

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by William Thorpe Tapley 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 Master of Science.

W. H. Alderman

Chairman

H. K. Hayes

G. R. Bisby

June 1920

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Willism Thorpe Tapley final oral examination for the degree of Master of Science . We recommend that the degree of Master of Science be conferred upon the candidate.

Minneapolis, Minnesota

*May 26* ..... 1920

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A PRELIMINARY STUDY OF THE INHERITANCE OF  
FRUIT CHARACTERS IN THE CUCUMBER

A Thesis Submitted to the Faculty of the  
Graduate School of the University of Minnesota

by

William T. <sup>Thorp</sup> Tapley

In Partial Fulfillment of the Requirements  
for the Degree of  
Master of Science

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## INTRODUCTION

The cucumber (*Cucumis sativus*) has been grown under glass in the United States since the earliest days of the vegetable forcing industry or beginning somewhere about 1885. At present the chief vegetable crops grown under forcing conditions are lettuce, cucumbers and tomatoes, their relative importance being in that order. During the early days of the cucumber forcing industry the long fruited English varieties were grown but the shorter cucumbers of the White Spine type soon became more popular on the market until they entirely replaced the English types as commercial varieties.

The growers now demand for market purposes varieties which produce fruits which are fairly long, dark green in color, uniform in diameter almost to the tip of each end and which have a smooth and regular surface. When ready to be picked it is desired that the seeds be poorly developed and the flesh crisp, tender and of the best flavor. There are several varieties which are fairly satisfactory from the growers standpoint but as in most of the vegetables there is still room for considerable improvement both in regard to growth characteristics and also in fruit characters.

The great vigor, small number of seeds, small diameter, lack of warts, and prolificacy of English varieties have interested greenhouse growers, and these factors have had the greatest influence in causing numerous crosses to be made between the two groups. Most of the crosses have been very unsatisfactory. The hybrids have been thrifty and prolific, but the fruits, in most cases have been too pointed or tapering and irregular in shape. From these crosses, however, two commercial varieties have originated, the Davis Perfect bred by Eugene Davis of Grand Rapids and the Abundance, originated by Chauncey West of Irondequoit, New York.

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While these varieties have not yet met with widespread success, they are grown exclusively in the sections originating them. It is possible that when they become better known they will be much more widely grown. Many growers at present favor a longer fruit than the White Spine strains produce so there is a place for new varieties that might be secured by crossing the English varieties with the White Spine. Several of the F<sub>2</sub> plants from the crosses used in this experiment have produced fruits that in every way measure up to the ideal market type. The fruit shown in Plate XV is an example.

### CLASSIFICATION

Cucumber varieties might be classified into two groups using length and diameter as a basis for classification, in this case the two groups would be designated as the English Group and the American Group. A careful study then of these two groups would also show that they have other characteristics which are distinctive.

### THE ENGLISH GROUP

The plants are thrifty in growth, develop thick stems, large leaves and are exceedingly prolific. The fruits vary in length from 14 to 24 inches, are about  $2\frac{1}{2}$  inches in diameter, contain few seeds and are cylindrical in cross section. The skin is usually thin and shiny, the surface presenting a more or less crinkled or wavy appearance. They are seldom grown out of doors and while they possess special merit in some respects for forcing, they have not met with general favor in this country. Typical fruits of the English type are shown in Plates IV and V.

## THE AMERICAN GROUP

The plants are vigorous in growth although not equal in this respect to those of the English varieties. The length of a typical fruit is usually about three times its diameter or from  $7\frac{1}{2}$  to 10 inches. The fruits are triangular in cross section, especially if not well filled out, and contain many seeds. A distinct characteristic of fruits of this group is the numerous small protuberances on which the white spines are borne. These protuberances are usually called warts and are clearly shown on fruits three and four of Plate III. The white streaks starting at the blossom end and extending about one half the length of the fruit are also characteristic. Plates III, VI, and VII show the leading varieties of the so called American or White Spine type.

## PREVIOUS WORK IN BREEDING CUCUMBERS

It is probable that much work has been carried on in crossing cucumbers yet there are very few reports of the work in the literature. Halstead (5) at the New Jersey Station in 1899 crossed White Spine, a strong grower with large green fruits abounding in minute prickles, with White Pearl, a weak grower having comparatively few prickles, smooth surface and white fruits. The  $F_1$  fruits showed the influence of both parents but were much nearer the White Spine than the White Pearl type. The next year 36  $F_2$  plants were grown: when the fruits appeared it was at once evident that the plot bore a motley lot of crossed plants. Many of them produced fruits of all degrees of color, from the clear white to a mottled middle type and then on through all the shades of green to the greenest that are produced. In size and shape the variation was no less, for some were nearly round while others were long and slender. Halstead states that "the type that was

fairly uniform the previous year had been broken up in the second generation, quite in keeping with the general expectancy with crossed and hybrid plants." One of the chief points in mind in this crossing was the removal of the spines and this was quite fully accomplished in some instances.

In picking out seventeen types and describing the fruits on the various plants he found they varied from exceedingly spiny to free from spines, dark green to white, clear color to white mottling, and cross section roundish to triangular.

The next year plants were grown from several of the most striking variations of the previous season and it was noted that there seemed to be much less variation as to size and shape than the previous season.

A cross was also made between "Telegraph", a long fruited variety, comparatively seedless and with firm flesh, with "Znaim", an Austrian variety, short, broad, rough skinned and dull yellow in color. The  $F_1$  fruits were firm in flesh and contained few seeds.

