A MOSAIC DISEASE OF TURNIP [1]

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INTRODUCTION

A mosaic disease of turnip (*Brassica rapa* L.) occurs on Long Island, N. Y. Typical specimens of this disease were obtained for comparative greenhouse studies with virus diseases affecting certain cultivated crucifers in California (*15*, *16*, *17*, *18*).[3]

It is the purpose of this paper to describe briefly the symptoms of this mosaic disease of turnip from New York, to present experimental evidence on transmission, host range, and properties of the virus, and to discuss its possible relationship to other crucifer viruses.

REVIEW OF LITERATURE

In reviewing the literature, it is apparent in some instances that the names, "turnip mosaic" and "rutabaga mosaic," have been used synonymously. It has seemed advisable, therefore, to include in this review all references pertaining to rutabaga mosaic, as well as to turnip mosaic, irrespective of the identity of the particular virus involved.

In 1921, Gardner and Kendrick (*4*) described a mosaic disease of turnip that was found in Indiana. The causal virus was transmitted to healthy turnip seedlings by rubbing wounded plant parts with cotton soaked in extracted juice from diseased plants. The incubation period ranged from 16 to 26 days. Unsuccessful attempts were made to infect red and white varieties of radish (*Raphanus sativus* L.).

What appears to have been the same disease on turnip, Chinese cabbage (*Brassica pe-tsai* Bailey), and mustard (*B. japonica* Coss) was also described by Schultz (*12*). By means of the leaf-mutilation, rubbing method of inoculation, healthy turnip, Chinese cabbage, and mustard seedlings were infected with extracted juice from the corresponding diseased plants, in 20 to 30 days. Further, when the green peach aphid (*Myzus persicae* (Sulzer)) was transferred to healthy turnip and mustard seedlings after having fed on diseased turnip, Chinese cabbage, and mustard plants, mosaic mottling developed in 12 to 20 days. Evidence for seed transmission was negative, since mustard seed from mosaic plants yielded healthy seedlings.

Gram (*5*) found a mosaic disease of turnip in eight localities in Denmark in 1921. Other plants susceptible to natural infection included swedes or rutabaga (*Brassica campestris* L. var. *napo-brassica* DC.), radish, and charlock (*Sinapsis arvensis* L.).

In a brief report by Thatcher (*14*), reference is made to inoculation experiments which showed that mustard, rutabaga, flat turnip, and

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[3] Italic numbers in parentheses refer to Literature Cited, p. 601.

Chinese cabbage are very susceptible to mosaic. Rape was considered to be less susceptible. The identity of this crucifer virus was not disclosed.

Apparently the preceding citation by Thatcher served merely as a preliminary announcement of a more detailed report on studies of a mosaic disease of crucifers conducted by Clayton (*2*). A mosaic disease of rutabaga was found to be common but not serious on Long Island, N. Y. It was also observed on Brussels sprouts (*Brassica oleracea* L. var. *gemmifera* DC.), cauliflower (*B. oleracea* L. var. *botrytis* L.), and black mustard (*B. nigra* Koch), but not on white turnip. Infection experiments involved the use of the leaf mutilation, rubbing method of inoculation and of the cabbage aphid (*Brevicoryne brassicae* (L.)) and the green peach aphid. The cabbage aphid proved very effective as a vector, but the green peach aphid gave negative results. An incubation period of 3 to 5 weeks was reported. Symptoms of the disease were favored by relatively high temperatures (70° to 80° F.), while lower temperatures (55° to 65°) induced masking. White mustard (*B. alba* Rabenh.), black mustard, Chinese cabbage, turnip, rutabaga, and rape (*B. napus* L.) were susceptible to artificial infection. Brussels sprouts and cauliflower were difficult to infect. Although cabbage (*B. oleracea* L. var. *capitata* L.) was considered to be highly resistant or immune to the disease, the suggestion was advanced that it might act as a carrier. No evidence of seed transmission was obtained. Apparently Clayton did not recognize any differences between the rutabaga mosaic virus with which he worked and the turnip mosaic virus reported elsewhere (*4*, *5*, *12*).

