* |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates
* Significant at the 5% level
** Significant at the 1% level

Table 11

**Influence of Plant Spacing and Nitrogen Fertilization on the Total Nitrogen Content of Kernels of Hybrid Sweet Corn**

Average percentage of total nitrogen of whole kernels (dried at 60 C) of sweet corn per plot, three replicates. (Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Varieties and Spacings between Plants (inches) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 2.20 | 2.31 | 2.69 | 2.40 | 2.43 | 2.48 | 2.56 | 2.49 | 1.96 | 2.10 | 2.27 | 2.11 |
| 50 | 2.13 | 2.48 | 2.44 | 2.35 | 2.61 | 2.47 | 2.55 | 2.54 | 2.05 | 2.33 | 2.19 | 2.19 |
| 100 | 2.14 | 2.22 | 2.29 | 2.22 | 2.59 | 2.55 | 2.56 | 2.57 | 2.22 | 2.08 | 2.33 | 2.21 |
| Ave. | 2.16 | 2.34 | 2.47 | 2.32 | 2.54 | 2.50 | 2.56 | 2.53 | 2.08 | 2.17 | 2.26 | 2.17 |

Replicates I, II and III (varieties 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 20.66* |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots
[2]Average of two replicates
* Significant at the 5% level
** Significant at the 1% level

It was observed that when plants were grown 12 inches apart a higher concentration of total nitrogen of the three varieties occurred than with 6 and 9 inches between plants, although these differences were not significant.

The percentage of total nitrogen of embryos of sweet corn is given in Table 12.

Varietal differences were significant at the 1% level for replicates II and III; the embryos of the variety Northern Cross contained a higher percentage of total nitrogen than Seneca Arrow or Seneca Chief.

There was at the 1% level for replicates II and III a significant interaction between varieties and spacings; some varieties differed from others in their response to spacing; Seneca Arrow and Northern Cross showed a higher concentration of total nitrogen in the embryos when grown 9 inches apart, and Seneca Chief when grown 6 inches apart.

(b) Total Nitrogen of Whole Kernels and Embryos of Field Corn

The influence of locality on the total nitrogen content of whole kernels of field corn varieties grown in Central America is given in Table 13.

There was no significant difference in the nitrogen content of kernels between varieties.

The influence of location on the total nitrogen content of whole

Table 12

<u>Influence of Plant Spacing and Nitrogen Fertilization on the Total Nitrogen Content of Embryos of Hybrid Sweet Corn</u>

Average percentage of total nitrogen of embryos (dried at 60°C) of sweet corn in three replicates. (Plot size, 6' x 16')

| Nitrogen side-dressing lbs. per acre[1] | Seneca Arrow | | | | Northern Cross | | | | Seneca Chief | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6[2] | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. | 6 | 9 | 12 | Ave. |
| 0 | 2.23 | 2.53 | 2.31 | 2.36 | 2.72 | 2.83 | 2.72 | 2.76 | 2.72 | 2.59 | 2.62 | 2.64 |
| 50 | 2.16 | 2.51 | 2.43 | 2.37 | 2.67 | 2.86 | 2.63 | 2.72 | 2.80 | 2.46 | 2.70 | 2.65 |
| 100 | 2.30 | 2.58 | 2.36 | 2.41 | 2.71 | 2.65 | 2.70 | 2.69 | 2.77 | 2.58 | 2.46 | 2.60 |
| Ave. | 2.23 | 2.54 | 2.37 | 2.38 | 2.70 | 2.78 | 2.68 | 2.72 | 2.76 | 2.54 | 2.59 | 2.63 |

Replicates II and III (varieties 1, 2 and 3)

| Source | F. ratio |
|---|---|
| Varieties | 415.2** |
| Varieties x spacings | 9.3** |

[1]Seven hundred lbs. of 2-12-12 fertilizer per acre was applied to all plots.
[2]Average of two replicates
*Significant at the 5% level
**Significant at the 1% level

Table 13

<u>Influence of Location on the Total Nitrogen Content of Kernels of Open-pollinated Varieties of Field Corn</u>

