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REPORT

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by James M. Curran for the degree of Master of Science. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of ....

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THE EFFECT OF ENVIRONMENT ON THE GROWTH AND CHARACTER OF CORN.

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A THESIS SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL OF THE UNIVERSITY OF MINNESOTA.

BY

James Martin Curran

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

June 1916.

THE EFFECT OF ENVIRONMENT ON THE GROWTH AND CHARACTER OF CORN.

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INTRODUCTION.

The term environment is used as an aggregate of all external conditions and influences affecting the life and development of an organism. In this paper environment shall include the soil in which the plant grows, and the climatic influences, namely, rainfall, temperature, and sunlight which are apparent during the period of growth.

For many years the effect of environment upon the composition of grain crops has been a subject of much study by numerous investigators, but the effect of environment on the growth and character of these crops has received very little attention. The particular characters to be considered herein are height of stalk, height of ear on the stalk, the circumference and length of ear, the weight of the ear, number of rows on the ear and the percent of shelled corn to the cob.

In considering this question it seemed important to eliminate all possible effects which might result from the source of seed, locality from which the seed was obtained and the soil on which it was grown. Therefore, the seed was secured from localities in nearly the same latitude and with the similar soil conditions.

General Influence of Water Supply.

The yield of corn obtained each year is more often decided or limited by this factor than by any other. Of equal or greater importance than the total amount of rainfall is its distribution during the growing season. Corn makes its most rapid growth during July and August, it is therefore, during these months that the greatest amount of moisture is needed for the best growth of the crop.

The precipitation for the previous season must be taken into account when considering the affect of moisture on the crop. All water of soils and plants is directly or indirectly derived from the rainfall (including therein snow and hail). Rainfall is naturally disposed of in two ways, a portion is absorbed by the soil, and another which is at once shed from the surface and constitutes the "surface run-off". The portion absorbed by the soil is either disposed of by seepage or by evaporation. The latter occurs in two different ways, that is, from the soil surfact itself or through the roots and leaves of the plant.

General Influence of Temperature.

High and low temperature affect crops in various ways, the principal ones being by preventing germination, by checking growth, by killing part or all of the vegetative parts, by injuring the blossoms, and by damaging the maturing fruit.

The length of the growing season is in general the most important factor in determining the size of the stalk produced. The long seasons of the Gulf States, with a growing period of 200 days, induce the growth of tall massive stalks with large yields of fodder and grain, while the shorter northern seasons induce a small stalk with a moderate yield of corn, such as the small South Dakota Pride which matures in approximately 90 days. The smaller stalks produce a better quality of fodder. The dependence of yield upon climate is seen when the average production per acre for the state for a term of years is considered.

General Influence of Sunlight.

Light is considered as one of the important sources of energy for the food-making activities of the plant. The only plants that do not need light are molds, mushrooms and similar types which use the food made by other organisms. Dr. Clements (8) has summarized the effects of light as follows: - "Decomposition of carbon dioxide and water to form sugar; the production of chlorophyl; loss of water from the chloroplasts; daily opening and closing of the stomata; turning of stems and leaves; day and night position of leaves; and changes in the form and structure of the leaf".

The work of Friedel (1901), Herzog (1902), Macchiati (1903) (6) and others show in the clearest possible manner that the evolution of oxygen takes place only in the presence of light and only in regions which are illuminated. From these experiments we can emphasize the necessity of Sunlight but little is known in regard to the effect of the quantity and intensity of light. Charts No. II to No. I7 inclusive, deal with the effect of the quantity (expressed by hours), of sunlight on the yield of corn.

General Influence of Soil.

The most important use of the soil is to act as a storehouse of water for the use of plants. The productiveness of any soil is determined in a very large degree by the amount of water it can hold. It must not be thought from this that the composition of the soil is not an important factor in fixing the land values for crop production. But without a sufficient supply of water neither the food constituents in the soil or that part taken from the air could be adequately procured by the plant. Birner and Lucanus (1866) (1), pointed out that plants can be grown to perfection in well water, if suitable physical conditions are preserved, and, as a matter of fact, they grew oat plants in such water renewed weekly; the yield of grain being double that from a rich garden soil.

II. Environmental Factors Affecting Growth, Yield and Character.

A - Yield as Affected by Precipation.

The relationship between precipation and yield of corn has been recognized for many years, but careful investigations into the nature of this relationship were only started recently. To have water furnished to the plant in any soil in sufficient quantities there must be an adequate supply available either through actual rainfall or through irrigation, considering rain as the source of all soil water. Thus it can be said, other things being equal, that heavy rainfall, - large yields, light rainfall, -light yields. If the latitude and elevation are favorable for the production of crops, precipitation has first place.

Description of the Charts.

The actual yields of Minn. No. 13 corn on Fields "T" and "C", at University Farm for the years 1906 to 1915 inclusive, were used as a basis in making the following charts. The precipitation data for the first six years were furnished by the weather bureau reports from St. Paul and for the last four years by the Division of Vegetable Pathology and Botany at University Farm.

Although the yield line does not follow the precipitation every year it does show relationship at times. The years in which yield does show any correlation with precipitation are 1907, 1909, and 1915. The reason for this variation in the relationship of this agent with yield is explainable. In 1907 the precipitation was 14.70 inches, a fraction of an inch less than the ten year average which is 14.76 inches - the yield of that year was 38.5 bushels or 13.1 bushels less than the ten year average - the temperature with an average of 61.30 degrees for the season was undoubtedly responsible for the low yield. In 1909 the yield was abnormally high and the precipitation was practically normal but the snowfall during the previous winter was 64 inches or 25 inches above normal. This large snowfall furnished the necessary moisture for a large yield and was assisted by a high temperature and a large amount of sunshine. In 1915 we had a very abnormal season - the precipitation was exceedingly heavy, a total of 18 inches for the four months of the growing season. This heavy rainfall combined with the abnormal action of the other climatic elements caused a very low yield.

In the first group of charts the precipitation is shown by the dotted lines and the yield by the full line. Yield is expressed in bushels and precipitation in inches.

Chart No. I.

This chart shows a comparatively slight relation between the precipitation for the month of May and the yield of corn per acre for the year. In 1907 and 1910 a very low precipitation is followed by a low yield but in 1914 the precipitation was very low and the yield was high. Therefore, the precipitation in this month is not as important as in the later months because a low rainfall in May can be offset during the later months providing the temperature in May is normal.

Chart No. 2.

A normal amount of rainfall during June will give the crop a sufficient start towards producing a large yield, 4 to 6 inches being considered as a normal rainfall. If the precipitation is below 4 inches as in the years 1910 and 1913 then a small yield becomes evident. In 1907 and 1915 when the precipitation was normal the temperature was responsible for the low yield.

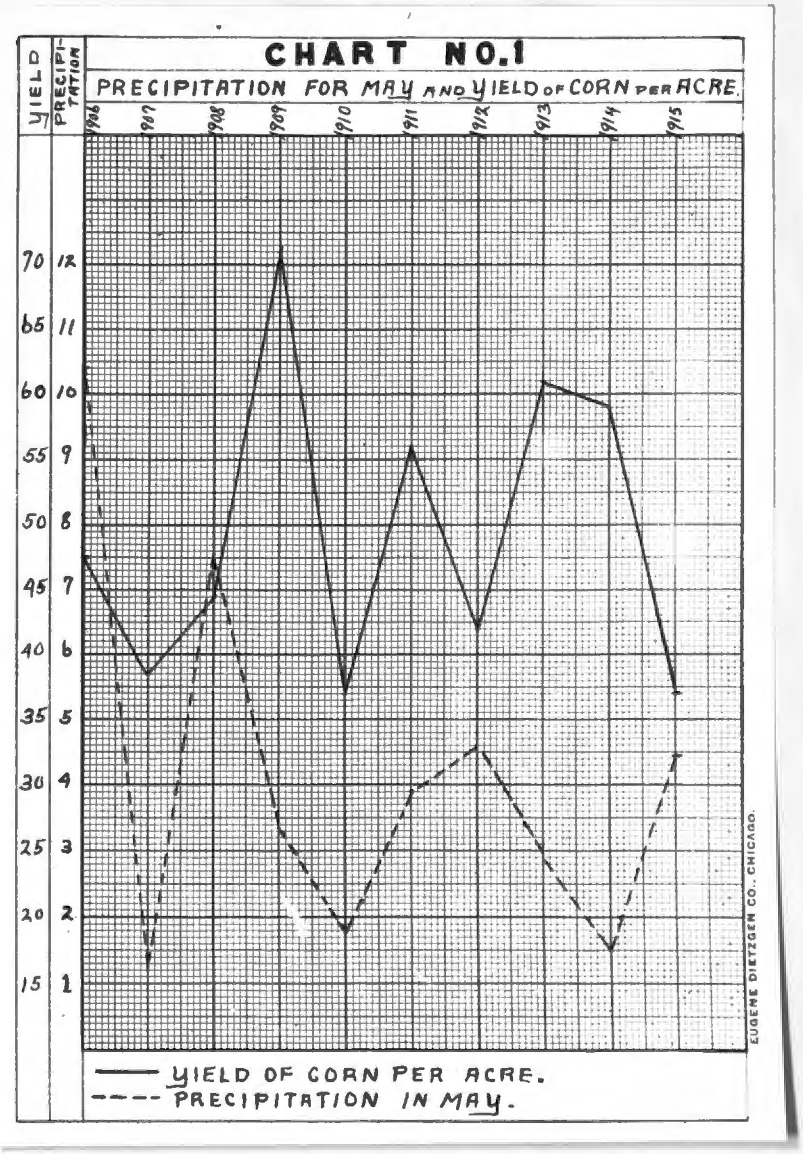

Figure No. I Precipitation for May and Yield of Corn per Acre.

Chart No. 3.

Perhaps this is the most interesting chart in the series. The most important period of growth for the corn plant comes during July. Therefore, a large amount of rainfall during this month could be correlated with large yield and a small amount with small yield. There are exceptions to this but for the most part they are explainable. In 1909, the yield was above normal, with the precipitation for July below normal, but the snowfall the previous year was 64 inches, practically twice as much as the normal. This furnished enough moisture for the normal yield while the rainfall increased the possibility of a crop to the maximum.

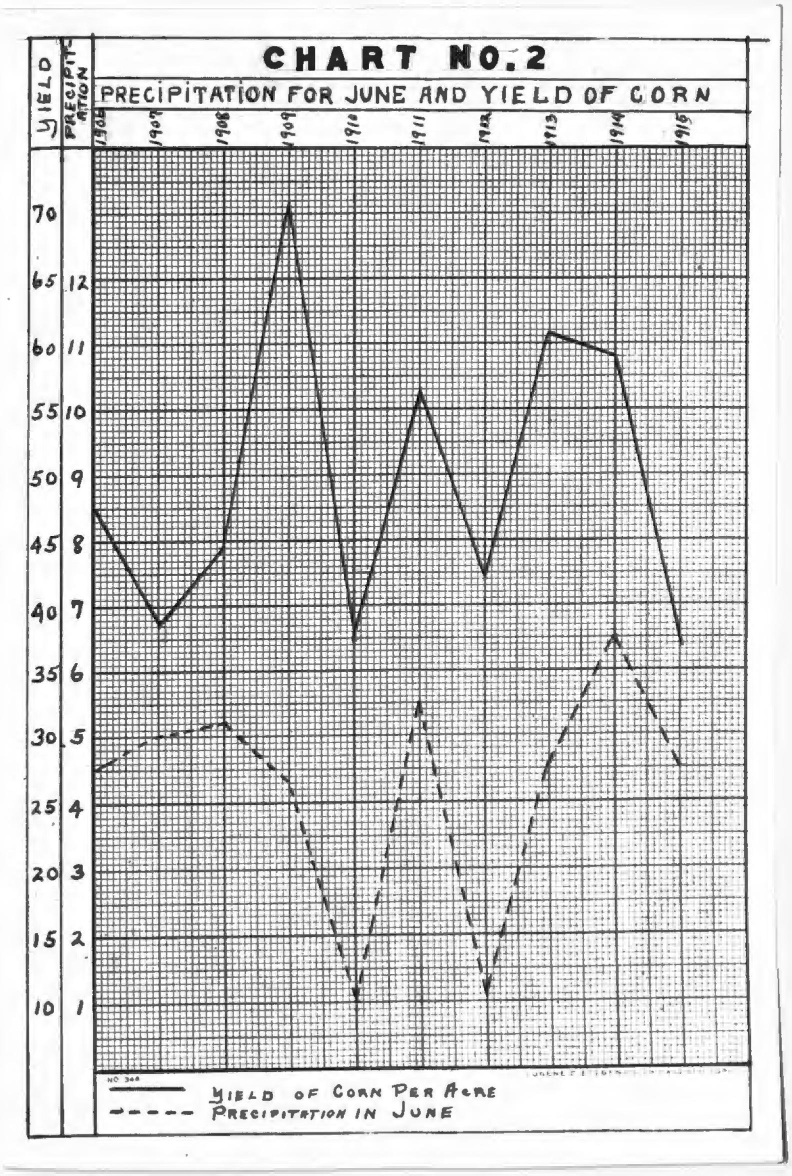

Figure No. 2 Precipitation for June and Yield of Corn per Acre.