Reeves, (15) working at the Canadian Station at Vineland reports as follows. Crossing was done in 1915 with the object in view of securing a "White Spine" type that would set its fruits without fertilization. The varieties used and crosses made were

Telegraph x Early White Spine

Fordhook Famous x Telegraph

Ten flowers on each plant were covered with a paper sack to test the plants ability to set fruit without fertilization. A few plants set about 20% of their fruits without fertilization but it was later proven that the pure White Spine varieties would also set a similar percentage without fertilization.

The  $F_1$  fruits were intermediate in type with one exception, a dwarf plant maturing several fruits which contained no seed. It was noted that the fruits which were developed parthenocarpically were not so highly

developed laterally as the fruits which contained matured seeds.

All of the work that has been done in crossing cucumbers shows that the most of the fruit characters are intermediate in the  $F_1$ . As a preliminary to a survey of first generation crosses, Hayes and Jones (6) grew four varieties in 1912 and the following crosses were obtained.

Early Russian x White Spine

White Spine x London Long Green

London Long Green x Fordhook Famous

Fordhook Famous x White Spine

The  $F_1$ s from these crosses showed that in average length and weight of fruit the crosses are of intermediate habit and considering the number of plants they correspond very closely to the average of the parents.

In respect to hybrid vigor the total average of the fruit per plant was taken as the most important test. All of the crosses exceeded the more prolific parent by an average of 1.6 to 8 fruits per plant which is from six to twenty-seven percent.

Wellington (18) at the Geneva Station crossed White Spine having numerous white epidermal spines or trichomes which roughen the skin, with Richards Invincible, a variety having few small indistinct early deciduous black spines which scarcely roughen the skin. The  $F_1$  fruits were intermediate in size and in number, and the prominence of the spines, all of which were black. Of 20 plants grown in the  $F_2$  generation, 15 had black and 5 white spines, 6 had smooth skin with indistinct spines and the remainder skins with various degrees of roughness, a few even surpassing the White Spine in that respect. No correlation between color of spine and skin character was noted. Simple mendelian segregation is indicated with black spine color dominant and smooth skin type recessive.

## STATEMENT OF THE PROBLEM

The original object of the work was to study the effect of crossing on vigor and productiveness and to secure a hybrid of commercial importance. It was believed that through a recombining of the characters a hybrid might result that would be more satisfactory in regard to fruit characters than some of the standard strains. The parthenocarpic character of the English varieties was especially desirable. In order to become more familiar with the material and to determine if it is possible genetically to secure a hybrid possessing the desired characters, a preliminary study of the inheritance of fruit characters has been made.

## HISTORY OF THE WORK AT MINNESOTA

In 1914 various strains of cucumbers were grown in the greenhouse and tested as to the desirability and stability of type. The breeding work was started by Richard Wellington and carried forth under his direction, the data being taken by various assistants. Most of the crossing and pollinating work was carried on by Fred Haralson, Superintendent of the Greenhouse. With the object of securing a variety having as many as possible of the desirable fruit characters for commercial purposes, crosses were made between strains each possessing certain of the desired features. Because the English group has many of the characters that are desirable in a commercial strain, the best of these English varieties were used in the crossing in order to bring together as many of the desired characters as possible. Many crosses were made and the seed saved for further trial. In 1916-17 many of the  $F_1$ s were grown and selfed. During the winter of 1917-18 and 1918-19 as many of the  $F_2$  plants as possible were grown and

descriptions taken of the fruits. In many cases the descriptions of important plants in the chain of inheritance are missing, especially good descriptions of  $F_1$  plants: also the descriptions of the individual male plants used in the original cross. The early work was carried on more with the object of securing a cross of commercial importance than to secure scientific data, which accounts for the discrepancies and missing descriptions. In 1920, 228 plants were grown in the greenhouse, the original varieties, the  $F_1$  and also plants of the  $F_2$ ,  $F_3$  and  $F_4$  generations were grown from surplus seed which had been saved, to check upon the descriptions and to get further data. As many  $F_2$  plants as possible of three of the crosses were grown, the number of seed available and limited space keeping this down to 14 - 42 - 44 plants respectively. Descriptions were taken on fruits from these vines with the object of studying the segregation and inheritance of fruit characters.

#### POLLINATION AND FERTILIZATION OF BLOSSOMS

Commercial growers of greenhouse cucumbers rely either on bees to do the pollination or on artificial fertilization of the female blossoms. Cucumbers like all members of the Gourd family, bear two kinds of blossoms, pistillate and staminate, on widely separated parts of the plant. The flowers are axillary occurring either on the main stem or on lateral branches.

The staminate flowers, Plate I, appear first, usually near the base of the plant, and later along the main stem and axillary branches. They are more numerous than the pistillate flowers and are open only one day, closing in the evening and falling off a day or two later. The female flower, Plate I, is easily recognized by the ovary or tiny "pickle": the pistil is compound with three stigmas, each two lobed. These pistillate flowers appear later than the staminate and usually near the extremity of the

newly forming and rapidly growing shoots or short lateral branches. They may remain open two or three days. The yellow corolla is somewhat larger on the pistillate than on the staminate flowers. Under greenhouse conditions and at the time of year cucumbers are forced, it is necessary to provide for pollination. In small establishments this can be done by hand. The staminate blossoms are removed, petals turned back so as to allow the anthers to project, and the pencil thus formed thrust into the cup of the pistillate flower so as to distribute pollen upon its stigma. In large establishments where hand pollination is out of the question a colony of bees is placed in each house to accomplish the work.

It is certain that the English cucumber will grow to perfection entirely without the aid of pollen. White Spine fruits often set without fertilization. Reeves (15) having placed the percentage as high as 20%. Fruits which have set without pollination are uniformly seedless throughout, the walls of the ovules remaining loose and empty. The fruits which contain no seed are smaller in diameter and more symmetrical in shape than those with seed.