Average percentage of total nitrogen of whole kernels (dried at 60° C.) of field corn

| Locations in Central America[1] | Papaloapan | | | | Venezuela 3 | | | | Rocamex 520-C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R-1[2] | R-II | R-III | Ave. | R-1 | R-II | R-III | Ave. | R-1 | R-II | R-III | Ave. |
| L-1 | 1.78 | 1.53 | 1.88 | 1.73 | 1.84 | 1.82 | 1.95 | 1.87 | 1.83 | 1.94 | 1.88 | 1.88 |
| L-2 | 1.35 | 1.35 | 1.44 | 1.38 | 1.68 | 1.52 | <u>1.72</u>[3] | 1.64 | 1.56 | 1.46 | 1.61 | 1.54 |
| L-3 | 1.76 | 1.56 | 1.82 | 1.71 | 1.56 | 1.72 | 1.76 | 1.68 | 1.56 | 1.81 | 1.88 | 1.75 |
| Ave. | 1.63 | 1.48 | 1.71 | 1.61 | 1.69 | 1.69 | 1.81 | 1.73 | 1.65 | 1.74 | 1.79 | 1.73 |

Analysis of Variance (Randomized Plot Design)

<u>Papaloapan</u>

| Source | F. ratio |
|---|---|
| Locations | 19.83** |
| Replicates | 7.12* |

<u>Rocamex 520-C</u>

| Source | F. ratio |
|---|---|
| Locations | 7.94* |

[1] L-1, L-2 and L-3 refer to the locations Santa Cruz Porrillo (L-1), San Andres (L-2) both in El Salvador; and Panama (L-3)
[2] R indicates replicates
[3] Missing number

kernels of these varieties was very marked; for variety Papaloapan with a significant difference at the 1% level and for variety Rocamex 520-C with a significant difference at the 5% level for location.

The influence of location on the total nitrogen content of kernels of the variety Venezuela 3 was nil.

When field corn was grown in Santa Cruz Porrillo, El Salvador (L-1), the total nitrogen of kernels of the three varieties was greatly increased than when grown in San Andres, El Salvador (L-2), or in Panama (L-3).

In Table 14 the average total nitrogen content of embryos of field corn is given. There was no significant difference in the nitrogen content of embryos between varieties. Some variation in the embryo nitrogen of field corn when grown in different localities was observed, but it was not significant.

One may conclude that the nitrogen content of the kernel and possibly the nitrogen content of the embryos of certain varieties may be higher when grown in certain localities, while other varieties do not respond to variation in environment in like manner.

Table 16 compares the average values of the percentage of total protein (N x 6.25) of sweet corn and field corn varieties. A much larger difference exists between the protein content of kernels and embryos of field corn varieties than between the protein content of kernels and embryos of sweet corn varieties.

Table 14

Influence of Location on the Total Nitrogen Content of Embryos of Open-pollinated Varieties of Field Corn

Average percentage of embryo total nitrogen of field corn varieties (dried at 60° C.)

| Locations in Central America[1] | Papaloapan | | | | Venezuela 3 | | | | Rocamex 520-C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | R-I[2] | R-II | R-III | Ave. | R-I | R-II | R-III | Ave. | R-I | R-II | R-III | Ave. |
| L-1 | 3.68 | 3.22 | 3.81 | 3.57 | 3.21 | 3.51 | 3.13 | 3.28 | 3.50 | 3.40 | 3.11 | 3.34 |
| L-2 | 3.26 | 2.94 | 3.08 | 3.09 | 3.22 | 3.00 | 3.20[3] | 3.14 | 3.01 | 3.10 | 3.02 | 3.04 |
| L-3 | 3.25 | 3.38 | 3.54 | 3.39 | 3.25 | 3.15 | 3.61 | 3.34 | 3.41 | 3.20 | 3.26 | 3.29 |
| Ave. | 3.40 | 3.18 | 3.48 | 3.35 | 3.23 | 3.22 | 3.31 | 3.25 | 3.31 | 3.23 | 3.13 | 3.22 |

No significant differences were observed.

