STUDIES ON THE BERMUDA LILY DISEASE

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TABLE OF CONTENTS.

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Introduction.

The growing of Easter lilies has always furnished difficult problems for the florist to solve. These problems are due chiefly to two causes: (1) Those connected with the reaction of the lilies themselves in their manner of growth, that is, their environmental relations, and (2) those brought about by the diseases to which the lily is subject. A combination of these two factors in lily culture makes the task of the grower more difficult.

Lilies are for the most part exclusively natives of the Northern Hemisphere and have been cultivated most extensively during the past centuries in Europe where they have gained great popularity as garden flowers. This popularity caused their early introduction into America. There are members of this genus that grow readily in very widely different ranges of temperature and it is found that there are cultivated lilies in northern and southern regions alike. By correct handling, the bulbs may be brought successfully through the winter outside in flower gardens in the temperate regions, but this method of culture includes only a small fraction of the lilies that are cultivated today. The greater part of the lilies that are cultivated are those that are forced in the greenhouse and sold for decorative purposes. Because of this fact the varieties that are most extensively cultivated are those that yield most readily to artificial conditions of growth. The lily that lends itself to this purpose most readily seems to be Lilium longiflorum and its varieties. This species is a native of Japan, and it is from Japan that the

greater percentage of the bulbs of this form are received today. However, the plant has been found to grow well in Bermuda, the Canary Islands, and South Africa. For quite a while the chief supply of bulbs was received in the United States from Bermuda; in 1875 the eximium variety of Lilium lohgiflorum was introduced. A lady returning from Bermuda brought back a few bulbs from that place. Growing them subsequently it was found that these bulbs were especially adapted to commercial growing. The attention of a Philadelphia grower named Harris (5) was called to these, whereupon he seized upon these bulbs and began to produce them, until in 1882 he placed several hundred bulbs on the market under the varietal name harrisii. This variety is correctly the Bermuda lily. However, it should be mentioned here that the varieties eximium and harrisii are synonymous, harrisii being the trade name of certain superior strains of the eximium variety as it is listed in classifications of the varieties of this species. This lily enjoyed great favor for some time, the demands for bulbs of this variety steadily increasing until the Bermuda growers could no longer supply sufficient numbers of these bulbs. Then the Japanese growers began to supply them. (5) This was the source of the bulbs until they were struck by the Bermuda lily disease. Extreme susceptibility to this disease was shown by this variety and after trying for several years to find an efficient control method or method to combat the disease the bulb growers began to look for a more sturdy variety. This they found in the variety giganteum, a very closely related variety yet sturdier in its general manner

of growth, and, although being subject to, it showed a greater degree of resistance to the attacks of this disease. Besides, the greater resistance to disease, this variety gave an equal flower yield and was therefore desirous from the commercial grower's standpoint. Hence it is seen that the attacks of this disease in the past forty years have lead to a substitution for the variety more commonly grown of a plant more adapted to commercial culture from a pathological view point.

The Minor Diseases of Lilies.

Several diseases of Easter lilies caused by parasitic fungi are known. These diseases are namely:

(1) The Botrytis disease attacking the stems, pedicels, flower buds and leaves causing brown or grayish specks which gradually spread, becoming covered with a delicate gray mold until the parts attacked are destroyed or become totally disfigured. This disease is caused by Botrytis sp., and may be controlled by spraying with a potassium sulfide solution or other fungicides.

(2) Rust, causing damage to the foliage by the production of large discolored areas on the leaves and stem. This rust is caused by Uromyces Erythronii and is commonly controlled by the removal of all the infected parts of the plant.

(3) Bulb rot, caused by species of Rhizopus and Penicillium attacking the bud scales, sometimes ultimately causing decay of the entire bulb. To prevent loss of this sort bulbs are handled carefully and commonly are packed in sawdust or clean sand. Certain writers recommend the packing of bulbs

in charcoal to which has been added flowers of sulphur. Losses from this source with high grade bulbs are small.

Besides the above mentioned diseases caused by fungi, it is necessary for the grower to combat aphids constantly by the use of contact sprays or dusts which are fairly effective agents in the destruction of these pests.

The Bermuda Lily Disease.

The most important disease of the Easter lily is one of unknown etiology concerning which little is known. Aside from comment by anonymous writers in various trade journals no discussion of this disease appears in the literature before 1897. At this time H. F. Woods published a bulletin upon the disease, describing its symptoms and classifying it as a "physiological" disease of unknown cause. Attention thus being called to this disease trade papers immediately were filled with references to the disease, and it is safe to draw the conclusion that at this time the disease was one of great importance in the lily industry.

Following the preliminary paper of Woods no further scientific studies on this lily disease have appeared, the practical growers and floriculturists accepting it as a matter of course or an indication of some unfavorable condition of culture. The attitude of florists and of scientific workers engaged in bulb culture is illustrated in the following comments upon the disease by Mr. David Griffith* of the United States Department of Agriculture, well known for his work on the culture of this plant. --"It is a simple matter to bring about the so-called lily disease in any

*In letter to H. H. Coons.

stock.----If you will take a few pots out of your material now being forced and increase the temperature 10 to 15 degrees suddenly, a large percentage of your plants will show disease within ten days. If you take plants which are in a high temperature and reverse the treatment you will get similar results but not so pronounced. Another thing you can do is to pot up your bulbs with some raw manure which will cause the basal rot in the bulb and at the same time the "lily disease"."

Economic Importance of the Disease.

The culture of lilies is an essential phase of greenhouse practice. Lilies are commonly grown by florists from bulbs which are merely forced under cool greenhouse conditions. Aside from occasional blooms needed throughout the season the attempt is made to force the bulk of the crop so that blooming takes place at Easter. In the aggregate the amount of capital involved in the lily business is large, amounting to at least a million dollars annually. The average large greenhouse in a city will purchase from $200 to $1000 worth of bulbs for forcing.

It is very difficult to determine losses caused by this disease since in none but the most severe forms are the bulbs killed outright or the flower buds blasted. The losses are due to the insidious action of the disease, causing short, weakened plants that produce only a few small blossoms. Observations made at a local greenhouse gave the following counts of the disease. In this table the unsalable plants were those rejected by the experienced greenhouse operator.

Total number counted.	Season.	% diseased.
1450	1922-23	41%
74	1923	81%
496	1924	70%

It will be seen that of the stock purchased at full price 20 to 30 percent was classed as unsalable. When the space occupied by the diseased plants, which otherwise might have been productive, is considered, it will be seen that this disease furnishes a constant source of loss to the grower.

Further evidence of losses may be found in various numbers of "Gardeners' Chronicles", as in an anonymous article as follows: "Many complaints have been heard regarding the behavior of Japanese longiflorum lilies. The loss to both private and commercial growers has been the failure of large proportion of the bulbs to produce useful plants and flowers. -- (Two illustrations show the rosette type and curly tip type, and one apparently healthy plant in a pot of two diseased ones, although the healthy one has leaves with a tendency to roll and crinkle.) The plant with the curling foliage is ready for the dump because if it ever gets to blooming the blooms will probably be twisted and deformed --- percentage of bulbs of this year (1902) show from 15 to 50 percent diseased--. One grower discarded 15,000 out of 55,000 plants. ---another grower says his loss was 1400 out of 4000 plants. --- Mr. S. Suzuki of the Yokahama nurseries explains the cause of the longiflorum malady as due wholly to the practice of digging bulbs before they are mature. ---Late harvested bulbs are recommended for forcing." (5)

In Gardening, Sept. 1895: F.C.C., Bath, Maine, reports that the lily disease has never been present to be diagnosed as such, but goes on to describe the characteristic mottling of the leaves. ---No use to grow seedlings close by because

these may take disease easily. Seedlings have been grown three to five years and then lost due to this disease." (6)

The above figures are in no manner exceptional. Observations on various other lots of bulbs showed much the same sort of percentages, and it is believed that the figures are typical.