Chart No. 4.

The yield curve agrees with the rainfall for August at times, but the yield is affected but little by the rainfall of this month unless there should be an excess precipitation which might retard the ripening of the crop enough so that it could not mature before the arrival of frost.

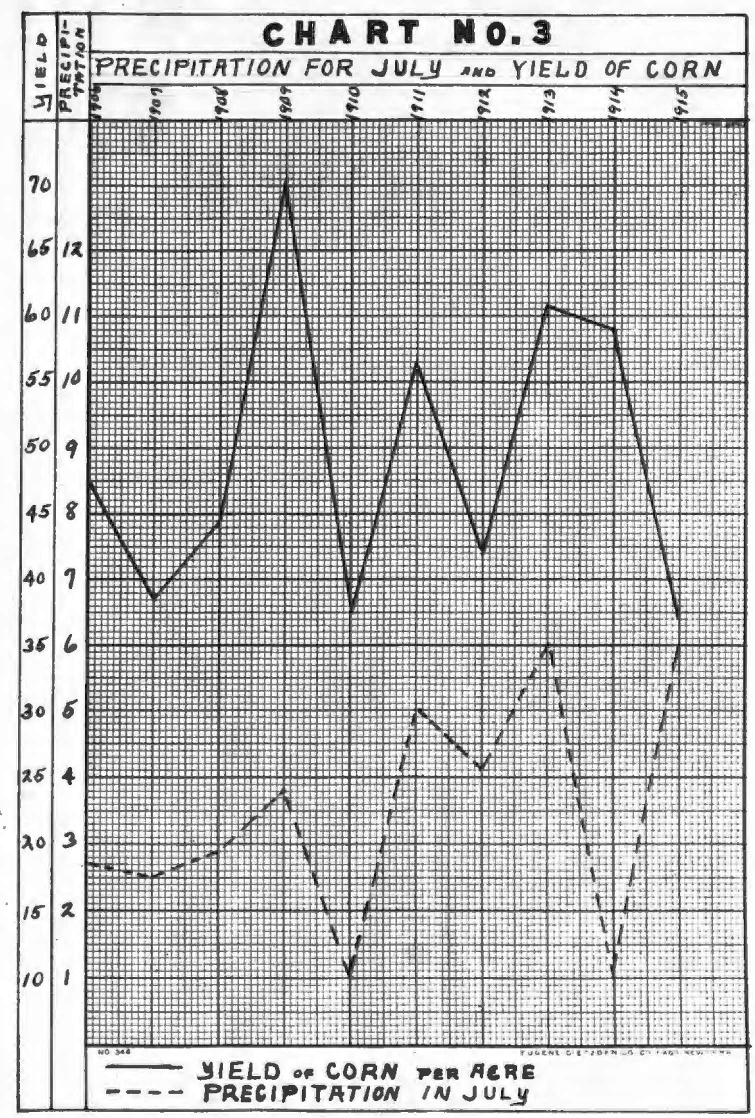

Figure No. 3. Precipitation for July and Yield of Corn per Acre.

Chart No. 5.

Combining the months of May, June, July, August and September does not materially affect the results shown in charts 3 and 4. The total precipitation for the season is given in this chart which shows some correlation between precipitation and yield of corn. If the precipitation for the season ranges from 14 to 17 inches it is sufficient for a large crop but other conditions may enter in and destroy the good effects of the normal precipitation. In 1910 the precipitation was very low and a draught resulted in a low yield.

In 1911 an excessive amount of rain produced a large yield but in this case the high temperature was an important factor. In 1915 there was a large precipitation and a low yield, this low yield being the result of continuous cool weather combined with precipitation which was above normal.

The distribution through the year determines the correlation of yield and precipitation, as for example a very light rainfall in June such as in 1910 and 1913 usually causes a light yield whereas a heavy precipitation in May is more detrimental than benificial as in the years 1907, 1910 and 1915. These figures corroborate the statement of Davy, E. J. (1909) (9), who said that, "Heavy rainfall and cloudy weather during the planting season decrease the yield".

As near as can be determined the relation to yield is shown in Table No. 4, in which the coefficient of correlation is expressed. There are years in which this factor has more direct influence upon yield than is expressed by this figure and undoubtedly if the coefficient of correlation were to be worked out for each month, it would bring out more emphatically, than has already been done, the importance of rainfall during certain periods of the growing season.

As might be expected, the pounds of water necessary to produce a pound of dry matter in a crop is large. Any data quoted in discussing this question must be general in its application because of the numerous difficulties in determing the necessary amount for each pound of dry matter. The following table gives the water requirements of corn as determined by different investigators. Perhaps the difference in the water requirements as determined by these men is due to the methods used in making the determination.

Table No. I.		
Investigator	Amount of Water	Pounds of Dry Matter
Wollny. 1876 Germany.	464 pounds	1 pound
Briggs & Shantz. 1913 Colorado.	369 pounds	1 pound
King 1895. Wisconsin	300 pounds	1 pound
Leather. 1910 India.	450 pounds	1 pound

A real difference in the results is expected if the climatic conditions differ at the places where experiments were conducted. From this point of view the observed differences in the water requirement may be looked upon as a measure of the climatic differences.

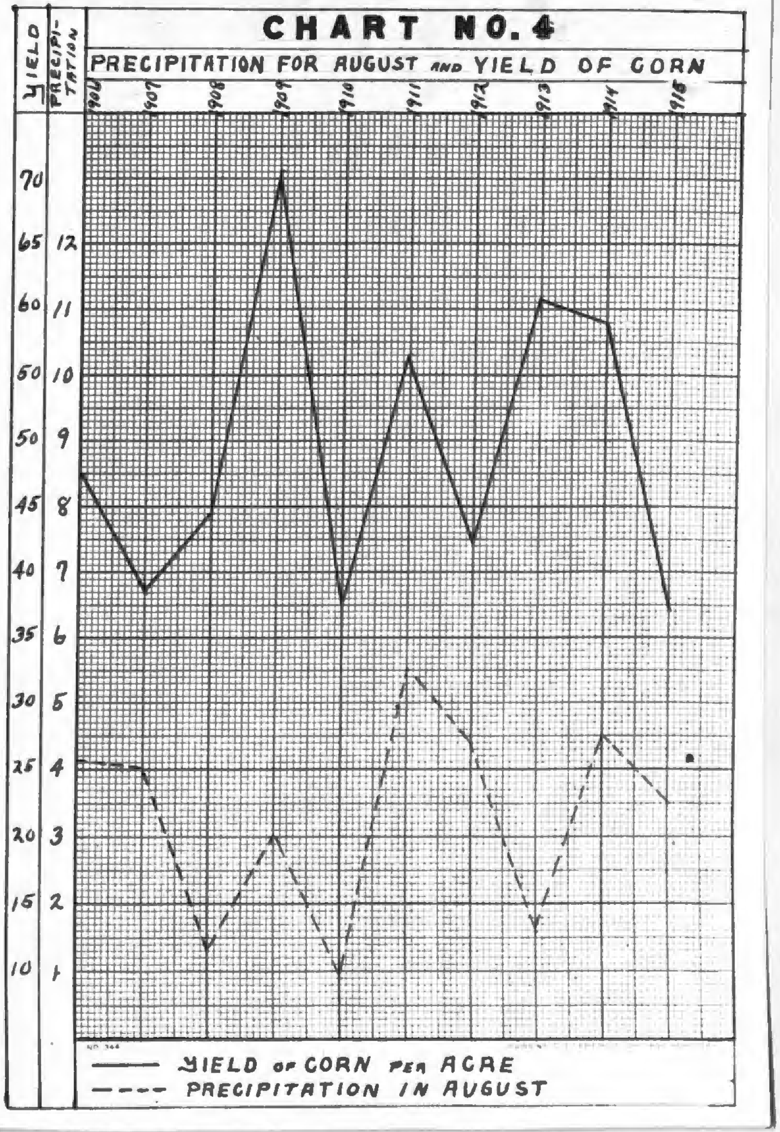

Figure No.4. Precipitation for August and Yield of Corn per Acre.

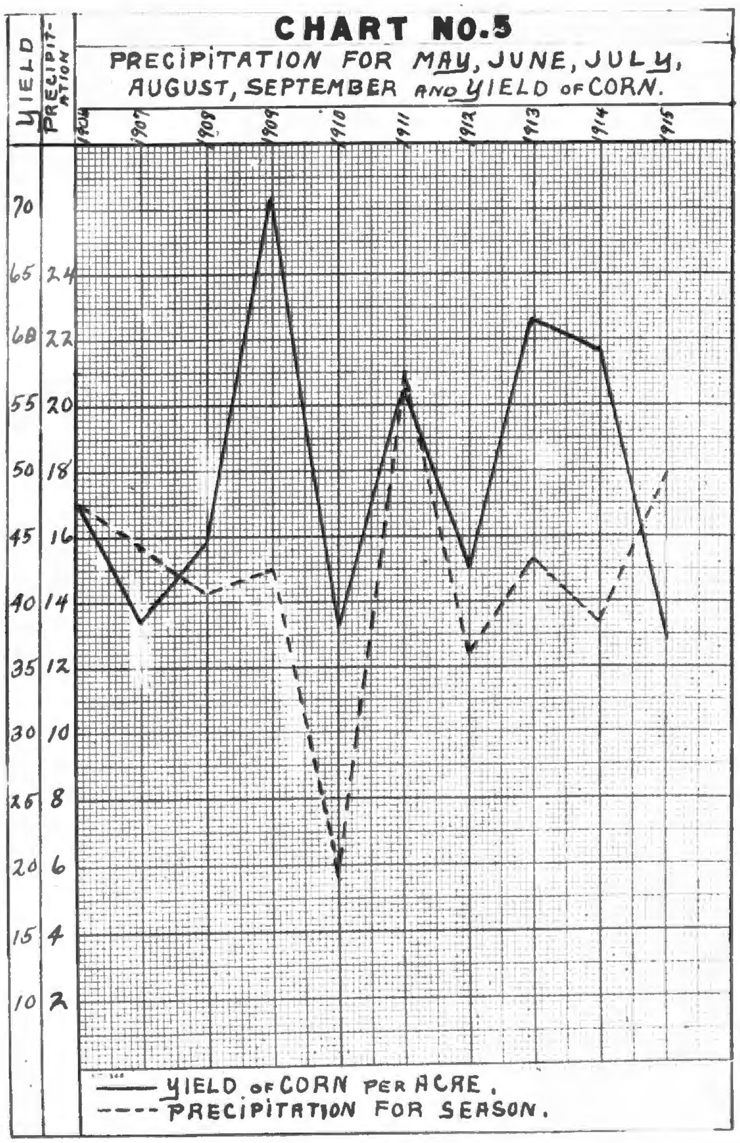

Figure No. 5 Precipitation for May, June, July, August, September and the yield of corn per acre.

The supply of water in the soil whether it be from rainfall or other sources has an influence not only on the quantity of the crop but also on the rapidity of growth and development of the plant. Wollny's (1875) (49) work on corn showed in general an acceleration of the date of ripening with a diminishing of the water supply. The following table gives the results of Wollny's work. He planted five plots with different number of corn plants, varying from 4 to 25 plants to the square meter of soil.

