THESIS

Infection Experiments with Septoria petrosellini var, apii Causing Late Blight of Celery

George Lorenzo Zundel

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Infection Experiments with Septoria petroselini var. apii Causing Late Blight of Celery

A MINOR THESIS

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INTRODUCTION.

It does not require technical knowledge for one to see the large amount of variation found in nature, extending in all fields of natural science. In the field of botany all plants vary in their requirements for food and not even the fungi are exceptions to this statement. In fact, in humid regions all plants, even the weeds have their parasites. The thought can be carried still farther, for even the parasites of our economic crops have parasites that in turn live upon them. A common example is the Darluca that is parasitic upon Puccinia, a common genus of our rusts.

Every individual plant has certain inherent properties so that not all plants within a given species have the same power to resist the attacks of fungi. There are many phases to the power of host plants in resisting the attacks of fungi that cause disease or as it is more properly called disease resistance in plants.

The common notion is, that any plant that is not diseased, is disease resistant. Orton (1908) however points out that there are at least the following divisions (a) disease-escaping, (b) disease-enduring, (c) disease-resisting or immune varieties. By disease escaping is meant, that some characteristic of the plant or environmental factor prevented infection, as, for example, an early variety might mature before the season when the disease occurs so that it is not subjected to the conditions of infection, as are the

later varieties, or, through lack of moisture, proper conditions for spore germination are not present so that no infection occurs. With disease enduring plants even fairly heavy attacks of disease seem not to injure them, as, for example, certain wheat varieties of the Dakotas and Minnesota seem to be able to withstand the usual attacks of rust.

However, disease-resistant or immune varieties have the inherent power of preventing infection from any particular fungus. Immunity to one fungus does not infer immunity from all fungi that attacks that particular host plant.

The production of disease resistant plants is a very promising field, involving both plant breeding and plant pathology. Many diseases of economic plants cannot be controlled by the ordinary methods of spraying so that in many cases the production of immune varieties will determine the extent to which certain industries will be carried on in the future.

To fully appreciate the significence of immune or even partially immune varieties one must understand the loss caused by some of the plant diseases. The following table partially compiled by Reed will show this:

Estimated Losses due to Plant Diseases

Crop	Disease	Region	Period	Estimated loss	Authority
Wheat	Rust-Puccinia gramimis	Illinois	1885	1,875,000	Burrill.
Wheat	Rust-Puccinia graminis	United States	1891	67,000,000	Galloway.
Wheat	Rust-Puccinia graminis	India	1892	1,700,000	Barclay.
Wheat	Rust-Puccinia graminis	Australia	1893	50,000,000	Galloway.
Wheat	Rust-Puccinia graminis	German Empire	1891	18,000,000	Sorauer.
Wheat	Rust-Puccinia graminis	German Empire	1892	1,600,000	Sorauer.
Rye	Rust-Puccinia graminis	German Empire	1891	45,000,000	Sorauer.
Rye	Rust-Puccinia graminis	German Empire	1892	1,900,000	Sorauer.
Oats	Rust-Puccinia graminis	German Empire	1891	41,000,000	Sorauer.
Oats	Rust-Puccinia graminis	German Empire	1892	3,000,000	Sorauer.
Oats	Smut-Ustilago avenae	Kansas	1888	1,382,328	Kellerman, Swingle
Oats	Smut-Ustilago avenae	Kansas	1889	850,000	Kellerman, Swingle.
Oats	Smut-Ustilago avenae	Kansas	1890	911,299	Kellerman, Swingle.
Oats	Smut-Ustilago avenae	Indiana	1889	797,526	Arthur.
Oats	Smut-Ustilago avenae	Indiana	1890	605,352	Arthur.
Oats	Smut-Ustilago avenae	Michigan	1891	800,000	Harwood.

Estimated Losses due to Plant Diseases

Crop	Diseases	Region	Period	Estimated Loss	Authority
Oats	Smut-Ustilago Avenae	Michigan	1892	1,000,000	Harwood.
Oats	Smut-Ustilaga avenae	Wisconsin	1901-'03	13,500,000	Moore.
Potatoes	Late Blight-Phytophthora infestans	New York	1904	10,000,000	Stewart.
Apples	BitterRot Glomerella rufomaculans	Illinois (four counties)	1900	1,500,000	Burrill.
Apples	Apple Blotch-Phyllosticta solitaria	Benton County, Arkansas	1906	950,000	Scott, Rorer.
Cabbage	Black Rot-Bacillus campestris	Wisconsin, (two counties)	1896	50,000	Russell.
Peaches	Brown Rot-Clerotinia fructigena	Georgia	1900	500,000	Quaintance.
Peaches	Leaf Curl-Exoascus deformans	United States	1900	2,335,076	Pierce.
Violets	Leaf Spot-Alternaria violae	United States	1900	200,000	Dorsett.
Celery	Late Blight-Septoria Petroselini var. apii	California	1908	550,0000	Rogers.

NATURE OF DISEASE-RESISTANCE.

The nature of disease-resistance is not well understood by investigators. Many attempts have been made to determine just why certain plants are resistant. There are three theories as to the cause of immunity in plants that are given most credence at the present time viz,--

A. That resistance of plants is due to the histological structures of the host plant.

B. That toxins and enzymes contained in the host plant render it immune.

C. That disease resistance is a unit character and follows the laws of Mendel.

As to the first theory, modern investigation has thrown a shadow of doubt. The thickness of the cuticle, the character of the foliage, whether pubescent or glabrous, size, shape and number of stoma might, in some cases, cause the plant to be disease-escaping but the susceptibility is the same as, for example, a glabrous leaf might dry sooner than one covered with hairs so that there is less opportunity for germination of spores and the pubescence would also tend to hold the spores on the leaf. After very careful research H. Marshall Ward (1902:323) came to the following conclusion. "The capacity for infection, or for resistance to infection, is independent of the anatomical structure of the leaf, and must depend on some other internal factor or factors in the plant."

The second theory has no direct proof but several

prominent investigators have obtained results that indicate that some such substances as a toxin or enzyme are responsible for non-infection. The subject is more complex than it seems at first. The fact that infection does not occur, does not say that the germ tube has not entered the host. Ward (1890) Salmon (1905) and Stakman (1913) show that the spores of a fungus can germinate and even enter the host plant but there seems to be something within the host cell that prevents further development.

The subject of parasitism is not well understood by investigators. The wide range in the relation between host and parasite is ~~very~~ phenomenal. The lowest form of parasitism is exhibited by such fungi that kill the host cell before feeding upon them, while the highest forms of parasitism are exhibited as symbiotic relationships. All gradations exist between the two extremes.

Bunzel (1914) has recently found that there is a greater oxydase activity in the foliage and tubers of potato plants attacked by curley dwarf than there is in the healthy plants.

The third theory was worked upon by Biffen (1907) in England, who found that so far as the yellow rust of wheat was concerned, immunity was a recessive unit character. So recessive was this character that much difficulty was encountered in raising his F_1 hybrids, due to attacks from rust. That immunity acts the same for other plants remains to be shown. However, enough work has been done to show that a certain plant that is immune in one locality is often the most

susceptible when taken to another locality. Under present conditions it is hardly possible to say what is the exact nature of disease resistance in plants. However, results of the foremost investigators seem to indicate that the enzymatic-toxin theory and the unit character theory are the ones that most nearly explain the phenomena.

REVIEW OF WORK ALREADY ACCOMPLISHED IN BREEDING DISEASE RESISTANT STRAINS.

Much remains to be done in breeding disease resistant strains of our cultivated plants. In many cases the disease is so easily controlled that it is not worth while to spend time in breeding resistant strains while there are many diseases that cannot be controlled except by this method. One big obstacle that is commonly met by workers in this field is that many of the most resistant plants are of least commercial value. In this case hybridization is the only way to combine the desirable qualities in commercial and non-commercial plants.

Many plants show natural resistance especially where the plant has existed longest. Ward (1902) says that the beginning of all work in breeding for disease resistance is to go to the locality where the disease has existed longest and look for natural resistance of host plants.

The work that has already been accomplished has been wery valuable, a review of which follows.

POTATOES. L.R. Jones and his co-workers at the Vermont Agricultural Experiment Station have done perhaps, the best

work on disease resistance in potatoes. The late blight of potatoes caused by Phytophthora infestans causes much damage to the potato crops in America and Europe. Jones et al (1912) found in general that European varieties were most resistant while American varieties were less resistant.

The earliest attempts at breeding resistant strains was in 1876 when, with aid given by Parliament, the English breeders produced the resistant variety Magnum Bonum by crossing the American variety Early Rose with the English variety Victoria.

Jones (1912) and his co-workers determined the rate of spread of the disease in resistant strains. The German variety Irene, the English variety Holborn Abundance and the American variety Ionia Seedling were used. A number of the plants of each variety were inoculated twenty times on twenty different leaves and the infected area was measured at intervals of two days It was found that the disease spread most rapidly in the non-resistant variety Ionia Seedling. At the end of twelve days the percentage of leaf area found diseased was as follows,- Ionia Seedling 58.98; Holborn Abundance 40.93; Irene 18.00.

Many varieties were tested for resistance and each variety showed different powers of immunity. The English variety Royal Kidney was the most resistant while the American variety Green Mountain was the most susceptible.

ASPARAGUS. The very efficient work of J.B. Norton of the U.S.D.A. has saved the asparagus industry of the United States. The asparagus rust caused by Puccinia asparagi De C. was first found in New Jersey in 1906. It spread rapidly causing much

damage. Norton (1913) found that there was much variation in the plants in their relative susceptibility to the rust. By careful selection and self pollination he found that the power of resistance was inherited. Plant "Washington" A7-83 was found to be the best breeding male plant in the rust resistant breeding work and a plant "Martha" B32-39 the best breeding female plant. From these two plants a superior strain of "commercially immune" plants ~~were~~ was obtained. The new variety has been named the Martha Washington.

SUGAR CANE. According to Lewton-Brain (1903) the best variety of sugar cane in the West Indies is the Bourbon. However, due to its susceptibility to the red rot disease caused by the fungus Colletotrichum falcatum Sacc it became practically impossible to grow this variety. The Caledonian Queen was introduced with other varieties and was found to be resistant but inferior in sugar production to the Bourbon. The Cheribon, a very good but susceptible variety, was crossed with the Chunnee, a resistant but inferior Indian cane, resulting in a good quality, resistant hybrid. Dr. Kobus has produced many good hybrids in Java.

COFFEE. Coffe arabica is the coffee with the highest quality. It is, however, subject to a leaf-spot caused by Hemileia vastatrix Berk. et Br. This disease threatened to make the growing of coffee impossible in Arabia and Ceylon. According to Lewton-Brain (1903) the Coffea liberica was found to be more resistant, more productive with a larger berry but of inferior flavor. In a recent lecture at Cornell

University Dr. Otto Appel said that the fungus had adapted its self to Coffea liberica which was now very susceptible so that wild coffee, Coffea robusta, of central Africa, was found to be very resistant and is now largely grown now. This last named variety is of a poorer flavor than C. liberica. Lewton-Brain reports (1903) that M. Henri Manes has hybridized Coffea arabica with Coffea liberica and has a hybrid plant with the good qualities of the parent plants combined.+

COW PEA. (Vigna sinensis). The cow pea is a forage crop grown largely in the southern part of the United States. The plant is attacked by a wilt disease caused by Fusarium tracheiphilium Erw. Sm. In 1902 Orton and Webber began working to obtain a disease resistant strain. Orton (1911) states that they found all the varieties that

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+The Gardeners' Chronicle (March 6, 1910, p. 153) says: A new species discovered growing wild on the shores of the Oubanghi, Central Africa, by Mr. Dyboneski, and named C. congensis, which has been grown since 1903 in the botanical garden at Ivoloina, has so far remained free from disease (Hemileia). Its market value is said to be fully equal to that of the best qualities of Arabian coffee. While the present crop of C. congensis has not suffered from the disease, C. arabica, planted at the same time, has been entirely destroyed.

were tested susceptible. However, they had their attention called to a cow-pea that was cultivated in a limited area in South Carolina which was called the Iron Cowpea. This variety proved to be resistant but inferior in yielding quality. Through the work of Mr. Gilbert of the U. S. Dept. of Agr. a cross between the Iron variety and Whippowill has resulted in a high yielding, good quality, disease resisting strain. It might be well to state here that in this series of crosses the F_1 generation (Iron x Whippowill) ~~were~~ resistant and resistance was found to be a dominant character.+

COTTON. There are at least two species of cotton cultivated in the Southern States, Gossypium hirsutum and Gossypium Gossypium barbadence. Both species are subject to cotton wilt caused by the fungus Neocosmospora vasinfecta (Atk.) Erw. Sm. and also the bacterial blight caused by Bacterium malvacearum Erw. Sm.

Orton of the U. S. Dept. of Agr. did the first work on wilt resistant cotton. He says (1911) that all the varieties were very susceptible to the disease. However, in large plantations a few occasional plants were not wilted either because they had escaped infection or were naturally resistant. It was found that the natural resistance was inherited so that by straight selection disease resistant strains were obtained. The Dillon and Dixie were two of the

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+The Iron-Cow-pea is, however susceptible to attacks from leaf spot caused by? Amerosporium oeconomicum and Mildew caused by Erysiphe polygoni. On the other hand it is resistant to rust caused by Uromyces appendiculatus (Pus) Link. and a leaf-spot caused by Cercospora cruenta.

varieties while the Modella was developed by A. C. Lewis and the Rivers variety developed by E. L. Rivers of James Island, South Carolina. The Centerville is a variety selected by Orton from the Rivers which is resistant to the wilt and also to the bacterial blight.