[1] L-1, L-2 and L-3 refer to the location Santa Cruz Porrillo (L-1), San Andres (L-2) both in El Salvador; and Panama (L-3)
[2] R indicates replicates
[3] Missing number

Table 15

The Protein Content of the Component Parts of Kernels of Field Corn as Influenced by Varietal Differences and Locality

Average percentage of total protein (N x 6.25) of whole kernels and embryos (dried at 60° C.) of field corn, three replicates.

| | Santa Cruz Perrillo El Salvador | | San Andres, El Salvador | | Panama | |
|---|---|---|---|---|---|---|
| Varieties | kernel N | embryo N | kernel N | embryo N | kernel N | embryo N |
| Papaloapan[1] | 10.81 | 22.31 | 8.62 | 19.31 | 10.69 | 21.19 |
| Venezuela 3 | 11.69 | 20.50 | 10.25 | 19.62 | 10.50 | 20.88 |
| Rocamex 520-C[2] | 11.75 | 20.68 | 9.62 | 19.00 | 10.94 | 20.56 |

[1] Highly significant differences for locations
[2] Significant differences for locations

Table 16

**Total Protein Content of Sweet Corn as Compared to that of Field Corn**

Average total protein content (N x 6.25) of whole kernels and embryos of both sweet corn and field corn varieties

% of total protein in whole kernels

| Sweet Corn | | Field Corn | |
|---|---|---|---|
| Seneca Arrow | 14.50 | Papaloapan | 10.06 |
| Seneca Chief | 13.56 | Venezuela 3 | 10.81 |
| Northern Cross | 15.31 | Rocamex 520-C | 10.81 |

% of total protein in embryos

| Sweet Corn | | Field Corn | |
|---|---|---|---|
| Seneca Arrow | 14.87 | Papaloapan | 20.94 |
| Seneca Chief | 16.44 | Venezuela 3 | 20.31 |
| Northern Cross | 17.00 | Rocamex 520-C | 20.12 |

# X

# DISCUSSION OF RESULTS

The total yield of Seneca Chief was higher than that of Seneca Arrow or Northern Cross. The yield of the three varieties was significantly higher at 6 inches of spacing than at 9 and 12 inches. This verifies the results obtained by Bailey (1), Bowers (2), Brandon (3), and Muhr (18) who reported higher yields with closer spacing. A significant interaction of varieties and spacings indicated different responses of the yield of the three varieties to spacing: Seneca Arrow followed the same trend as Seneca Chief; Northern Cross also obtained a higher total number of ears with close spacing, but the lowest yield of this variety resulted with medium spacing or 9 inches between plants which was not the case with the other two varieties. This difference can be attributed to differences between varieties as pointed out by Enzie (7).

The significant characteristic of the yield data seems to be the consistency with which Seneca Chief outyielded the other two varieties studied.

The yield of total marketable ears of Seneca Chief was significantly higher than that of Northern Cross or Seneca Arrow.

A highly significant difference in the yield of usable ears resulted from the spacing treatments, the three varieties obtained the highest yield with 6 inches between plants and the lowest yield with 12 inches between plants.

Picket (21) pointed out that yield differences due to spacing are almost entirely due to the stand obtained; if stands are too heavy, yield of marketable corn is reduced because of small ear size, even though total yield may be somewhat increased by closer planting.

There was no difference in the number of usable ears due to the nitrogen fertilizer levels applied to the soil.

The total weight of ears per plot of Seneca Chief was significantly higher than that of Northern Cross. The total weight of ears and the weight of marketable ears per plot were higher when plants were grown 6 inches apart. Several authors, Bailey (1) and Muhr (18), have reported smaller ears with increase in population or closer spacings. Krantz (15) reported that close spacing reduced ear size only at a low rate of fertilization. Hinkle (12) concluded that with increased levels of nitrogen fertilization, for any given spacing, there was a tendency for the ear size and number of ears per stalk to be increased. This study confirms these statements; it was observed that ear size, measured by the total weight of ears per plot, increases as population increases, assuming adequate nitrogen in all cases. Nitrogen applied to the soil failed to affect the weight of ears and the yield per plot; an explanation for this behavior is that the soil where the corn was planted was evidently already high in nitrogen as a result of previous crops and therefore an added amount of nitrogen fertilizer did not affect the various factors under study in this experiment. Another possible explanation is that the corn plants were one third grown when the nitrogen fertilizer was applied; lack of rainfall prevented the application of the nitrogen fertilizer at an earlier date; it is possible that at this late stage of growth the plants were unable to utilize completely the fertilizer applied.