Table No. 2.

No. of Corn plants to sq. meter soil.	No. of sq. centemeters to each plant.	Order of Ripening.	Percentage of Unripe ears.
25	400	1	3.7
16	625	2	0.0
9	1109	3	26.7
6	1160	4	34.8
4	2500	5	56.2

The table also shows in the last column what proportion of the corn was unripe in the sparsely planted plots when that which was closely planted was already fully ripe. Ripness varies inversely as the number of stocks per unit of area.

Wollny (49) concludes that, "In general the harvest increases with increasing water supply up to a definite limit, beyond which the harvest diminishes steadily with any increase in the water supply, until when the earth is completely saturated with water the harvest in some cases becomes almost nil". The most advantageous percentage of moisture in the soil varies for the different plants, depending on their own method of using the water, on the transpiration from their leaves, and on the number of plants to the unit of area of the field, namely, their closeness to each other.

The results shown by Wollny are substantiated by the work of Widstoe (1912) as shown in the accompanying table, that as available water increases the dry matter ascends until a maximum is reached.

Table No. 3.

The Yields of Dry Matter with Different Quantities of Water.

Inches of Water	Pounds of Dry Matter in Corn.
13.04	10,757
15.54	12,762
20.54	13,092
25.54	13,856
30.54	14,606
35.54	15,294
60.54	12,637

Again as also shown by Wollny, (48), more water is used in proportion as more nutriment is available in the ground, because the development of the organs of transpiration on the leaves is thereby increased. Therefore, in general the quantity of water required to attain a maximum crop will increase with the richness of the soil and the closeness of the plants as well as the dryness and velocity of the wind.

Fortier (1903),(11), working at Montana showed that the yield of grain crops increased quite regularly with the amount of water supplied, up to the depth of 36 inches of water. In this case not only the quantity but the quality of the grain was greatly improved as the water supply increased, becoming larger and more uniform.

The importance of the water supply in the soil was recognized in 1870 by Johnson (17), who said - "It is a well recognized fact that next to temperature the water supply is the most influential factor in the production of a crop. Poor soils give good crops in seasons of plentiful and well distributed rain or when skillfully irrigated, but insufficient moisture in the soil is an evil that no supply of plant food can neutralize."

B. Yield as Affected by Temperature.

The ideal climate for corn is one with a summer four to six months long, without frost, with sunny skies and sufficient rains to supply the demands of this rapid growing luxuriant crop. The distribution of corn is determined by temperature in that below an annual average of 40 degrees and above an annual average of 75 degrees there is very little corn grown.

Corn is peculiarly sensitive to frost during the whole period of growth, late frosts in the spring cutting off the young plants, early ones in the fall retarding the ripening or injuring the quality.

Description of the Charts.

THE MEAN TEMPERATURE for each month is used in the following charts, represented by the dotted lines while the yield of corn is shown by the solid line.

Chart No. 6.

Some relationship is shown between the temperature of May and the yield of corn for the year. If the other climatic elements are normal a temperature of from 54 to 60 degrees will produce an average crop but if the temperature drops below 54 degrees it is usually followed by a low yield as in 1907, 1910 and 1915.

Chart No. 7.

The temperature for June during the decade is remarkably uniform, varying only 7 degrees in the ten years. The variation in temperature during this month is so slight that it is impossible to maintain that the variation in yield is affected by this element, unless it should happen to be very low as in the year 1910.

Chart No. 8.

During this month the corn plant makes its greatest growth and if the other agents are normal the yield follows the temperature very closely. In 1910 the yield was low and the temperature high thus showing that other elements may enter in and over-rule the influence of temperature. The two extremes in temperature during the ten years were in 1909 and 1915. In 1909 the average temperature was 77 degrees and in 1915 it was 65 degrees, giving a spread of 12 degrees. If the temperature during July remains between 68 and 75 degrees the other climatic elements become the controlling factors but if the temperature drops below 68 degrees as it did in 1915 then it becomes the controlling factor.

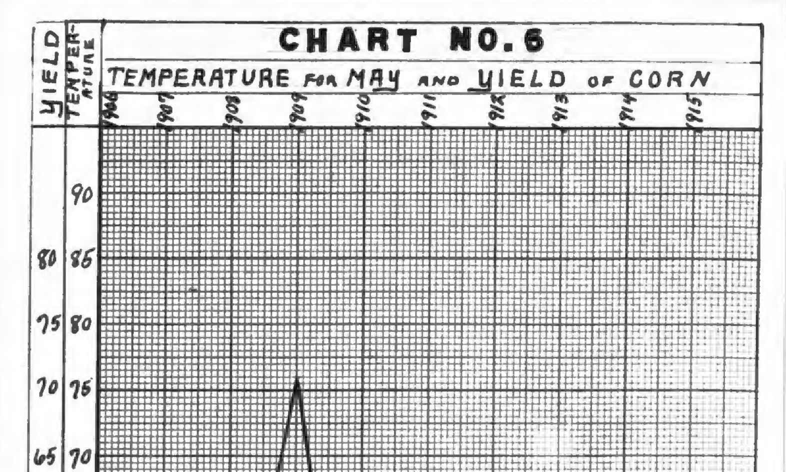

Figure No. 6. Temperature for May and Yield of Corn per Acre.

If the temperature goes above 75 degrees a large amount of moisture is necessary for the crop and if the moisture is supplied the yield increases.

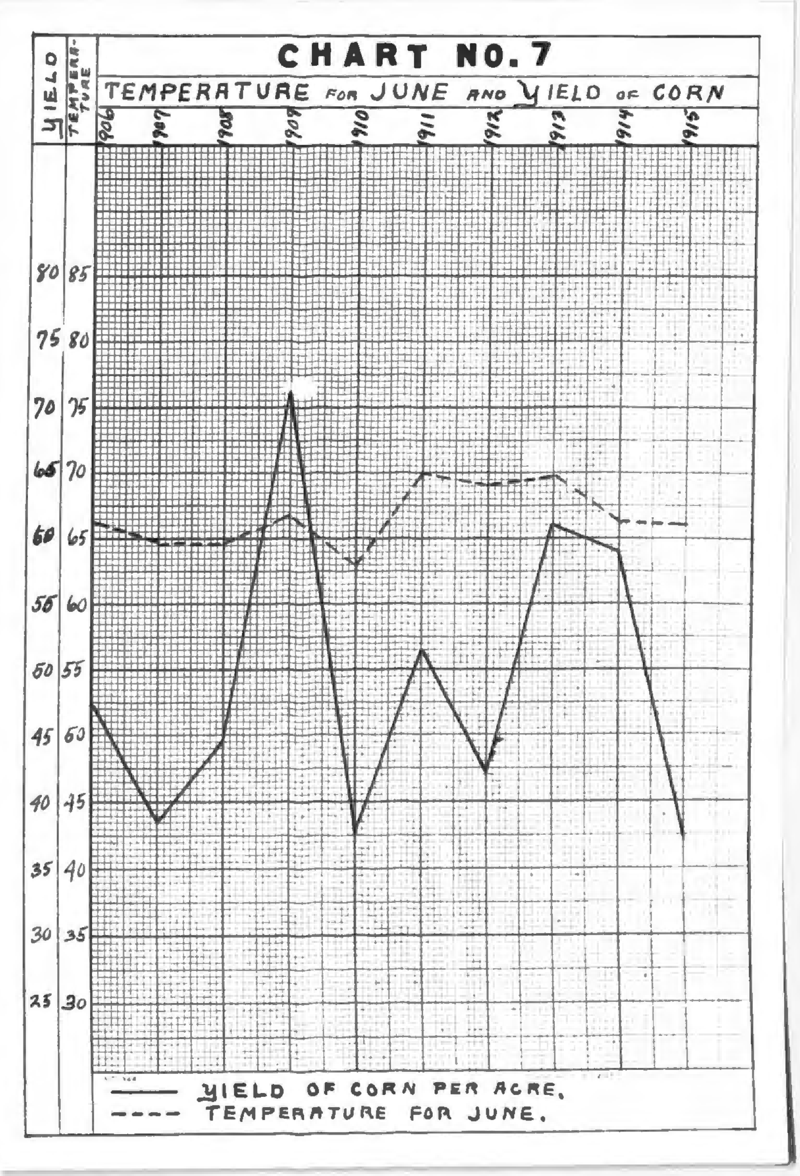

Figure No. 7. Temperature for June and Yield of Corn per Acre.

Chart No. 9.

High average temperature in August is usually followed by a large yield. The temperature in this month follows the average temperature for July every year and has nearly the same relation to the yield of corn for the year. The range of temperature in August for ten years was 8 degrees, this range being from 65 to to 73 degrees. Although the variation in temperature is very small it seems to be followed consistently nearly every year, the only years in which the yield line does not follow the temperature during this month being 1911 and 1912.

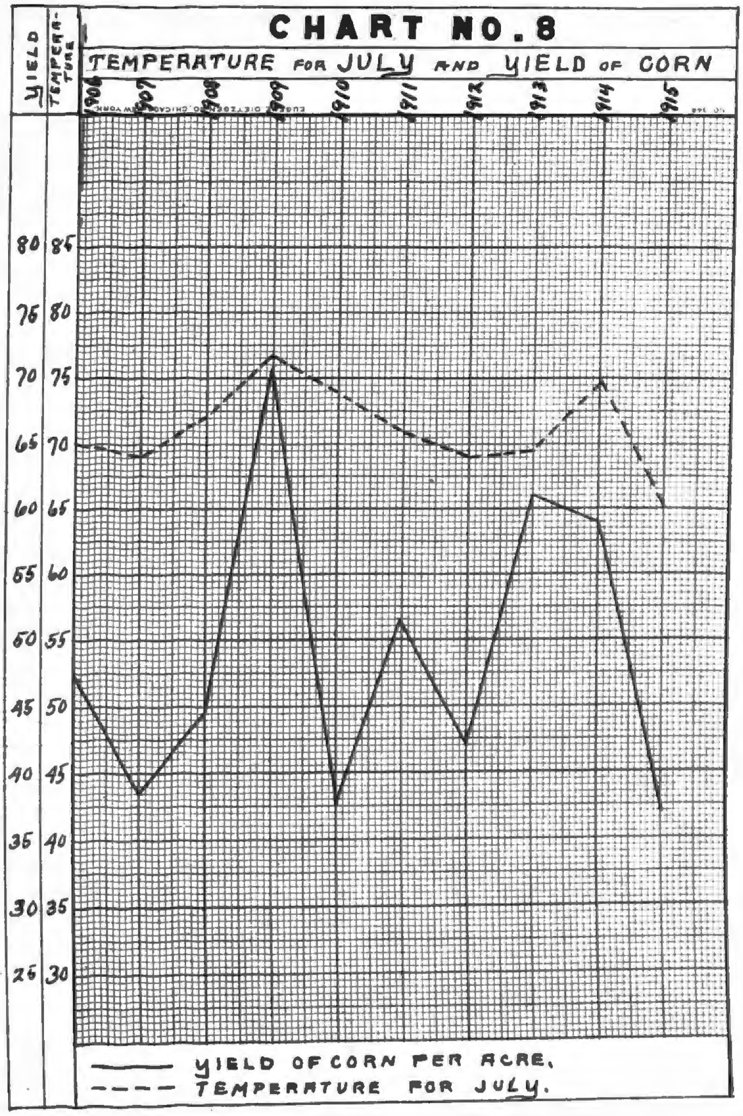

Figure No.8. Temperature for July and Yield of Corn per Acre.

Chart No. 10.

The yield line agrees with the temperature at times but normally it is affected very little by the temperature during September, especially if the summer months have been very favorable for the growth of the crop. In years such as 1915, it might be possible for the temperature of this month to produce a crop after the other months were unfavorable for plant growth. The date of the first frost in September oftentimes checks the growth of crops and thereby lowers the yield.