WATER MELLON. (Citrullus valgaris) The water melon in the Southern and Pacific coast states is subject to epiphytatics of the wilt disease due to the fungus Fusarium niveun Erw. Sm. Orton (1911) referring to his work in producing a wilt resistant water melon says that all varieties of the 120 or more tested were very susceptible. However, the inedible form known as "citron" or "stock water melon" was very resistant. A cross with the citron as the male parent with the excellent commercial variety Eden as the female parent resulted in having most of the citron characters dominant in the hybrids. Out of the ten possible chances from 5,000 plants, eight were found undesirable, so that of the two which were pollinated from the Eden, promising results were obtained. However, the progeny of these two plants varied much, all kinds of shapes, colors and flavors were represented. Five years selection resulted in the highly resistant strain, but some what inferior in quality, known as the Conqueror. This strain proved highly resistant in Iowa but was not ~~maintained when grown~~ in Oregon on the Pacific coast. This is but one proof of the need of breeding for certain local conditions only.

WHEAT. Biffin (1907) reports the loss of wheat due to rusts during 1891 in Prussia as £20,600,000 or about 2/3 of the crop. Mc Alpin is quoted as reporting that is Australia £100,000,000 does not cover the annual loss due to rusts. By means of hybridization Biffin (1905) in England produced a rust resisting wheat. He found that resistance was a recessive character. Howard (1907) reports that when Biffin's immune wheats were grown outside of their original conditions some then ~~became~~ very susceptible.

Farrar (1898) reports some progress in getting immune varieties of wheat for Australian conditions while Pole-Evans (1911) gives as his opinion that hybrids seem to be bridges by which the rust is carried from the susceptible to immune varieties. Butler (1905) reports rust-resistant work being done for India conditions.

RED CLOVER. (Trifolium spp.) The red clover in and about Tennessee is attacked by an anthracnose caused by the fungus Colletotricuim trifolii Bain. By careful selection Bain and Essary (1907) of the Tennessee Agr. Exp. Station developed a resistant strain of red clover. They report that the odds in favor of the selected plants for non-resistance is 50 to 1.

TOBACCO. (Nicotianum Tabacum L.) Jackson (1908) reports that by selection, Shamel and Cobey have obtained a tobacco in Connecticut resistant to the wilt caused by Bacillus solanacearum Erw. Sm. Favorable results have also been obtained in North Carolina for a similar disease.

<u>CANTALOUPE.</u> Blinn (1905) of the Colorado Agr. Exp. Station by careful selection has developed a variety resistant to the leaf blight caused by the fungus Macrosporium cucumerinum Ellis and Everhart.

<u>VIOLET.</u> Lewton-Brain (1914) estimates that the violet crop in the United States is worth one million dollars and that 200,000 worth of damage is caused each year by the violet leaf-spot caused by the fungus Alternaria violae Galloway and Dorsitt. Investigation has shown that varieties differ in their susceptibility. The variety "Maria Louise" is very resistant but does not produce such perfect flowers as the more susceptable variety "Lady Hume Campbell. (See U.S.D.A Dw. Phy. and Path. Bul. 23 1900)

<u>GRAPE.</u> It is a well known fact that European grapes cannot be grown in the Eastern United States due to their susceptibility to Phylloxera and downy mildew caused by Plasmopara viticola. The subject is too well known to take more space at this time.

<u>FLAX.</u> Bolley (1908) has made great progress at the North Dakota Agr. Exp. Station in breeding strains of flax resistant to wilt caused by Fusarium lini Bolley and rust caused by Milampsora lini (DC) Tul. He succeeded in getting his resistant strain by selecting a few sickly plants, that had not been entirely killed in a field badly infected with wilt. By planting the seed from these plants on badly infested ground and continually selecting the best plants for a few years, he at last obtained his resistant strain.

ROSES AND SAMD CHERRIES. Hansen(1905) of the South Dakota Agr. Exp. Station, by continuous selection has obtained strains of the Western Sand Cherry (Prunus Besseyi) which are resistant to mildew caused by the fungus spaerotheca pannosa (Wallar) Lev. He finds that glossiness of leaves is correlated with disease resistance.

By crossing the cultivated Hybrid Perpetual roses with a hardy prairie rose, a strain resistant to dowdery mildew caused by the fungus Spharotheca pannosa (Wallr) Lei.

CHERRY. Salmon (1906) working at Wye England noticed that Waterloo Cherries were badly infected with cherry leaf scorch caused by the fungus Gnomonia erythrostoma Anersw. while alternate rows of the turks cherry were not damaged.

CARROT. Halsted (1897) found that varieties of carrots differed in their susceptibility to the blight caused by Rhizoctonia (?) In order of resistance the test showed Danver's Half Long most resistant with Long Orange, Early, Half Long Carentatn and Long white Belgian next in order.

Plate I.

A Wild Celery Plant

(after Gerard, 1597)

The History of Celery.

The speculation as to what might have been the case had America been the home of modern civilibation and Columbus had sailed east, resulting in the British Isles being discovered seems interesting guess work. Nodoubt our modern seed catalogues would have contained many new species derived from native plants. Most of our modern vegetables are of European or Asiatic origin. Although many of them have been known for many years, yet, have not been extensively cultivated until recently.

Celery has been known to mankind under one name or another ssince early Grecian times. It was spoken of by Homer and Theophrastus under the name of Selinori, and later Dioscorides distinguishes between the wild and cultivated forms. However, Pilny the Elder in his "Pleasures of the Garden" does not mention celery although several vegetables common at that time are mentioned. De. Sturtevant sayd that the first mention of the word celery that he dan find is in Walafridus Straba's poem entitled "Hortulus" which was written in the ninth century. The medical properties of celery are given and in line 335 the following sentence appears; "Passio tum celeri credit deviota medelae," and then gives the translation to be "The disease then to celery yields, conquered by the remedy." Dr. Sturtevant further states that he cannot find celery mentioned in Fuchsuis (1542) Tragus (1552) Matthiolas Commentaries (1558) Camerarius Epitome (1558), Pinnarus (1561), Pena and Lobel (1570), Gerarde (1597), Clusius (1601), Dedonacius pempt. (1629)

In searching through the old "Herballs" and other old agricultural writings in Cornell University Library the first mention of celery was by Dodoeus (1578) in the "Nierve Herball". It is spoken of under an old Greek name Elioselinon and the following names are given:

"Greke-

Latin- Apium palustre, Paludapium called by some Hydroselinon agrio

In shoppes- Apium etc.

Dodoeus' work contains many good pictures of the various forms of Apium. About 1633or 1636 Gerarde and Johnson in their revised edition of "The Herball or Generall Historie of Plants" mention Eleoselinum or Paludopium and writes that it "Grows in moist places from which place it is brought into gardens". Grows abundantly upon banks of salt marshes of Kent and Essex". The names are about the same as those given by Dodoeus. The Gaza name is given as Paludapium. Much, in fact, most of the space is given to a discussion of the virtues among which are the following; It is good for long lasting agues and yellow jaundice. The juice cures "venomous ulcers of the mouth" and mixed with honey is good for cankers. Pliny writes that it is good for bites of venomous spiders, etc.

Parkinson (1640 Theatrum Botanicum) speaks of two kinds of celery as follows:

"1. Eleoselinon, Paludapium sive Apium palustre, Smallage.

2. Selinum Sive Apium dulce, Sweete Selium or Smallage, familiar in Greece and Italy where it is eaten"

Meager (1688) includes smallage or celery in his list of "Physick Herbs, usually planted in Gardens."

Selery in its wild state has a very pungent tast which is changed by cultivation. De Condolle gives the habitat of celery as being from Sweden, through central and western Europe and along the Mediterianean to Greece and Turkey. As has been shown the ancients used celery primarily as a medical herb and the Italians seem to be the first people to have used celery as food.

Miller (1757) gives the first classification of the genus Apium using the form of nomenclature common before the time of Linneus. Of the genus Apium he says under the heading of "Celery, or Salary, vida Apium",-"Apium (Apium is so called, as many say, of Apes, Bees, because Bees are said to be delighted very much with it; or of Apex, because the Ancients made Crowns of it to adorn the Head".) To the sixth sort is given the name Eleoseninum which comes from two Greek words meaning Marsh-Parsley. The work Parsley is more common about this period and thirteen species are mentioned as follows:

"1. Apium <u>hortense</u> <u>sen</u> petroselinum, vulgo. C.B.P. Common Garden Parsley

2. Apium <u>vel</u> <u>petroselinum</u> <u>crispum</u> C.B.P. Curled Parsley.

3. Apium <u>hortense</u> latifolium. C.B.P. Broad leav'd Garden Parsley.

4. Apium <u>Lusitanicium</u> <u>rotumdifolium</u>, <u>Inst</u>: R.H. Round leav'd Portugal Parsley.

5. Apium hortense latifolium, maxima, crossissima, suave, and eduli radice Brerh. Broad-leaved Garden Parsley, with a large seet, edible root.

6. Apium Palustre, and Apium officinarum, C.B.P. Smallage

7. Apium dulce, Celeri Italorum, H.R. Par. Celery.

8. Apium dulce, degener, radice rapocea Jussien. Turnit-rooted Celery, commonly call'd Celeriac.

9. Apium Macedonicum C.B.P. The Macedonian Parsley.

10. Apium Lusitanicum maximum, folio trilobata, flore luteolo, Brerh. Ind. Great Portugal Parsley with a trilobated Leaf, and a yellowish Flower.

11. Apium Pyrenarcum, thapsiae facie, Inst. R.H. Pyrenean Parsley, with the Face of the Deadly Carrot.

12. Apium montanum, sive petraeum album J.B. Raii White Mountain Parsley.

13. Apium montanum, sive petraeum album Elatuis. Taller White Mountain Parsley."

That celery was cultivated at this time is shown by the fact that directions for growing the crop and hilling up the plants are given and the conclusion is that celery "Will not keep over 3 to 4 weeks after blanching." Smallage is spoken

of as a weed, the seed of which is used as medicine.

That some of the species given were mere variations seems to be upheld by the fact that Miller in his 8th edition of "The Gardeners Dictionary" (1768) follows the Linnean classification and only gives seven species as follows:

"1. Apium (Petroselinum) common Parsley
2. Apium (Crispum) Curled Parsley
3. Apium (Latifolium) The large rooted Parsley
4. Apium (Graveolens) Smallage
5. Apium (Dulce) Upright Celery or (Apium dulce dulce celeri Italorum)
6. Apium (Rapaceum) Celeriack
7. Apium (Lusitanicum) Celeriack

Miller then critisizes Linnaeus for putting celery in species , with smallage, supposing the only difference to be due to cultivation. It is maintained that Smallage and Celery are different. From forty years experience in cultivating smallage, Miller cound not bring it to "the same goodness as Celery" the only changes was "a larger size" but not so tall as Celery. Smallage sends out many suckers from the root and will not "rise with a straight stem but can be blanched by earthing up. Physicians mean smallage when Apium is prescribed."

From studying the descriptions of the modern varieties of celery and comparing them with the descriptions of Miller, Gerarde, and other early herbalists it seems to indicate that

our modern Celery originated from several varieties and it is very probable that the different peoples had reached different stages in the culture of the crop and then again, since Celery is prone to excessive variation that might have made matters more complex.

The first mention of varieties is by Mawe (1778) under Apium dulc, two varieties being mentioned, the Hollow Celery and the Solid Celery. The Hollow Celery is spoken of as the original variety and was known long before the Solid Celery. One thing that impresses its self in this early article by Mawe is the complete cultural methods given for growing Celery and also, in his earlier work (1765) Celery is spoken of as good for soup. Abercombie in (1786) mentions three varieties of Celery, 1. Common upright, 2. Solid stalked upright, 3. Giant upright and a fourth Celeriac, or dwarf turnep-rooted Celery is given. Later Abercombie (1797) in discussing the subject says "Apium graveoleus or Smallage is a common weed, bearing great resemblance to Celery, insomuch that the latter is by some supposed to be a variety of the former, raised to its present state of perfection by long culture;but I greatly doubt this; since both sorts retain their difference from seed." It is further stated that it is the smallage that is used for medicine and only used for culinary purposes by poor country people who use it for broth or potage. Abercombie classifies common Celery as Apium dulc and mentions three kinds viz, 1. Hollow Celery, the original variety, 2. A solid kind, but it is not recommended as it will not endure as well as the

hollow kind and 3. a giant kind which is good for autumn or early winter.

Previous to this period no mention of a named variety of celery could be found, however, in 1805 Abercombie speaks of the common upright celery as the Italian. About this time celery culture had also begun in the United States. McMahan (1806) a nurseryman and florist of Philadelphia puts celery under the following heads,- 1. Common upright with hollow stalks, 2. Italian or upright, 3. Solid stalked Celery, 4. red-stalked solid celery. This is the first mention of a red variety and whether the red or white sorts were the original could not be determined. Not much progress was made the next twenty years for in 1829 Mawe gives almost the identical list of varieties of Celery as was given by Abercombie (1805) and M Mahon (1806). However, interest was beginning to be aroused and in 1841 the first classification of Celery is given in the Gardener's Chronicle as follows:

1. Violet, solid, with a violet tinge where the stalks are exposed to the light but blanching to very pure white, and of delicate flavor. The Manchester celery appears to be only a stronger growing variety of this. Flavor not so good.
2. Turc, a white solid autumn celery.
3. New Flat Stemmed White Solid, very large and solid. Best white celery.
4. Seymour's Supurb White Celery, This celery is mentioned on page 113 and the reader is referred to the London Magazine for F eb. 1841 for fuller

description.

5. (White Solid and Manchester Red, recommended for home garden)

The cultivation and production of new varieties must have been stimulated about this period as shown by the large number of synonyms found in the classification of 1850 given in Gardner's Chronicle, viz,-

Celery. The varieties of celery may be divided into two classes,-

A. White Celery

B. Red Celery.

The hollow stalk celery known as Common Red and Common White is no longer worthy of notice and ought to be excluded from cultivation.

A. White Solid.

White Solid, alias Fine White Solid, Celeri Turc, Celeri plein blanc.