Northern Cross consistently gave higher weight of individual unhusked and husked ears than Seneca Arrow and Seneca Chief.

Interaction between varieties and spacings of both unhusked and husked ears indicates that the varieties studied did not respond equally to spacing.

Comparing Table 2 with Tables 6 and 7 which give the yield per plot, weight of unhusked and husked individual ears respectively, it can be observed that Seneca Chief obtained the highest total number of ears per plot and the lowest weight of individual ears; the opposite is true for the variety Northern Cross.

The height of sweet corn plants to the tassel and to the first ear were measured; however, since there were no significant differences between varieties, and since the spacing and nitrogen fertilizer treatments failed to affect the height of the sweet corn varieties studied under the conditions of this experiment, these measurements are not given in tabular form.

The number of tillers or shoots per plant tend to decrease as the distance between plants decreases. The spacing treatments show a highly significant difference at the 1% level in the number of shoots as indicated in Table 8. Enzie (7), working with Seneca Golden and Tendergold, found that these varieties produced the greatest number of tillers when planted in 36 inch drill rows with plants 12 inches apart. In this study there was a significant difference as to varieties for replicates II and III; Seneca Chief produced greater number of shoots than Northern Cross and Seneca Arrow.

The competition that exists between plants is very low when the plants are widely separated, and therefore, the plants are able to utilize the soil moisture, light and available nutrients in the formation of tillers. Another factor that might be responsible for the increased number of tillers with wide spacing is shading. When plants are close together, the rate of photosynthesis is reduced, but when they are widely separated, light is no longer a limiting factor and the plant produces a larger number of tillers.

It is evident from these observations that increase in the number of plants in the row increases the yield of sweet corn as to number and weight of both total and usable ears, decreases the number of shoots, but does not affect the height of plants.

Table 9 gives an average of three replicates of the toughness of the pericarp of sweet corn ears. The significant difference for varieties at the 5% level indicates that the toughest of the three varieties was Northern Cross. Neither the fertilizer nor the spacing treatments affected the toughness of the pericarp.

Certain factors, such as firmness of the endosperm are likely to induce errors in measuring toughness of the pericarp; nevertheless, the puncture test should be considered fairly accurate in giving approximate readings of the increasing toughness of the pericarp.

Another factor which interferes with the accuracy of the puncture test is the variation between kernels of the same ear. This difference in tenderness is due to differences in age of the kernels as determined by the time of pollination of the silks. In the present study this error was minimized by puncturing kernels from the middle portion of the ear.

Table 10 shows that the percentage of total soluble solids of the variety Seneca Arrow was higher than that of Seneca Chief and Northern Cross; however, it was not affected by the spacing and nitrogen fertilizer treatments. This method may not be considered by some workers a good means for evaluating varietal differences, since the variation in soluble solids content is likely to be due to maturity. Nevertheless, several reliable methods were used to measure the optimum stage of maturity at the time of harvest which was relatively uniform for all varieties.

From this discussion on sweetness and toughness we may conclude that:

1. The quality of Seneca Arrow was higher with respect to toughness of the pericarp and percentage of soluble solids than that of Seneca Chief and Northern Cross.
2. Northern Cross was generally tougher and less sweet than the other two varieties.
3. Interactions between any of the factors studied were not observed; this is an indication that, in this study, the percentage of soluble solids and toughness of sweet corn was independent of the spacing treatments and fertiliser levels applied.

Total nitrogen determinations made on samples from each variety showed Northern Cross to contain more total nitrogen in both kernels and embryos than Seneca Arrow and Seneca Chief; this difference between varieties was significant at the 5% and 1% levels for whole kernels and embryos respectively.

The non-zein embryo protein was influenced by the spacing treatments in this study; 9 inches of spacing gave higher amount of the non-zein fraction of the varieties Seneca Arrow and Northern Cross; Seneca Chief obtained this maximum amount with 6 inches between plants.