The fruits of English varieties which have developed from artificially pollinated flowers often have a much enlarged blossom end. When the fruits are cut open, perfect seeds are found only in the enlarged area. Bailey (1) states "It is probable that much of the irregularity in shapes is but an expression of plant variation rather than a result of particular treatment". This swelling was directly traceable to the action of pollen in impregnating the ovules. The reasons for the failure of the seeds to develop throughout the length of the fruit is probably due to the extreme length of the ovary and the inability of the pollen tubes to penetrate so far. There has been a variation in length of the ovary without a corresponding variation in the pollen tube growth. The amount of pollen applied does not appear to affect

the results to a noticeable extent. The English cucumber is usually deformed by the production of seeds.

Munson (8) growing the variety "Telegraph", covered with paper bags more than twenty blossoms before they expanded. Out of this number but two developed fruits. These fruits were typical in size and form, contained a large number of partially developed ovules but no perfect seeds. Of ten covered blossoms of "Scion House" only one fruit developed. Other fruits of both varieties left to natural conditions, showed few or no seeds formed when the matured cucumber was cut open. Very often when pollen is withheld the fruit will be withered and shrunked at the blossom end.

Fruits of the White Spine often show a constriction about the middle of the fruit and when cut open seeds are found at the blossom end and not in or beyond the constricted area. According to Fooke (4) "Pollen has two actions on the female organs, one on the seeds, and one exciting the growth of the fruit". The  $F_1$  plants in this experiment nearly all produced fruits which either showed a constriction or a tendency toward constriction. The number of warts was usually increased in the constricted area and some fruits while showing little constriction, did show a larger number of warts in the area where the constriction is found. In the  $F_2$  this constriction tendency seems to show up as an inherited character for it occurs in all degrees, some plants producing fruits with a considerable constriction and others being perfectly symmetrical throughout their length. See Plates IX, X, XI, and XII. The length of the fruit does not apparently affect this character for both short and long fruits may develop constriction. A careful study of the pollination of cucumbers should be made to throw light on the effect of pollen on fruit growth and shape. Cross sections of the young "pickles" from parent plants, from  $F_1$  plants, and from various  $F_2$  plants should show length of growth of pollen tubes and possible causes for the

constricted area and swelling of blossom end. The young pickles on some of the English varieties are sometimes three or four inches long, so that some of the pollen tubes would have to make rapid growth to reach the stem end in order to fertilize the ovules in that region before the fruit begins to swell.

It is possible that the ability to develop without fertilization may be an inherited character. No data was taken on this except to cut fruits from various plants and note seed development. At least one fruit from about 35% of the  $F_2$  plants was found to be seedless. See Plates XIII and XIV.

#### THE FOLLOWING VARIETIES WERE USED IN THE CROSSING WORK

##### Arlington White Spine:-

Average length about 7.75 inches, triangular in cross section, straight with tendency toward constriction about the middle of the fruit, in which area the warts are more numerous and noticeable. Both ends well rounded, the largest diameter being about 2" from the stem end. The warts are numerous and raised: spines large blunt and white. The skin dull, thick, surface smooth with tendency to slight grooving on the faces. The color is a medium dark green with longitudinal bands of white speckling on the faces and along the white streaks which extend from the blossom end one half to three fourths the length of the fruit.

##### Davis Perfect:-

Straight dark green fruits with little speckling and less tendency to constriction than the White Spine. Average length about nine inches. White streaks from blossom end extending about one half length of fruit. Cross section triangular with tendency toward grooving on the faces. Both ends taper gradually. Warts are raised, spines large white blunt; skin, dull, thick.

**Lockies Perfection:-**

Medium to light green fruits that lose color quickly after picking tiny white specks noticeable under skin which is thin, shiny and transparent. Surface very nearly smooth, slight indications of crinkling and ridging presenting a wavy appearance. Warts are absent, spines few, very small, pointed, greenish changing to white with maturity. At the blossom end there are very faint yellow green streaks for about an inch. Cross section is round, blossom end abruptly tapered with protuberance, stem end well filled, rounded or short taper. Average length about 15 inches.

**Convent Garden Favorite:-**

An English variety, fruits slender, averaging about 17 inches in length. Cross section round, blossom end abruptly tapered to point, fruit symmetrical to about 3 inches from stem end where there is an abrupt taper, then a long slender neck. Skin is shiny thin and transparent, the surface is crinkly and also has irregular ridges about  $\frac{1}{4}$  of an inch high and running the length of the fruit. Warts very slightly raised, scattered, spines small, pointed, greenish, changing to white at maturity. Color medium to light, darker on ridges, there is no white speckling but what appears to be tiny air bubbles under the skin. No streaks.

**Largin Green:-**

Average length about ten inches, cross section triangular usually with constriction, shoulder and gradual taper to stem end. Warts large raised and numerous, spines black, blunt, large. Surface very irregular due to combination of warts. Constriction and grooving on faces, skin dull and thick. Both ends taper considerably and there is a tendency toward slight protuberance at blossom end. Color a medium green over yellow which

increases until at maturity the fruit is an orange yellow color. Streaks not present.