1. SEYMOUR'S SUPERB WHITE,

Italian, alias Italian Upright, Upright, Large Upright, Giant, Patagonian.

Curled White, alias Nain frise. Leaves resemble parsley

Wall's White, (syn) Imp. Italian.

2. EARLEY DWARD SOLID WHITE, alias Court hatif, Celeri Turc of some.

B. Red Solid

3. RED SOLID, alias New large Red, New Large Purple, New Russian, Cole's Red, Cole's Superb Solid, Violet de Tours, Gros Violet de Tours.

Even in 1853 the authors of agricultural books had not given up the old method of classification for in that year Johnson gives the varieties as follows:

1. Gigantic dward curled
2. Common upright red stalked
3. Upright giant
4. Hollow upright
5. Solid stalked (red and white)

He then adds that reds are for soups while the white are of more delicate flavor. Progress is shown in that the following named varieties are given, viz,- Violet; Turc; Cole's superb (red and white) and Nutt's Champion. The latter variety is said to be the best.

In 1876 the Royal Horticultural Society made a celery test which was reported by A. F. Brown in Gardeners Chronicle p. 106

CLASSIFICATION OF CELERY FROM TESTS MADE BY THE VEGETABLE COMMITTEE OF THE ROYAL HORTICULTURAL SOCIETY, MADE AT CHISWHIK, FROM SEED OBTAINED FROM 10 ENGLISH SEEDSMEN AND VILMORIN et CIE OF FRANCE.

1. Red Varieties.

1. Mammoth Red, (syn. Laig's Mammoth, Radford's Pink, Sulham Prize Pink, Hooley's Conqueror Prize, True

Manchester Giant Red.)

2. Ivery's Nonsuch, (syn. Violet de Tours, Osborn's Selected Red, London Market Red.)

3. Kimberley's Red, (syn. Imperial Solid Red, Stuart and Mein's Red.)

4. Carter's Incomparable Crimson, syn. Carter's Incomparable Dwarf Crimson, Hood's Dwarf Red.)

5. Webster's No. 1, (syn. Webster's No. 4.)

6. Leicester Red, (Major Clark's Solid Red, Turnmoss Red, Ramsey's Solid Red.)

7. Wright's Improved Grove Red, (no syn.)

2. White Varieties.

8. Grove White,

9. Incomparable Dwarf White, (syn. Plein Blanc Court Hatif, Sandringham, Dean's Compact White.)

10. Plein Blanc,

11. A Coupier,

12. Turc Grand,

13. Seymour's White, (syn. Goodwin's White, Northumberland Champion White.)

14. Prize-taker White, (syn. Veitche's Silver White.)

15. Dixon's Mammoth White.

16. Great Eastern.

17. Haywood's White Queen, (syn. Stuart and Mein's Giant White, Goodall's Flat-stalked, Webster's White.)

18. Veitche's Solid White, (syn Danesbury.)

19. Boston Market.

20. Prise, Curled or Garnishing Celery.
21. Turnip-rooted, (syn. Celeri Navet, Rave, Rave d'Erfurt, Soup Celery.)

Much controversy arose over this classification and many growers objected having their varieties of celery placed as synonyms. So strong were some of the objections that even as late as 1884 the Gardener's Chronicle printed objections sent in by celery growers.

Up to about 1883 all celery was blanched by hilling up soil around the plants. About this tima a new variety of celery was introduced that was destined to revolutionize the celery industry of America. At Issy, near Paris, France there appeared a sport in the celery patches of a Mr. M. Chemin in 1883. The next year Jas. Vicks and Sons introduced this celery into America. It was called Chemin's Celery, or White Celery and at present is known as Paris Golden-Self Blanching.

In 1884 Peter Henderson and Co. introduced the White Plume celery which was a sport from Half Dwarf and originated in Henderson's trial grounds in New Jersey. In 1885 Henderson'sNew Rose Celery was introduced. The New Rose and Giant Pascal in 1892 and the New Pink Plume in 1894 are some introductions by Peter Henderson and Co. After about 1885 celery culture was stimulated in America. The introduction of Golden Self-Blanching and Henderson's White Plume gave two excellent summer celeries to the markets, and the Giant Pascal is a leading winter variety, while the Boston Market retains its commercial importance even with these modern additions.

No breeding of celery has been done. The plant is very easy to produce variations and by selection the modern varieties have been produced.

The Royal Horticultural Classification of 1893 shows many changes from the one in 1876.

Jour. Roy. Hort. Soc. 16:250-251.

Celeries admit of division into three classes, viz:

Class 1. White varieties.

Class 2. Red varieties.

Class 3. Celeriac.

Class 1. White Celeries.

1. White Plume (Messrs. Vilmorin et Cie.)Plants dward. Outer leaves pale green, the younger or heart leaves pale silvery white, as if blanched. Hearts small, not very firm, of inferior quality, but very ornamental, and suitable for garnishing. Plant somewhat tender.

2. White Plume (Messrs P. Henderson and Co.) Same as No. 1, but of taller and stronger stock.

3. Paris Golden Yellow (Messrs Vilmorin et Cie.) Plants dwarf, stocks thick and broad. Hearts large, firm, and solid.

4. Henderson's Golden Dwarf (Messrs. P. Henderson and Co.) Stock mixed. Inferior to No. 3.

5. Sandringham White (Messrs. J. Veitch and Co.) Plant dwarf. Hearts firm, solid white.

6. Sutton's White Gem (Messrs, Sutton and Sons.)A very dwarf stock of No. 5.

7. Henderson's Half Dwarf (Messrs, P. Henderson and Co.) Of taller and stronger growth than No. 5.

8. Dwarf Large-ribbed White (Messrs. Vilmorin et Cie.) A late variety. A very broad-stalked variety, with solid hearts.

9. White Solid Pascal (Messrs. Vilmorin et Cie.) Stock mixed and irregular.

10. Wright's Giant White (Messrs J. Veitch and Sons.) Plants of moderate height. Hearts large and solid.

11. Dobbie's Invincible White (Messrs. Dobbie and Co.) Plants tall. Hearts firm and solid, and of good quality.

Class II. Red Celeries.

12. New Dwarf Red (Messrs. J. Veitch and Sons.) Plants dwarf and compact in growth. Hearts of moderate size, firm and solid.

13. Sutton's A1 (Messrs. Sutton and Sons.) Similar to No. 12

14. Improved Purple (Messrs. Vilmorin et Cie.) Plant dwarf. Heats firm and solid. Stock somewhat mixed.

15. Carter's Standard Bearer (Messrs. Carter and Co.) Plants tall. Leaves broad, deep green. Hearts firm and solid, and very hardy.

16. Veitch's Early Rose (Messrs. J. Veitch and Sons.) Tall growing. The stalks rounded, firm crisp, and solid. Early.

17. Ivery's Nonsuch (Messrs. J. Veitch and Sons.) Tall growing Leaf-stalks broadly ribbed. Hearts pale, large and solid.

18. Carter's Solid Ivory (Messrs. J. Carter and Co.) Similar to No. 17.

19. Standard Bearer (Messrs. J. Veitch and Sons.) Tall growth. Heads large, solid, deeply coloured.

20. Dobbie's Select Red (Messrs Dobbie and Co.) Tall growth Stalks broadly ribbed. Hearts large, very solid and good.

21. Major Clarke's Solid Red (Messrs. J. Veitch and Sons.) Plants of compact, medium growth. Leaves deep green, deeply serrated. Hearts very firm and solid. Excellent for early use.

22. Hartshorn (Messrs. Vilmorin et Cie.) Dwarf. Leaves deeply toothed and lobed, shining green.

23. Large Smooth Prague (Messrs. Vilmorin et Cie.) Plants of tall growth. Bulbs large.

24. Variegated (Messrs. Vilmorin et Cie.) Plants small. The leaves prettily variegated with white.

The very early varieties were produced by the gardeners of the big estates in England. In fact about 1750 celery was considered a luxury for the tables of lords and others of rank.

In concluding this brief history it might be well to give a list of men that have contributed in making celery culture what it is to-day.

Jas. Waters (1855) the Rectory, Penshaw, Fence House, Durham was one of the early cultivators. Also Samuel Jas. Patshull of Ullrighton, Wolvertonhampton, G. Adams and Son, Domino Cross Nursery, East Retford in 1859 introduced the

Monarch Celery. Celery shows are mentioned as early as 1866 and Mr. John Cox was a leafing exhibitor. In 1867 Hooley's Conqueror Celery was first shown by the originator, Mr. S. Hooley, a mechanic of Nottingham who obtained his strain by careful selection for a number of years. Alexander Ingram, of Alnwick Castle Garden was a leading judge about 1875 at the celery shows around Nottingham which is a big English celery centre. At a celery show in Carlton Nottingjam in 1869 there were twenty eight exhibitors. Other English seedsmen that have helped to develop celery are;- Chas. W. Breadmore, Winchester; William Bull, Chelsea, London, S. W.; Jas. Garaway and Co; Daniels Brothers, Limited, Norwich; J. Veitch and Sons; Sutton and Sons; Dobbie and Co. In France Vilmorin Andrieux et Cie have done much for celery culture. In America Peter Henderson, C. C. Morse and Co., D. M. Ferry and Co., Vaughn Seed Co., W. A. Burpee, Jos Breck and Sons with many others could be mentioned.

It was the early English varieties of celery that were introduced into America. The Country Gentleman for 1859 gives an account of the introduction of Cole's Chrystal White celery. A Mr. F. A. Flemming of Curwensville Clearfield co., Pa. reports that it was introduced into the United States through the U. S. Patent office. In 1860 Mr. Flemming mentions the Solid White celery and the Country Gentleman for 1874 reports Dwarf Incomparable as the most popular variety in New York. In 1853 the same paper speaks of the New Red Celery and in the same

year a gentleman signing as W. G. S. From Romulus, Seneca Co., N. Y. reports their success with celery on Mt. Airy Farm. Mr. W. F. S. says that celery is indiginous to America and grows luxuriantly along the shores of the Potomac and James rivers, The Chesepeake Bay and the Coast farther south. He attributes the good flavor of the Canvas back duck to the fact that they live on wild celery during the winter.

While about one new variety of celery has been introduced each year for the last century yet they are more or less related.

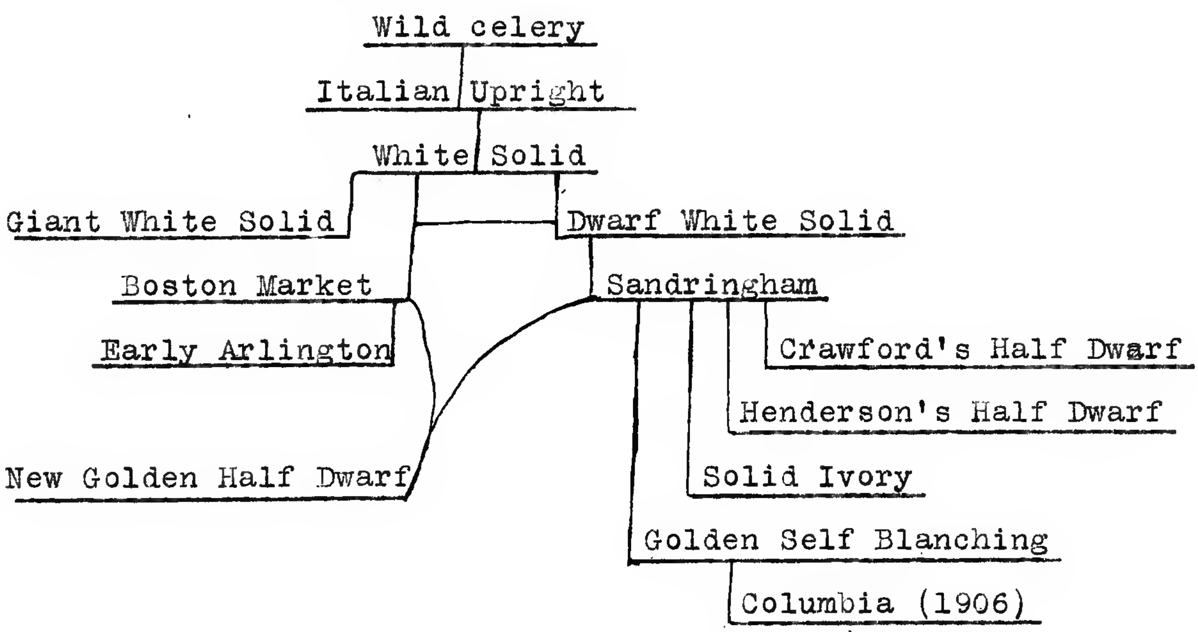
Through the kindness of Prof. U. P. Hedrick of the New York State Experiment Station, Geneva, N. Y., the celery notes of the late Dr. Sturtevant were made available, by the aid of which the writer was able to get the history of the Golden Self Blanching celery of the Chemin and also its relatives.

The Golden Self Blanching celery originated near Paris from the Sandringham celery which was much cultivated at Sandringham, England, and said to have originated in the garden of the Prince of Wales.

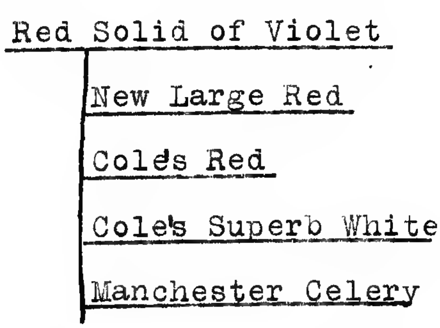
The Boston Market is spoken of as being closely allied to the Sandringham except that it is taller and given more to suckering. Vilmorin speaks of the Boston Market celery as being closely allied to Dwarf White Solid, and trials at Geneva N. Y. showed the foliage of Crawford's Half Dwarf White to be not perceptibly different from Boston Market and the Crawford's Half Dwarf is closely related to Early Dwarf Solid White and

Henderson's Half Dwarf from which originated Henderson's White Plume. Again New Golden Half Dwarf is related to Boston Market, as is also the Early Arlington. The Solid Ivory is similar to Sandringham but blanching perfectly white. Here is a case of another celery originating from Sandringham before the Golden Self Blanching of Chemin. The Giant White Solid is related to Boston Market. Dr. Sturtevant gives the following as probable synonyms of Sandringham; Dwarf White Solid, Henderson's Dwarf White, Incomparable, Incomparable dwarf White, Sandringham Dwarf White and Turner's Dwarf White.