The effects of this disease in the production of loss are further illustrated by the change of economic practice which it is thought the disease brought about. For years the Easter lily was grown almost exclusively in Bermuda, so that the lily itself was called by many the Bermuda lily. The growers began to find that excessive prevalence of the disease caused forcing of Bermuda grown bulbs to be unprofitable because of the great loss. For this reason, more hardy varieties were sought and a very profitable industry passed out of the control of the Bermuda growers and the business went into the hands of the Japanese. After some years of depression and low volume of trade the industry in Bermuda is slowly struggling to regain its position and is slowly increasing in volume. During the past ten years the shipment of lily bulbs from Bermuda has been as follows:

1913----------	2,357 cases
1914----------	941 cases
1915----------	881 cases
1916----------	1,224 cases
1917----------	1,009 cases
1918----------	823 cases
1919----------	890 cases
1920----------	749 cases
1921----------	936 cases
1922----------	1,004 cases

In 1922, 354,040 lily bulbs of the harrisii type were shipped into the United States. G. E. Winters, Inspector of

Produce in Bermuda, states that the larger proportion of the lily bulbs that he observed were of excellent quality but there also are some which are not worh a farmer's while to spend his time cultivating.

As will be seen by these introductory statements, the Bermuda lily disease is a subject which arouses the interest of anyone concerned with floricultural crops. It is one of the most important diseases of greenhouse ornamentals and one about which very little is known. Since the early description by Woods, no one has investigated the disease nor have any suggestions been made as to its etiology. Because of its importance and the interest which at present is being shown in somewhat similar diseases of unknown etiology, the writer has carried on a series of investigations during the past two years at the Michigan Agricultural College.

The purpose of this investigation was to secure information as to the nature of this disease. Is it a non-infectious disease merely caused by variations in the temperature factor, etc., or are we dealing with a specific disease caused by some parasite or virus?

Names applied to the Varieties of the Easter Lily.

At the present time there are prevalent erroneous uses of varietal names for species names among the florists and horticulturists. The names of the species and varieties of this genus have been made after the usual method of botanical classification. A common error, for example, that the writer has noticed many times is the use of the name Lilium giganteum as the name for the giganteum variety of Lilium longiflorum.

This use would make much confusion possible because there is a true species of this genus by the name of giganteum that is very pronouncedly different from the variety of the same name. These differences are plainly shown in the following discussion of the two. Lilium giganteum proper is a native of the Himalaya Mountains and is known as the Giant Lily. It has from 12 to 20 flowers on each stalk that are tinged with purple inside and green outside, these flowers being 5 inches wide and 6 to 9 inches long. The leaves are heart shaped and a height of 10 to 14 feet is common for the plant.

Lilium longiflorum giganteum, known as the Easter lily, is a native of Japan and ordinarily is about three feet in height producing 3 to 7 flowers on the average, (although there may be from 1 to 10 flowers produced) which are almost pure white. Therefore, it is quite evident that the differences are very pronounced botanically but commercial terminology fails to differentiate between them. There are other errors of the same nature prevalent in calling varieties species which are not correct because the differences of these varieties are not sufficient in number nor are they important enough to merit their promotion to species. The fact that there is common error in the designation of these lilies has lead to confusion in the various discussions of the disease, particularly in trade papers. In this article, the terminology of the systematist will be adhered to and the names used are those given in Bailey's "Standard Cyclopaedia of Horticulture".

Easter Lily in Health and Disease.

In order to describe a plant disease it is necessary to consider the deviations of a diseased plant from a normal one. In the disease in question, we are dealing with a series of symptoms which are variable with the conditions of growth, which at times are evanescent and far less precisely definite than the symptoms or signs accompanying most plant diseases. Accordingly it seems desirable to establish the normal by giving a brief description of the lily plant in health. For this purpose the species Lilium longiflorum is taken as the type and its characteristics are follows:

The Bulb.

The bulb is 2-4 inches in diameter, sometimes nearly globular. It is composed of scales more or less loosely imbricated, which terminate at the apex or growing axis. The healthy bulb has a white or yellowish color.

The Stem.

The stem arises from the center of the bulb and is stout, 1/2 to 3/4 inches in diameter, and smooth, growing ordinarily from 1 to 3 feet high, having a bright green color, sometimes tinged reddish brown at the base.

The Leaves.

The leaves are usually 20-40 in number, horizontal, with the upper ones semi erect, and are 3-5 inches in length and 1/8 to 1/2 inch in width. They are normally dark green in color and show little, if any, marking between the veins. Healthy leaves show no tendency toward twisting or rolling.

The flowers.

The flowers may vary in number from 1-10, although the average with large bulbs is 6 or 7. They are usually 4-6 inches in length and nearly as wide. The color is a pure waxy white, sometimes tinged with green near the base. A deliciously fragrant odor is given off.

The varietal differences are slight and seem to be based, in part, upon vigor of growth, shape of blossoms and stem color. It is rather questionable whether the names of the varieties are correctly applied by commercial growers and bulb dealers, or else the commercial lily stocks are made up of many races as yet poorly selected.

Description of Diseased Plant.

The most striking characteristic of the Bermuda lily disease is the prevalence of a mottling or a pattern on the leaves. The leaves, which in health should be a uniform, deep dark green, are variously mottled or marked with yellow areas, and in some advanced cases of the disease they are no longer green, but a greenish yellow, except for random flecks of green. It will be seen at once that the symptoms of the Bermuda lily disease are closely akin to the symptoms deported and described by various workers who have made a detailed study of that class of diseases known as "mosaic". The first noticeable symptom is commonly a slight variation in the color of the leaves, exhibiting the typical mottling evidenced in the light and dark green areas as in mosaic of other species. The markings differ in the lily due only to the parallel

veining typical of this host, the mottled areas occurring between the veins. At the time that the leaves on the shoot begin to unfold from the central axis the markings characteristic of the disease may be seen. Plants are found, however, where the symptoms put in a much later appearance. In some cases the symptoms occur at the close of the blooming season. Sometimes very close observation is necessary to detect the color differences at the beginning, but often as the plant approaches maturity the color difference will become more and more pronounced.

Different environmental conditions greatly affect the expression of leaf mottling as will be shown later. Leaves of the apical regions of a growing plant almost always exhibit the greatest color differentiation. However, the writer has noticed very pronounced variations from this general rule, for example in a plant of Lilium longiflorum giganteum the lower 27 whorls of leaves were noticed to show a marked mottling while the remaining 13 whorls showed absolutely no symptoms of the disease, appearing normal in every respect and producing seven apparently normal flowers. Evidently the conditions for the growth of the plant had become favorable enough for the plant to so grow as to mask the disease, or it may be that conditions became so unfavorable for the development of the disease that it was suppressed.

Sometimes the apical leaves may be markedly discolored but after further growth the yellowish green of the leaf becomes dotted or interspersed with the dark green islands. Very often the diseased condition is hard to recognize when the plant is

young and not of full color, but after a short period in strong light the disease becomes pronounced.

The common form of this disease consists of yellow flecks in the normal green of the leaf. These yellow spots become lighter and lighter in color until in some cases dry areas result. However this latter stage only occurs in the more severely diseased plants and therefore occurred only in a small percentage of the plants under observation. In some of these more severe cases the entire foliage had a pock-marked appearance, resemoling the description of "Pockenkrankheiten" described in Iwanowski's "Ueber die Mosaikkrankheiten der Pflanzen".