**Abundance:-**

Average length 10.17 inches although occasionally a plant appears producing fruit from 14 to 17 inches long. Cross section indistinctly triangular to round, fruit straight with occasional constriction: surface smooth, skin dull, thick. Color a dark green with considerable white speckling or splashes, slight amount of dust like bloom. Streaks prominent, broad, white, extending  $\frac{1}{4}$  to  $\frac{1}{2}$  length of fruit. Blossom end rounded to abruptly tapered with distinct point or protuberance. Stem end rounded short taper, some fruits show a slight neck especially if there is a noticeable shoulder. Warts very slightly raised, large: spines large, white, blunt. Occasionally fruits may show considerable russetting or cracking. The slight variation of characters in some strains indicates that the type is not well fixed. This was more noticeable in regard to length although occasionally fruits having slightly raised warts appeared. A careful study of various fruits in Plates VI and VII will show the extent of the variation of fruit characters.

**Telegraph:-**

Fruits about 14 inches long, cross section round, blossom end rounded with protuberance, neck slender and about 4 inches long. Surface crinkly and slightly ridged: skin, shiny, thin, transparent. Color, dark green: air bubble speckling, no bloom. Warts absent, spines small, pointed, greenish to white, no streaks.

Duke of Edinburgh:-

Fruits long and slender averaging  $2\frac{1}{2}$  inches. Cross section round, blossom end abruptly tapered with protuberance. Stem end long, slender neck. Warts absent and spines few, small, greenish and scattered. Surface slightly crinkled and ridged. Color medium green with tiny white speckling.

Rockford Market:-

Average length 15 inches, cross section round, fruit symmetrical with tendency toward constriction, blossom end abruptly tapered with point, stem end rounded to short taper. Color dark green, heavy dust like bloom and considerable scattered white speckling. Skin, dull, thick: surface crinkly and ridged longitudinally; color between ridges is a lighter green and skin rather transparent. Warts raised numerous, spines large, white, blunt. Faint streaks at blossom end.

FRUIT CHARACTERS UNDER OBSERVATION IN THIS EXPERIMENT

The fruit characters under observation show much variation, in fruits from different vines, from the same vine and fruits harvested at different periods. In general however, it may be said that the fruits on the same vine are uniform. The time of taking the data has much to do with this variation especially in regard to the size, characters and color. It has been attempted to take the descriptions when the fruit is at its best using the period when the fruit would be picked for market as a standard. In this way at least a basis for comparison is reached. It has been noted that such factors as position of vine, weather, number of fruits ripening, age of vine, shading of fruit, position of fruit on the vine, whether the fruit has been

selfed or open pollinated, modify to a certain degree many of the characters studied. The color of the fruits is possibly the most difficult factor to describe accurately due to the great variation in and number of factors that make up the whole, and the influence of environmental conditions. Following is a brief outline of some of the possible forms that the fruit characters may take.

The length of the fruits varies from 7 - 11 inches in the American and from 12 - 24 inches in the English groups. The diameter and circumference are smaller in the English varieties. These two characters together with the weight of the fruit vary considerably with maturity. The length however, increases but little after the cucumber reaches marketable size.

The shape of the fruits varies from straight in the American to straight with an occasional crescent shape in some of the English varieties. A cross section of the fruits shows a variation from triangular to round. The blossom end may be round, tapered long, abruptly tapered, either smooth or having a distinct protuberance. The stem end may be rounded, have a short or long taper or a distinct neck either short or long. The American types also may have a shoulder or enlargement about two inches from the stem end from which there is a gradual taper to the blossom end. Another character is the tendency toward constriction about the middle of the fruit in the American varieties, particularly the White Spine: this appears to be correlated in some way with pollination. It is noticeable that in this constricted area there is usually an accumulation of warts.

The color of the fruits varies from a dark to a light green, the fruits may be covered with a more or less heavy dust like bloom or entirely free from bloom. A considerable white speckling or white splashing also occurs in the White Spine. This speckling is more evident on the faces, or is found in three bands, one on each face running the length of the fruit and

also along the white streaks. In the English types this speckling is scattered and more or less prominent, in some it looks like small air bubbles under the skin. The coloring in general of the American varieties is darker and holds up longer than in some of the lighter colored fruits of the English varieties.

A characteristic of the White Spine is the white streaks that start from the blossom end and extend to about the center: in some strains nearly to the stem end. They are usually about one quarter of an inch wide, the blossom end where they join being nearly white. These streaks are also found to a lesser degree on some of the other American varieties. They are entirely lacking in most of the English varieties but in others faint greenish streaks can be noted extending two or three inches from the blossom end. Russet markings may be found in some of the English varieties and occasionally on the American Abundance.

There is a considerable contrast in the character of the skin from the dull thick skin of the American sorts to the thin, shiny, brittle appearing, transparent skin of the English. The fruits that are triangular in cross section with relatively flat faces usually have a smooth surface. If the fruit is not well filled out the faces may appear grooved or hollowed. The surface of some of the English fruits presents a considerably crinkled or ridged appearance. The ridges, running lengthwise from the blossom end to where the neck of the fruit begins, are about one quarter of an inch high and about one half inch apart. In some of the varieties the crinkling is very slight giving more of a wave like appearance. In other varieties this crinkling is absent and the surface of the fruits is quite smooth.

The warts or small protuberances that bear the spines are more prominent in the American varieties. They may be absent, flat, slightly raised or raised, small or large. In the White Spine these warts have a

cluster of white dots surrounding them or they appear set in a "ray" of white specks.

The spines may be white, greenish, greenish turning white with maturity, or black. In size and shape they may be small, large, pointed or blunt.

A more careful and extended study would undoubtedly show other fruit characters that may be inherited but for this paper the above characters described are the chief ones on which data have been secured. No data have been taken regarding strength and vigor of vines, freeness regarding setting of fruits, number of male and female blossoms, earliness or lateness of plants in ripening fruit nor in number of parthenocarpically developed fruits. Fruits without seeds have developed on many of the  $F_2$  plants but no definite record has been kept.