The Following diagram will probably tend to make clear the relationships given above:



Probable Ancestry of Red Celery.



Henderson's Rose

New Rose Dwarf

Under Major Clark's Solid Red celery, Dr. Sturtevant puts as synonyms,- Wiseor's Durham Red, Ramsey's Solid Red, Turm or Red. Vilmorin describes the plant as vigorous, almost of the size of London Market Red, but the foliage is more bushy and of a deeper green.

The diagrams do not represent in each case exact origins of the varieties but probable relationships as shown by Dr. Sturtevants' work at Geneva, N. Y. and also by the aid of other literature. The classification at least shows the many small variations that arise by subjecting a plant to different cultural conditions and each cultivator with a different ideal. In other cases varieties are mutations. The Columbia is a mutation of the Golden Self Blanching, having been found in a celery field in Ohio. It was introduced by D. M. Ferry and Co. in 1906.

EXPERIMENTAL.

The object of the present experiment was to make a preliminary test of the relative susceptibility of different varieties of celery to the late blight disease or leaf spot caused by the fungus Septoria petroselini Desm. var. Apii Br. and Cav. This fungus caused very heavy losses to celery growers. It is reported by the California Agricultural Experiment Station that in 1908 the loss to the California celery growers amounted to 1950 car loads or a money loss of 550,000.

Klebahn reports that due to this disease in certain parts of Germany celery culture has become almost extinct. The value of a variety of celery immune or even partially immune to the fungus would therefore be of great value to European and American celery growers.

METHODS USED IN THE EXPERIMENT.

The seed of forty three varieties and strains, previously obtained from the Vegetable Garden Department of Cornell University, was planted in a rich sandy soil, June 17, 1914, in ordinary flats. The flats were covered with glass and kept in the Plant Breeding greenhouse. The seedlings received the same kind of care as ordinary commercial seedlings. On July 17, the seedlings were transplanted into flats containing a rich soil prepared by the Vegetable Gardening Department and were pricked out 1 1/2 x 1 1/2 inches. The plants were then put out in a cold frame and exposed to ordinary weather conditions.

August 17, the seedlings were planted into 6 inch flower pots containing a rich sandy loam. One plant was put into each pot. At this point in the work it was found impossible to use all the 43 varieties and strains so 13 of the best commercial sorts were selected. Sixteen plants each of eleven varieties and eight plants each of two varieties were used. The plants were then kept in the south end of the Plant Breeding greenhouse and watered every day or two by sprinkling.

About October 1, the plants were inoculated with spores of the Septoria fungus as follows:-

The source of the material was from three badly infected plants sent to the writer by Mr. Henry Griffrath of South Lima, N. Y., President of the N. Y. Vegetable Growers Assn. By placing pieces of the leaves infected with ripe pycnidia into water the spores ooze out and by squeezing the wet leaves, more spores are forced out. This water containing spores was then strained through one thickness of cheese cloth into an atomizer.

Each variety had previously been given a number and in order to eliminate, as far as possible, the possibility of previous conceived ideas of the relative susceptibility of the different varieties, the numbers were used entirely.

The plants were divided into series for innoculation and named A. B. C. and D. This was necessary due to the fact that the inoculating chamber of the Plant Pathology Department could not hold all of the plants at once.

Series A. contained 3 plants taken at random from each variety.

Series B. contained 4 plants of each variety

Series C. contained 5 plants of each variety

Series D. contained 4 plants of each variety

The only exceptions were the two varieties in which only 8 plants plants were used and they were inoculated as follows;

Series A. - 3 plants

Series B. - 5 plants

The plants were then placed in the large glass inoculating chamber in the Plant Pathology greenhouse. This chamber is equipped to furnish air saturated with moisture

Just before the plants were put into the inoculating

chamber they were sprayed with water from an atomizer until the plants was thoroughly covered with droplets of water. They were then sprayed with the water from a second atomizer containing spores. In order to get as even an inoculation as possible each plant received four long sprays from the second atomizer by pressing the bulb of the atomizer four times. The plants were left in the inoculating chamber from 24 to 48 hours. Previous tests showed that in 24 hours there was a nearly 100% germination and in 48 hours there was a germ tube formed about twice as long as the spore.

After inocluation the plants were taken back to their original place in the Plant Breeding greenhouse and in from 3 to 4 weeks infection appeared

It might be well to state here that the writer realizes that it is not possible to get equal inoculation by using the atomizer as one is not sure that the same number of spores are placed on each plant. However, no other bettwe way was known

METHOD OF COMPARING RELATIVE AMOUNT OF INFECTION ON EACH VARIETY.

When it was found that the disease had reached its maximum, the leaf area and number of spots on each plant were calculated and also the number of spots per square decimeter of leaf surface were calculated. This was done as follows:

For series A. and B. an apparatus on a drawing table was arranged so that the plant could be tipped on its side and the

area of ten representative leaves was measured with a plainimiter. The number of leaves on the plant were counted and from this data the leaf area of the plant was calculated as follows:

Example.

No. of leaves on plant 46

Leaf area of 10 leaves........350 sq. cm.

Average area of each leaf ....35 sq. cm.

Total area of plant ....46 x 35 = 1610 sq. cm.

The total number of spots was counted on each plant. This was done with an ordinary watch counter. If there were 437 spots on the plant, the number of spots per square decimeter of leaf surface was found as follows:

$\frac{437}{1610}$ x 100 = 27.12 spots per sq. decm. of leaf surface;

or to convert this to a mathematical formula, let N= total number of spots on plant and A= total leaf area of plant in sq. cm. D= no of spots per sq. decm. Thus;

$$100 \frac{N}{A} = D.$$

RESULTS.

It must be kept in mind that the results are only preliminary since the experiment was carried through only once. However, the following facts are brought out very forceably.

In the first place the different varieties showed differences in their relative susceptibilities to the disease. The number of spots cannot always be taken as a basis to estimate immunity, i.e. according to Plate V. the curve shows

that No. 11, variety White Plume, is high in immunity, however, while there were few spots they were very large and tended to cover the whole leaf surface. The photograph Plate XVIII. also shows the susceptibility of this variety. On the contrary, the curve in Plate XIV. shows that No. 23 or French's Success, to be relatively immune and very few infection spots were found on this variety. This is very well shown in Plate VIII. giving the graphic results of this variety and also in the photograph Plate XX.

Other varieties as No. 17, Giant Pascal, and No. 29, New Rose, had a very large number of small infection spots from the size of lead in a lead pencil to the size of the end of a lead pencil. Aside from the foregoing observations there are at least two facts that are of primary importance.

The first is the pronounced individuality of each plant. This is very well shown by the tables I. to IV. and also in plates II. to XIV. For instance note the great variability of variety No. 1, Golden S elf Blanching, plate II. One individual has nearly 120 infection spots per square decemeter of leaf area while another goes as low as 7 infection spots per square decemeter. This same individuality is also very well shown in variety 17, Giant Pascal and No. 23, French's Success.

The fact that each plant has an individuality, is of much importance to a breeder about to begin the task of breeding a disease resistant strain of celery. Instead of trying to select any one particular variety, the breeder must start with the individual plant and first test its power of transmission of the immunity character and then by selection, where possible

gradually breed up the immune type.

The second point is that each variety has a different range of variability. The French grown seed of variety No. 1 Golden Self Blanching, having the greatest range, while variety No. 23, French's Success has the least range. This last named variety is also the most nearly immune.

Since the seed used was not from a pure strain but merely commercial seed, the question naturally arises as to the genetic relationship between the various individuals in the different varieties. This, of course, depends upon the method of pollination. As to this Knuth in his Handbook of Flower Pollination, Vol. II. says, "1107. Apium graveolens L. , Kirchner states that the small whitish flowers of this species are self-fertilized, perhaps in consequence of imperfect protandy."

The fact that celery flowers are self-fertilized make the predeeding points more significent, i.e. the individuality of the plants is due to the transmission of heritable characters from self fertilized parents and not the results of the breaking up of hybrid forms. The other point emphasized is that the variability of the different varieties indicates a mixed population much the same condition as breeders of cereals in Germany had bu mass selection before the method of selection was discovered and which is now used by Nilsson of Sweden.

The writer has not been able to find any other method used in breeding celery other than selection. It was simply a process of selecting pure strains, so that commercial var-

ieties include several strains within a given variety.

CHARACTER OF THE SPOTS.

The character of the infection spots varied with the particular variety. In an article on, "The Possible Source of Origin of the Leaf-Spot disease of Cultivated Celery",[δ] a proof sheet of which was kindly sent to the writer by the author, Dr. George H. Pethybridge of Dublin, Ireland, it is stated that this disease was found on wild celery growing in West Galway, Ireland. Infection was obtained on cultivated celery from spores taken from wild celery.[δδ]

The spores on wild celery leaves are described as "seldom, if ever, confluent; they were relatively small, and retained their form and individuality even on old leaves which were apparently otherwise dying a natural death." However, when spores from these same small spots on wild celery were used to inoculate the cultivated celery "the attack was much more severe and in fact resembled in every way the appearance of the now, unfortunately, too well known leaf spot disease on cultivated celery. The spots enlarged in area and confluent, pycnidia appeared in abundance, and the foliage underwent decay, apparently as a direct result of the attack of the fungus."

δ To be published in the Jour. Roy. Hort. Soc. vol. XL part 3, 1915.

δδ Dr. Pethybridge kindly sent the writer specimens of wild celery that were infected with Septoria petroselini Desm. var. Apii Br. et Cav. and also specimens of cultivated celery that had been inoculated from spores taken from the wild celery plants.

The above observations of Dr. Pethybridge are of interest for the following reasons,-

1. In the present experiment the same thing was observed in the different varieties in connection with the character of the infection spots. In such varieties as Golden Self Blanching and Columbia the spots spread so that in some cases nearly the entire leaf became one large spot of infection. In other varieties as French's Success and Celeriac there were a large number of spots which were no larger than the point of an ordinary lead pencil. These spots did not spread but remained distinct even after the leaf had died.

2. It seems that this is one way that can be relied upon as indicating the immunity of a variety of celery.

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1897 Het Groepsgewijs afterven der Koffie heesters in gestoten plantsvenen Teysmannia.

Key to the Varieties Of Celery		Name of Company from Whom Seed was Obtained
No. 1	Golden Self Blanching	A. W. Gilman.
No. 7	Golden Self Blanching	Burpee (American Seed)
No. 10	Maule's American Yellow	W. H. Maule, Phil.
No. 11	White Plume	Burpee.
No. 17	Giant Pascal	D. M. Ferry and Co.
No. 20	Columbia	" " " " "
No. 23	Frenchs' Success	" " " " "
No. 24	Winter Queen	Burpee
No. 29	New Rose	J. M. Thorburn and Co.
No. 30	Kalamazoo	" " " " "
No. 31	Celeriac- Turnip Rooted,	Burpee
No. 38	Boston Market	C. C. Morse and Co.
No. 43	Giant Holden Heart	" " " " "

Table I. Series A.

Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. cm.	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
1-1	46	350	1610.00	437	27.12
1-2	43	180	1849.00	369	20.00
1-3	47	107	502.90	226	44.95
7-1	51	151	770.10	340	44.20
7-2	46	197	906.20	213	23.50
7-3	40	75	300.00	208	69.32
10-1	27	128	345.60	69	19.97
10-2	37	84	310.80	120	38.55
10-3	40	109	436.00	97	22.25
11-1	49	103	504.70	89	17.65
11-2	60	91	546.00	193	35.38
11-3	68	139	945.20	175	18.52
17-1	89	121.9	1084.91	406	37.40
17-2	93	153	1422.90	449	31.50
17-3	56	117	655.20	466	71.05
20-1	42	137	575.40	172	29.86
20-2	32	228	729.60	490	66.28
20-3	40	212	848.00	533	62.90
23-1	67	68	455.60	164	35.98
23-2	44	132	580.80	178	30.68
23-3	46	88	404.80	169	41.78
24-1	63	158	995.40	266	26.73
24-2	66	174.6	1152.36	133	11.55
24-3	55	155	852.50	128	14.16
29-1	49	130	637.00	638	100.20
29-2	61	142	862.20	406	47.15
29-3	56	188	1052.80	458	43.42
30-1	53	128	678.40	485	71.55
30-2	59	134	790.60	500	63.25
30-3	55	145	797.50	708	88.82
31-1	63	140	882.00	109	12.37
31-2	59	94	554.60	55	99.25
31-3	61	170	1037.00	156	15.05
38-1	95	97	921.50	684	74.30
38-2	50	147	735.00	806	10.98
38-3	62	152	942.40	271	28.78
43-1	63	213	1341.90	771	57.47
43-2	60	123	738.00	115	15.58
43-3	60	115	690.00	365	52.89

Table II. Series B.

Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. cm.	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
1-1	58	190	1102.0	1010	91.56
1-2	40	187	748.0	385	51.50
1-3	52	121	629.0	750	119.15
1-4	49	114	558.6	490	87.71
7-1	62	132	818.4	200	24.47
7-2	60	145	870.0	1012	116.55
7-3	43	193	829.9	326	39.31
7-4	43	172	739.6	168	22.73
7-5	50	147	735.0	163	22.18
10-1	32	111	355.2	37	10.42
10-2	46	118	542.8	191	35,16
10-3	51	88	448.8	141	31.41
10-4	48	134	643.2	228	35.49
10-5	47	160	752.0	115	15.29
11-1	60	140	840.0	75	8.93
11-2	60	114	684.0	74	10.82
11-3	46	145	667.0	320	47.98
11-4	40	132	528.0	250	47.30
17-1	39	119	464.1	625	13.47
17-2	44	154	677.6	360	53.24
17-3	37	136	503.2	225	44.75
17-4	53	112	593.6	780	13.15
20-1	41	165	676.5	441	65.25
20-2	36	215	774.0	225	39.10
20-3	36	147	529.2	375	70.80
20-4	35	212	742.0	520	70.20
23-1	47	148	695.6	160	23.00
23-2	53	124	657.2	140	20.88
23-3	59	175	1032.5	130	12.59
23-4	48	118	566.4	95	16.80
24-1	63	229	1442.7	324	22.47
24-2	46	179	823.4	170	20.65
24-3	59	172	1014.8	509	50.22
24-4	79	131	1034.9	470	45.40
29-1	40	142	648.0	466	71.91
29-2	60	177	1062.0	870	81.92
29-3	65	213	1384.5	923	66.66
29-4	53	136	720.8	400	55.49

Table II. Series B. Cont.

Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. dm.	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
30-1	48	134	643.2	450	70.00
30-2	57	133	758.1	530	69.98
30-3	64	118	755.2	119	15.75
30-4	49	168	823.2	421	51.18
31-1	59	67	395.3	140	35.45
31-2	65	103	669.5	250	37.38
31-3	60	124	744.0	167	22.45
31-4	64	69	441.6	130	29.52
38-1	51	204	1040.4	230	22.11
38-2	52	173	899.6	370	41.20
38-3	52	219	1138.8	500	43.90
38-4	40	202	808.0	460	56.90
43-1	49	155	759.5	197	25.94
43-2	60	108	648.0	446	68.80
43-3	57	154	877.8	184	20.98
43-4	62	112	694.4	470	67.73

Table III. Series C.

Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. cm.	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
1-1	51	238	1213.8	297	24.45
1-2	41	223	914.3	448	49.15
1-3	45	189	850.5	157	18.47
1-4	50	209	1045.0	127	12.15
1-5	35	195	682.5	53	7.77
11-1	74	134	991.6	64	6.47
11-2	67	84	571.2	66	11.57
11-3	73	103	751.9	79	10.51
11-4	45	198	891.0	132	14.84
11-5	80	165	1320.0	221	16.75
17-1	57	149	849.3	299	35.20
17-2	51	178	907.8	257	28.15
17-3	49	159	779.1	119	65.50
17-4	30	111	333.0	104	31.22
17-5	58	126	730.8	165	22.60
20-1	47	226	1062.2	124	11.70
20-2	35	296	1036.0	230	22.22
20-3	59	192	1132.8	346	30.50
20-4	47	225	1057.5	219	20.72
20-5	57	180	1026.0	167	16.29
23-1	52	151	785.2	20	2.55
23-2	72	92	662.4	41	6.18
23-3	65	106	689.0	85	12.34
23-4	82	101	828.2	68	8.22
23-5	50	81	405.0	47	11.61
24-1	43	209	898.7	192	21.35
24-2	71	122	866.2	241	27.84
24-3	58	142	823.6	119	14.45
24-4	50	167	835.0	360	43.20
24-5	54	170	918.0	202	22.00
29-1	45	118	531.0	117	22.08
29-2	53	157	832.1	57	68.50
29-3	60	156	936.0	281	30.25
29-4	50	134	670.0	52	77.65
29-5	46	145	667.0	56	84.00

Table III. Series C. Cont.

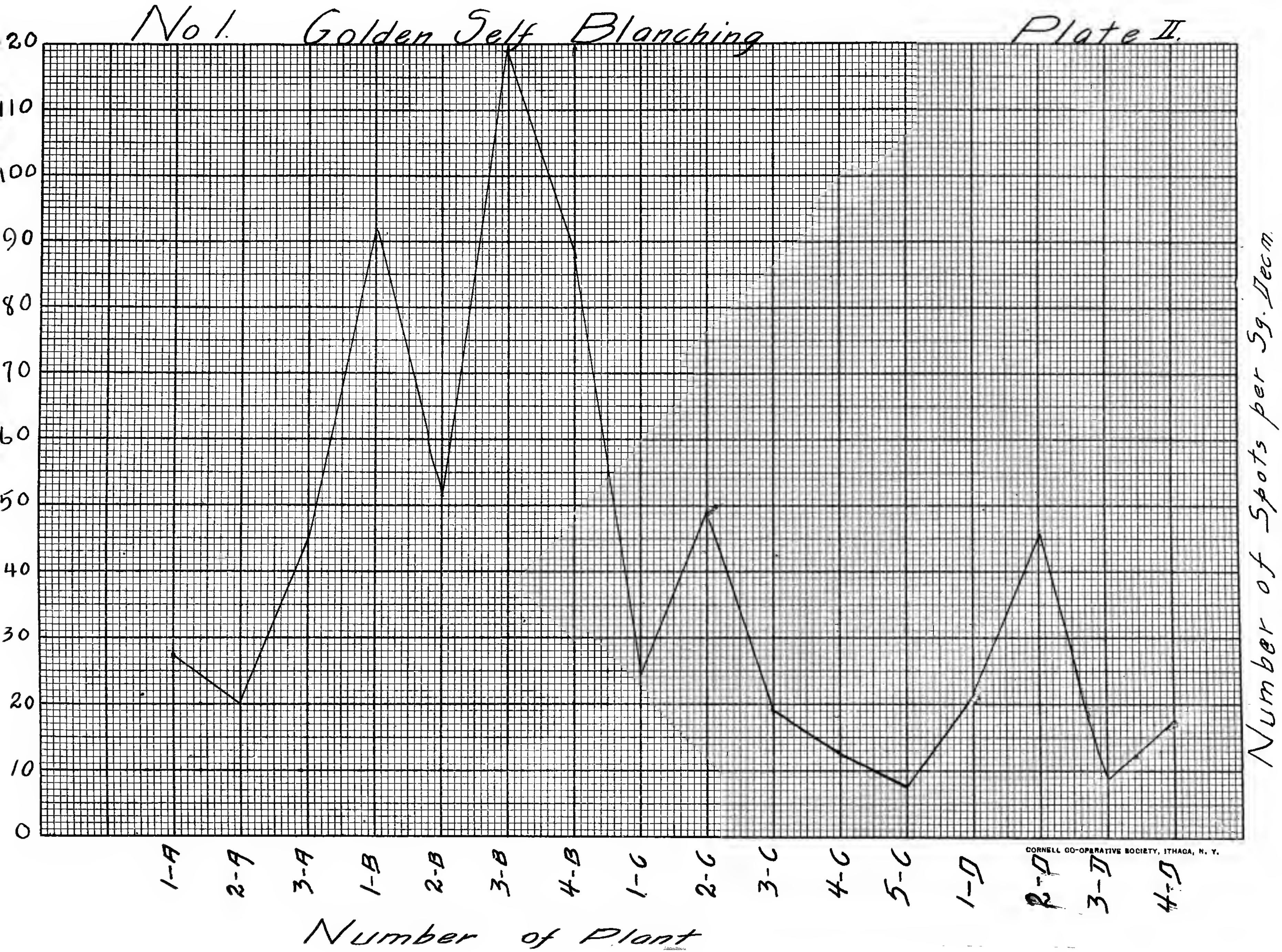
Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. cm.	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
30-1	54	163	880.2	98	11.13
30-2	76	149	1132.4	195	17.23
30-3	56	141	789.6	75	94.99
30-4	49	177	867.3	92	106.00
30-5	42	219	919.8	90	97.85
31-1	54	149	804.6	178	22.14
31-2	75	124	930.0	229	24.65
31-3	80	95	760.0	284	37.39
31.4	54	117	631.8	51	8.08
31.5	80	115	920.0	88	9.57
38-1	30	207	621.0	120	19.31
38-2	60	149	894.0	228	25.51
38-3	61	153	933.3	233	29.80
38-4	57	156	889.2	430	48.37
38-5	55	159	874.5	132	15.12
43-1	35	243	850.5	307	36.09
43-2	52	141	733.2	261	35.60
43-3	49	161	788.9	236	29.80
43-4	65	132	858.0	315	36.71
43-5	65	105	682.5	187	27.40

Table IV. Series D.

Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. cm.	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
1-1	53	171.16	907.15	199	21.90
1-2	50	149.00	745.00	345	46.30
1-3	49	184.00	901.60	73	8.11
1-4	58	136.50	791.70	137	17.31
11-1	91	42.50	386.75	83	22.48
11-2	65	126.00	819.00	106	12.95
11-3	81	126.00	1020.60	56	54.80
11-4	77	153.00	1178.00	129	10.99
17-1	37	149.50	553.15	480	86.75
17-2	53	120.00	636.00	661	103.80
17-3	60	132.00	792.00	539	68.15
17-4	55	100.50	552.75	296	53.65
20-1	59	195.00	1150.50	386	33.50
20-2	47	160.00	752.00	202	26.87
20-3	70	90.50	633.50	316	49.85
20-4	60	166.00	996.00	362	36.38
23-1	59	142.00	837.80	74	8.83
23-2	70	118.00	826.00	112	13.56
23-3	65	96.00	624.00	118	18.90
23-4	69	82.00	565.80	206	36.41
24-1	58	131.00	759.80	105	13.85
24-2	59	154.00	908.60	71	7.82
24-3	52	138.00	717.60	52	7.25
24-4	53	171.00	906.30	124	13.68
29-1	49	160.00	784.00	109	13.90
29-2	51	102.00	520.200	33	6.33
29-3	48	129.00	619.20	80	12.92
29-4	41	164.00	672.40	87	12.95
30-1	51	174.00	887.40	133	14.99
30-2	62	140.00	868.00	342	39.35
30-3	33	153.00	504.90	107	21.20
30-4	57	145.00	826.50	242	29.30
31-1	82	73.48	602.54	61	10.13
31-2	62	45.00	279.00	48	17.20
31-3	67	93.00	623.10	119	19.10
31-4	47	1o3.00	484.10	29	5.98

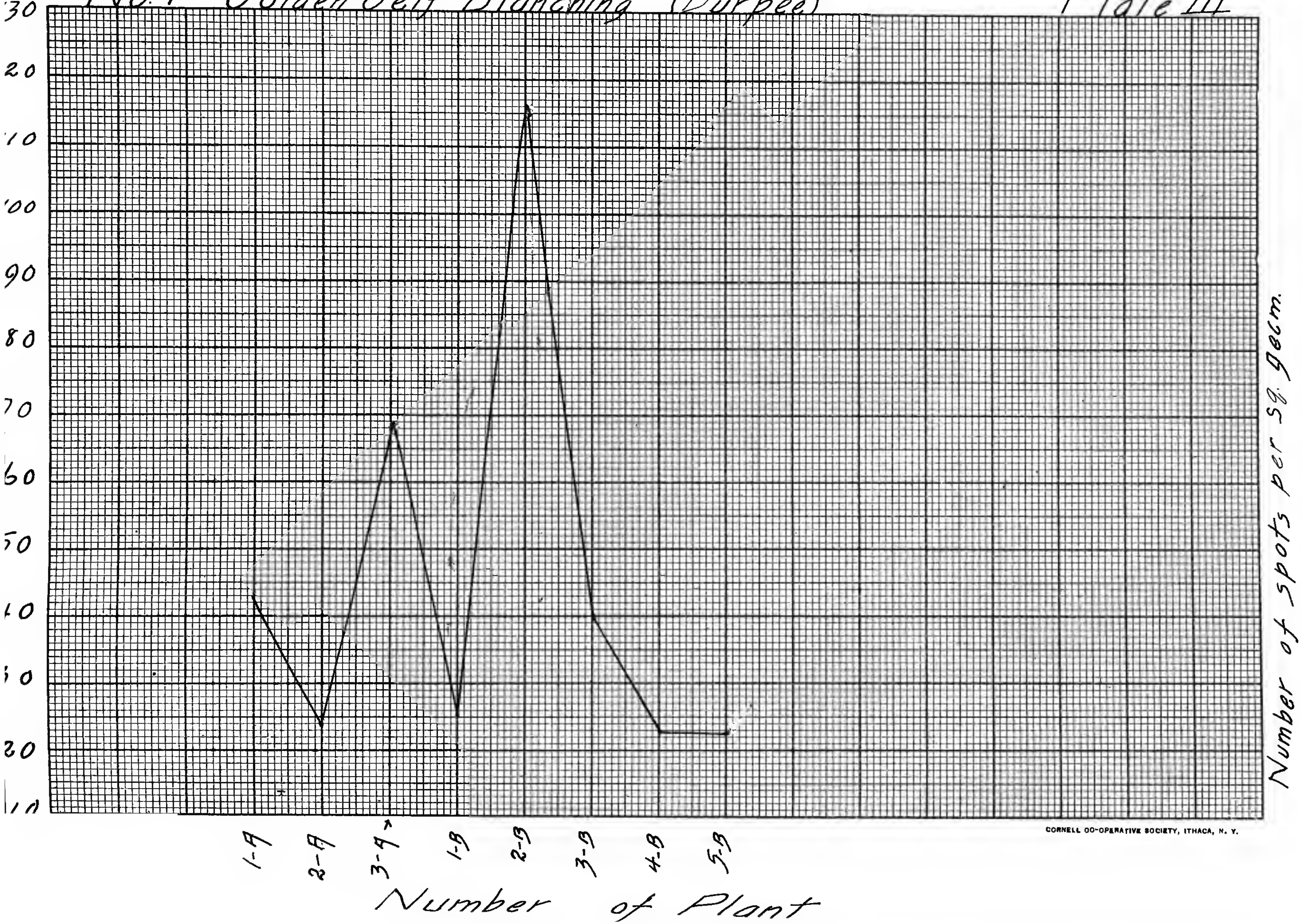
Table IV. Series D. Cont.

