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An Etiological and Host Range Study of Celery Mosaic in Utah

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AN ETIOLOGICAL AND HOST RANGE STUDY OF CELERY MOSAIC IN UTAH

by

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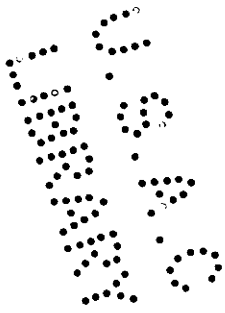

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INTRODUCTION

Celery mosaic is a virus disease of major economic importance in Utah. In years of severe epiphytotics, it has been a limiting factor in celery production. In 1947 losses due to this disease were estimated to exceed 8 per cent of the total crop (17). This estimate does not include losses resulting from reduction in grade or from plants discarded in the packing sheds. The celery acreage in Utah dropped from a high of 950 acres in 1946 to 750 acres in 1947 and dropped again in 1948 to 420 acres. Leaders in the industry attributed this reduction in acreage, in part at least, to losses incurred by the growers from celery mosaic.

Stability and dependability of a highly organized agricultural industry, such as celery production, is essential to the success of the marketing of the product. The significance of celery mosaic as an economic factor and the lack of information concerning the nature of the disease made it imperative that an experiment be conducted to determine the etiology and other characteristics of the causal agent. The purpose of this investigation was to establish the etiology and to make a host range study to provide a sound basis for control recommendations.

This report includes the definite identification of the causal agent, a description of the symptoms of the disease as observed in Utah, inoculation studies by mechanical and insect vectors, and some overwintering studies of the mosaic virus. Included also is a host range study limited to certain plants both crop and weed found in and around celery fields.

MATERIALS AND METHODS

The virus used in this study was obtained from naturally infected celery plants collected in Salt Lake and Utah Counties, Utah. The diseased plants were transplanted to a bench in the greenhouse. All the plants collected were Utah Pascal Variety with the exception of one plant of self-blanching variety obtained from Salt Lake County. Only one series of inoculations to celery was made from the self-blanching plant before it died.

The virus was extracted from the diseased plants either by grinding in a food chopper or, more commonly, by grinding the tissue in a mortar with a pestle. The plant juice was separated from the pulp by squeezing it through two layers of new cheesecloth. If only a small amount of extract was needed, only a part of the diseased plant was ground in a mortar and the juice separated from the pulp by pressing the ground-up tissue against the side of the mortar with the pestle.

The plants used in the experiments reported in this study were grown from seed. In the host range study where seed was not available, it was necessary to collect young plants from the field. Plants grown from seed were started in 10-inch clay pots and when of sufficient size to ensure successful transplanting were transferred to No. $2\frac{1}{2}$ cans with perforated bottoms. The soil mixture was composed of three parts loam, one part sand and one part leaf mold. All the plants, regardless of how they were obtained, were allowed to become well established in the greenhouse before any inoculation attempts were made. The time required for the plants to become established varied, but generally was not longer than two weeks.

Plants designated as controls for the experiments, using mechanical inoculation, were divided into two equal groups. One group was inoculated mechanically with distilled water by the carborundum method, the second group received no treatment.

The method of mechanical inoculations used was that described by Rawlins and Tompkins (9) with some modifications. Where they used cotton held with forceps and new pot labels to support the leaves being inoculated, in the experiments reported here sterilized cotton-tipped sticks were used with the leaves supported by the forefinger. Supporting the leaf in this manner resulted in little or no mechanical damage. Use of a pot label to support the leaf resulted in some damage, if extreme care were not exercised. If danger of contamination with other juice extract existed, especially in attempts to recover the virus, a new 6-inch pot label was used to support the leaf. When plants other than celery were inoculated, inoculation of four or more celery plants was made as a check for the presence of the virus in the inoculum. If the celery plants used as a test failed to develop symptoms, the experiments were repeated.

The green peach aphid, Myzus persicæ (Sulzer), was used in the insect inoculations. The insects were reared in cages on potatoes and sugar beets. One aphid colony was established on a mosaic-infected celery plant, but this method of culture proved unsatisfactory because of the relatively slow rate of reproduction of the insect. The aphids were transferred according to the method described by Severin and Freitag (12). When wingless aphids were taken from potato or sugar beet plants, they were allowed to feed at least 24 hours on diseased celery plants before they

were transferred to healthy test plants. After feeding on the healthy plants for 24 hours, they were destroyed either by nicotine fumes, by burning tobacco dusty with the plants in a confined area, or by spraying the plants with parathion at the strength recommended by the manufacturer. Parathion was easiest to use and was completely effective.