## THE FOLLOWING CROSSES WERE MADE IN 1914 AND SEED SECURED

Arlington White Spine x Convent Garden Favorite. (Eng.)

" " " x Rockford Market. (Eng.)

" " " x Lockies Perfection. (Eng.)

" " " x Abundance. (Am. x Eng.)

" " " x Largin Green.

" " " x Davis Perfect.

" " " x Duke of Edinburgh. (Eng.)

" " " x Telegraph. (Eng.)

" " " x Davis Telegraph.

Largin Green x Abundance. (Am. x Eng.)

Telegraph (Eng.) x Davis Perfect.

Telegraph (Eng.) x Convent Garden Favorite. (Eng.)

THE FOLLOWING TABLE SHOWS THE CROSSES WITH THE NUMBER OF PLANTS GROWN IN  
EACH GENERATION

			F1	F2	F3	F4
A. W. S.	x	C. G. F.	8	20	13	
" " "	x	R. M.	4	54	18	4
" " "	x	L. P.	8	53	35	
" " "	x	A.	4	9	7	
" " "	x	L. G.	6	2		
" " "	x	D. P.	4	10	2	
" " "	x	D. of E.	6	9	12	
" " "	x	T.	6			
" " "	x	D. T.	4			
L. G.	x	A.	2			
T.	x	D. P.	2			
T.	x	C. G. F.	2			

The characters studied are listed below.

Length

Cross Section round vs triangular

Blossom End round vs abrupt taper with protruding point

Stem End round vs abrupt taper vs neck

Constriction present vs absent

Skin dull and thick vs thin, transparent and shiny

Surface grooved and smooth vs crinkled and ridged

Warts raised vs flat

Spines large, blunt vs small pointed

white vs black

Color	dark green vs light green
	white splashes vs air bubbles speckling
	speckling scattered vs speckling on three faces
	warts rayed vs not rayed
Streaks	white vs greenish
	absent vs $\frac{1}{2}$ to $\frac{3}{4}$ length

IN THE  $F_1$  GENERATION THE FOLLOWING CHARACTERS SHOWED DOMINANCE

Dominant	Recessive
Skin dull, thick.	Skin shiny, thin, transparent.
Surface smooth with shallow grooves on faces.	Surface crinkly and ridged.
Constriction or constriction tendency.	No constriction.
Black spines.	White Spines.
Spines large, blunt.	Spines small, pointed.
Warts rayed.	Not rayed.

The remaining characters showed an intermediate condition or incomplete dominance. The  $F_1$ s of all of the crosses made between varieties with short fruits as against those with long fruits showed almost exact intermediate length as is shown in the table below. Three crosses were made between varieties producing fruits of nearly the same length. The average length of the  $F_1$  progeny of two of these crosses were slightly longer than the average length of fruits of the parent plants. The average length of the  $F_1$  progeny of the third cross was slightly shorter than the average length of fruits from the parent plants.

TABLE SHOWING INTERMEDIATE LENGTH OF FRUIT

Each figure represents the average length of the total  
number of fruits produced

<u>Cross</u>	$\delta$	$F_1$	$\eta$	$\frac{\delta \text{ and } \eta}{2}$	$F_1$ Diff.
A.W.S. x C.G. F.	17	11.3	7.75	12.37	-1
" " " x R.M.	14.8	11.7	7.75	11.3	.4
" " " x L. P.	15.3	12.2	7.75	11.5	.7
" " " x A.	10.1	9	7.75	8.9	.1
" " " x L.G.	9.9	10	7.75	8.8	1.2
" " " x D.P.	9.1	7.7	7.75	8.4	-.7
" " " x D of E	21.5	14	7.75	14.6	-.6
" " " x T.	21.-	13.7	7.75	14.3	-.6
L.G. x A.	----	----	----	----	----
A. W.S.x D.T.	----	----	----	----	----
T. x D.P.	9.1	16.5	21.0	15.	1.5
T. x C.G.F.	17	18.9	21.0	19	-.1

## F<sub>2</sub> GENERATION

During the winter of 1919-20 as large a number as possible of F<sub>2</sub> plants of three of the crosses were grown in the greenhouse. The amount of F<sub>2</sub> seed on hand was small and the space was not available to grow plants in large quantities yet enough were grown and fruited to show which of the fruit characters were inherited, and something of the way in which the segregation occurred. The following tables have been made up from the data taken. The three crosses used will be designated as A. B. C.

- A. - Arlington White Spine x Rockford Market.
- B. - Arlington White Spine x Lockies Perfection.
- C. - Arlington White Spine x Convent Garden Favorite.

Cross	No. Plants Grown	No. Fruiting
A	41	34
B	44	26
C	20	9

### CROSS SECTION

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>	
				Triangular	Round
A	T	R	Intermediate	12	22
B	T	R	"	14	12
C	T	R	"	2	7
				<u>28</u>	<u>41</u>

There were  $F_2$  fruits showing cross section intermediate between the triangular and round but it was difficult to draw a definite line and they were placed as nearly as possible in one of the two classes.