The data presented in this report confirms the findings of Earley and DeTurk (6) who stated that when yield of corn was increased through increased rates of planting, protein percentage decreased as the yield increased but the percentage decrease usually diminished for each increment of nitrogen added to the soil. These investigators also reported that the two most important factors controlling protein content of corn are rate of planting and nitrogen fertility of the soil. Schaible (22) reported that there is no consistent relationship between the protein percentage and the yield of corn. Norden et. al. (20) stated that apparently the corn plant uses the available nitrogen first for growth processes related to maximum yield, and excess nitrogen not needed for these processes is devoted to an increase in protein.

There seems to be a negative correlation between sweetness, toughness and protein percentage. Seneca Chief, the highest yielding variety, contained the lowest kernel protein, while Northern Cross was the lowest in yield, in soluble solids content, the toughest, and the highest in protein content.

No reports have been found in the literature indicating that nitrogen either accelerates or delays matruity of sweet corn. Northern Cross which matured first, contained the highest percentage of the three varieties, while the opposite was true for Seneca Chief. This statement does not hold true for the variety Seneca Arrow which indicates that nitrogen does not influence the rate of maturity of sweet corn.

Spacing treatments influenced the yield, the closer the spacing the higher the yield; a reverse trend was observed with the percentage of total protein of sweet corn kernels, the closer the spacing the lower their protein content; this trend was consistent for all the spacing treatments although it was not statistically significant.

Fertilizer treatments did not affect the total yield, total nitrogen content or the soluble solids content of sweet corn.

According to Schneider et. al. (23) all nitrogen fractions of the whole kernel usually increase when the total nitrogen of the kernel is increased by nitrogen fertilization; however, the alcohol-soluble nitrogen or zein increases at the fastest rate. Zein is a low quality protein, which means that the protein of high protein corn has a lower biological value than the protein of low protein corn. It has been suggested that since the large germ of high oil corn contains a larger proportion of the total grain nitrogen than the small germ of low oil corn, high oil corn protein should be of higher biological value than low oil corn protein. The basis for this line of reasoning is that corn germ is a high-quality protein feed and corn endosperm a low-quality protein feed; this is substantiated by the data presented by several authors, Hansen et. al. (11), Frey et. al. (10), Sprague and Brimhall (24), and Miller and Brimhall (17).

From these observations we gather that an increase in size of germ at the expense of endosperm will improve the nutritional value of the protein of the whole kernel. Schneider et. al. (23) refute this statement as the results of their work proved that the increase in the proportion of germ nitrogen in high oil corn occurred at the expense of the alkali-soluble nitrogen of the endosperm and not of the alcohol-soluble zein. Although the various nitrogen fractions of corn were not determined in this study, we can safely state, based on Schneider's data, that increase in embryo nitrogen is not always desirable from the nutritional standpoint in that the glutelin present in the endosperm decreases as the concentration of embryo protein is increased.

Zein was demonstrated by Hansen et. al. (11) to be absent from corn germ although it constitutes the major protein of the endosperm. The rest of the endosperm protein, largely glutelin, was shown to contain the amino acids, tryptophane and lysine, which zein lacks.

No significant differences in the nitrogen content of samples from ears that had been cross-pollinated were observed. This confirms the statement made by several authors; Doty et al. (4) reported that no significant differences were noted in the chemical composition of more than 40 commercial hybrids and open-pollinated varieties.

The varieties of field corn Papaloapan and Rocamex 520-C varied in their total kernels nitrogen content according to the location in Central America where they were grown. A significant difference at the 1% level is shown when the variety Papaloapan was grown at Santa Cruz Porrillo, El Salvador, but had a low total kernel nitrogen when grown in another experiment station, San Andres, El Salvador. The same trend was followed by the variety Rocamex 520-C, this difference being significant at the 5% level. No differences in total nitrogen of whole kernels grown in different locations was observed in the variety Venezuela 3.

Environmental factors such as soil and climate seems to have a relatively greater effect on protein content than any other factors, according to Norden et. al. (19).

There was no significant difference between varieties as to whole kernel protein content of field corn varieties. In working with corn hybrids Norden et. al. (19) concluded that protein content of corn was the result of complex interactions of environmental, genetic, and physiological factors.