Control of undesirable insects in greenhouse was accomplished by fumigating with burning tobacco dust for the control of aphids and "Benzo-Fume" for the control of mites. This procedure was carried out once every two weeks or more often if the situation warranted.

SYMTPOMATOLOGY

Many diseases of celery, listed as mosaics, have been described by various workers. Poole (8) in 1922 described a mosaic disease of celery that caused severe malformation of and blister-like pustules on the leaves of the diseased plants. A mosaic disease of celery that caused a mottling of the foliage was described by Harvey (6) in Minnesota. Elmer (3) described a disease of celery in Iowa that caused mottled and deformed leaves and a stunting of the plants. Foster and Weber (4) summarized briefly the symptoms of a mosaic disease of celery in Florida in 1934. But it was not until ten years later that a complete description of the disease was given by Doolittle and Wellman (2). The early symptoms of the disease were reported to be clearing of the veins, and at the same time a downward curling of the young petioles. The clearing along the veins soon developed into whitish areas with intervening areas of green that became darker with age. Irregular sunken areas developed on the petioles as the disease progressed. Because of distinctive differences in the symptoms expressed, Doolittle and Wellman believed that Poole in New Jersey, Elmer in Iowa and Harvey in Minnesota had worked with mosaic diseases different from that found in Florida.

Severin and Freitag (11) described two mosaic diseases of celery in California and proposed western celery mosaic as the name for one and celery calico as the name for the other. They reported their experiments with western celery mosaic in 1938 (12) and gave a complete description of the disease and reported some physical and biological properties of the virus. The first symptoms, as described by them, for greenhouse-grown plants, were clearing of the veins and veinlets and puckering of

the youngest leaves. A mottling of the leaves developed as the disease progressed and necrotic spots appeared on the upper surface of the outer leaves. In the advanced stages the leaflets became twisted, cupped and narrow with the petioles sometimes showing white spots or streaks. In the field the most striking symptoms were yellowing of the foliage, stunting of the plants, shortening of the central petioles and the horizontal instead of upright position of the outer petioles. In a later paper, Freitag and Severin (5) described crinkle-leaf disease of celery, caused by a strain of the western celery mosaic virus. The symptoms expressed by this strain are similar except for the severe crinkling and malformation of the leaves of the plants infected with the crinkle-leaf strain.

A calico-like mosaic that developed when celery was infected with alfalfa mosaic virus was reported by Synder and Rich (13). On celery this virus causes a mottling on the leaves and, more strikingly, green islands of tissue in the yellow areas.

The symptoms of western celery mosaic, caused by Marmor umbelliferarum H. (Apium Virus 1, Smith), in Utah as observed on Pascal, a green variety of celery, differed somewhat from those reported in California (12).

The first symptoms of western celery mosaic observed on plants grown in the greenhouse were a distinct clearing of the veins and slight puckering of the leaflets. On young vigorously growing plants the symptoms occurred within 6 to 10 days, but sometimes disappeared and reappeared within two weeks after the vein clearing was first evident. The disappearance of the early symptoms may have been due to the high temperatures encountered in the greenhouse. Mosaic-infected plants were relatively slow growing and usually showed stunting within a week after the first symptoms appeared.

As the disease progressed, an almost indistinguishable mosaic pattern appeared on the leaflets. Accompanying the mosaic pattern was a narrowing, twisting, and downward cupping of the leaflets. The color of diseased plants as a whole was a lighter hue than that of healthy plants. Leaves formed before the first symptoms developed did not, as a rule, show the downward cupping.

As pointed out by Waldee (16), the most noticeable symptom seen in the field is a dull, lusterless, grayish-green color. He stated that it was possible in badly infected fields to pick out the diseased plants from a considerable distance by the color alone. Mosaic-infected celery plants in the field exhibited the twisting, narrowing and downward cupping of the leaflets typical of the late symptoms observed in the greenhouse.