## SKIN

Cross	♀	♂	$F_1$	Dull-Thick	Shiny-Thin-Transparent	Ratio
A	D T	D T	D T	26	8	3.2:1
B	D T	S-TH-TR	D T	20	6	3.3:1
C	D T	S-TH-TR	D T	9	0	
				<u>55</u>	<u>14</u>	<u>3.9:1</u>

## SPINES

Cross	♀	♂	$F_1$	Large-Blunt	$F_2$ Small--Pointed	Ratio
A	L B	Sm P	L B	23	11	2:1
B	L B	Sm P	L B	20	6	3.3:1
C	L B	Sm P	L B	7	2	3.5:1
				<u>50</u>	<u>19</u>	<u>2.6:1</u>

## WARTS (Color)

Cross	♀	♂	$F_1$	$F_2$ Rayed	Not Rayed
A	Rayed	Not Rayed	Rayed	16	18
B	"	" "	"	17	9
C	"	" "	"	5	4
				<u>38</u>	<u>31</u>

## WARTS (Raised vs Flat)

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>		
				Raised	I	Flat
A	R	I	I	10	15	9
B	R	F	I	3	10	13
C	R	I	I	2	2	5
				<u>15</u>	<u>27</u>	<u>27</u>

## SURFACE

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>	
				Crinkly	Grooved
A	G	C	G	8	26
B	G	C	G	8	18
C	G	C	G	1	8

## STREAKS COLOR

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>		
				White	Green	Absent
A	W	G	W	22	9	3
B	W	G	W	11	8	7
C	W	G	W	5	2	2

## STREAKS LENGTH

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>			
				Absent	2" long	$\frac{1}{2}$ " length	$\frac{1}{4}$ " length
A	$\frac{1}{2}$	2"	$\frac{1}{4}$	3	14	10	7
B	$\frac{1}{2}$	absent	$\frac{1}{4}$	7	7	6	6
C	$\frac{1}{2}$	absent	$\frac{1}{4}$	2	3	2	2

## STEM END

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>	
				Neck	Round
C	R	NL	I	6	3

## BLOSSOM END SHAPE

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>	
				Round	Abrupt Taper
A	R	AT	R	23	11
B	R	AT	R	17	9
C	R	AT	R	8	1

## B END PROTUBERANCE

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>	
				Present	Absent
A	absent	present	absent	20	14
B	absent	present	absent	19	7
C	absent	present	absent	4	5

## COLOR BLOOM

Cross	♀	♂	F <sub>1</sub>	F <sub>2</sub>	
				Present	Absent
A	absent	present	I	17	17
B	absent	present	I	17	9
C	absent	present	I	5	4

## COLOR SPECKLING

Cross	♀	♂	F <sub>1</sub>	Bands	F <sub>2</sub>	
					Scattered	Clear
A	Bands	Scattered	I	7	24	3
B	Bands	Scattered	I	6	20	0
C	Bands	Scattered	I	I	8	0

## CONCLUSIONS AND DISCUSSION

The data presented in this thesis offers an indication of what a more thorough investigation will probably show in regard to the inheritance of fruit characters. In view of the lack of descriptions and because in the early work data on only a limited number of the fruit characters is available, the  $F_2$  data cannot be regarded as conclusive in regard to all factors discussed, nor is it believed that the exact behavior of all of the factors can be predicted from the data shown. However the  $F_2$  data taken alone clearly indicates that the various fruit characters are inherited and that they behave according to the present conception of Mendelism. It is believed that a more extended study would show other characters that are inherited and that a further division of some of the characters used in this thesis should be made. All of the characters studied showed independent segregation, nearly every possible combination being noted in the  $F_2$  fruits.

As regards the economic value of the crosses several types were secured in the  $F_2$  that would, if fixed, be desirable as commercial strains; the fruit shown in Plate XV is an example. Since this was primarily a study of inheritance of fruit characters no data were taken in plant characters, but it was noted, however, that the  $F_2$  plants showed considerable variation in regard to number of female blossoms and other important economic characters.

## SUMMARY

The results obtained in this preliminary study of the inheritance of fruit characters in the cucumber (*Cucumis sativa*) indicates that (a) the characters studied are inherited independently (b) that they segregate according to Mendelian laws (c) that it would be possible to secure by crossing the best of the English and American strains, a hybrid strain that would be more satisfactory from the growers standpoint than many of the present strains.

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PLATE I

- Figs. 1 and 2      Male blossoms.
- Fig. 3.            Female blossom showing ovary or young "pickle".
- Fig. 4.            A group of small pickles taken from different  $F_2$  plants. A careful inspection of the young fruits will show that they differ considerably. The characters that appear later on the mature cucumbers can be very accurately foretold from the young fruits, especially the size and number of warts and the shape characters. The relative length of the young cucumbers if taken while blossom is open will give an index of the relative length of the mature fruits.
- Fig. 5.            A female flower from an  $F_2$  plant producing fruit without warts and with very small spines.
- Fig. 6.            Showing young pickles from  $F_2$  plants producing fruits from 2 to 4 inches longer than fruits from the plants represented by Fig. 4.