Plant No.	No. of Leaves	Leaf Area of 10 Leaves sq. cm	Total Leaf Area	No. Spots per Plant	No. Spots per sq. decm.
38-1	76	99.00	752.40	449	59.75
38-2	56	107.00	599.20	305	50.85
38-3	64	108.00	691.20	105	15.20
38-4	74	109.00	806.60	606	75.20
43-1	64	125.00	800.00	251	31.38
43-2	50	144.00	720.00	194	26.95
43-3	65	148.00	962.00	224	23.28
43-4	73	92.00	671.60	205	30.52

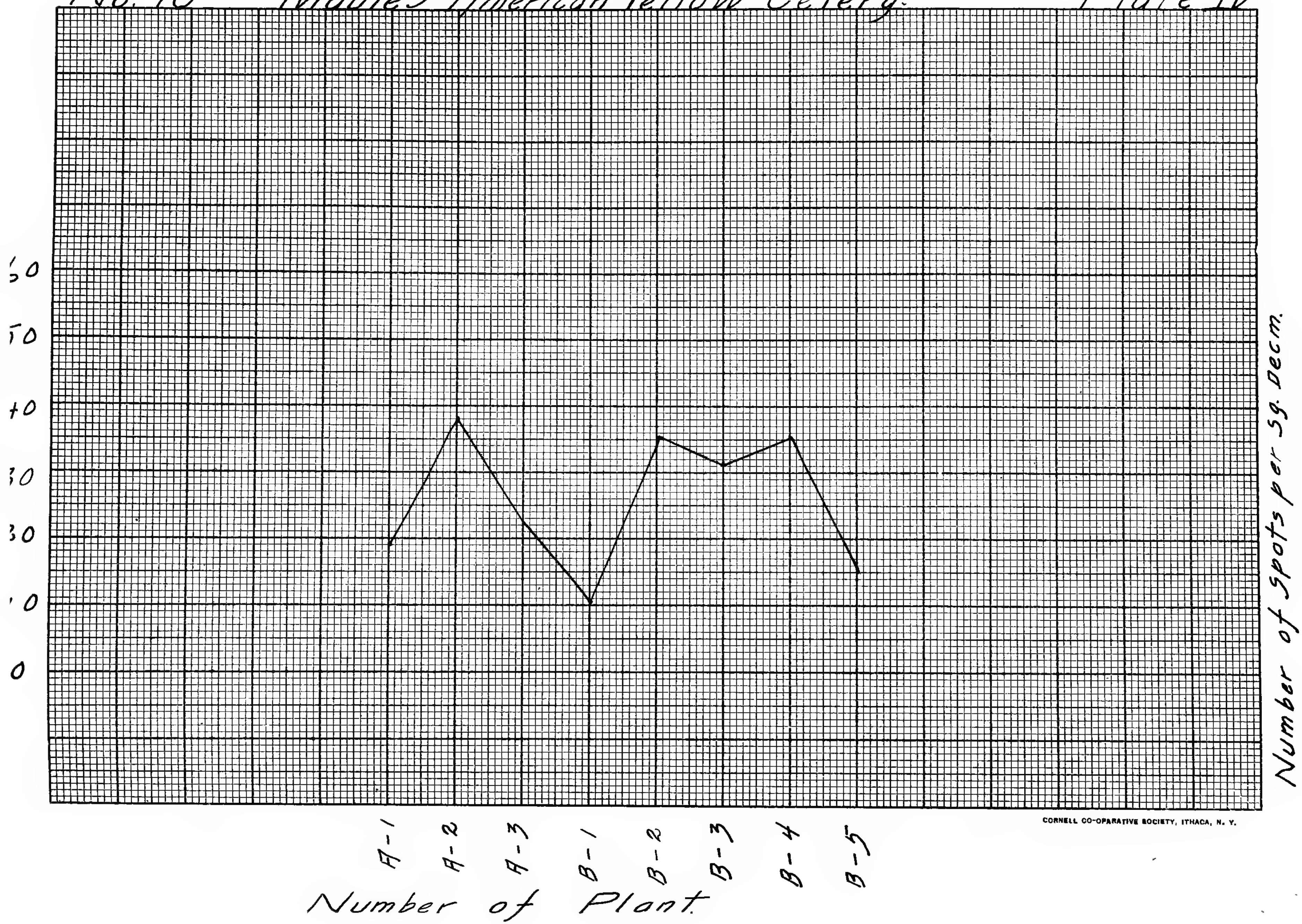


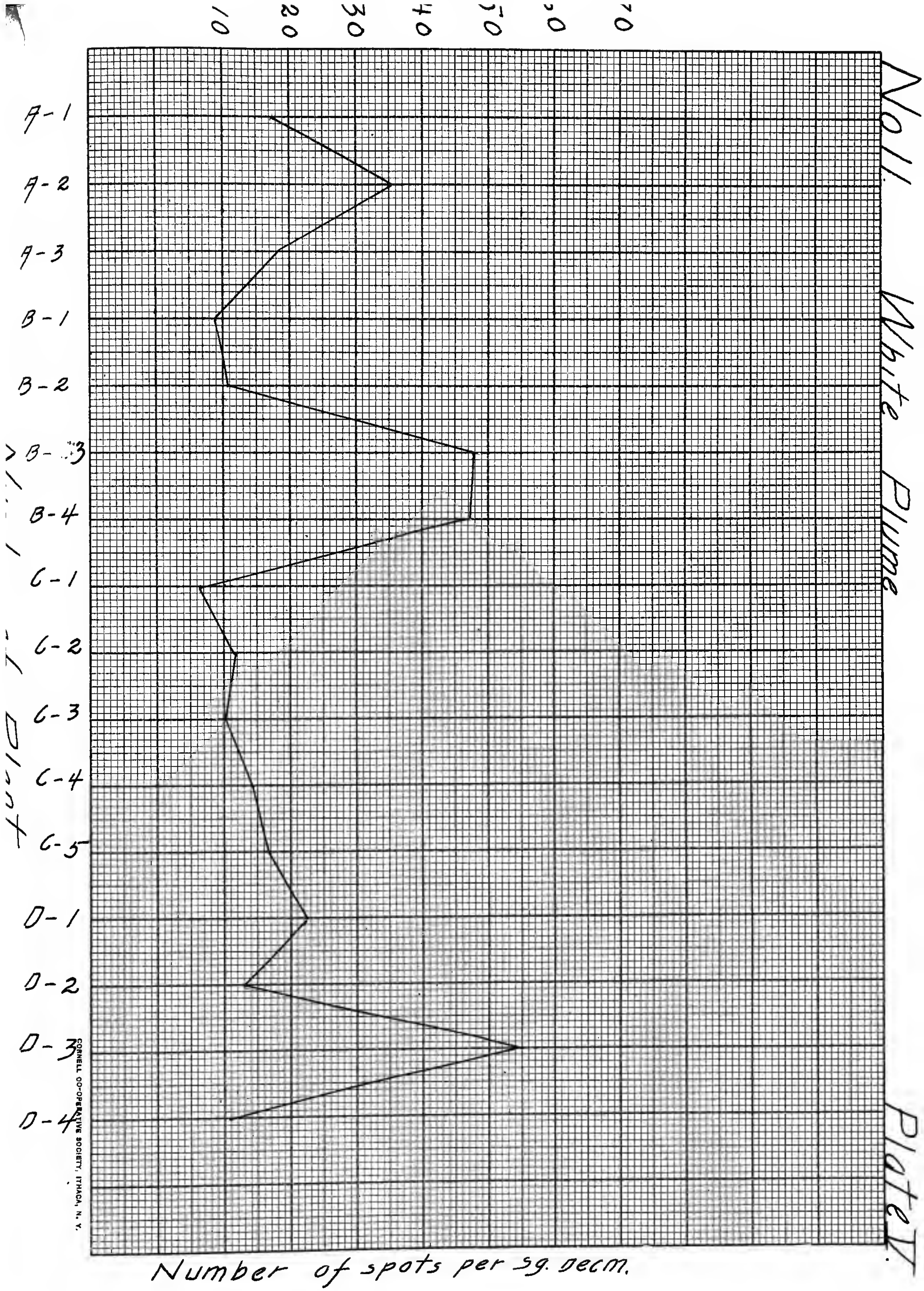
No. 1. Golden Self Blanching
Plate II.
120
110
100
90
80
70
60
50
40
30
20
10
0
1-A
2-A
3-A
1-B
2-B
3-B
4-B
1-C
2-C
3-C
4-C
5-C
1-D
2-D
3-D
4-D
Number of Plant
Number of Spots per Sq. Decm.
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.