Some of the symptoms for western celery mosaic described by Severin and Freitag (12) such as the horizontal position of the older petioles, necrotic spots on the upper surface of the older leaves, and frequent appearance of whitish areas of the petioles were never observed either in the field or in the greenhouse in Utah. Differences of symptom expression observed in Utah and those described in California may have been due to climatic factors, soil relations, cultural practices, or possibly the variety of celery grown.

DISCUSSION OF RESULTS

Transmission Studies

When this study was initiated, the celery mosaic disease as it occurs in Utah was assumed to be of virus origin. Following this assumption, inoculations from diseased plants collected in the field were made to two series of celery plants using the carborundum method of Rawlins and Tompkins (9). The first series consisted of 23 plants inoculated with juice extracted from naturally infected celery plants obtained from Salt Lake County and 10 plants inoculated with expressed juice from diseased plants collected in Utah County. Healthy celery plants inoculated with juice extracted from the plants of the first series comprised the second series. From each of the inoculated plants and from each of the plants used as controls in the first series, juice was extracted and inoculated into three healthy celery plants. For each set of three plants inoculated with expressed juice, one plant was inoculated with distilled water and one plant received no treatment.

The results of this study, summarized in table 1, demonstrated the virus to be readily transmitted to celery from naturally infected plants. Table 2 shows that the virus could be transmitted to celery from experimentally infected plants as well and that infection occurred only when inoculum from plants expressing characteristic mosaic symptoms was used.

One series of healthy celery plants was inoculated with juice from a naturally infected plant of self-blanching celery collected in Salt Lake County. The symptoms that developed on plants inoculated with juice from

Table 1. Results of transmission of mosaic to healthy celery plants using juice extracted from naturally infected plants collected in the field.

Source of Juice Extract	Juice Inoculations		Controls			
			Water Inoculated		No Treatment	
	Number	Infected	Number	Infected	Number	Infected
Salt Lake County	23	22	4	0	4	0
Utah County	10	5	2	0	2	0

Table 2. Recovery of Western celery mosaic virus by mechanical inoculation of juice from experimentally infected plants.

Source of Juice Extract	Juice Inoculation		Water Inoculation		No Treatment	
	Number	Infected	Number	Infected	Number	Infected
Inoculated plants with symptoms	69	64	23	0	23	0
Inoculated plants without symptoms	18	0	10	0	10	0
Control plants	36	0	12	0	12	0

the mosaic-infected self-blanching plant were similar to those observed on plants inoculated with juice obtained from infected Utah Pascal plants. It was assumed, therefore, that the mosaic disease of the self-blanching variety was western celery mosaic and no further transmissions were made with the virus obtained from this source.

Severin and Freitag (12) have shown that the green peach aphid, Myzus persicae (Sulzor), is one of the aphid vectors of western celery mosaic. An experiment was conducted to show whether celery mosaic virus, as it occurs in Utah, was capable of being transmitted by the green peach aphid. The aphids were allowed to feed first on naturally infected celery plants for 24 hours and then transferred to young healthy celery plants and allowed to feed for 24 hours. Five insects were used on each healthy plant inoculated. From each plant showing symptoms inoculations were made again to three healthy celery plants both by means of aphids and by the carborundum method. No inoculations were made from plants that did not show symptoms.

The results shown in table 3, demonstrated that the green peach aphid was capable of transmitting the virus from diseased to healthy celery plants. Of the forty-four plants inoculated by Myzus persicae with virus from naturally infected plants, fifteen developed symptoms. Table 4 shows that the virus was transmitted from insect-inoculated plants to healthy celery by both the green peach aphid and the carborundum method.

An attempt was made to transmit celery mosaic virus by means of dodder, a parasitic seed plant. Because of the inability of the species used (Cuscuta campestris Yunker) to become established on diseased celery, the experiment was not successful.

Table 3. Transmission of celery mosaic virus by the green peach aphid from diseased to healthy celery.

Source of Virus	Plants Inoculated	
	Number	Infected
Salt Lake County	32	7
Utah County	12	8

Table 4. Recovery of mosaic virus from plants which had been infected by means of viruliferous green peach aphids.

Aphid Transmission		Mechanical Inoculation	
Number	Infected	Number	Infected
21	17	21	19
36	13	36	22

Experiments Comparing the Infectivity of Juice From Frozen and Unfrozen Plants

Freezing diseased plant material before extracting the juice for purification studies, is commonly used to obtain a high yield of virus (1, 7, 14, 15). Freezing of diseased plants does not reduce the infectivity of those viruses considered stable (15).