The Stem.

The only difference in the stem is that a stunting may occur in the severe types of the disease. No mottling or other color variations were ever noticed in the stems of diseased plants.

The Bulb.

It is impossible to diagnose a diseased plant from an examination of the bulb because as far as could be determined there were no visible symptoms on the bulb. However, it is quite logical to think that material injury is done to the bulb due to lessened activity of the leaf, and that this injury would eventually become noticeable.

The Flower.

In cases of severely infected plants the flower yield is materially decreased. In plants found to be infected at

the time of emergence from the bulb the flowers were rather reduced in size, and in some cases were noticed to be badly twisted and otherwise misshapen. Such plants are rendered unsalable because of their unsightliness, and therefore are a total loss to the grower. The flowers are even made unfit for use as cut flowers due to the attack of this disease.

Spindle Leaf Type of Disease.

In a small percentage of the diseased plants under cultivation a peculiar type of leaf was noticed. The leaves of such plants grew to their normal length while they were very narrow, only about 1/2 their normal width, and occurring in less number on the flower stalk. Sometimes in connection with this leaf condition a distinct mottling was present on the leaves. Such plants grew to normal height, the stalk being somewhat less in diameter than stalks of normal plants. Never was more than one flower noticed to be matured on such plants. The plant was thereby rendered highly undesirable for commercial purposes and was discarded by the grower. In a few cases the normal stalk development did not take place, the plant merely consisting of a clump of spindling leaves on a very short stem.

Leaf Droop Type.

Another interesting type of disease was noticed occurring somewhat more frequently than the spindle leaf type. The plant would start to grow normally, producing several whorls of leaves showing in most cases a distinct mottling, then the leaves would begin to droop over from the tips downward, sometimes becoming sufficiently reflexed to touch the stalk underneath slightly

below the point of leaf attachment. The leaves forming at the tip would continue to develop this typical curling and the whole plant would, with the exception of the basal leaves, show the curling. This seemed to be the most severe type of the disease and the plant would very soon show the stunting effect, that is the change from an upright habit to a low, squatting habit. All plants of this nature were dwarfed, about 1/5 natural height, and in no case was it noticed that the buds that were set blossomed. Hence, the plants of this type were total losses to the grower. #

Hosts attacked by this disease.

During the course of this work and from publications the following plants have been recognized as subject to this disease.

Lilium longiflorum eximium* (Severely affected (Woods) (26)
Lilium longiflorum giganteum (Susceptible but tolerant).
Lilium longiflorum formosum (Susceptible but tolerant).
Lilium speciosum rubrum (one plant observed affected).
Lilium candidum.
Lilium superbum.
Lilium auratum.

It is quite likely that further observations upon a wider range of hosts would show still other species affected by the disease.

#Severely infected plants of this type may present a rosetted appearance. These rosetted plants grew to only about 1/3 to 1/4 normal height and the leaves appeared very close together on the flower stalk.

*Synonymous with Harrisii of the trade.

Conditions Likely to Confusion with Disease.

There is a mite that attacks the roots, bulbs and stem of the lily that causes a condition of the plant that is somewhat likely to be mistaken for pathological conditions of the Bermuda lily disease. The plant from the beginning exhibits very backward tendencies, presenting a very stunted and dwarfed appearance. The leaves will be of a generally pallid nature and tend to droop very much, presenting a leaf droop appearance. The stem slightly above the point of emergence from the bulb will be much larger in diameter than normal. The leaves at this point are shed prematurely. Upon cutting open the stem, a white sluggish mite with brown legs may be seen. When mature, this mite is about the size of a mustard seed. They are found in large numbers at the point of swelling and keep boring their way into perfectly healthy tissue. Woods says "No root is immune from their attacks, but they are most destructive at the base of the bulbs which they may often completely honeycomb. ---They do not stop here, however, but follow the roots up into the bulb, injuring them to such an extent that they are made useless to the plant". The mite was determined* to be Rhizoglyphus hyacinthi and evidently the same in nature as the Rhizoglyphus echinopus of Woods. (25)

Aphids that attack the succulent leaves of the lily may cause discolored areas that may be mistaken as marks of the lily disease. Besides the color variation due to aphid injury there may be a twisting and curling of the leaves due to the activities of these insects. These two effects may easily be mistaken for the curling that is sometimes evident in the disease in question.

*Determination by Miss Eugenia McDaniel, Entomology Dept.

Certain unfavorable growing conditions may also cause yellowing of lower leaves but these conditions are entirely different from symptoms of the Bermuda lily disease, here under consideration.

Etiology.

The lily disease is one of unknown etiology. It will be seen from the foregoing descriptions of diseased lilies that this disease in practically all of its characteristics simulates very closely the mosaic disease described for a wide range of hosts. Every symptom described can be watched by similar appearances in plants affected with the mosaic disease. The spindle leaf and the leaf droop types described also find their counterparts in the virus diseases of other hosts.

The mosaic diseases are of unknown cause. They are a class of diseases showing marked infectiousness and careful work has shown that aphids are vectors of the infectious principle or virus. Because of this close similarity of the mosaic disease to the disease under investigation it is pertinent to consider the suggestions advanced concerning the mosaic diseases. There are many hypotheses as to the nature of the etiological factor in mosaic, each hypothesis having been at one time more or less widely accepted.

(1) Mayer (21), Ivanowski (17), Boncquet (7), and Hunger (16) have all reported the finding of bacteria in the cells and tissues of diseased plants, and attributed the causation of the disease to these bacteria. Ivanowski (17) cultivated these bacteria on an artificial medium and by inoculations was able to produce pronounced mosaic symptoms. The other writers

named above reported similar results but later work showed that the causation of mosaic diseases in general could not be attributed to any of the organisms found in connection with the disease. The infection obtained by these workers was explained in that some of the infective principle must have been inoculated along with the bacteria thereby leading to an infection.

(2) Following the suggestion of the bacteria as the etiological factor, several workers, Woods (26), Heintzel(16), Chapman (11), and Freiburg (14) attribute the disease to an enzyme. Woods (26) suggests that an excessive development of oxidizing enzymes prevents the normal development of chlorophyll in the chloroplasts, hence the lighter colored areas in the leaf. Allard destroyed oxidase by the use of hydrogen peroxide but still obtained an infective principle, but by destroying the infective principle and leaving the oxidase he was unable to obtain infection. From the results obtained by subsequent investigators Freiburg's statement (14) that "from the above it is obvious that when injecting the infected substance obtained from a diseased plant into a healthy plant, we are handling an enzyme and not an organism" does not seem supported by incontrovertible evidence.

(3) Beijerinck (8), although at first favoring the bacterial theory, later proposed the theory that mosaic disease is caused by a "contagium vivum fluidum", the causal agent in this case being non corpuscular and water soluble. Lodewijks (20) in 1911 not only postulates a virus theory, but also the development of an antivirus in healthy tissue. However, Lodewijks failed to take all factors into consideration and experiments performed later failed to substantiate positively his work.

The term virus, in a general sense, includes ultramicroscopic organisms or an infective principle of unknown type. Duggar (13) by the use of ultra filters, of which the pore measurements could be determined found the particles of the infective principle to be in the neighborhood of 30 to 40 millimicrons.

(4) "Amoeba" Theory. Lately Matz (21) and Kunkel (19) have published results of studies in which they suggest the possibility of an amoeba-like body being the cause of mosaic in sugar cane and corn. Matz found in parenchyma cells of internal canker in the stem of sugar cane and in leaf sheaths, a peculiar densely but finely granulated and slightly browned plasma. Usually a group of cells were so filled. Throughout the mass hyaline bodies less than one micron in length are found, and in a test of externally sterilized material kept in a moist chamber motility was observed after eight days. The substance "resembling Plasmodium" was found to be "constantly associated with yellow striped cane in an advanced stage of the disease."