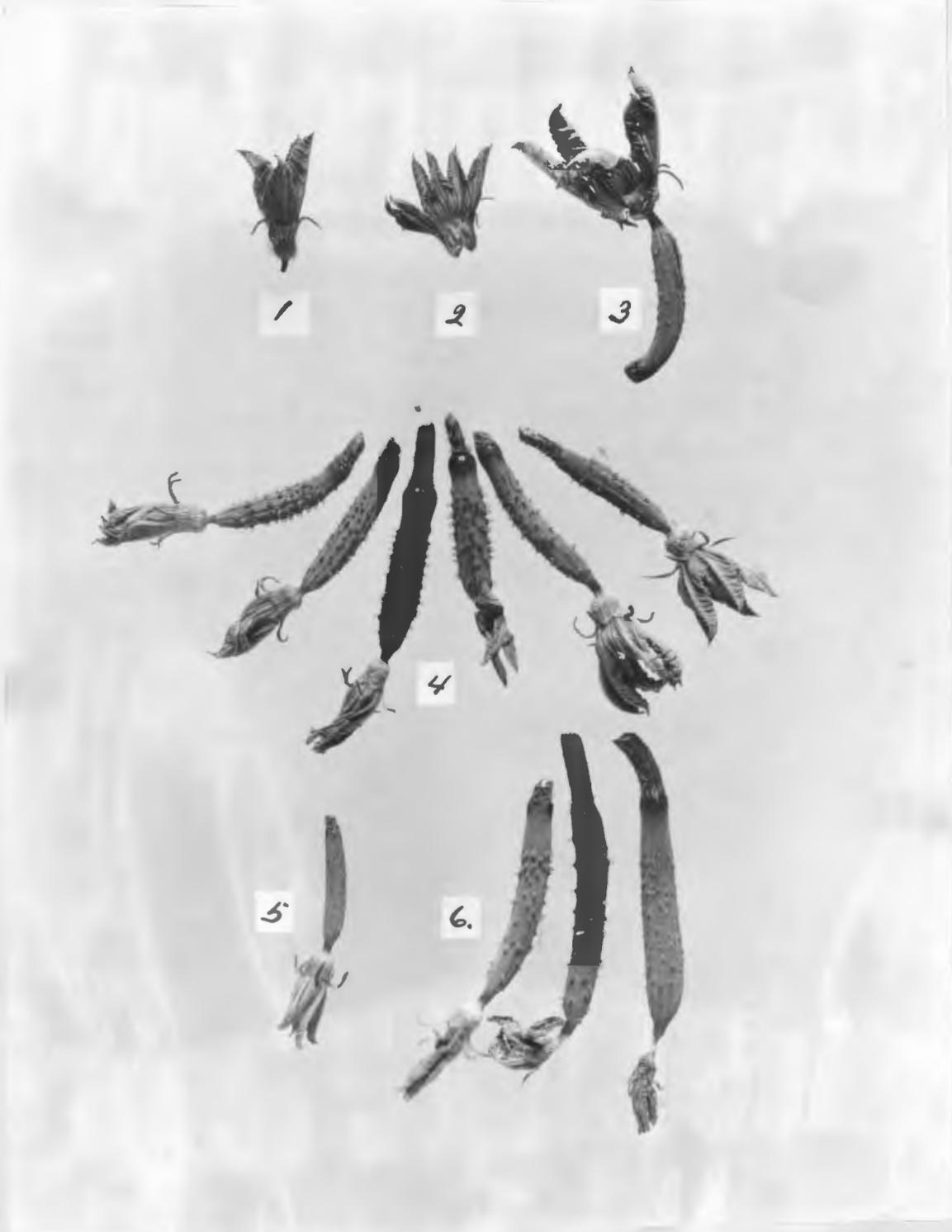


PLATE II

Representative young fruits from 6 different  $F_2$  plants: the relative length of the mature cucumbers would be comparable to the respective lengths of the young fruits. For example, fruits from plant represented by Fig. 1 would be about 8 inches long while the plant represented by Fig. 6 would produce fruits about 15 inches long. Figs. 2 and 6 show fruits having a protuberance at the blossom end.

Fig. 5. A type with warts flat and spines small.  
Other fruit characters can be readily noted.



PLATE III

Fruits of American varieties used in crossing.

1. Arlington White Spine.
2. Abundance.
3. Davis Telegraph.
4. Davis Perfect.

These are not as perfect specimens as might be represented but bring out the general characteristics of the varieties.



PLATE IV

English varieties used in crossing.

5. Convent Garden Favorite.
6. Duke of Edinburgh.
7. Telegraph.



5

9

7

PLATE V

English varieties used in crossing.

8. Rockford Market.
9. Sion House Improved.
10. Lockies Perfection.

The fruit shown in Plate XV is from  
an  $F_2$  plant of the cross Arlington Spine  
x Lockies Perfection.



PLATE VI

Typical fruits of the variety "Abundance",  
showing variation within a variety.



PLATE VII

Variation of fruit characters within a variety. Different strains of the "Abundance" No.36 B showing characters that are similar to those of the Davis Perfect. The "Abundance" is a hybrid between an American and English variety.



PLATE VIII

- 19 B Fruit from  $F_3$  plant Rockford Market.
- 18 A Fruit from  $F_2$  plant Arlington White Spine x  
Rockford Market showing swollen blossom end  
due to fertilization and seed development.