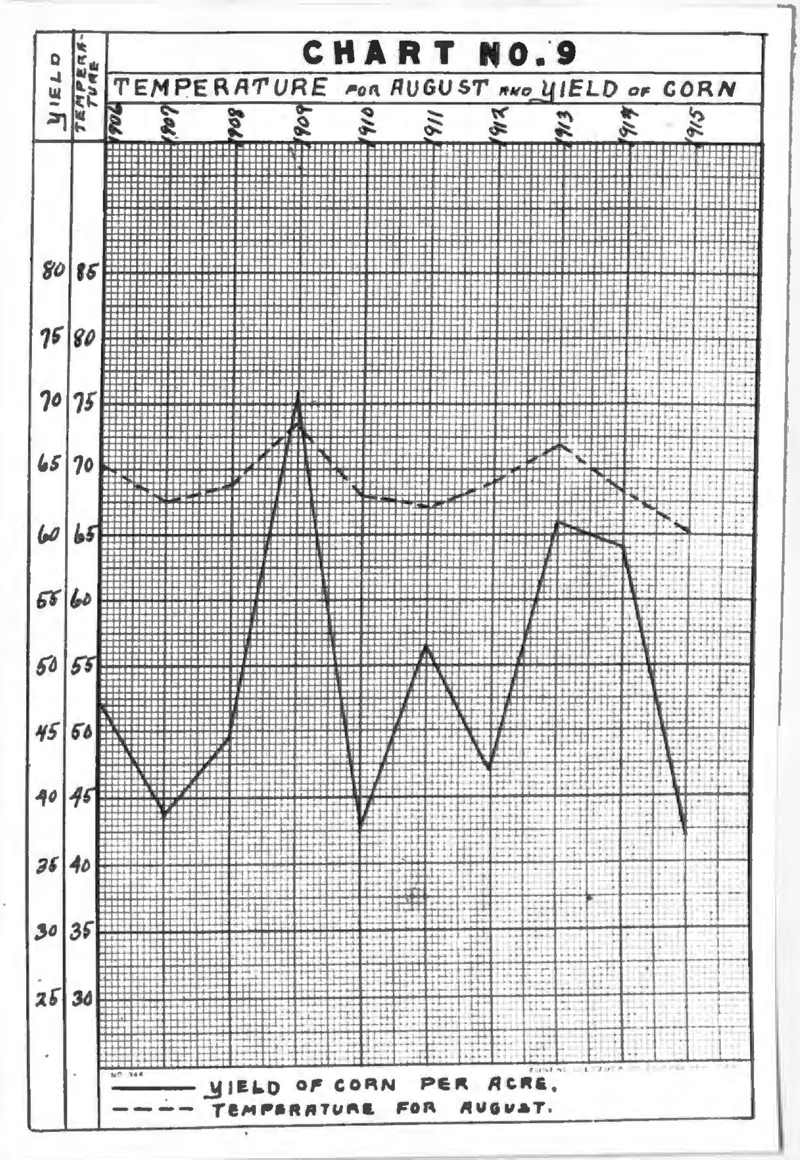

Figure No. 9. Temperature for August and Yield of Corn per Acre.

Chart No. 11.

A very close relationship between the average temperature of the season and the yield of corn per acre is shown in this chart. The yield line follows the line representing temperature more uniformly than it does the line representing precipitation. The average temperature for the ten years was 64.75 degrees. Every year that the temperature was as high as the average the yield was nearly up to the average yield, and in the years 1907, 1910, 1912 and 1915, when the temperature was below the average, it pulled the yield down. Almost perfect correlation is shown between temperature and yield as expressed in Table No. 4, by the coefficient of correlation which is .849 ± .0128. As the coefficient of + I indicates perfect direct correlation, .849 shows the close relationship of this element with yield.

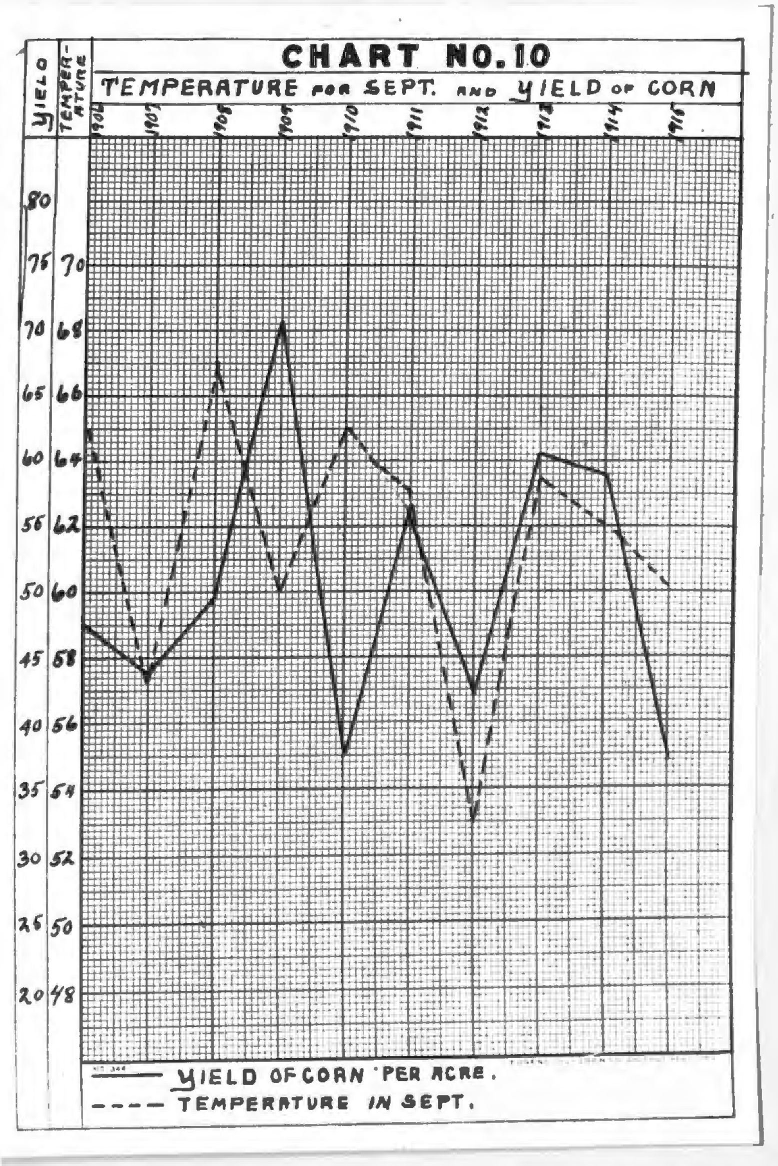

Figure No. 10. Temperature for September and Yield of Corn per Acre.

The principle factors in the life of plants discussed thus far are heat and moisture. If it is necessary for the plant to economize in its use of heat, then the whole life of the plant is intimately dependent on the course of this heat, as in Minnesota and the greater part of the Temperate Zone where the moisture is otherwise sufficient.

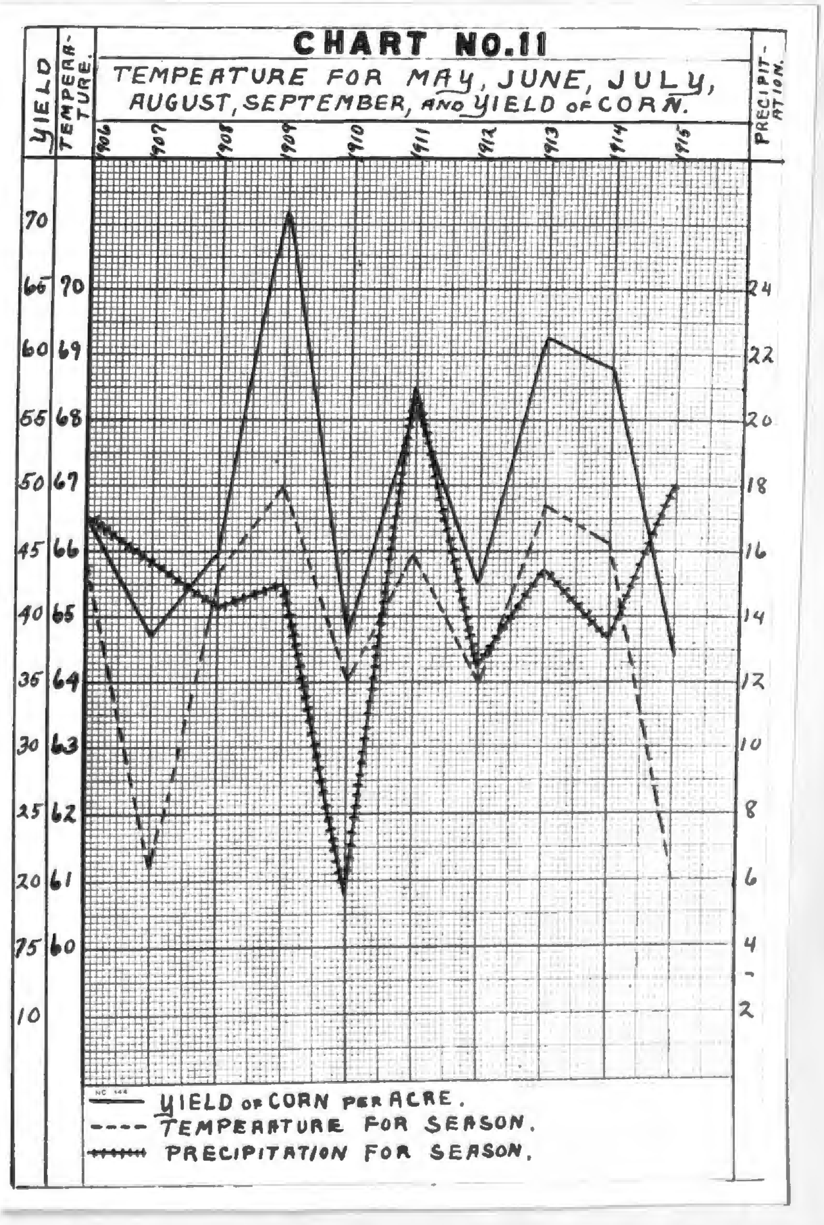

Figure No.11. Temperature for June, July, August, September and Yield of corn.

If it is the moisture that is subject to large periodical changes and the question of the quantity of heat becomes unimportant because of its abundance, the cycle of plant life depends upon the periodicity of this moisture, as in Texas and Arizona. If the variations of the climate are such that there is sometimes insufficient heat and moisture, then the necessity of economy in the use of both of these materials is enforced and plants must develop in accordance with both these necessities as on the shaded mountain sides. Therefore, it can be said that these elements are limiting factors either acting together as such or acting independently. In the sections of the country where the raising of a crop every other year is practiced, precipitation is the limiting factor, in that the land is summer fallowed every other year in order to store up enough moisture with which to raise a crop. In regions with an average annual temperature of 40 degrees or lower this element becomes the limiting factor, as well as in the regions where the other extreme of temperature is prevalent. Along the Atlantic coast the soil becomes the limiting factor because of the small yields of corn, which make it unprofitable to produce this crop and truck crops are better adapted to this type of soil.

C. Yield and Plant Growth as Affected by Sunshine.

While it is probably true that the greater part of plant growth takes place in the darkness, according to Jost (18), it is fully ascertained that the assimilation of carbon from the atmosphere takes place only in direct sunlight, that the brightest diffused daylight is insufficient to effect the necessary breaking up in the green plants of the carbonic acid, which is the source of carbon, of which compound the plant is almost entirely composed. It has been further observed that the transpiration of water, which plays a very important part in the life activity, and especially in the nutrition of the plant, is greatly increased by the action of direct sunlight. As compared with diffused light Wiesner found that the following amounts of water were transpired in one hour from 100 square centimeters of surface of green corn leaf - in darkness, 98 milligrams - in diffused daylight 114 milligrams and in sunlight 785 milligrams.

Although biennial plants can live a time and develop their organs from the stored-up food supplies of their roots or stems, it is evident from the above facts that the aid of the direct rays of the sun is essential to enable any plant to assimilate food from outside of itself, or, in other words, while the rate of growth is not dependent solely upon the amount of sunshine to which the plant is exposed, no plant unless it be a parasite, can obtain the materials necessary for development without an abundance of sunshine.