Kunkel (19) working on Hippeastrum (a close relative of the lily) corroborates the findings of Matz and states further that similar "plasma" filled cells are observable in diseased sugar cane tissue. However, he describes an intracellular body of a different type showing great variation in size, and in early stages of the disease these are so minute that it is extremely difficult to see under high magnification. These bodies finally reach a size where they are conspicuous. They were never observed to be spherical, but are amoeboid in shape and always closely associated with the cell nucleus, in fact they are usually attached to it. The host nucleus enlarges and is often deeply imbedded in the body. Sometimes a membrane is present

but in most cases the body appears to be naked and all attempts to demonstrate a nucleus have failed. Host cells containing these bodies may enlarge rapidly or rather slowly, and is usual to find that the more rapidly hypertrophied cells break down the more readily.

It is interesting to recall here that Ivanowski described and depicted somewhat similar bodies closely appressed to the nuclei in tobacco mosaic.

(5) Present studies concerning etiology. Dickson (12) in his "Studies concerning Mosaic Diseases" states that in his study of hundreds of sections he has in no instance observed any such bodies as those described by Kunkel (19) in corn mosaic. However, he found more or less amoeboid hyaline bodies in diseased cells of leaves but concludes them to be more secondary in nature. On the other hand, in free hand sections of leaves in advanced stages of the disease there are often to be seen, among the hyaline bodies in spongy mesophyll cells and trichomes, smaller bodies having an erratic movement, and further appearing similar to a flagellate in nature, but in spite of careful killing no definite proof can be made from non-living sections. A bacterial flora was found to be present in diseased leaves in almost every case, and Dickson (12) was unable to isolate a protozoan organism from the cultures. The isolation of a protozoan was doubly difficult because of a possible change in form.

In sections of tobacco killed in concentrated alcoholic solution of Mercuric chloride and stained according to Hiemsa's method, Dickson (12) found minute, dark staining bodies, 3 microns long and slightly less in width, sometimes in great numbers in the border parenchyma of the vascular tissues of

diseased leaves and was not able to find these in healthy leaves. These bodies may be observed in close contact with the walls of the chlorenchyma and in some cases were seen surrounding the chloroplasts. They are apparently the same bodies of Ivanowski and possibly the same as mentioned by Boncquet and Hunger. The occurrence of such bodies in diseased tissue does not prove that they are other than secondary or symbiotic, but there is a possibility that they are akin to the chlamydozoa mentioned in discussions of "virus" diseases of man. Cultural attempts were made by Dickson (12), but although he was successful in getting a turbidity in broth culture of zoogloeae and of streptococcus-like chains, also succeeding in causing infection in 12 out of 15 inoculated plants, his methods are open to criticism because he inoculated the plants with virus as well as with the streptococcus-like organism, as there were no separations of the bacteria from the plant juice. He was not able to culture on agar or gelatin plates any organisms that could be definitely designated as causing the disease, i.e. no organisms such as Ivanowski (16) reported on gelatine or on agar plates.

Allard (2) in his work on tobacco, has found that plant juice of heavily infected plants is very resistant to strong acid solutions and retains its infectivity for some time after being treated with solutions of strengths that would ordinarily destroy fungi and bacteria. Filtration experiments show that the infective principle may pass through the Chamberlain F filters and still retain its infectivity. Further, certain aphids such as Myzus persicae and Macrosiphum solanifolii have been found to be capable of transmitting this infective principle from plant to plant, even from plants that are not related, to plants

that may be infected. The virus may be preserved for some time in alcoholic solutions. Further, Allard was able to transmit the disease by merely rubbing an infected plant with the thumb and then rubbing a healthy leaf with the thumb, thereby getting infection through glandular hairs. In all, Allard has found the causative principle to be highly infectious and has succeeded in causing infection at will. There has been no definite organism or organisms proven to be the cause of the disease, and no successful attempts have been made to cultivate the virus upon artificial media. The "virus" has been found to be filtrable through rather fine filters. Inoculations made upon a healthy potato from a diseased potato seldom show infection before the next growing season. Many of the mosaic-causing agents have a very long incubation period while others may show signs or symptoms in a very few days. Tests upon the oxidase content of healthy and diseased plants have failed to reveal anything conclusive concerning the etiology of the disease.

The pathologist, although rapidly becoming more and more acquainted with the nature of the disease, its symptoms and its workings, has a large field for research in the attempts to isolate the causative agent or the causative organism, if there be an organism involved in the production of the disease. The etiology remains a puzzle yet to be solved by intense and careful work.

Experimental Work.

Observations of Commercial Crop #1.

Table I.

Tabulated reports on the effects of the lily disease on plants growing under normal greenhouse conditions. Record as to presence or absence of disease.

Plant No.	1-21-24	2-2-24	2-29-24	No. Blossoms	Remarks.
11	-	-	-	1	
28	-	±	±	12	Exceptionally high yield of normal flowers
1	++	++	++	6	Diseased plant matured 6 good blooms despite disease.
5a	+++	+++	+++	3	Runt, flowers rather small.
5b	++	++	++	3	Almost normal in size but much diseased.
6a	++	++	++	2	
6b	++	++	++	2	
6c	+	+	+	2	
9	+++	+++	+++	1	Diseased condition approaching rosetted condition.
10	+++	++	++	3	Plant very pale at beginning, later becoming streaked. Blossoms small.
12	++	++	++	4	Apparently normal flowers.
13	++	++	++	3	
14a	++	+	+	4	At first the leaves were clasping the stalk later becoming free; flowers apparently normal.
14b	++	+	+	3	
19a	++	++	++	2	
19b	++	++	++	2	
19c	++	++	++	2	
20a	+	+	+	3	
20b	-	+	+	2	Plant became diseased later than other shoot

Table I continued.

Plant No.	1-21-24	2-[illegible]-24	2-29-24	No. Blossoms	Remarks.
21a	++	++	++	3	
21b	+	+	+	3	
22	+	+	+	4	Plant dwarfed, yet matured 4 apparently normal flowers.
25a	++	+	+	2	Plants in both cases apparently succeeded in partially recovering
25b	++	+	+	2	
2	+	+	+	7	Plant showed rosette-like appearance yet 7 normal flowers matured.
3	+	+	+	3	
7a	+	+	+	4	
7b	+	+	+	2	
8a	++	++	++	1	
8b	+	++	++	2	
8c	-	+	+	3	Plant contracted disease later.
17	+	+	+	3	Aphids present on 1-21-24 and flowers misshapen. Unsalable.
4a	+	+	+	1	Spindle leaf type. Mottled, producing but one flower.
4b	+	+	+	0	Discarded both.
15	-	-	-	1	Plants showed stunting but no symptoms of disease.
16	+	+	+		Discarded. Leaf droop type.
18	-	+	+	4	Leaf droop & twisted. Flowers apparently normal.
23	++	++	+	1	Spindle leaf type. Plant undesirable.
24	+	+	+	-	Spindle leaf, discarde
26	+	+	+	1	Spindle leaf.
27	+	+	+	1	Leaf droop type, plant greatly injured.

Note: When there are two or more shoots in the same pot they are designated above as a, b and c.

- = Healthy, ± = Suspicious, + = Mottled (mild), +++ = Very severe.

Observations of Commercial Crop #2.

Table II.