An experiment was conducted to test the infectivity of juice extracted from frozen and unfrozen plants for the purpose of finding the best method of extracting juice for inoculation studies. For this study eight experimentally infected plants of the same age were selected. Four of the plants were frozen at -10° C for 24 hours. Both frozen and unfrozen plants were washed with distilled water and ground separately in a sterilized food chopper. The juice was extracted by pressing the plant pulp through two layers of new cheesecloth. The pulp from the frozen plants was allowed to thaw before the juice was removed. Inoculations were made by the carborundum method in two series of fifty celery plants each.

The results, summarized in table 5, show that 90 per cent of the plants inoculated with unfrozen juice extract became infected as compared with only 2 per cent for plants inoculated with juice from frozen plants. The high percentage of infections obtained using the juice from unfrozen plants was much greater than expected.

The experiment was repeated to check the possibility that the four plants used as a source of the frozen inoculum had a low virus titer. Greater accuracy was assured by using one-half of each of the eight plants selected as the source of frozen plant extract. This plant material was

Table 5. Comparative infectivity of juice from frozen and unfrozen mosaic-infected celery plants.

Type of Inoculum	No. of plants Inoculated	No. of plants Infected	Per cent
Trial 1:			
Frozen	50	1	2
Unfrozen	50	45	90
Trial 2:			
Frozen	40	2	5
Unfrozen	40	22	55

frozen at -10° C for 24 hours, as before. The remaining portion of the eight plants was used as the source of unfrozen inoculum. The juice from both sources was extracted in the manner described above.

The results, summarized in table 5, show tendencies similar to those obtained in the first test of frozen and unfrozen inoculum. The fact that juice from unfrozen plants was eleven times as effective in producing disease as juice from frozen plants warranted the use of unfrozen juice extract in inoculating plants used in the host range study. Although the percentage of infections resulting from inoculation with unfrozen juice extract was less than that of the first trial, it was more nearly the percentage that had been obtained from other inoculations. The difference in infectivity exhibited by frozen and unfrozen juice extract in this experiment appeared to be the result of some inactivation of the western celery mosaic virus. The results of this study are not complete, and further work must be done before any definite conclusions can be drawn.

Ross (10), in a similar experiment, found that freezing and thawing of tobacco plants infected with alfalfa mosaic virus, considered to be an unstable virus, resulted in a marked reduction of infectivity. He found that juice from unfrozen plants was 2 to 4 times as active as juice from plants frozen at -14° C.

Overwintering Study of Celery Mosaic Virus

It was learned from growers in 1947 that celery may overwinter in Utah in one of three ways: as unused pitted celery, as root stock in fields not disked after harvest in the fall, and as seed stock. This condition suggested the possibility that celery mosaic virus might live over winter

in diseased celery plants. To test this possibility, overwintered plants were collected from the field and from pits in Salt Lake County in early April of 1948. Juice extracts were made from each plant collected and inoculated by the carborundum abrasion method into healthy celery plants.

The results, summarized in table 6, demonstrated that the mosaic virus overwintered in infected celery plants. Of the seven plants collected, juice from one plant proved to be infectious.

Overwintered plants were collected from the field again in early April of 1949 in Box Elder County and Salt Lake Counties. The plants collected in Box Elder County were transplanted to a bench in the greenhouse where they survived and grew vigorously. Two of these plants developed mosaic symptoms. Juice extracted from each plant was inoculated into healthy celery plants.

The results, shown in table 6, corroborated the results obtained from the first experiment with overwintered celery. One plant out of the eight collected from Salt Lake County and two plants from the five collected in Box Elder County proved to be mosaic diseased plants.

Winged aphids (Aphis heraclella Davis) were found feeding on the plants in one field in Salt Lake County in 1949 less than 300 yards from celery seedlings being grown in a greenhouse for transplanting into the field later in the spring. The situation as it existed in this community had all the prerequisites for an epiphytotic of the mosaic disease. Field observations during the summer revealed that this area was the only one in the state in which western celery mosaic occurred to a significant degree. One field showed nearly 80 per cent of the plants showing severe mosaic symptoms. In the other celery-growing areas of the state incidence

Table 6. Inoculations with juice extract obtained from overwintered celery plants showing inoculated and infected plants.