Another element of importance in this connection is the relation of the amount of direct sunshine to the temperature of the soil. The difference in the amount of radiant heat transmitted to the soil with diffused light and with sunshine is clearly shown by the different appearances of the north and south sides of a hill toward the close of winter - the north side is still white with snow, while on the south the grass is green and the ground almost fit for plowing.

Description of the Charts.

The total hours of Sunshine for each month is used in the following charts, represented by the dotted line while the yield of corn per acre is shown by the solid line.

Chart No. 13.

Only the extreme amount of sunshine during the month of May seems to have any noticable affect on the yield of corn as shown in this chart. In 1911 the hours of sunshine ware largest and the yield of corn was above the average while in 1915 the hours of sunshine were lowest and the yield of corn was below the average.

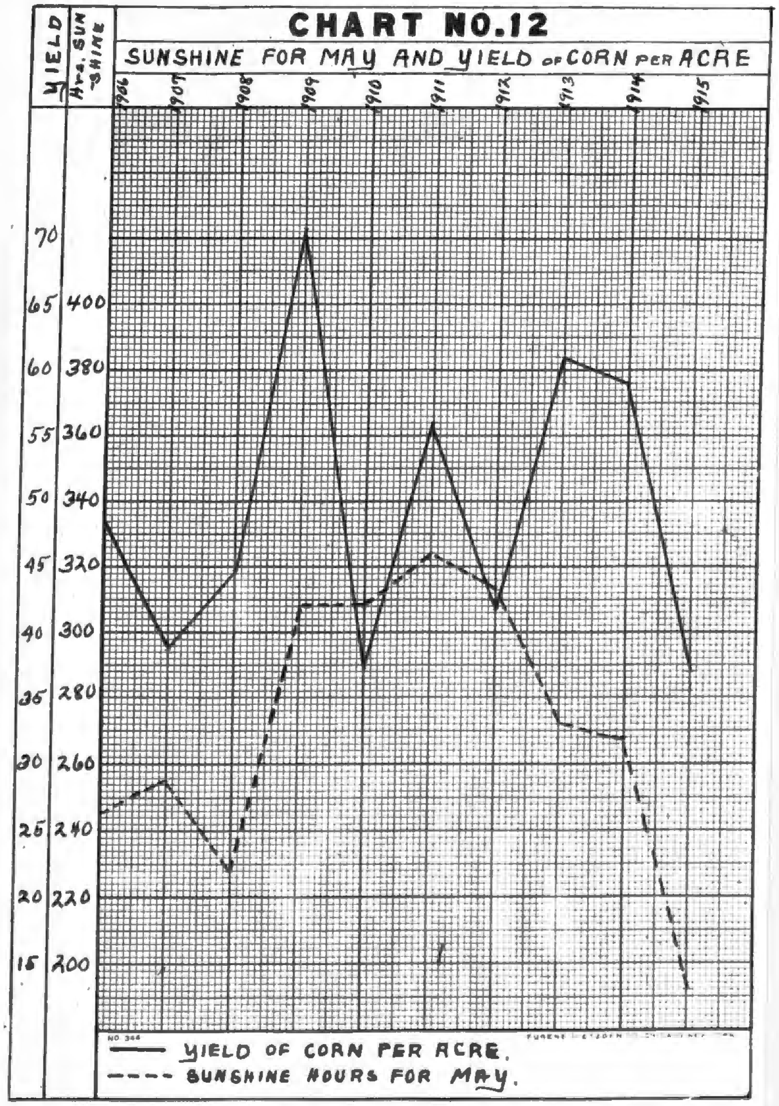

Figure No. 12 Hours of Sunshine for May and Yield of Corn per Acre.

Chart No. 13.

Again very little relationship is shown between the hours of sunshine and the yield of corn. With the exception of the years 1913 and 1915 the yield line runs just the opposite of the hours of sunshine. In both of the mentioned cases the hours of sunshine are extreme, in 1913 a large number of hours and in 1915 a very small number of hours. The yield in 1914 was just a little smaller than that of 1913, but the number of hours of sunshine was very small, showing that other factors must have more effect than sunshine.

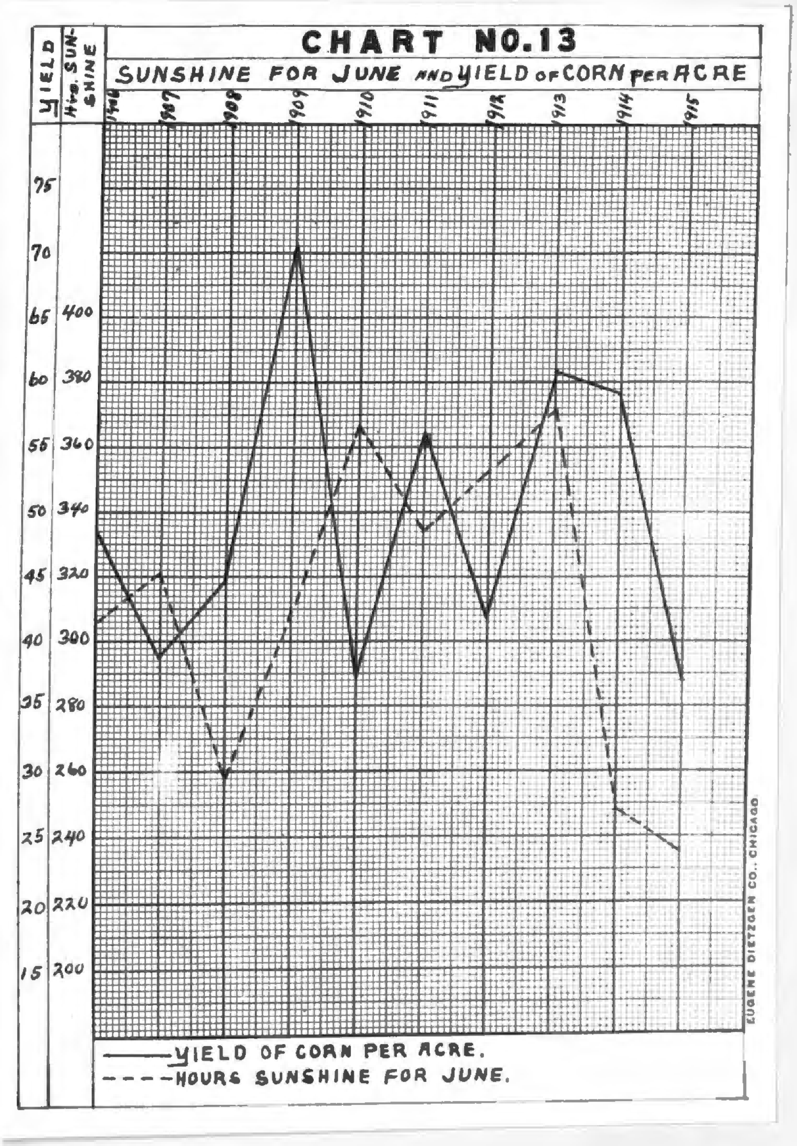

Figure No. 13. Hours of Sunshine for June and Yield of Corn Per Acre.

Chart No. 14.

Within a range of 100 hours, that is, between 300 and 400 hours of sunshine in July there seems to be a lack of correlation between sunshine and yield but when the hours exceed these limits either above or below it seems to affect the yield in the same way. The excess number of hours produce a draught which causes a small yield while the lack of sunshine as in 1915 also causes a small yield.

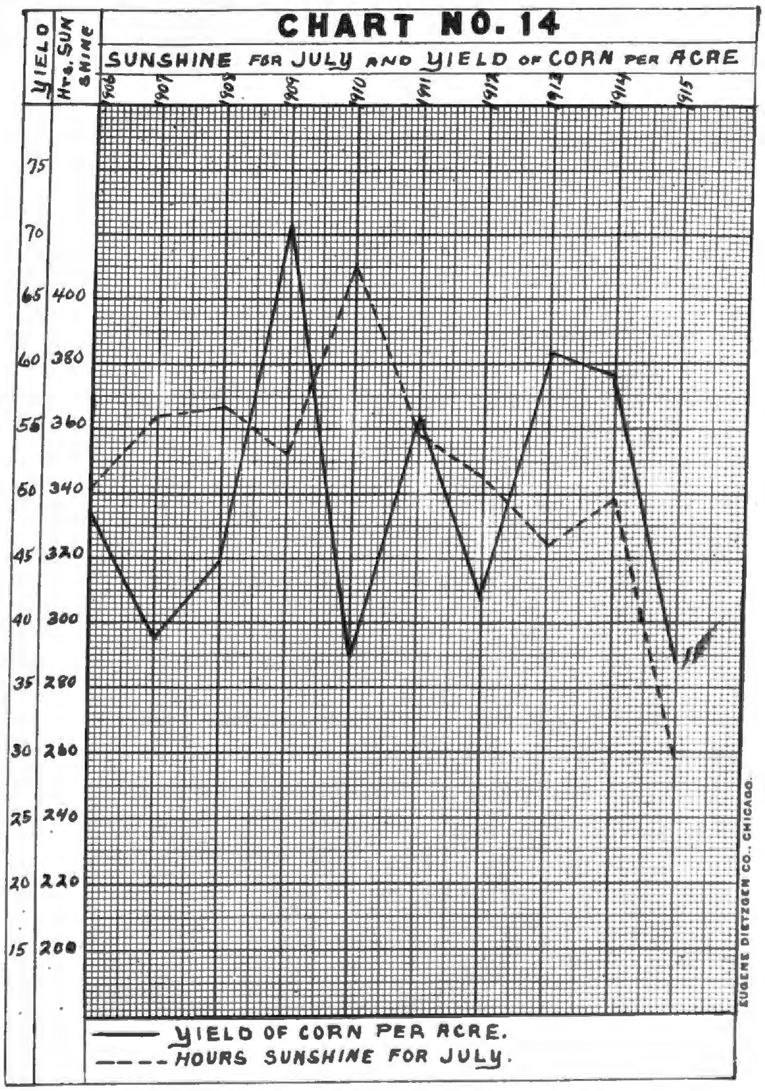

Figure No.14.Hours of Sunshine for July and yield of Corn per Acre.

Chart No. 15.

The hours of Sunshine in August do not seem to affect the yield of corn any more than the other months, in fact the years 1914 and 1915 show two extremes in which no relationship is evident. In 1914 the hours of Sunshine in this month were less than any other year during the decade and the yield was above normal. In

1915 the hours of sunshine were normal and the yield of corn was the lowest of the decade, therefore, if the hours of sunshine affected the yield directly this variation could not occur.

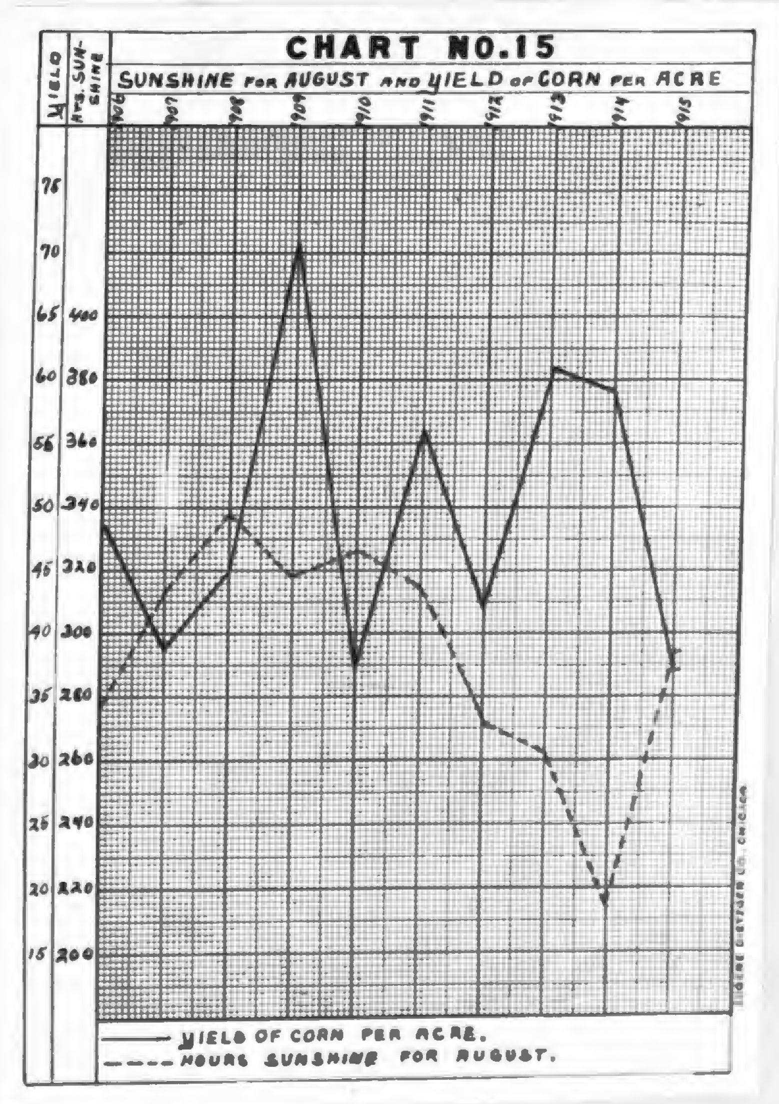

Figure No.15. Hours of Sunshine for August and Yield of Corn per Acre.