Plant No.	1-21-24	2-2-24	2-16-24	2-29-24	No. Blossoms	Remarks.
1	+	+	+	+	2	Curling & twisting leaves; flowers malformed.
2	++	++	+	+	?	Record lost as plant was sold between visits.
3	-	-	-	-	2	
4	++	+	+	+	12	Great number of flowers in spite of severe disease at start.
5	++	+	+	+	9	
6	-	-	-	-	5	
7	-	-	-	-	3	
8	±	-	-	-	4	
9	-	-	-	-	5	
10	+	±	+	+	4	
11	-	+	+	+	3	Healthy plant becoming diseased.
12	-	-	-	-	2	
13	-	+	++	++	2	Aphids present, disease becoming more severe.
14	-	±	±	+	5	Healthy plant attacked and becoming diseased.
15	-	+	+	+	4	
16	+	+	+	+	4	
17	-	-	-	-	3	
18	+	±	±	±	3	
19	+	+	+	+	2	
20	-	-	-	-	4	
21	++	++	++	++	1	Unsalable.
22	+	+	+	+	3	

Table II continued.

Plant No.	1-21-24	2-2-24	2-16-24	2-29-24	No. Blossoms	Remarks
23	-	-	-	-	4	
24	+	+	+	+	3	
25	+	+	+	+	7	
26	-	-	-	-	1	Mechanical injury caused malformed flower.
27	-	-	-	-	5	
28	-	-	-	-	Lost	
29	-	-	-	-	8	
30	-	-	+	+	6	Aphids present 2-16. Flowers apparently normal.
31	-	-	-	-	6	
32a	+	+	+	+	4	
32b	+	+	+	+	4	
33	-	-	-	-	4	
34	-	-	-	-	5	
35	-	±	+	+	3	Plant became diseased after 2nd observation.
36	-	-	-	-	5	
37	-	-	-	-	4	
38	-	-	±	+	3	Flowers malformed presumably due to aphid injury.
39	-	-	+	+	3	
40	+	+	++	++	4	
41	+	±	±	-	3	Upper leaves outgrew the disease.
42	+	+	+	+	4	
43	+	++	+++	+++		Thrown out.
44	+	+	+	+	3	Flowers misshapen.
45	-	-	-	-	4	

- = Healthy, ± = Suspicious, + = Mottled (mild), ++ = Severe, and +++ = Very severe.

From the two foregoing tables* a careful study of diseased plants under greenhouse conditions may be made, and it may be seen that plants in the greenhouse differ greatly in their reactions to the disease. However, it will be noticed that a plant once attacked, very seldom, if ever, completely recovers. This latter fact is evidenced in the first of the two tables which is a study of the workings of the diseased plants more than a study of an average run of plants as is shown in the second table. Some of the severely diseased plants show an average number of apparently normal flowers. The reason for this is unknown except that it is known that plants of this variety are tolerant of the disease to a marked degree. Healthy plants may, from the start, show great vigor, and continue healthy throughout their life, or may at some time in their period of growth develop the symptomatic mottling of the leaves, finally coming down with the disease. Even after becoming very noticeably diseased these plants may continue their growth and produce an average number of apparently normal flowers. The spindle leaf type and the leaf droop type evidently are the most severely diseased either in the presence or the absence of a mottled condition, the plants in such cases being often worthless or maturing only a few, often malformed flowers. In cases where the same bulb has sent out two or more shoots there may at the beginning be symptoms only on one of the shoots, but in every case the entire number of shoots became infected

*Acknowledgment is made to the Smith Floral Company, Lansing, for facilities furnished for this work.

before the plant had finished its cycle of growth. The writer, in following the life growth of the plant, was able to study the disease at regular intervals and to determine various effects of the disease upon the production of flowers under the forcing methods employed in the ordinary floral greenhouse. It was observed that diseased plants were able to mature flowers, that is in cases where the development of the disease was held in check by the ordinary greenhouse care. The superintendent of the greenhouse was well satisfied with the results obtained from the plants in question from the standpoint of commercial flowers, because only a few of the plants were discarded and on the whole a high percent of flowers was obtained from this crop.

In some cases it will be noted that the heaviest diseased plants produce the normal number of flowers which in no manner show the symptoms of the disease or show any harmful effects of the disease; however, it should be remembered that this variety of lilies under observation is tolerant of the disease to a marked extent and the conclusions about flower production in no way negate the former statements about the severity of this disease attacking the more susceptible varieties.

Having observed an apparent spread of the Bermuda lily disease in the greenhouse, the writer attempted to determine how this spread would be affected by the removal of infected plants, as soon as they appeared, from the locality of the healthy plants. To do this one hundred bulbs were selected and evenly divided according to size, general appearance, etc. These bulbs were planted in 5-inch pots in ordinary greenhouse compost. Plants numbering from 1 to 50 were kept in the Botany greenhouse at

the college and plants 51 to 100 inclusive were removed to another greenhouse where lilies had not grown and which had been free from plants since July, a period of several months. The plants 1 to 50 kept in the Botany greenhouse were allowed to grow without the removal of any diseased plants as a check upon the plants 51 to 100 kept in the other greenhouse, and from which all diseased plants were to be removed immediately upon their appearance. As the plants in the latter greenhouse showed mottling they were removed until the entire lot of fifty had been removed, showing a 100% infection in spite of the removal of all diseased plants. The check showed 96% diseased plants, or 48 out of 50 plants.* The writer hoped to demonstrate the practicability of the removal of diseased plants as a method in halting the spread of the disease, this, of course, to be done in conjunction with control of the aphid situations. It may be seen that the results here were not of the nature to permit the drawing of conclusions of the practicability of roguing experiments, due to the excessive percentage of disease apparently inherent in the bulbs.

Infective Principle is Carried Over in Bulbs.

Fifteen bulbs were chosen for this experiment by picking out bulbs of average size, shape, general appearance and general conditions. Soil, ordinary greenhouse compost, was autoclaved

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*Considerable trouble was experienced here due to an abundance of aphids which put in their appearance. The aphid was determined as being Siphonophora circumflexa.

for an hour at five pounds pressure. Tall glass battery jars were filled approximately one-third full of the autoclaved soil and the bulbs were planted at a depth of one and a half to two inches. Cheesecloth was then tied over the mouth of the jar and the jars were placed in a well lighted place in the greenhouse and the bulbs allowed to grow. The cheesecloth allowed aeration, but kept out all insect pests. The table below will show the results obtained in this experiment.

Table III.

Bulb No.	Date planted.	Results taken 3-29-24.	Results taken 5-1-24.
313	2-18-24	++	++
314	"	++	++
315	" (2 sprouts)	1 +++, 1 +	1 +++, 1 +
316	"	+	+
317	"	++ Died	
318	"	++	++
319	"	± (Very mild)	± (Mild)
320	"	+	±
321	"	-	-
322	"	++	++
323	"	+++	+++
324	"	+	+
325	"	-	-
326	"	+	+
327	"	±	±

- = Healthy
± = Suspicious
+ = Mild
++ = Severe
+++ = Very severe.

From the foregoing table it may be seen that the disease showed up even in plants from bulbs grown in sterile soil and grown under insect free conditions in 86 2/3 of the plants under observation. Inasmuch as there was no entry for insect carriers of the infective principle except those that could possibly get in through the bulbs, and since upon careful scrutiny of all the plants no insects were seen at any time during their period of growth, the source of the disease is evidently the bulbs. From this experiment it may be seen that the disease may be carried over the storage period in the bulb only to find expression when the bulb grows again in the next growing season.

Are Aphids or their Eggs Carried in Soil in Which the Bulbs are Packed?