County and Year	Plant No.	Number of Plants	
		Inoculated	Infected
Salt Lake	1	5	0
	2	5	0
1948	3	5	3
	4	5	0
	5	5	0
	6	5	0
	7	5	0
Salt Lake	1	4	0
	2	4	0
1949	3	4	0
	4	4	0
	5	4	0
	6	4	0
	7	4	3
	8	4	0
Box Elder	1	8	3
1949	2	8	0
1949	3	8	0
	4	8	7
	5	8	0

of mosaic was negligible. This condition could undoubtedly have been avoided if no mosaic host plants had been allowed to grow in the area between the time of seed bed preparation and the setting of the young celery plants in the field.

HOST RANGE STUDIES

Among the mosaic diseases of celery, considerable differences are to be found in the host range of each. Southern celery mosaic has been reported to infect ninety-one host plants representing four families of the Monocotyledonae and nineteen families of the Dicotyledonae (17, 18, 19). Elmer (3) in Iowa reported a mosaic disease of celery capable of infecting a relatively wide range of host plants. Western celery mosaic was reported to have a narrow host range, restricted, apparently, to a few species within the family Umbelliferae (12).

A host range study of the western celery mosaic virus was made during the spring and summer of 1949 to clarify the identity of the causal agent and to determine whether any plant other than celery may serve as overwintering host. Various plants, collected from the field or grown from seed, were used for the host range study. With the exception of those plants chosen specifically for the etiological determination, the plants selected, both crop plants and weeds, were those found growing in and around celery fields. An effort was made to obtain as many plants of the family Umbelliferae as could be found in the celery growing regions. Mechanical inoculation, using the carborundum method, was the chief means of attempted transmission of the mosaic virus.

Besides celery, Apium graveolens L. var. dulce D.C., the plants listed below were experimentally infected with western celery mosaic virus. Carrots were infected using green peach aphid as well as the carborundum method.

Umbelliferae

Carrot, Daucus carota L. var sativa D. C.
Chantenay red cored
Danvers

Parsley, Petroselinum crispum Nym, var. latifolium
Moss curled
Turnip rooted
Paramount

Water Hemlock, Cicuta Douglasii (DC) C&R

The virus was recovered from the experimentally infected plants by inoculating juice extracted from them back into healthy celery.

The symptoms expressed by carrots infected experimentally with western celery mosaic virus were distinct mottling and cupping of the leaflets followed by a slight twisting of the petioles (See Plate 4). The plants as a whole were stunted and appeared chlorotic. Some difficulty was experienced in transmitting the mosaic virus to both varieties of carrots used. Two series of inoculations were made using the Chantenay red cored variety. Of the first twelve plants inoculated, none developed the disease; and of the seventeen plants inoculated in the second attempt only two developed the disease. The failure noted in the first attempt was probably due to the use of plants which were too old. In the second experiment thirty-two plants of the variety Danvers were inoculated with mosaic virus, of which four developed the disease. A test made to transmit the virus mechanically from diseased to healthy carrot was successful. Of twenty-four carrot plants inoculated by means of green peach aphid, four developed characteristic symptoms.

The symptoms of mosaic disease on parsley were difficult to distinguish, especially on the moss curled variety. A slight mottling of the leaflets of the diseased plant was the only direct indication of the disease.

Although the effects of the disease on parsley were mild, some stunting of the infected plants was apparent. The first attempt to transmit mosaic virus by mechanical means to parsley was unsuccessful. A later attempt showed that of the twenty-two plants of the turnip rooted variety inoculated, two showed symptoms. From the two series of twenty-two plants each of the varieties moss curled and paramount, one plant of each variety showed symptoms.

Severin and Freitag (12) demonstrated that it was possible to recover the celery mosaic virus from parsley plants showing no symptoms. In the experiment described above the virus was recovered only from plants showing symptoms.

The most striking symptom of the mosaic disease on water hemlock was the prominent vein clearing (see Plate 5). Some twisting of the petioles and cupping of the leaflets occurred. This is the first report of infection of water hemlock by the western celery mosaic virus. Water hemlock is a potential overwintering host plant for the western celery mosaic virus. It is doubtful that the susceptibility of this plant is very significant, however, in as much as water hemlock is not prevalent in the celery growing regions of Utah.