A mosaic disease of Chinese cabbage, turnip, and mustard occasionally caused 30 percent loss near Fukuoka, Japan, according to Takimoto (*13*). The virus was transmitted by mechanical inoculation to cauliflower but not to cabbage or radish. Aphids (species not given) were held responsible for natural transmission of the disease. Takimoto considered the disease to be similar to those described by Gardner and Kendrick (*4*), Schultz (*12*), and Clayton (*2*).

Samuel (*11*) reported on turnip mosaic in Australia in 1931. A mosaic disease of turnip and rutabaga was reported from Florida by Weber (*19*) in 1932 and from Japan by Hino (*6*) in 1933.

Edson, Miller, and Wood [4] recorded the occurrence of rutabaga mosaic in Connecticut and turnip mosaic in Mississippi in 1934.

A virus disease of cabbage, mustard, turnip, and horseradish (*Radicula armoracia* Robins) was described by Hoggan and Johnson (*7*) in 1935. The virus was transmitted by mechanical inoculation and by the cabbage and green peach aphids to cabbage, black mustard, turnip, tobacco (*Nicotiana tabacum* L.) var. Connecticut Havana No. 38, *N. glutinosa* L., the hybrid *N. tabacum N. glutinosa*, currant tomato (*Lycopersicum pimpinellifolium* Dunal), and spinach (*Spinacia oleracea* L.) var. Bloomsdale. The temperature range favorable to infection was 70° to 80° F. Properties of the virus were given: Thermal death point, 54° C. for a 10-minute exposure; longevity in vitro, less than 3 days at 20°–22°; tolerance to dilution, 1 to 1,000.

[4] EDSON, H. A., MILLER, PAUL R., and WOOD, JESSIE I. DISEASES OF PLANTS IN THE UNITED STATES IN 1934. U. S. Bur. Plant Indus., Plant Disease Reptr. Sup. 90: 75. 1935.

Losses caused by turnip mosaic in Germany, according to Pape (*9*), may vary from 1 to 90 percent. Some varieties of turnip were found to be much more susceptible to infection than others. He reported transmission of the virus to healthy turnip plants by mechanical inoculation and by means of the tarnished plant bug (*Lygus pratensis* (L.)).

Chamberlain (*1*) recognized turnip mosaic on rape plants at Palmerston North, New Zealand, in 1932 and subsequently on rutabagas, rape, and turnips in the same and other districts. He obtained mechanical transmission of the disease by the rubbing method and by means of the cabbage and green peach aphids which commonly occur on cruciferous crops in New Zealand, but failed to give the time required in either case for symptom expression. Tests for seed transmission involved planting seeds derived from mosaic-infected rutabaga plants. Of 432 seedlings, none showed symptoms of mosaic. In host-range studies, no infection, by means of artificial inoculation, was secured on cabbage, cauliflower, Brussels sprouts, broccoli (*Brassica oleracea* L. var. *botrytis* L.), and radish. However, all of these crucifers, except radish, were infected when the green peach aphid served as the vector. Brown necrotic lesions were obtained on tobacco (variety not specified). Annual stock (*Matthiola incana* R. Br. var. *annua* Voss) is a natural host for the turnip mosaic virus which induces flower breaking as well as leaf mottling.[5] Other natural hosts include wallflower (*Cheiranthus cheiri* L.) and a number of common cruciferous weeds. In tests for varietal resistance, one variety of turnip proved highly resistant and several others less so. Recommendations for control of the disease in seed crops were dipping the leaves of plants at transplanting time in a nicotine solution in order to kill the insect vectors, rogueing of all infected plants, avoidance of other cruciferous crops and volunteer seedlings, and, when mosaic appears, spraying the plants with nicotine solution.

Edson and Wood[6] listed turnip mosaic as prevalent in Connecticut in 1935.

In 1936, Kaufmann (*8*) described a virus disease of winter-sown rape (*Brassica rapa* L. var. *oleifera* Delile), rutabaga, and colza (*B. napus* L. var. *oleifera* Delile). Infection of healthy rape, rutabaga, and colza plants resulted from juice inoculations and when the tarnished plant bug was used, both in the greenhouse and in the field. Significant losses were observed only on rutabaga. The identity of this virus was apparently not clearly established.