The bulbs used by the writer were received in a shipping box packed in a sandy clay. A small quantity of this packing soil was sifted in order to remove the coarser particles and to remove all the loose bud scales that had become detached in transit. Portions of this soil were then put into six two-quart Mason jars and lettuce seed was sown. In a few days the lettuce had come up but there were no aphids or insects of any kind present on the leaves during its subsequent growth. This would tend to indicate that the soil in this case in which the bulbs were packed did not contain aphid or other insect eggs. The results here are not taken as conclusive for all conditions, since it has been shown that insect enemies of plants are commonly harbored by packing material, especially soil. It is likely that the soil used was not the soil in which the plants grew.

The Effect of Hot Water upon Plants from Bulbs.

Knowing that hot water treatment is often successfully used in the treatment of parasites that may be present in bulbs, (23) the writer undertook to determine the effects of hot water treatment of bulbs upon the appearance of the lily disease. For this purpose one hundred average bulbs were chosen from about three hundred bulbs and divided into lots of twenty five bulbs each. Another group of twenty five bulbs were selected as checks. All bulbs except the checks were treated after the manner shown in the following table.

Table IV.

No. of bulbs.	Date planted.	Temp.	Time.	No. of treatments.	% growth.	% diseased.
25	2-14-24	43°C.	15 min.	3	100	88%
25	"	45°C.	12 min.	3	100	84%
25	"	47°C.	10 min.	3	100	92%
25	"	50°C.	8 min.	3	100	88%
25 checks	"	Check	Check	Check	100	84%

The bulbs were submitted to the foregoing treatment on three consecutive days and then planted in six inch pots in ordinary greenhouse compost. The hot water apparently exercised no harm to the bulbs allowed to remain in it the greatest length of time, nor did the lower temperature for a greater length of time because in 100% of all cases a healthy sprout resulted and all subsequent growth was normal in all respects. The percentage of diseased plants resulting showed no evidence of the successful diminution of the disease to any great extent such that it might

be considered as a possible method of control of the Bermuda lily disease. Because of the unfavorable results obtained here further experimentation with hot water treatment was not carried on.

Effect of Heat.

Certain investigators of the mosaic diseases of plants have used varying degrees of heat in order to study the effect of that agent upon the mottling as exhibited in the leaves of diseased plants. Certain of these investigators claim that they have noticed an appreciable change inthe degree of mottling. With this idea in mind the writer selected a pot having two shoots of Lilium with almost identical conditions of disease, each part of the plant being mottled to the same degree. A temperature chamber arrangement was so made that this plant could be placed so that one part of the foliage would be on one side of a glass partition and the other part would be on the other side. An electric light bulb was then introduced intoone half of this temperature chamber and the other half was left unheated. The electric light bulb was carefully wrapped with asbestos so that there would be no unequal light effects. In this way it was possible to secure an average difference of 6°C. between the two sides of the chamber. The unheated side showed a temperature of 22°C. $\pm$ 1°C. and the other side showed a temperature of 28° $\pm$ 1°C. As this experiment was carried on in the laboratory it was necessary to introduce artificial light so that the photosynthetic process would not be interfered with too greatly. The temperature chamber containing the plant was allowed to stand a week, the plant being constantly

subjected to the difference in temperature. At the end of this time the plant was closely examined for any change that could in any way be attributed to the effect of the increased temperature. There was no marked difference in the conditions of the two parts of the plant, nor was there any difference in the plant as a whole. This experiment was carried on on three occasions and no different results were obtained at this temperature.

Four other diseased plants were then taken and subjected to a somewhat higher temperature. The temperature in this case was 35° to 36°C. Artificial light was also introduced to supply the light necessary for proper plant functioning. Plants in the same room not subject to heat were kept as checks. Those plants at this high temperature developed a pronounced pallid appearance and in a few cases certain of the leaves of the plant showed evidence of injury due to the heat. The development of this pallid condition corresponds to that condition described by Dickson (12). This pallor that may appear naturally makes the detection of the mottled areas more difficult because the lessening in amount of color takes place chiefly in the dark green areas. However it is thought that the difference in appearance is due to a generalized plant paling rather than to any modification of the diseased tissue. Hence, it may be concluded from this experiment that temperatures ranging from 25°C to 35°C exercise no material influence upon the Bermuda lily disease. Temperatures over 35°C materially harmed the plants subjected to it.

Effect of Shading.

Twenty five plants were placed in a cold frame and shaded. The shading effect was brought about by the nailing of cheese cloth over the glass frame ordinarily covering the plants. Twenty five were left unshaded as a check. After four weeks no change could be noticed in the plant thus shaded, and no difference was visible between the shaded and the unshaded plants. Hence, it was concluded that shading exercised no effect upon the diseased plants and that marking of symptoms had not occurred under the light conditions imposed. It should be noted, however, that the weather conditions during this period were unusually cold, and cloudy days were numerous.

Effect of Continuous Light.

Six diseased plants were subjected to continuous light for five days and then compared with diseased plants not subjected to the continuous light, and were found to be of a slightly lighter color than the others. Otherwise there was no change. Another test under the same conditions gave the same results. The soil and pots were ordinary greenhouse compost and pots that were at hand.

Seedling Culture.

Owing to the great abundance of infection that was apparently within the bulbs as they were received, no direct attempts were made to cause artificial infection of plants forced from bulbs. For inoculation purposes, plants were grown from seeds received from David Griffith of the U. S. Department of Agriculture.

For this purpose the seedlings were germinated in sand flats away from all lilies or mosaic plants and then transplanted after the sprouts were about an inch to an inch and a half in length into 2-quart Mason jars* about one-fourth full of soil that had been autoclaved for an hour at 5 pounds pressure in order to insure the killing of insects and insect eggs. Great care was used in watering these plants because of the ease of getting an excessive amount of water and thereby hindering the plant growth. Pieces of cheesecloth were securely fastened over the tops of these jars so that no insects could gain entrance into the jars. By this method of treatment the only infection that could be obtained would be through the seed or through artificial methods. Seeds planted in January germinated the latter part of February and in a week were ready for transplantation. Close scrutiny of the seedlings showed no evidence of the disease being seed borne. Observation of uninoculated seedlings to the number of 160 has shown absolutely no sign of disease in any of the seedlings grown. However, it was impossible to ascertain whether or not the seeds that were planted came from diseased parents, and lack of time prevented the production of seeds from such parents and the subsequent germination of the same. At least in 165 seedlings grown there was no evidence of the disease being seed borne. For all inoculations seedlings were used and the results given are those obtained of artificial causation of the disease as secured from seedlings

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*For this purpose, in order not to increase the quantity of light, 2-quart jars of white glass were chiefly used.

used.

Again emphasis must be placed upon the difficulty of growing seedlings successfully. By nature, seedlings of the Genus Lilium are all slow in their manner of growth. Seedlings planted require several years to mature into plants capable of flowering, the usual time being from 3 to 5 years, depending upon the species. Throughout this long preparatory period it is necessary to guard against outside dangers in the form of diseases and insect injuries to which the plants are subject.

Inoculation of Seedlings with Juice.

In 25 plants inoculated with juice from active cases of infection no evidence of infection was present two months later. These inoculations were run in three series, 10, 10 and 5 plants being used, and in each series a different diseased plant was used as the source of the inoculum.

Discussion.

Juice was extracted from a rapidly growing diseased plant and without dilution was inoculated into the growing regions of seedlings after they had reached the two-leaved stage. The plants were segregated and an adequate number of checks were kept on the inoculated plants. Although these plants were inoculated by the placing of juice on the growing region and pricking it into the tissue by means of a dissecting needle, in no case were any symptoms of mottling, leaf droop or spindle leaf noticeable, although daily readings were made after the second day. Some of these inoculations were made and watched for two months but no successful infection was noticeable.