Two species of the family Umbelliferae, poison hemlock, Conium maculatum L. and Cow parsnip, Herocleum lanatum Mischx., developed a symptom expression after being inoculated with juice extracted from mosaic diseased celery. One of the nineteen poison hemlock plants inoculated showed a mottling of the leaflets (see Plate 6). Two attempts to recover the western celery mosaic virus from this plant were unsuccessful. Two cow parsnip plants showed a slight puckering of the margins and mottling of the leaflets (see Plate 7). Two attempts to recover the virus from these plants were also unsuccessful.

Plants That Failed to Develop Symptoms

The plants listed below failed to develop symptoms when inoculated with western celery mosaic virus. These plants were inoculated with both expressed juice and with green peach aphid that had been fed on mosaic infected celery plants.

Chenopodiaceae

Sugar beet, *Beta vulgaris* L.

Compositae

Zinnia, *Zinnia elegans* Jacq.

Cucurbitaceae

Cucumber, *Cucumis sativa* L.

Leguminosae

Alfalfa, *Medicago sativa* L.

Umbelliferae

Parsnip, *Pastinaca sativa* L.

Wild variety
All American
Improved Hollow Crown

The following plants were inoculated with expressed juice by the carborundum method only.

Compositae

Prickly-lettuce, *Lactuca serriola* L.

Aster, *Callistephus chinensis*

Crego mix

Goldon rod, *Solidago spp.*

Cruciferae

Shepherds-purse, *Capsella bursa-pastoris* (L.) Medic.

Geraniaceae

Storksbill, Erodium cicutarium (L) L'Her.

Leguminosae

Sweet clover, Melilotus alba Descr.

Garden pea, Pisum sativum L.

Bush bean, Phaseolus vulgaris L. var humilis Alef.

Malvaceae

Cheeses, Malva rotundifolia L.

Polygonaceae

Curly-dock, Rumex crispus L.

Ranunculaceae

Creeping buttercup, Ranunculus repens L.

Solanaceae

Potato, Solanum tuberosum L.

Red bliss

Umbelliferae

Desert parsley, Lomatium simplex (Nutt) Macbr.

All attempts to recover the virus from the inoculated plants by transmission attempts to healthy celery were unsuccessful.

CONCLUSIONS

Inoculation studies showed that the mosaic disease of celery, as it occurs in Utah, is of virus origin and was readily transmitted by means of mechanical abrasion and green peach aphid to celery. A host range study showed that the disease is apparently limited to certain members of the family Umbelliferae. The host range of this virus differs from that of the southern celery mosaic virus in that the former is narrower and does not include cucumber and zinnia, two known suscepts of the southern celery mosaic virus.

It has been previously demonstrated that the western celery mosaic virus is restricted to certain members of the family Umbelliferae. It has been shown also that parsnip, a member of the family Umbelliferae, is immune to the western celery mosaic virus. The apparent restrictions of the celery mosaic virus of Utah to members of the Umbelliferae and the failure to infect parsnip with the virus indicates that the mosaic disease of celery in Utah is western celery mosaic. Further evidence to support this contention is provided by the transmission of the virus by the green peach aphids, a known vector of the disease, and by similarities in the symptom expression observed. Although some differences in symptoms were noted between those described for western celery mosaic as found in Utah and those described in California, these can be attributed to various environmental factors.

Field observations of the characteristic spread of the virus, expecially from the edges of the field, has led to the belief that a

more extensive host range study will show that plants found commonly in the vicinity of celery fields, but not necessarily of the family Umbelliferae, may prove to be susceptible to infection by the virus.

SUMMARY

1. Because of the economic importance of celery mosaic disease in Utah, a study was made in 1948 and 1949 to determine the etiology of the disease and the host range of the virus.

2. Transmission of the virus was readily accomplished by inoculating expressed juice by the carborundum method and by the aphid Myzus persicae (Sulzer).

3. Juice extracted from unfrozen diseased plants was found to be eleven times as infectious as juice extracted from frozen diseased plants.

4. The mosaic virus was demonstrated to be present in juice extracted from overwintered diseased celery plants collected in the field.