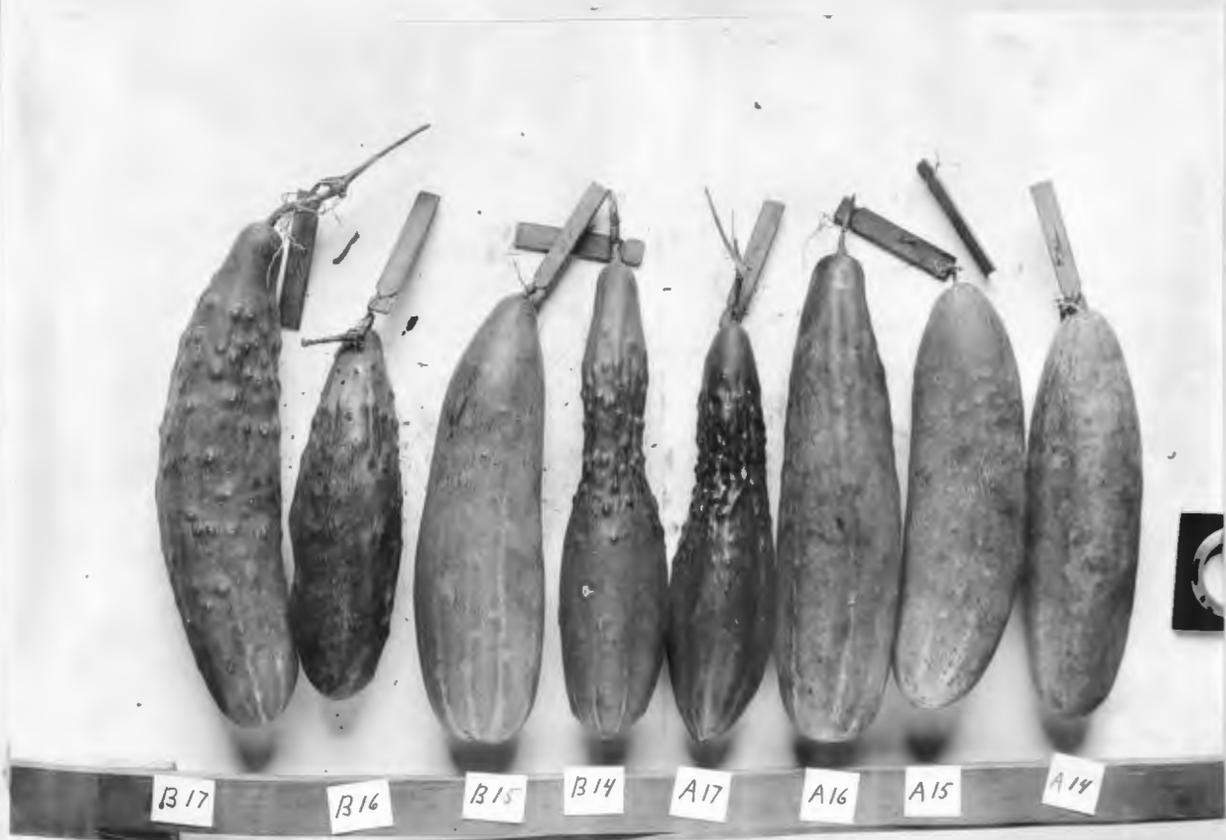


PLATE IX

Fruits from different  $F_2$  plants of cross  
Arlington White Spine x Rockford Market.

Different types and segregation of fruit characters.

B 14 and B 17 show an abnormal constriction with warts gathered in that area. Other fruits are noticeably free from warts. The stem ends also show various shape differences.



B17

B16

B15

B14

A17

A16

A15

A14

PLATE X

Fruits from  $F_2$  plants of the cross  
Arlington White Spine x Lockies Perfection  
showing different types.

3 B has the large blunt white spines  
but the warts are flat.

4 B and 5 A show constricted areas.  
The white streaks are prominent in some  
specimens while they are entirely lacking in  
others.

The fruit shown in Plate XV came from  
the same  $F_1$  parent as all of the fruits shown  
in this Plate.



PLATE XI

This group of fruits from  $F_2$  plants of cross Arlington White Spine x Duke of Edinburgh shows length segregation especially well.

Fruit A 10 while having the length of the English parent yet shows the constricted area with warts and white streaks of the American parent.

The white speckling is shown in fruits 8 A, 9 B and 12 A.



PLATE XII

These  $F_2$ 's are from cross Arlington  
White Spine x Convent Garden Favorite.

20 A and 24 B are practically straight  
English while 22 B is typical of Arlington  
White Spine. The white speckling occurring  
in longitudinal bands on the flat faces is  
shown in 22 B.



PLATE XIII

Fruit from  $F_3$  plant of cross Arlington  
White Spine x Rockford Market. Completely  
seedless.

111-15-27-1-2-60  
112



PLATE XIV

Seedless F<sub>3</sub> fruit. Arlington White  
Spine x Rockford Market.

$\frac{10}{16} \times \frac{15}{10} - 3) - 1-7-93$

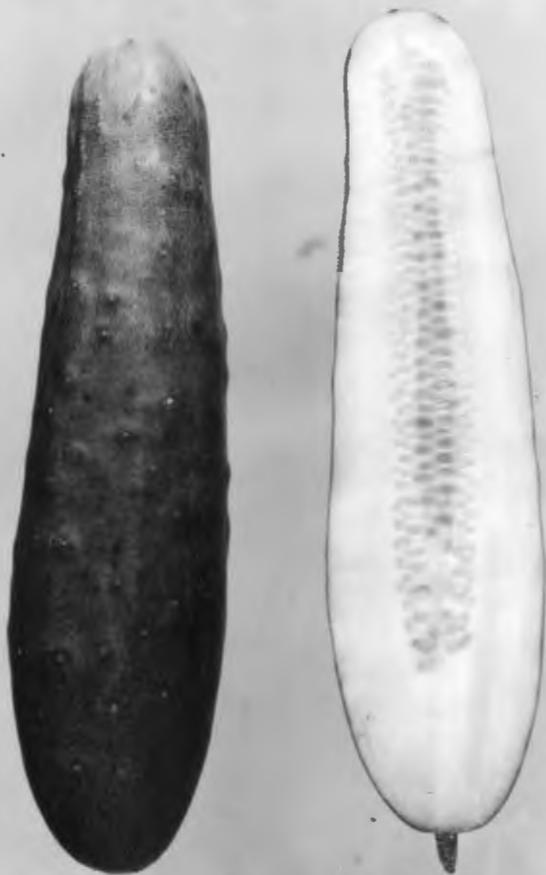


PLATE XV

Fruit from  $F_2$  plant of cross Arlington White Spine x Lockies Perfection. An ideal market fruit 13.5 inches long and 2.25 inches in diameter, dark green with heavy bloom, warts slightly raised, streaks about 2 inches long and greenish in color. This fruit was open pollinated and contained a few seed scattered throughout its length to within about 4 inches of the stem end. It held its dark green color until the fruit withered and dried.