Because of the fact that the plants concerned have bulbs the question occurred whether the Bermuda lily disease, having a marked mosaic likeness, might not be in some way comparable to the mosaic disease of the potato where the symptoms and effects of the mosaic disease fail to show up until the second growing season.

Aphid Tests.

Several strains of Aphids were easily accessible in the greenhouse and upon surrounding plants. Among the aphids that were obtainable were Siphonophora circumflexa (commonly on lilies), and Myzus persicae. Tests made with these two genera of aphids (37 with Siphonophora circumflexa and 25 with Myzus persicae) gave negative results when transferred, after feeding several hours upon a diseased plant, to a healthy seedling and allowed to feed for five days. It is rather difficult to control aphid growth upon such young, succulent seedlings sufficiently to prevent aphid injury to the plants. Sometimes the aphids in feeding upon the plants cause a pseudo-mottled appearance due to their feeding. It is important, therefore, to allow the aphids to feed only a sufficient time to get established and then remove them before they have left any markings that might be confused with the characteristic markings of the disease. These aphids can easily be removed by the use of Black Leaf 40 spray 1:400 without harming the plants to any noticeable extent. However, it is of great importance not to confuse insect injury with any diseased conditions. In no case were there any pathological symptoms present resulting from the insect's feeding that could constitute a logical basis for positive diagnosis of the disease.

The same question arises again as to whether or not these plants will also show mottling during their next growing season. The two aphids named are known to be carriers of the infective principle of mosaic diseases, and Myzus persicae is capable of carrying it to quite a number of different hosts, but apparently does not possess the ability to transmit this disease of lilies, and has never been reported as doing so. No aphids other than those mentioned were used in attempts of aphid transmission of this disease.

Could the Juice of Lily Diseased Plants Cause an Expression on some Annual Plant such as the Tomato, Corn, or Tobacco?

Seedlings of corn, tomato and tobacco were grown and when they had reached the more rapidly growing condition they were inoculated with juice of a severely diseased lily plant. In no case was there evidenced any symptom of mosaic in any of the plants. As we know these three plants are susceptible to the infective principle of mosaic, there must be a slight difference in degree of infectivity of the juice of diseased lilies than in those plants that are more rapidly growing and less subjected to forcing. Perhaps the latter plants named are not susceptible to inoculations of juice from the lily, and perhaps the nature of the invective principle is such that there is no infectivity to such plants.

Cultural Studies.

Small sections of leaves were treated with a 1% solution of chlorazene to kill any surface organisms present. The sections

were then washed in sterile distilled water and then laid on the surface of cornmeal agar that had been previously poured in sterile petri dishes. Fifteen such petri dishes were prepared and placed in places conducive to the growth of organisms. The resulting growths were, with two exceptions, growths of Blue Mold and certain bacillus forms. With two exceptions the bacillus growths were discarded because of their rare appearance. The two exceptions exhibited no tendencies whatsoever to produce any symptoms of the disease when inoculated into healthy seedlings. Further culture studies on common laboratory media failed to show any different results.

Plain non nutrient agar was prepared and to this agar was added filtered plant juice. Extracted plant juice was transferred to these tubes. The tubes were then watched for any appearance of organism growth. In no case was there evidence of growth on the tubes so prepared. However, this is not to be considered strange because the infective principle of diseases of this type has never been cultivated successfully upon any artificial laboratory medium.

The results of this attempted artificial cultivation would tend to indicate that up to the present no definite organism has been isolated upon which can be fixed the causation of the Bermuda lily disease.

Freehand Sections.

Freehand sections were made of the diseased and healthy tissue of various parts of the plant, leaves, stem and bulb. No attempt was made at staining these freehand sections but a comparative study was made of the general shape, size and

structure of healthy and diseased tissues and a study of chloroplasts was also made. Between the diseased and healthy tissue there was no difference to be noticed from this experiment. The general cell shape of the palisade cells was the same and the chloroplast counts and their locations were the same. This, however, does not agree with the work of certain writers who report quite a noticeable difference in the general shape of the palisade cells as well as in the location of chloroplasts in these cells. However, these differences were noticeable only in certain ones of the Solanaceous plants, the potato, tomato, tobacco and petunia. Other writers have failed to find comparable differences between healthy and diseased plants in the same group studied in the same manner.

Juice Examinations.

At the same time with the study of the freehand sections the juice from healthy and diseased plants was also examined but no difference could be seen through the microscopical study of the two.

Discussion of Results.

The results of the experimental work carried on and described in this paper indicate that the Bermuda lily disease differs from mosaic diseases only in the fact that the writer was unable to get infections from inoculations of the juice of diseased plants into the tissues of healthy plants, nor was he able to get a transfer of the disease by the use of aphids known to be carriers of the virus of mosaic diseases. In spite of the fact that no visible pathological conditions were evident, these results can

not be accepted as conclusive evidence that symptoms will not show up at some future time, because this is true in the case of the potato where the tuber is a resting organism functioning similarly to the bulb of the lily. This may be the point at issue because both plants are ordinarily propagated vegetatively by the use of portions of the underground stem. Aside from the above it may be seen from the summary following that the Bermuda lily disease in practically all other aspects measures up to the requirements of the mosaic diseases:

1. The characteristic appearance of mosaic diseases due to the mottling and twisting of the leaves present.

2. There is evidence of a slow insidious spread in the greenhouse under ordinary growing conditions.

3. The Bermuda lily disease has all earmarks of a typical mosaic disease, in that it is persistent within the host, shows differences in virulence according to variety and cultural conditions, and gives evidences with an infected host of gradual increase in area of involvement and severity of effects.

4. No organism has been found concerned with the causation of this disease.

5. The "virus" of this disease is heat-resistant when in an actively growing plant.

6. Although the writer was unable to prove transfer of the disease by aphids, such transfer seems probable. Similarly juice inoculations have not yet caused the disease. A parallel to the Bermuda lily disease is to be found in "peach yellows" which is known to be transmissible by buds, but which has not been shown to be transmissible by juice inoculations or by insect vectors. Peach yellows, by many authorities, is considered of

mosaic nature.

7. In the cases of seedlings under observation there is no evidence that the disease is seed borne.

8. The spread of the disease geographically, and its development under local conditions are identical with the spread and local development of mosaic diseases.