5. A host range study involving plants found in and around celery fields showed that the virus is apparently limited to a certain few species in the family Umbelliferae, including celery, Apium graveolens L., var. dulce D. C.; carrot, Daucus carota L. var. sativa D. C.,; parsley, Petraselinum crispum Nym. var. latifolium; and water hemlock, Cicuta Douglasii (D.C.) C & R. The infection of water hemlock with celery mosaic is the first to be reported.

6. From these experiments it was concluded that celery mosaic as it occurs in Utah is western celery mosaic, Marmor umbelliferium H.

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PLATE I

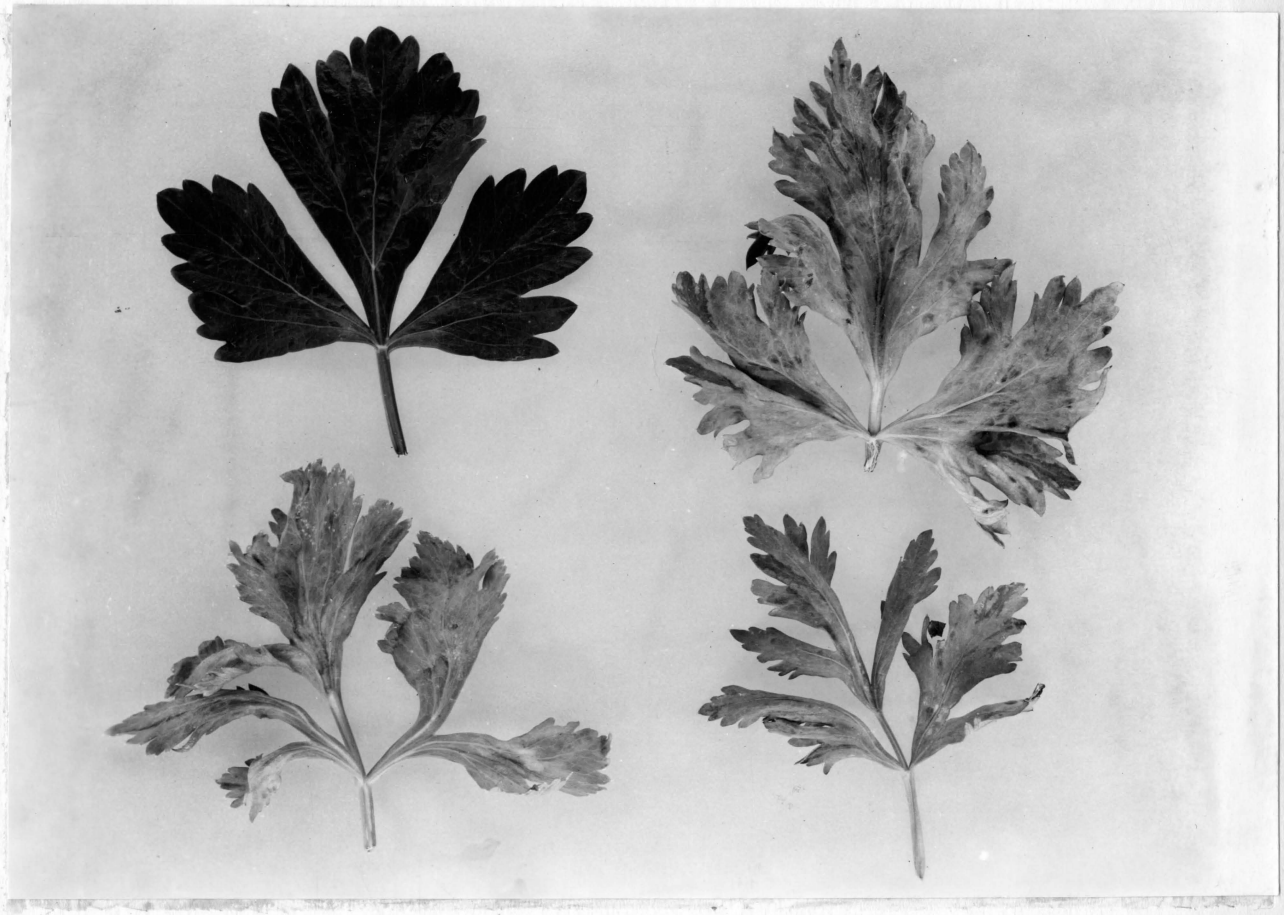

Plate 1

Leaflets from Utah Pascal celery plants naturally infected with western-celery mosaic virus. Note the light colored, twisted, downward cupped leaflets from the diseased plants as compared to the leaflet from healthy celery, upper left. (After Waldee).