SYMPTOMS OF THE DISEASE

Studies of the symptoms caused by the turnip mosaic virus from New York have been limited to greenhouse observations. Initial symptoms of the disease on leaves of Purple Top White Globe turnip seedlings consist of a conspicuous, coarse, systemic clearing of the veins, with interveinal mottling, which collectively impart a yellowish caste. The leaves show marked crinkling and slight dwarfing (fig.

[5] Letter dated July 2, 1937, from E. E. Chamberlain, Plant Diseases Division, Plant Research Bureau, Palmerston North, New Zealand.

[6] EDSON, H. A., and WOOD, JESSIE I. DISEASES OF PLANTS IN THE UNITED STATES IN 1935. U. S. Bur. Plant Indus., Plant Disease Reptr. Sup. 96: 200. 1936.

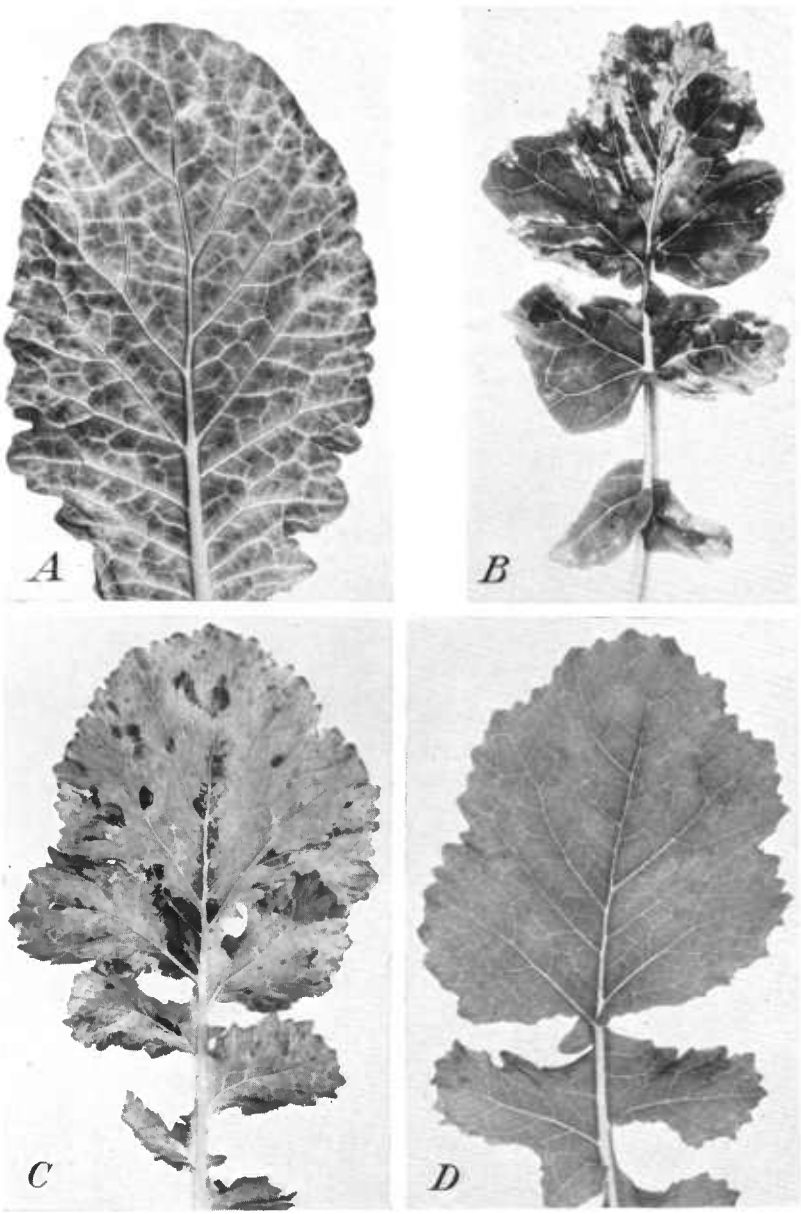

FIGURE 1.—Symptoms produced by the turnip mosaic virus on Purple Top White Globe turnip leaves after artificial inoculation in the greenhouse at 13°–19° C.: *A*, Early symptoms consist of coarse, yellow vein clearing and mottling; *B*, intermediate symptoms consisting of dark-green tissue with numerous raised islands of irregular shape and a small amount of chlorotic tissue; *C*, late symptoms in which the leaf has become very chlorotic with only a few dark-green, raised islands; *D*, noninoculated control.