No. 7 Golden Self Blanching (Burpee) Plate III

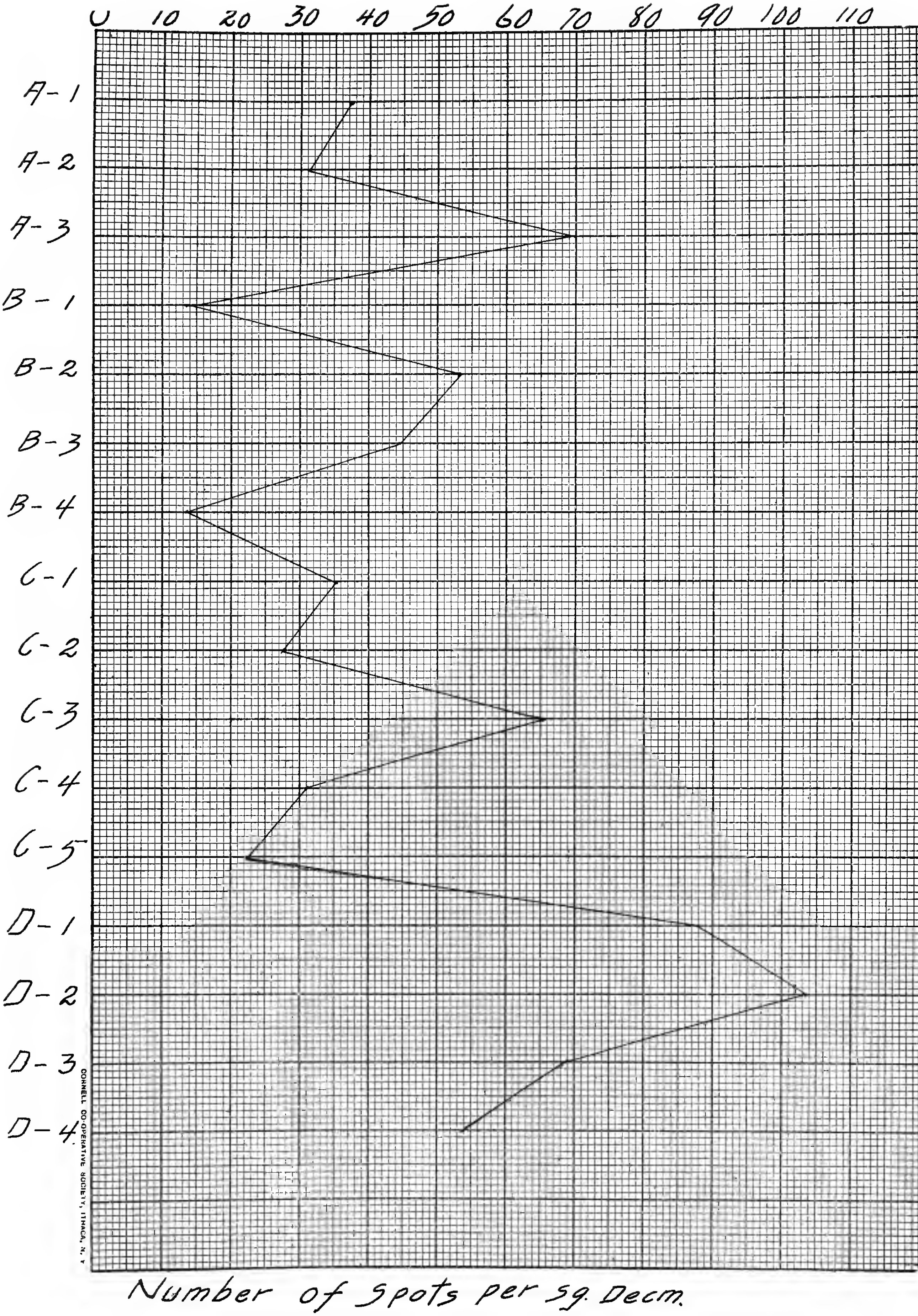


No. 10 Maule's American Yellow Celery. Plate IV



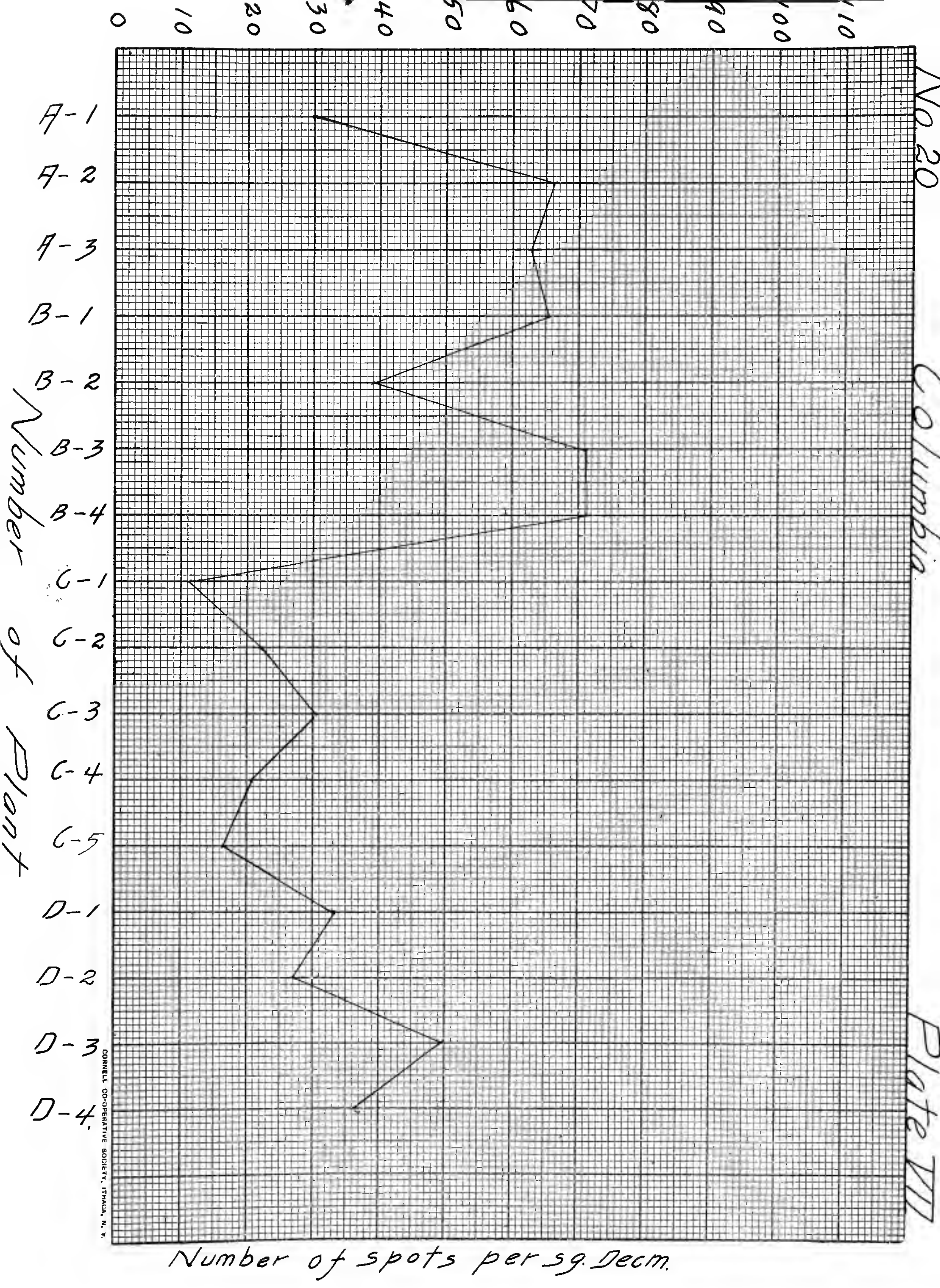


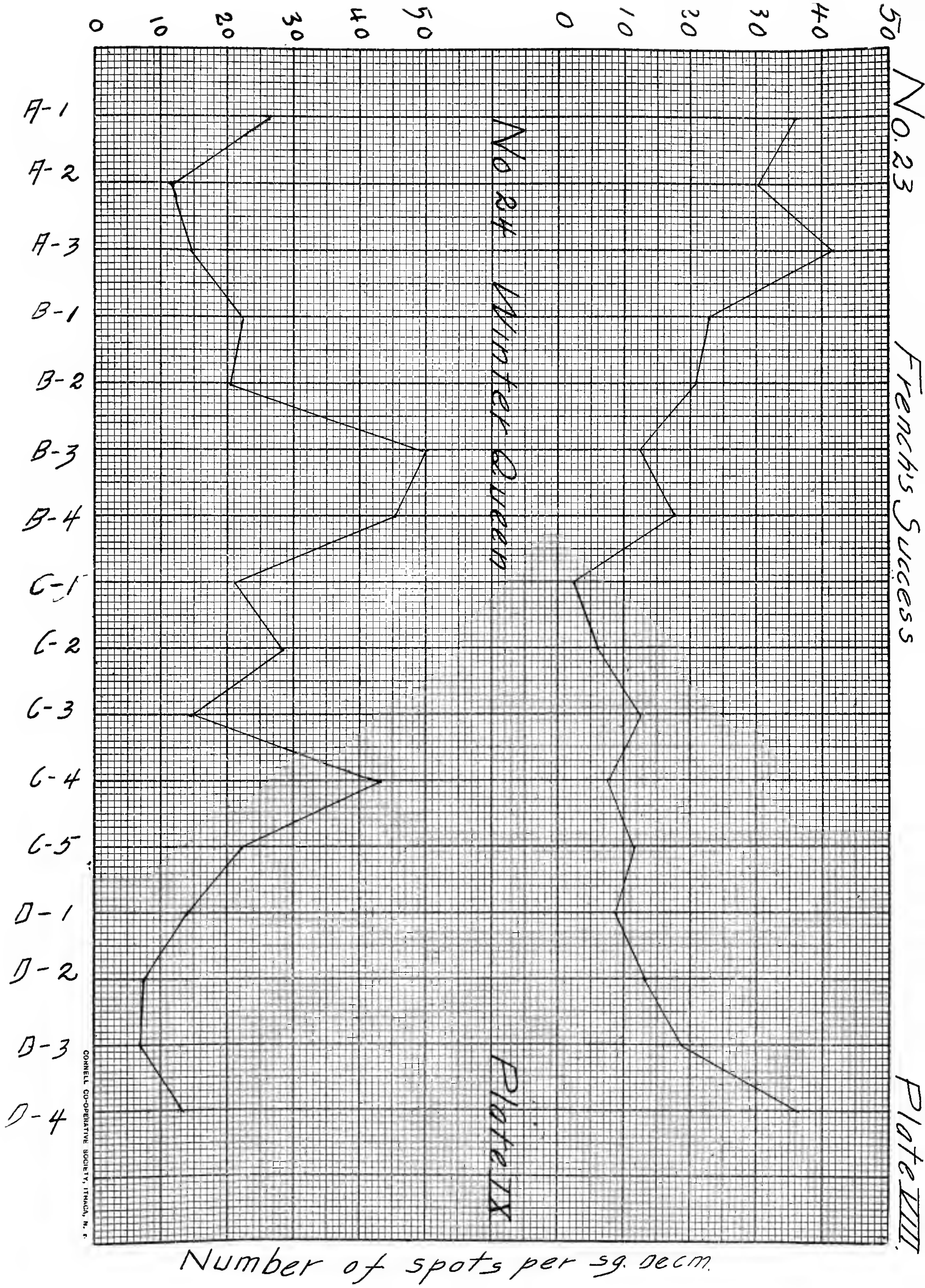
Noll. White Plume
Plate I
10
20
30
40
50
A-1
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
Plant
Number of spots per sq. decm.
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.