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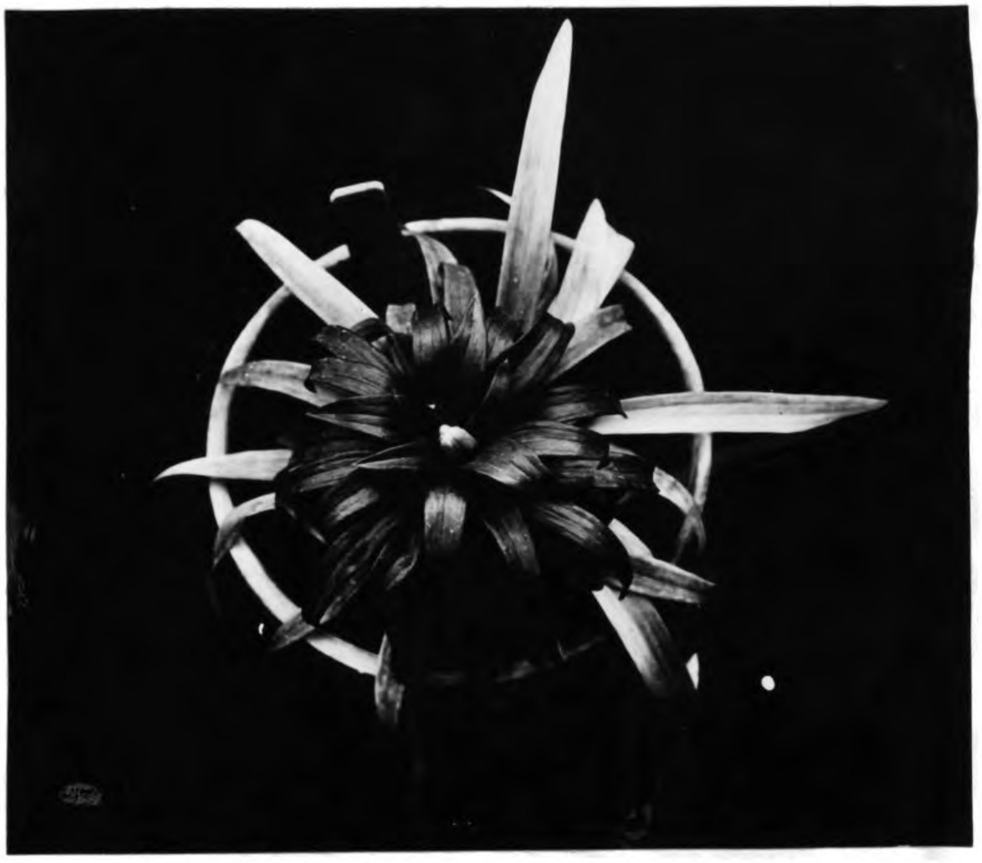

Plate I. Leaf droop type of the Bermuda lily disease.

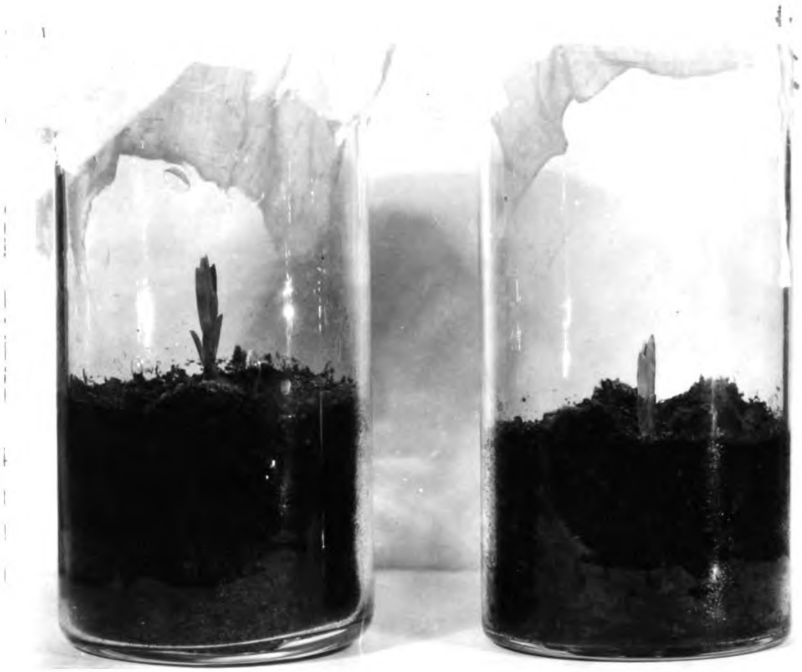

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Plate II. Shoots of lily plants growing in sterile soil and under insect-free conditions.

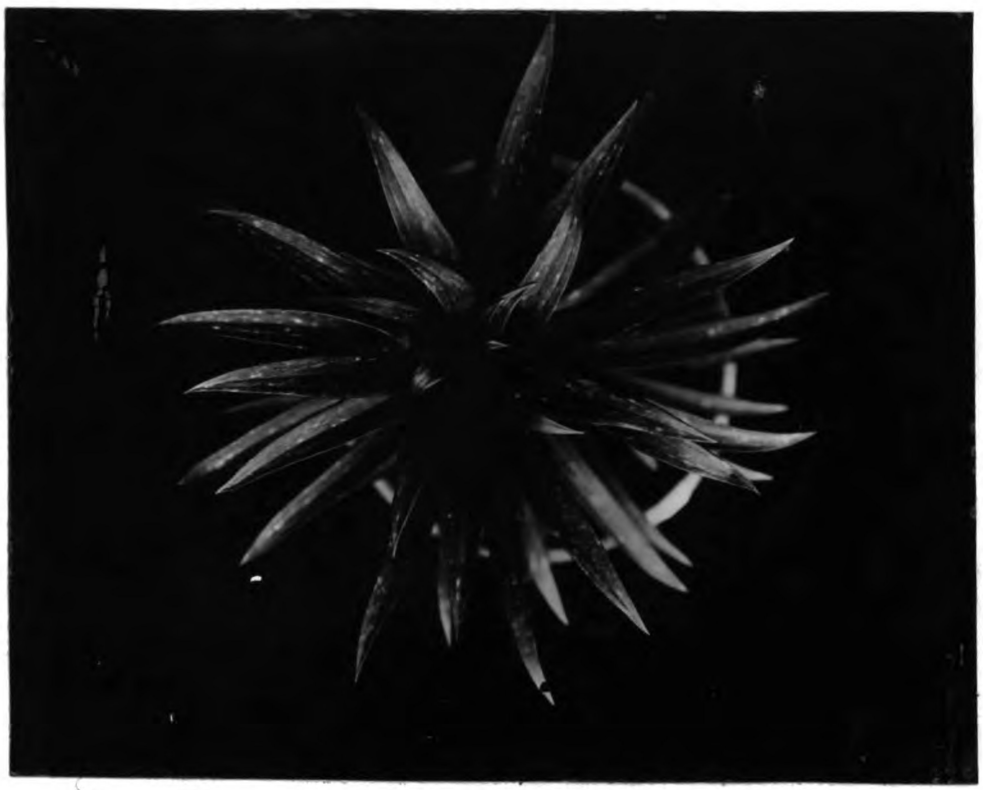

Plate III. Severe leaf mottling on growing plant.

Plate IV. A severely diseased plant in advanced stages.

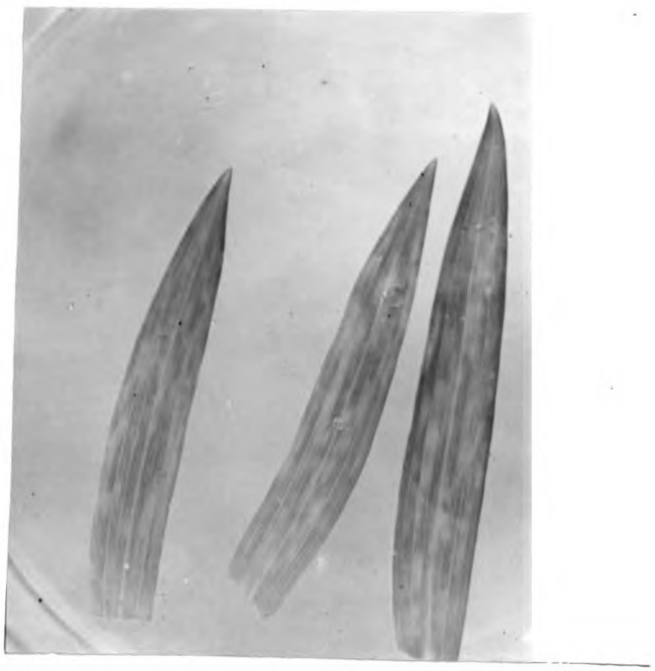

Plate V. Leaves showing mottling. (Photographed under glass.)