Chart No. 16.

Within certain limits the hours of sunshine in September have no effect on the yield of corn, unless it be that there is not enough sunshine to ripen the crop as in the year 1915. A large amount of sunshine during this month should assist in ripening the grain mare rapidly and avoid the frost thereby increasing the yield.

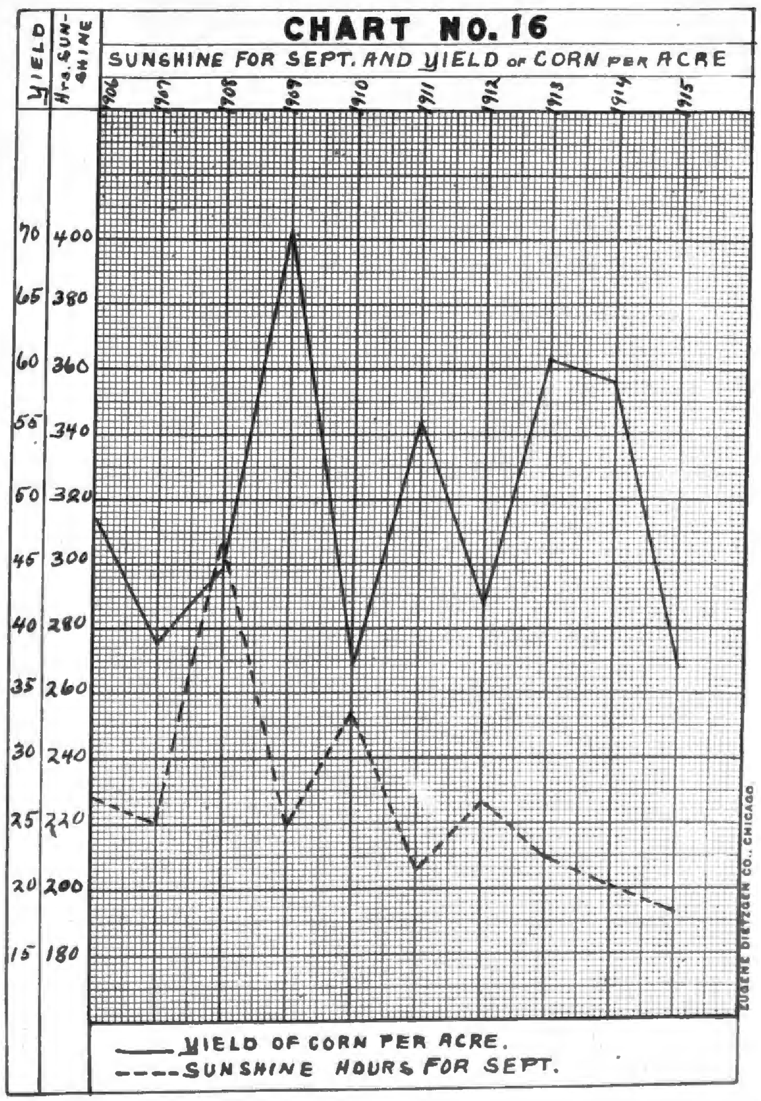

Figure No. I6. Hours of Sunshine for September and Yield of Corn.

Chart No. I7.

A summary of the relationship of the three environmental factors to yield as discussed in the earlier pages is shown in this chart. In totaling the hours of Sunshine for the season it can be readily seen that sunshine does not affect the yield as much as either precipitation or temperature. The yield line follows the line representing sunshine only in I908 and in I9I5, the most direct relationship being in I9I5.

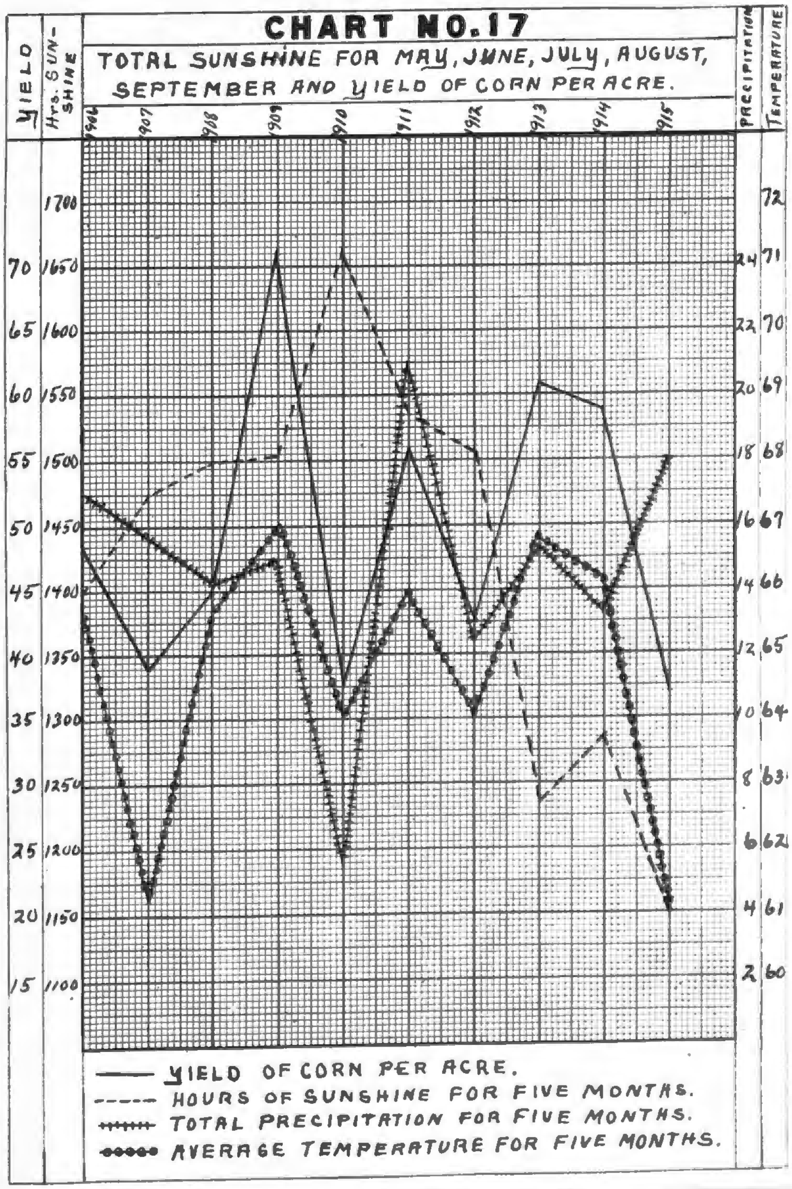

Figure No. I7. Total hours of Sunshine for May, June, July, August, September and Yield of Corn per Acre. Also showing the Total Precipitation and the Average Temperature for the same months.

Table No. 4 in which the coefficient of correlation is expressed shows that there is just a slight relation between the hours of sunshine for the season and the yield of corn. With a correlation of only .006 $\pm$ .0009 it can be readily seen that the effect of sunshine on yield is very small although at times it might be of some importance to the crop. The distribution of sunshine throughout the season does not seem to affect the relationship of this element with yield, that is, it does not seem to affect the yield any more during one month than it does during the others. Yet it has been observed by Ewing,E.C.(1910),(10), that the timenof flowering is influenced by sunlight in that on warm,sunny days, a great many more plants bloom than on the cool cloudy days, but there is little or no correlation between the time of flowering and yield.

Table No. 4.

Correlation between Environmental Factors and Yield of Corn perAcre.

	Coefficient of Correlation.
Precipitation for May,June,July, August,September and Yield of Corn.	.125 ± .00187
Precipitation for June,July,August a nd Yield of Corn per Acre.	.235 ± .0035
Temperature for May,June,July,August, September and Yield of Corn per Acre.	.849 ± .0128
Hours of Sunshine for May,June,July, August,September and Yield of Corn.	.006 ± .0009

This table shows the comparative relation of the different environmental factors with yield. When considering the precipitation for June,July and August it can be seen that during these months this element is more important than the average for the entire season indicates. The closer relation during these months is caused by the fact that the most important periods of growth come during these three months.

A peculiar circumstance is shown in Chart No.17, that is, the lack of correlation between the hours of Sunshine and the Average Temperature. Only on one occasion, namely in 1915,is there any near relationship shown by these two elements. It is natural to suppose that the greater the hours of sunshine the warmer the temperature and the smaller the hours of sunshine the lower the temperature, but in 1910 the temperature was low while the total amount of sunshine was large. In 1915 the temperature was low and the hours of sunshine were also below the average, showing some correlation. The coefficient of correlation which is .312 ± .00319 shows very little relationship between sunshine and temperature, this is for the five months of the summer season but if it were to be worked out for each month there would be a closer relationship at times. The months of July and September, especially the latter show some correlation.

Sunshine and precipitation act inversely, that is, in years showing a large amount of precipitation the total amount of sunshine is small and in years showing a small amount of precipitation the amount of sunshine is large. The yield line follows the line representing precipitation more closely than it does the line representing the hours of sunshine, therefore the natural conclusion is that, precipitation is more important than sunshine. The coefficient of correlation as given in Table No. 5 shows a negative correlation between these two elements.

Table No.5.

Relation of the Environmental Factors to each other.

	Coefficient of Correlation.
Precipitation and Temperature.	-.0016 ± .000176
Precipitation and Sunshine.	-.632 ± .0009
Temperature and Sunshine.	.312 ± .00319

Precipitation and temperature seem to work together although in some years they show little in common. In seven out of the ten years a low or high temperature is accompanied by a light or heavy rainfall. From this it would seem quite safe to assume that low temperature is accompanied by low precipitation and high temperature is accompanied by a large precipitation, but the coefficient of correlation as expressed in Table No.5 shows that there is practically no correlation whatever.

D. Yield as Affected by Soil.

It has been believed that the chemical characteristics of soil have a direct and controlling influence on the yield of a crop on any particular soil; but the Bureau of Soils, U.S. Department of Agriculture report in Bulletin No.22 that there is no obvious relation between the amount of the several nutritive elements in the soil and the yield of crops; that is no essential chemical difference has been found between the solution produced in the soil yielding a large crop and that in the soil of the same character in the adjoining fields giving much smaller yields. The investigations of the Bureau indicate approximately the same amount and same proportion of plant food per unit of soil solution in the black clay loam of Ohio, the different loam soils of Kentucky, Tennessee and other types of soil with which they worked. La Clerc,J.A. and Leavitt,S.(23), carried on an investigation to determine the effect of environment on the composition of wheat in California, Kansas, and Texas. They concluded that soil and seed play a relatively small part in influencing the composition of crops. Wheat of the same variety from different sourced a nd possesing widely different chemical and physical characteristics, when grown side by side in one locality, yield crops which are almost the same in appearance and in composition. Wheat of any one variety from one source grown in different localities, yields crops of different appearance and chemical composition. Thus it would seem that the climatic agents and not the soils are the controlling factors in the production of crops.