Total nitrogen content of embryos of the three varieties of field corn studied did not show any significant differences regardless of the location where they were grown. Analysis of Table 14 shows nevertheless that the variety Papaloapan had a higher embryo nitrogen than either of the other two varieties, this being a varietal difference; and that when corn was grown in Santa Cruz Porrillo, El Salvador, the total embryo nitrogen was higher than when grown in the other two locations, although these differences were not significant. The following conclusions may be drawn from the above discussion:

1. The total nitrogen content of kernels of the varieties Papaloapan, and Rocamex was influenced by the location in which they were grown.
2. No interaction of varieties and locations with respect to the protein content of kernels and embryos of field corn was observed.
3. Regardless of varieties, the location where the corn was grown influenced the total kernel nitrogen. Field corn grown in Santa Cruz Porrillo, El Salvador, gave higher total kernel nitrogen values than corn grown in Panama, or in San Andres, El Salvador.

The percentage of total protein of whole kernels and embryos of both sweet corn and field corn varieties is given in Table 16. Although sweet corn and field corn were not grown under the same experimental conditions, several observations made on this table are of interest:

1. Sweet corn kernels contained a higher percentage of protein than field corn kernels.

2. Sweet corn embryos contained less total protein than field corn embryos.

These facts suggest that field corn, which is low in quality from the standpoint of sweetness, contains a higher embryo protein percentage than sweet corn. It was observed that the sweet corn hybrid Northern Cross was the toughest, the lowest in percentage of soluble solids and the highest in protein content; Seneca Chief possessed more desirable quality characteristics as to tenderness and sweetness, but contained the lowest kernel protein of the three varieties.

Good quality sweet corn as measured by sweetness and tenderness is not necessarily the more desirable from the nutritional standpoint. Field corn is consumed in countries where the food value is a more important factor than quality as mentioned at the beginning of this report. It is interesting, therefore, that the embryos of maize or field corn are superior in protein content than either whole kernels of maize or sweet corn.

# XI

## SUMMARY

A study was made to determine (1) the influence of plant spacing and nitrogen fertilizer on the yield, percentage of soluble solids, toughness of the pericarp, and protein content of embryos and kernels of hybrid sweet corn and (2) the influence of locality on the protein content of field corn varieties.

Highest yields and weight of ears of sweet corn are obtained with plants spaced 6 inches apart. Of the three varieties, the medium late maturing Seneca Chief is more desirable from the standpoint of higher yields and weight of ears. Northern Cross had the lowest number of total ears when grown 9 inches apart, and the other two varieties with 12 inches between plants in the row.

Differences in earliness, yield, weight of ears, and number of ears per plot are found among the varieties studied.

The number of shoots or tillers of Seneca Chief is higher than that of Northern Cross or Seneca Arrow; with increases in spacing the number of shoots per plant increases.

The early maturing variety Northern Cross was less desirable in that the kernels at harvest contained a lower percentage of soluble solids, had the toughest pericarp; however, it contained a higher average percentage of total protein (15.31) than either Seneca Arrow (14.50)

and Seneca Chief (13.56). Northern Cross also contained a higher average percentage of total protein in the embryos (17.00) than either Seneca Chief (16.44) and Seneca Arrow (14.87). The embryo protein, considered to be more digestible than protein of the endosperm was not influenced by spacing treatments.

Under the conditions of this experiment there was no association between the amount of nitrogen fertiliser and percentage of soluble solids, toughness of the pericarp, protein content, and yield of sweet corn. The supply of nitrogen seemed adequate since the corn crop followed a crop of soybeans.

Considering the entire experiment, regardless of variety, spacing, and fertilizer levels, the increase in yield decreased the food value of sweet corn in terms of protein content of the kernels, but did not influence the protein content of the embryos; this cannot be considered conclusive because of the limited experimental period and small number of hybrids studied.

It was found that the total protein content of kernels of three field corn varieties grown in Central America varied more between locations than between varieties grown at the same location. The average protein content of the three field corn varieties ranged from 8.44% to 12.12%.

Embryos of the field corn varieties contained a higher percentage of total protein than embryos of sweet corn. This fact suggests that field corn, which is low in quality from the standpoint of sweetness, contained a higher digestible protein content than sweet corn.

XII

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