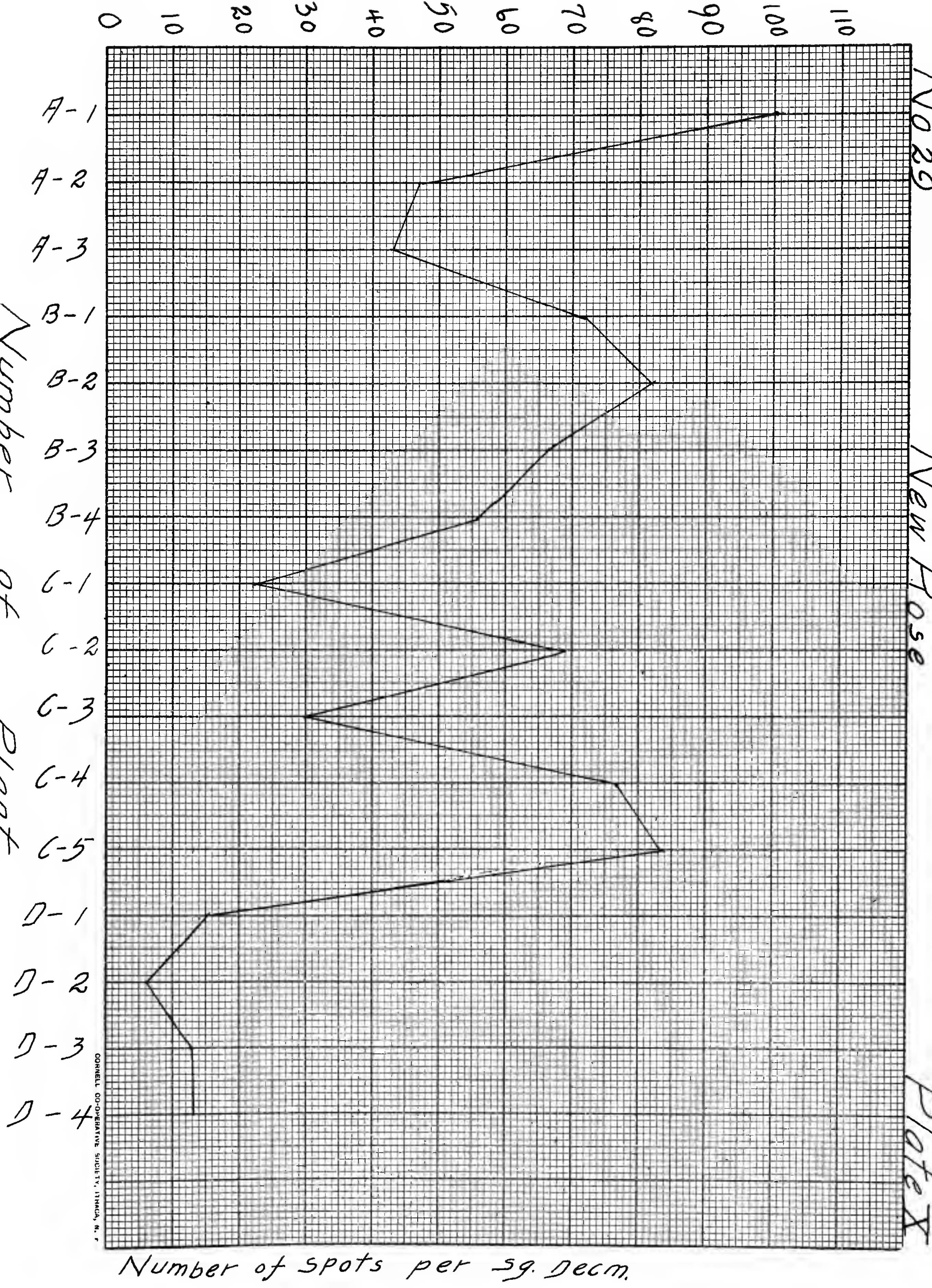


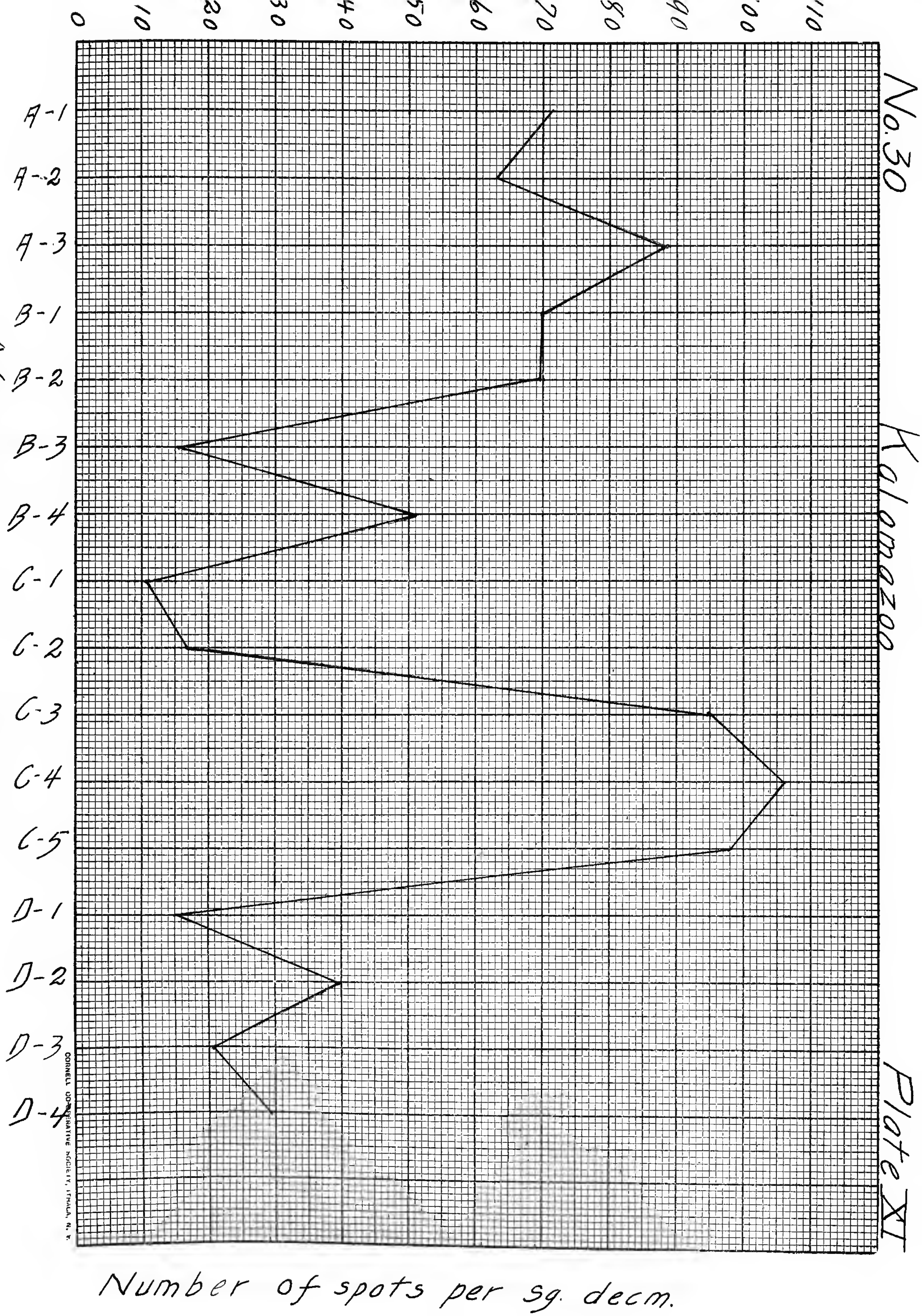
No 17 Giant Pascal

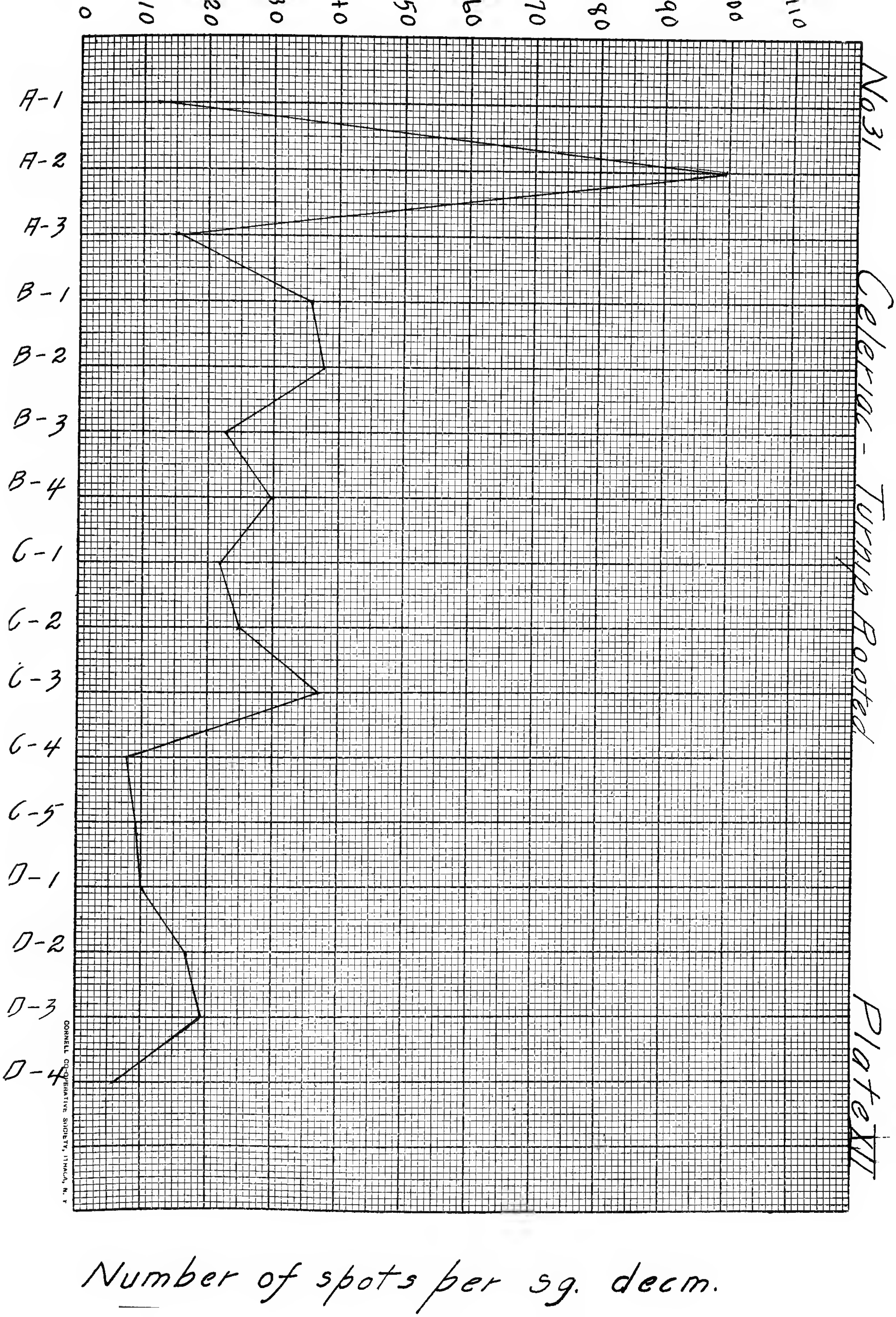
Plate VI


No. 20 Columbia
Plate VI
0
10
20
30
40
50
60
70
80
90
100
110
A-1
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4.
Number of Plant
Number of spots per sq. Decm.
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.

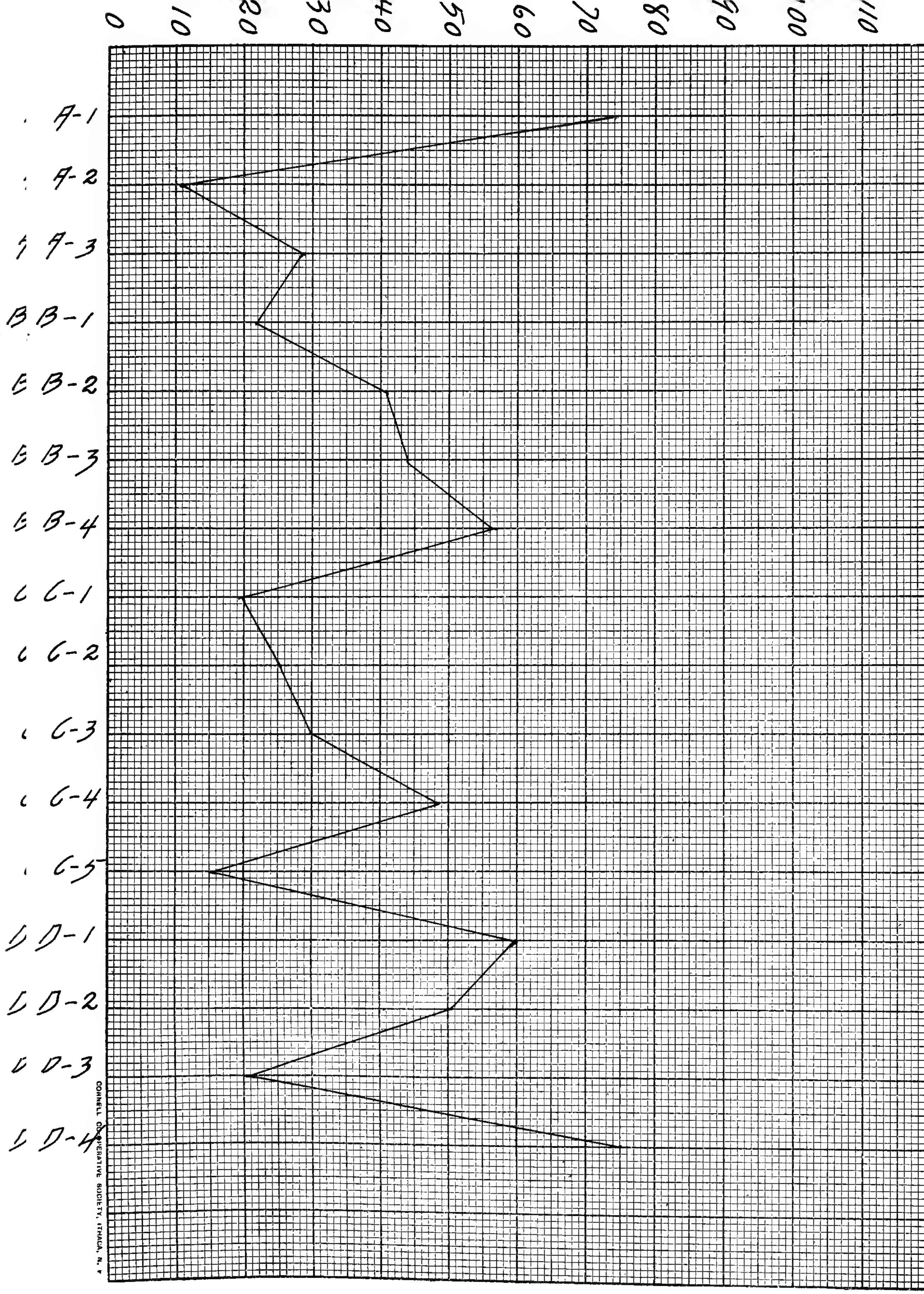

No. 24 Winter Queen
No. 23 French's Success
Plate IX
Plate VIII
A-1
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
0
10
20
30
40
50
Number of spots per sq. decm.
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.


No 29 New Rose
Plate X
Number of Plant
Number of spots per sq. Decm.
0
10
20
30
40
50
60
70
80
90
100
110
A-1
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.

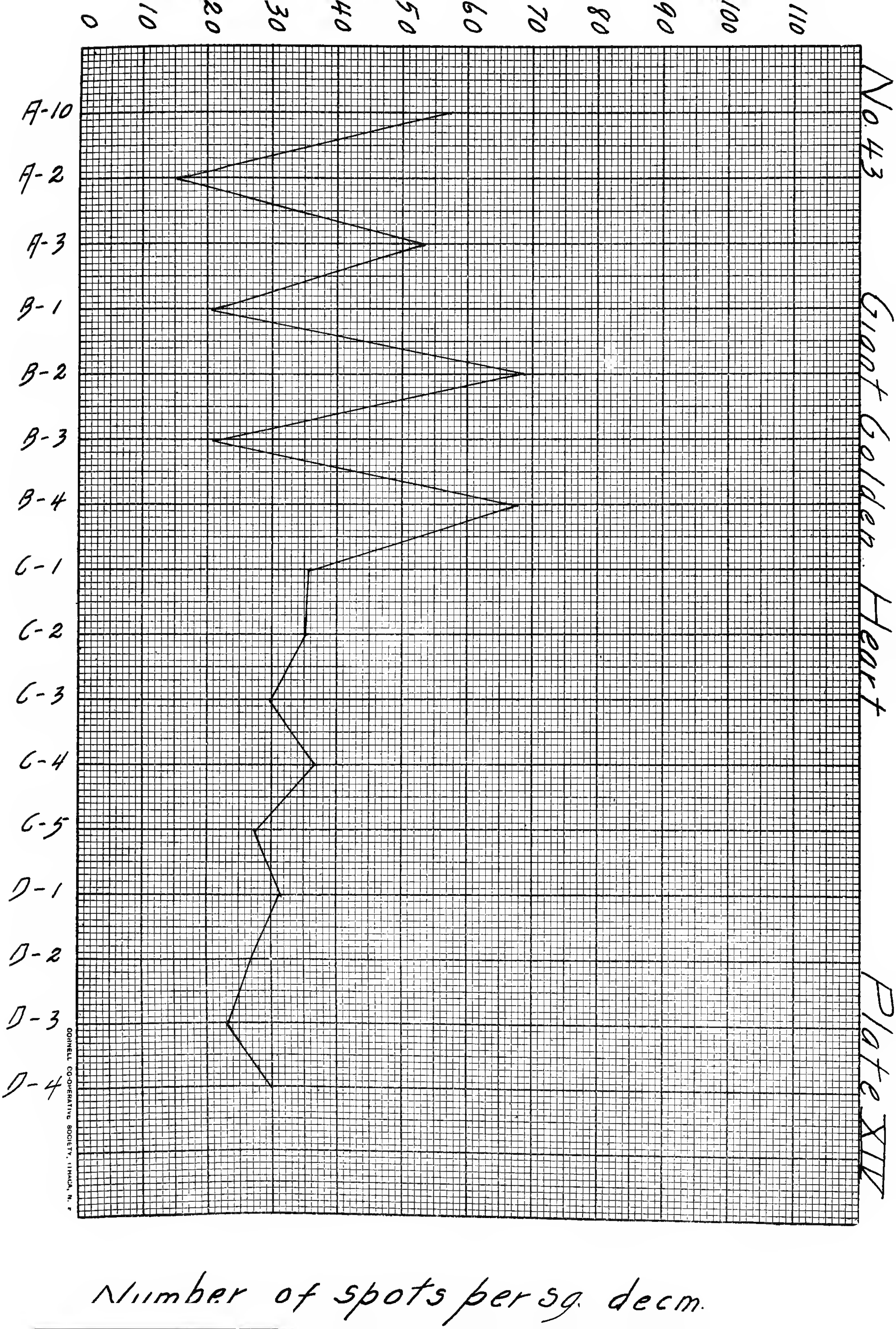

No. 30
Kalamazoo
Plate XI
Number of Plant
A-1
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
0
10
20
30
40
50
60
70
80
90
100
110
Number of spots per sq. decm.
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.


No 31 Celeriac - Turnip Rooted.
Plate XII
0
10
20
30
40
50
60
70
80
90
100
110
A-1
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.
Number of spots per sq. decm.

No. 38 Boston Market Plate XIII



Number of spots per sq. decm.



No. 43 Giant Golden Heart
Plate XIV
0
10
20
30
40
50
60
70
80
90
100
110
A-10
A-2
A-3
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
C-5
D-1
D-2
D-3
D-4
CORNELL CO-OPERATIVE SOCIETY, ITHACA, N. Y.
Number of spots per sq. decm.

Plate XV.

Late Blight of Celery on

No. 1 Golden Self-Blanching variety

No. 17 Giant Pascal variety.

Plate XVI.

Late Blight of Celery on

No. 30 Kalamazoo variety

No. 7 Golden Self-Blanching variety. (Burpee)

Plate XVII.

Late Blight of Celery on

No. 10 Maule's American Yellow variety.

No. 11 White Plume variety.

Plate XVIII.

Late Blight of Celery on

No. 20 Columbia variety.

No. 38 Boston Market variety.

Plate XIX.

Late Blight of Celery on

No. 23 French's Success variety.

No. 24 Winter Queen variety.

Plate XX.

Late Blight of Celery on

No. 29 New Rose variety.

No. 43 Giant Golden Heart variety.

Plate XXI.

Late Blight of Celery on

No. 31 Celeriac- Turnip Rooted variety

(two plants)