The texture of the soil influences the climate of the soil in that it affects the water supply and temperature,under which the crop is produced and presumably in connection therewith the supply of nutrient material. The affect of this on the yield of crops is shown in the cropping of the light sandy soils of the Atlantic coast, which,because of the light yields of corn and wheat are used for early truck crops. The conservation of the water which falls is regulated almost entirely by the physical characteristics of the soil, though modified to some extent by the physiographic position. The black clay loams contain a bout 35 per cent water and are considered as our best corn lands while the sandy lands contain about 6 per cent water when in good condition for plant growth. Smith,J.W.(1903)?(35), said,"That the actual quantity of water a soil could furnish a plant,irrespective of the percentage of water actually present in the soil has probably a very important influence on Yield."

Among the physical conditions that exercise a vital influence upon the growth of plants,none is probably more important than that of soil heat. At different depths the temperature of the soil varies with the seasons,thus,in JUly the soil at a depth of 2 feet is about 7 degrees colder than the atmosphere;in August the soil is wa rmer at a depth of six inches than at the surface;later two feet from the surface is the warmest.

III - Evidence Bearing on Environmental Influences.

A - Project.

1 - Location (See Figure No. 18).

Figure No. 18 - Location of Trial Plots in State.

a. Southern Section of State.

Worthington, Nobles County.

Waseca, Waseca County.

b. Central Section.

Anoka, Anoka County.

Graceville, Big Stone County.

Morris, Stevens County.

St. Paul, Ramsey County.

c. Northern Section.

Duluth, St. Louis County.

Crookston, Polk County.

Grand Rapids, Itasca County.

Brainard, Crow Wing County.

2. Object.

To study the Effect of Environment upon the growth and character of corn.

3. Method of Procedure.

Three varieties of corn were used in the experiment - (a) Silver King, a white late maturing variety, seed grown at Cokato - (b) Minn. No. 13 a yellow medium early maturing variety, seed grown at University Farm, St. Paul - (c) Minn. No. 23 a white capped yellow dent, seed grown at Lake Harriet.

These three varieties are standard types of the different corn sections of the state. Minn. 23 is an early maturing variety for the northern Section, the seed used is from the original strain of this variety. Minn. No. 13 is a medium maturing variety for the central Section, seed grown at University Farm, coming from the original Minn. 13, as sent out a few years ago by the Experiment Station. The Silver King is a large medium late maturing variety, seed grown at Cokato and coming from a pure strain that has been tested for a number of years.

Description of the Soils at the Station.

The Carrington Silt Loam is the predominating type of soil at Worthington, Morris and Waseca, this consists of a grayish-black or black heavy silt loam with a depth of 15 inches, grading into a drab or brownish silty clay which atabout 24 inches is underlain by dark heavy clay. The soil is friable and easy to work when dry, but sticky when wet.

At University Farm we have a Silt Loam which is mellow, friable and of high organic matter content. It is remarkably uniform both in structure and texture. The type is well adapted to corn, wheat and all other farm crops.

Fargo Clay Loam is the prevailing type at Crookston. It consists of a gray or grayish black silty loam, varying in depth from 8 to 12 inches with a heavy clay subsoil. The soil is easy to work containing a fair proportion of sand. It is a rich soil and very retentive but badly in need of drainage.

The soil at Duluth is a Stony Clay Loam. When wet it resembles a clay, being soft and sticky. If plowed under favorable moisture conditions, it can be put in a state of good tilth but it needs drainage. The large rocks and boulders make it difficult to till properly.

At Brainerd and Grand Rapids we have a Gravelly Sandy Loam. This consists of a dark brown to nearly black loam with a sandy subsoil, which makes it a very easy soil to handle and put in condition for crops. The presence of a large quantity of small stones in a soil should make it warmer, for rocks absorb heat more freely than soil, and loses it more slowly, thus keeping the soil warmer at night. The failure of the trial station men to gather the soil temperature makes it impossible to discuss the bearing of this question on the results obtained.

The soil at Anoka is made up mostly of sand with a small percent of clay. Sandy soil is usually considered too light for general farm crops, but the addition of humus in the form of manures have made the soil at Anoka quite retentive. It has not lost its earliness by the addition of manure, so that it maintains that condition, making it a valuable soil as shown by the 1915 crop.

B - Results.

1 - Growth of Plant.

a - General discussion.

Table No. 3 shows the time of planting, number of cultivations given each plot, the average date of tasseling, average date of silking, average date of denting at the different stations throughout the state for the year 1915.

The time of planting was unusually late because of the cool wet weather which delayed the work on the preparation of the soil. The average time of planting corn for ten years (1905 to 1914), at University Farm was May 10th, and in 1915 it was planted on May 18th. In the northern Section of the state as represented by Crookston and Grand Rapids the average date of planting is May 18th, and in 1915 corn was planted on the 25th of May. At Duluth we find the date of planting is quite late due to its peculiar geographical location near Lake Superior, the corn was planted on June 1st, in 1915. At Worthington May 5th to 10th, is the usual corn planting time, but May 15th, was the earliest last year. There is usually ten days difference between the time of planting in the southern part of the state and the time of planting in the northern part.

Cool temperature and the large amount of moisture made the germination of the seed very slow in the spring of 1915. There are exceptions to this, for example at Duluth it took only 6 days for the corn to germinate and sprout but they had a week of dry hot weather immediately after the corn was planted. At Worthington we find the same condition but at Anoka the open sandy soil was perhaps responsible for the quick action of the seed. On University Farm at St. Paul it took 19 days for the seed to sprout, due to the low temperature and large amount of rain.

The number of cultivations given the plots at the different stations varied a great deal because of the poor condition of the soil. At Graceville and Crookston it was not cultivated at all - At Worthington, Morris and Grand Rapids three cultivations were given - At St. Paul, Waseca and Anoka five cultivations were given. It is impossible to say whether the number of cultivations given had an effect upon the ultimate yield of the crop at the different places but had weather conditions allowed all plots would have secured the same number. According to Bulletin No. 149 of the Minnesota Experiment Station, the number of cultivations materially affects the yield per acre. Four cultivations proved the most profitable although the yield from these plots was not quite as high as from the plots getting six cultivations.

What is termed as the average date of tasseling means the date on which over 50 percent of the total number of plants had tasseled. The plots at Anoka were the first to tassel due perhaps to the sandy soil. At Crookston and Duluth the corn was heavily frosted before it tasseled.

Only four stations out of ten show any records as to the

TABLE NO. 6.

Date of Planting, Silking, Tasseling, Denting, Date plants come up, Depth of Planting and Number of Cultivations at the Trial Stations.

		St.Paul	Anoka	Waseca	Worthington	Morris	Crookston	Duluth	Grand Rapids
Date of Planting.		May 18	May 24	May 13	May 15	May 24	May 25	June 5	May 24
Depth Planted. Inches.		1 1/2	2	2	2	1 1/2	2	2	2
Date up.	Minn.No.23	June 6	May 29	May 31	May 22	June 3	No Notes Taken	No Notes Taken	JUNE 4
	Minn.No.13	June 4	May 30	May 31	May 20	June 3			June 4
	Silver King	June 4	May 31	May 31	May 20	June 3			June 4
Number of Cultivations.		5	5	5	3	3			3
Average Date of Tasseling.	Minn.No.23	Aug. 9	July 23	Aug. 9	Aug. 5	Aug.16			
	Minn.No.13	Aug. 14	July 29	Aug.13	Aug.13	Aug.23			
	Silver King	Aug. 15	July 29	Aug.16	Aug.16	Aug.23			
Average Date of Silking.	Minn.No.23	Aug. 13	July 25	Aug.12	Aug. 5	Aug.16			
	Minn.No.13	Aug. 18	Aug. 8	Aug.16	Aug. 13	Aug.23			
	Silver King	Aug. 19	Aug.10	Aug.19	Aug.16	Aug.23			
Average Date of Denting.	Minn.No.23	Oct. 15	Sept. 4	Sept.10	Sept. 7				
	Minn. No.13	Oct. 10	Oct. 9	Sept.21	Oct. 1				
	Silver King	Oct. 10	Oct.10	Sept.20	Sept.26				

denting of any of the varieties. Both Worthington and Waseca in the southern Section had some of all varieties reach the dent stage. Anoka and St. Paul were the only other stations to secure any mature corn. The time of denting was delayed until late in September or early in October at these places which is an extremely exceptional case.

The season of 1915 was a very unfavorable one for corn, and in some localities light frosts occured every month. At Duluth the corn was killed on July 24th, at Grand Rapids a light frost touched the crop on August 15th, and on September 11th, a killing frost finished what plants were left by the earlier frost. Crookston was visited by a light frost on June 8th, and a killing frost on August 23rd. The Killing frost did not occur at Graceville until later but the weather was so cool during August and September that the corn did not reach the dent stage.

What might be termed as positive results were impossible under the conditions of the past season, but the results obtained show that environment is a very important factor in the growth of this crop.

The amount of precipitation at the different stations was sufficient for a normal crop, but the average temperature for the season was too low, in fact it was the lowest it has been since 1907. At St. Paul the mean temperature for the season of 1907 was 61.3 and in 1915 it was 61.1 as shown in chart No. II. The effect of the low temperature and large rainfall on the yield of corn is shown in Chart No. II which also compares 1915 with the ten previous seasons.

Table No. 7.

Mean Temperature and Rainfall for the months of May, June, July, August and September.

Locality	May		June		July		August		September	
	Temp.	Rain	Temp.	Rain	Temp.	Rain	Temp.	Rain	Temp.	Rain
Worthington	50.0	4.63	59.2	4.85	64.1	5.42	62.	4.30	57.1	3.61
Waseca	51.5	6.89	64.2	7.48	67.8	7.44	64.8	2.40	60.5	2.33
St. Paul	52.2	4.46	62.	4.78	65.6	5.96	63.8	3.38	60.	2.92
Anoka	55.1	3.98	62.5	4.91	67.2	5.92	65.4	3.49	60.7	2.57
Morris	56.3	5.23	59.7	8.78	65.2	4.53	64.8	2.42	57.9	2.47
Duluth	44.2		53.2		59.8		61.6		55.6	
GrandRapids			56.2	7.78	62.	3.02	61.8	2.10	55.2	1.36
Crookston	52.	3.06	58.4	8.01	64.6	2.98	65.2	1.	56.4	1.73

The reason for the complete or partial failure of the corn crop in 1915 is shown in Table No. 6, which gives Mean Temperature for each month and in Table No. 7, which gives the dates of the last frost in the spring and the first frost in the fall. The starred (*) figures represent light frosts, and the others killing frosts.

Table No. 8.

The Last Spring and the First Fall Frosts.

Locality	Spring	Fall	Days Frost Free
Worthington	May 18	Oct. 4	139
Waseca	June 9*	Aug. 30*	82
St. Paul	May 18	Oct. 4	139
Anoka	May 18	Oct. 4	139
Morris	June 9*	Oct. 5	118
Duluth	May 19	July 24	66
Grand Rapids	June 9*	Aug. 18	70
Crookston	May 18	Aug. 5	79
Brainerd	June 9*	Aug. 26	78

Table No. 8 gives the lowest temperature for each month of the summer season at the different stations. From this one can plainly see that corn had very little chance to mature at many of the localities.

Table No. 8.

Lowest Temperature for each Month.

Locality	May	June	July	August	September
Worthington	27	34	41	38	35
Waseca	29	35	45	35	31
St. Paul	29	36	49	43	39
Anoka	27	38	48	39	40
Morris	28	34	44	42	36
Duluth	27	35	32	26	36
Grand Rapids		29	38	30	30
Crookston	29	33	43	31	37
Brainerd	28	31	43	31	35

According to the original plan of the project, soil temperature data was to be taken and soil thermometers were sent to the trial stations, but no data was gathered. The importance of soil temperature is recognized and discussed in a general way, but as no data was gathered it is impossible to discuss it in as full a manner as the other climatic elements have been discussed.

2 - Height of Plant.

The growth of the different varieties is, of course, affected by hereditary tendencies as well as environmental conditions, but with the hereditary factors the same for all the plots of each variety the difference in height as shown in Table No. 9 is due no doubt to environment.

Table No. IO.

Comparing Height of Plants at Trial Stations with Average Height at University Farm. Height expressed in inches.