PLATE 2

PLATE 3

Plate 2

A young healthy Utah pascal celery plant.

Plate 3.

A young Utah pascal celery plant experimentally infected with western celery mosaic virus showing early symptoms of the disease. Note the prominent vein clearing of the younger central leaflets. Some of the leaflets are beginning to show a slight downward cupping.

PLATE 4

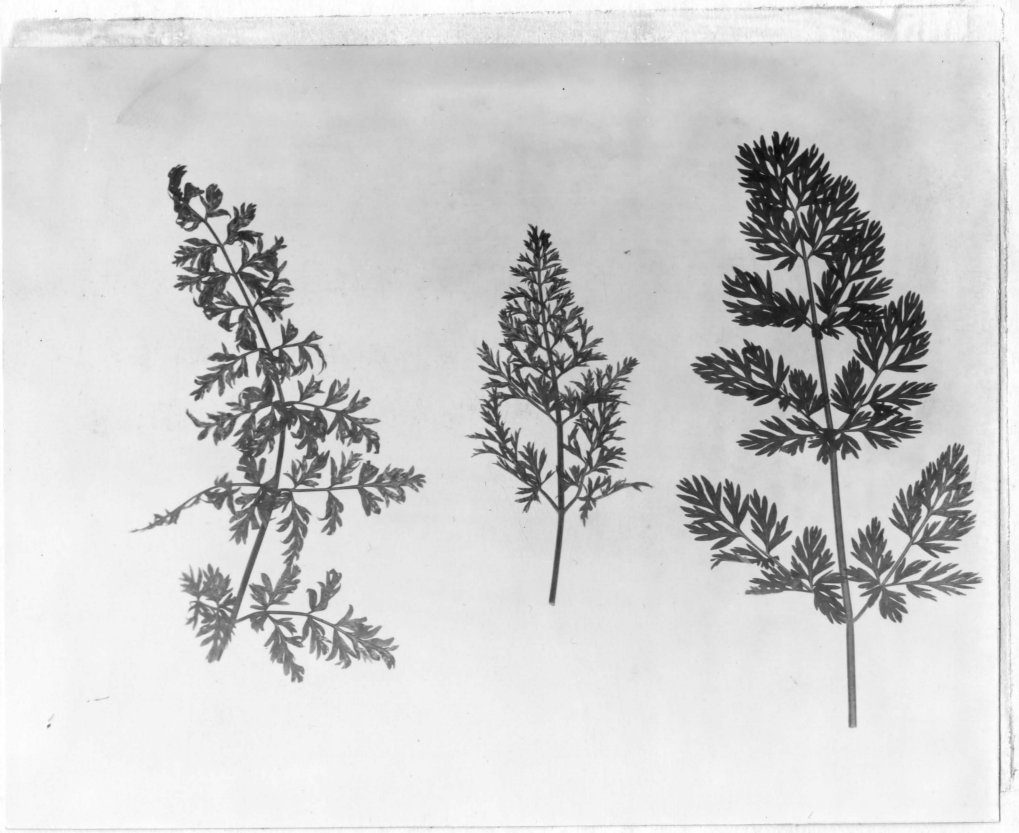

PLATE 5

Plate 4

Leaflets from carrot experimentally infected with western-celery mosaic virus. Note the mottling and twisting of the leaflets from the diseased plants as compared to the healthy leaflet at the right.

Plate 5

Leaflets from water hemlock experimentally infected with western celery mosaic virus. Note the prominent vein clearing and the twisting and downward cupping of the leaflets as compared to the leaflet from a healthy plant, upper left.

PLATE 6

PLATE 7

Plate 6

Left, leaflet from a healthy poison hemlock plant. Right, leaflet from poison hemlock plant mechanically inoculated with juice extracted from a mosaic-diseased celery plant. Note the distinctive mottling on the leaflet from the inoculated plant.

Plate 7

Left, leaflet from healthy cow parsnip plant. Right, leaflets from two cow parsnip plants that had been inoculated with juice extracted from a mosaic-diseased celery plant. Note the faint mottling on the leaflet to the right and the upward rolling of the margins of the center leaflet.