Variety	Worth-ington	Waseca	Anoka	St. Paul	Grand Rapids	5Yr.Av'g. atSt.Paul
Minn.No. 23	66	60	68	62	54	74
Minn. No. I3	90	72	94	69	64	88
Silver King	96	84	96	88	67	90

The slight difference between the height of the Silver King and Minn. 23 at some of the places may be accounted for in the fact that the season of I9I5 was very unfavorable for corn,so that the large plants suffered more in their development from the adverse conditions than did the smaller type represented by the Minn. No. 23.

The average of Minn. No.23 at University Farm is 74 inches. Only one station,namely, Morris was able to produce plants which equaled the average height of the variety. The plants at Worthington were I2 inches taller than the plants at Grand Rapids.

Minn.No.I3 at University Farm averages 88 inches in height, in I9I5 Worthington and Anoka produced plants with an average height over 90 inches. This shows again the tendency of the Anoka soil located as it is II5 miles north of Worthington, to produce plants of the same size in a shorter growing season, as those produced at Worthington.

Silver King plants at University Farm average 90 inches in height. In comparing this with the Silver King grown in I9I5 at the different stations,there is only one place,namely,Worthington which had plants that would equal the normal height of the variety.

3 - Height of Ear on the Stalk.

The height of the ear on the stalk varies with the varieties and even within the varieties as has been shown by the Illinois Experiment Station. Smith, L. H. (36), at Illincis found that the plants which were selected for high ears also produced the highest stalks, and that the low ear plants were the early maturing plants.

Table No. 15 shows the average height of the ears of three varieties grown at the different stations throughout the state.

Table No. 11.

Comparing Height of Ear on Stalk at Trial Stations.

Variety	Worthington	Waseca	Anoka	St.Paul	Morris	Grand Rapids
Minn. 23	32	14	27	36	25	16
Minn. 13	44	27	43	39	47	25
Silver King	48	28	46	40	36	26

The variation in height of ear is not as great as the variation in the height of plant. A very peculiar circumstance is shown in Table No. 11, in that the height of the ears at Waseca are very nearly the same as height at Grand Rapids.

Again the results at Worthington appear to be nearly the same as the average height of ear at University Farm, which shows the effect of climatic agents in delaying the growth at Worthington where normally larger plants are produced than at St. Paul.

The greater average height of plant at Anoka can be accounted for by turning to Table No. 7, which gives the mean temperature for the five summer months at the different stations. With the exception of the month of June the mean temperature at Ancka was higher than any of the other stations.

2 - Ear Characters.

A very thorough study was made at Ohio, (48) as to the effect of different ear characters on the yield. Very little difference was found between the yield from short ears and the yield from long ears, that is, within a variety. Tapering ears excelled cylindrical ears by 1.65 bushels per acre. This work was all carried on at Wooster, Ohio. The effect that variations in environment would have on the ear characters was not considered.

The variations of the different characters caused by environment is shown in Tables No. 12, 13 and 14. The difference in the characters of Minn. 23 at Worthington and Morris is caused by temperature or precipitation because the soil at these places is the Carrington Silt Loam which would eliminate the soil factor.

In looking over the score card of Minn. 23, some characters show only slight variation, such as, circumference of tip and butt, length of ear and circumference of cob. There is considerable variation in the weight of ear; the seed ears averaged 145.5 grams and the crop produced in 1915 was lighter. At one place, namely Waseca, ears of half that weight were produced. The corn at Worthington and Anoka averaged about the same while at St. Paulthe ears were a trifle heavier than those produced at Waseca. The percent of moisture in the harvested corn was exceedingly high at every station. At Anoka it was just a few points below 50 percent and at the other three places it was above 50 percent. The estimated moisture content of the seed being about 12 percent, it can readily be understood that the precipitation of the season must have been exceedingly large. The large percent of moisture in the corn at time of harvest is responsible for the light weight of the 1915 crop.

Table No. 12.

Score Card for Minn. No. 23.
Comparing the crop of 1915 with the Seed Ears used.

Measurements	Seed Ears.	Anoka	St.Paul	Waseca	Worthington
Score Card Ave.	79.67	76.82	69.00	69.50	76.64
Cir. 2 in. Tip.	4.7	4.92	4.36	4.17	4.47
Cir. 2 in. Butt.	5.	5.08	4.84	4.56	5.
Length of Ear	6.22	6.17	5.64	5.13	6.05
Weight of Ear	145.5	115.	78.92	71.37	114.47
Weight of Cob	21.9	19.52	17.58	13.07	21.35
Weight of Shelled Corn	123.6	95.48	60.35	58.3	93.12
% Shelled Corn	84.95	83.03	77.72	81.79	81.35
Cir. of Cob 2 in from Tip.	2.94	2.92	2.98	2.73	2.53
Cir. of Cob 2 in from Butt.	3.06	3.27	3.58	3.73	3.47
% Moisture		47.9	57.67	54.1	51.36

More variation is shown by all characters of Minn. 13 than in Minn. No. 23. At every station the circumference of the tips and butts, the length of ear and the circumference of the cob were smaller than the same characters of the seed ears. The heaviest ears were produced at Anoka, but they were only about one-third as heavy as the seed ears. The percent of shelled corn to the ear was smaller in the 1915 crop than in the seed. The moisture in the seed ears did not exceed 14 percent and in the 1915 crop it went as high as 63.54 percent.

Table No. 13.

Score Card for Minn. No. 13.
Comparing the crop of 1915 with the Seed Ears used.

Measurements	Seed Ears	Anoka	St.Paul	Waseca
Score Card Average	81.65	70.18	56.69	65.30
Cir. 2 in. from Tip	5.57	4.04	5.04	4.78
Cir. 2 in.from Butt	6.23	5.5	5.62	4.78
Length of Ear	7.09	5.65	5.72	5.
Weight of Ear	248.	90.1	78.82	77.2
Weight of Cob	35.6	22.96	22.98	20.8
Weight of Shelled Corn	212.4	67.14	55.84	56.4
Percent Shelled Corn	85.65	74.52	70.85	73.1
Cir. of Cob 2 in.from Tip	3.58	3.30	3.04	3.58
Cir. of Cob 2 in.from Butt	3.68	3.74	3.88	3.93
Percent Moisture		52.71	65.54	60.13

The Silver King varied more in all respects than did the Minn. No. 23 and Minn. No. 13. A greater variation is to be expected in a large variety from an adverse year. Such characters as circumference of tip and butt, and length of ear, do not show any more variation than the Minn. No. 13, but it does show more variation in weight of ear and percent moisture. The weight of ear produced in 1915 at St. Paul and Waseca was approximately one-fourth the weight of the seed ears. Ears of greater weight and lower moisture content were produced at Anoka, due to some extent to the sandy soils because the temperature and precipitation was about the same at Anoka as at St. Paul. The moisture content of the corn produced in St. Paul, was nearly as large as the percent of dry matter in the seed ears.

Table No. 14.

Score Card for Silver King.
Comparing the crop of 1915 with the Seed Ears used.

Measurements.	Seed Ears.	Anoka	St.Paul	Waseca
Score Card Average	83.48	76.	59.66	58.5
Cir. 2 in. from Tip.	6.23	5.85	5.18	5.33
Cir. 2 in. from Butt	6.92	5.82	5.76	5.89
Length of Ear	8.39	6.23	5.74	5.75
Weight of Ear	345.85	166.28	85.1	91.58
Weight of Cob	49.82	33.37	22.51	26.16
Weight of Shelled Corn	296.03	132.91	62.59	65.42
Percent of Shelled Corn	85.6	79.98	73.55	71.44
Cir. 2 in. from Tip of Cob	3.54	3.68	3.38	3.84
Cir. 2 in. from Butt of Cob	4.16	4.17	3.92	4.21
Percent Moisture		57.47	71.66	68.42

3 - Kernel Characters.

Table No. 15 gives the average size of kernel produced at the different stations, and show a considerable variation in size character.

Table No. 15.

Comparing size of kernels of 1915 crop with the Seed used.

Variety	Seed Kernels		Anoka		Waseca		St. Paul	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
Minn.23	12	10	13	11	9	11	11	9
Minn.13	13	8	11	8	10	9	9	8
Silver King	15	9	12	8	11	7	11	9

*Size of kernels expressed in Millimetres.

Minn. No. 23.

Very little variation is shown in size of kernel of Minn.23.

At Anoka the kernels are a little larger than the seed kernels which brings out again the effect of the light sandy soil. The tendency of this strain of corn is to produce kernels a little longer than they are broad, but this condition was reversed at Waseca and the breadth is greater than the length. The seed kernels were made up largely of corneous (hard) starch, Anoka produced kernels of practically the same texture as the seed. At Waseca and St. Paul the kernels produced are made up largely of soft (white) starch.

Plate No. I.
Minnesota No. 23.

I.
2.
3.
4.
5.

1. Seed Used - 1914
2. Anoka - 1915
3. St. Paul - 1915
4. Waseca - 1915
5. Worthington - 1915.

Plate No. 1, shows representative samples of the seed used and the 1915 crop as produced at the different stations. The difference in size of kernel is shown very clearly, with Anoka producing the largest kernels of practically the same texture as the seed. The difference between the size of kernels from Anoka and St. Paul is noticeable and undoubtedly due to the soil, as there is very little difference in the action of the climatic elements at these places.

Minn. No. 13.

The variation in size of kernel was in the same proportion at the different stations as the Silver King. Although the kernels were nearly up to standard in length and breadth, they lacked plumpness. The corn from Anoka had a high percent of corneous starch but that produced at St. Paul and Waseca was made up largely of soft starch. The size of the germ varies with the size of the kernels.

Plate No. 3.

Minnesota No. 13

I.

2.

3.

4.

1. Seed Used - 1914
2. Anoka - 1915
3. St. Paul - 1915
4. Waseca - 1915

The variation in size of kernel is shown in Plate No. 3, which is a photograph of representative samples of the seed used, and the 1915 crop from the different stations. The kernels from Anoka were a trifle smaller than the seed used but they were plump and well filled, while the kernels produced at St. Paul are not only smaller, but they are not well filled, nor do they have good texture. A peculiar thing was noticed in the Minn. No. 13 produced at St. Paul - a number of kernels without germs were found on different ears. The three kernels on the right of the St. Paul group in Plate No. 3, have no germs at all.

Plate No. 3.
Silver King.

1.
2.
3.
4.

1. Seed Used - 1914
2. Anoka - 1915
3. St. Paul - 1915
4. Waseca - 1915.

There is more variation shown by the kernel characters of Silver King than is shown by Minn. No. 23 and Minn. No. 13. The seed kernels averaged 15 millimetres in length and 9 millimetres in breadth at the broadest point. Although the measurements of the kernels indicate that they are not much smaller than the seed kernels, the figures are deceiving in that the thickness of the kernels of the I9I5 crop does not come up to the thickness of the seed kernels. The seed kernels contained a large percent of corneous starch and the I9I5 crop is made up mostly of soft starch with the exception of the crop at Anoka.

Plate No.3 shows the difference in size of kernels from the trial stations and the seed used. The difference in size as shown in the photograph is not as great as the difference in Texture. The largest kernels in this variety were produced at Anoka, while there is very little difference in the size of those produced at St.Paul and Waseca.

CONCLUSIONS.

I. Temperature is the controlling factor in Minnesota. The ideal temperature being approximately 66 degrees; that is, the average for May, June, July, August and September.

2. If the temperature were to be ideal then precipitation would become the controlling factor. Other factors being favorable the indications are that a precipitation of from I4 to I8 inches during the five months of the summer season will produce an average crop of corn.

3. A large amount of sunshine does not seem to materially affect the production of corn. The charts on sunshine indicate that enough sunshine to assist in the manufacture of chlorophyl is all that is necessary for a corn crop, but it is difficult to determine the quantity necessary for that purpose.

4. Indications are that a large amount of Precipitation and warm Temperature will increase the size of the plant.

5. The time of maturity depends to some extent upon the texture and composition of the soil, as brought out by a comparison between the results obtained at Anoka and St.Paul where

climatic conditions are nearly the same.

6. The greatest fluctuations seem to occur in the weight of dry matter and the moisture content of the ear.

7. There is more variation in the texture of the kernels than in size characters.

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