1, *A*), when contrasted with normal, healthy specimens. Stunting of the plants is also apparent in the early stages of infection. Gradually, as the leaves expand, the coarse, yellow appearance is replaced by a preponderance of very dark-green, irregular, raised islands, interspersed with a restricted amount of chlorotic tissue (fig. 1, *B*). In later stages of infection, the dark-green islands are almost entirely replaced by chlorotic, light-green areas (fig. 1, *C*). Crinkling of the leaves is accentuated in the latter two stages of infection (fig. 1, *B*, *C*) in contrast to the normal, healthy leaf (fig. 1, *D*). Occasionally in some infected plants the leaves were unsymmeterical. Although the turnip mosaic virus causes severe stunting of turnip plants, no lethal effect has been observed on this or any other susceptible host.

MATERIALS AND METHODS

In 1934, 12 white turnip stecklings showing pronounced symptoms of mosaic infection were collected in a commercial planting near Mattituck, Long Island, N. Y., and forwarded to Berkeley, Calif. Within several weeks after transplanting, these stecklings produced new leaves, all of which were mottled. Transfers were then made to healthy Purple Top White Globe turnip seedlings by mechanical inoculation. The virulence of, and the symptoms produced by, this virus have remained unchanged through successive monthly transfers since 1934. Purple Top White Globe turnip seedlings were used as the standard test plant for recovery of the virus from infected plants and for property studies.

All inoculations were made in a greenhouse where temperatures ranged from 13° to 19° C. The methods followed were essentially those described in recent papers (*16*, *18*). Mechanical inoculations were made by dusting the leaves with 600-mesh, powdered carborundum (*10*) and lightly rubbing with absorbent cotton dipped in juice from a diseased plant.

EXPERIMENTAL RESULTS

TRANSMISSION

The turnip mosaic virus can be transferred to healthy turnip seedlings by mechanical inoculation with or without carborundum (*10*), but the percentage of infection is reduced approximately 50 percent when this abrasive is omitted. As a result of numerous tests, the incubation period was determined as ranging from 13 to 21 days.

Clayton (*2*) used both the cabbage aphid and the green peach aphid in his insect transmission studies with the rutabaga mosaic virus, finding that the latter was much less efficient. Since Essig (*3*) found that the cabbage and green peach aphids breed naturally on cultivated and wild crucifers in California and other Western States and because the New York turnip mosaic virus may eventually be found in California, it seemed desirable to test the two aphid species under greenhouse conditions.

Following the procedure outlined in a recent paper (*18*), noninfective cabbage and green peach aphids[7] were fed on recently infected

[7] Noninfective cabbage and green peach aphids, previously identified as such by E. O. Essig, were kindly supplied by H. H. P. Severin and J. H. Freitag, Division of Entomology and Parasitology, University of California.

turnip plants for 24 to 48 hours, after which they were transferred in lots of approximately 20 aphids each to healthy turnip seedings. After 24 hours, all plants were sprayed with nicotine sulphate solution. Healthy turnip seedlings infested with noninfective aphids and noninoculated plants free from aphids served as controls.

Of 20 turnip plants infested with viruliferous cabbage aphids, 16 showed typical symptoms of the disease in 15 to 17 days, while 4 plants damped off. When infective green peach aphids were placed on 20 turnip plants, 100-percent infection occurred, the incubation period ranging from 12 to 18 days. The virus was recovered from all infected plants by mechanical inoculation. None of the controls became diseased. Other possible means of transmission were not investigated.

EXPERIMENTAL HOST RANGE

Young seedlings of various turnip and rutabaga varieties were tested by mechanical inoculation, with a suitable number of plants for controls. The following varieties of turnip proved to be highly susceptible: Amber or Yellow Globe, Bortfelder, Cowhorn, Early Purple Top Milan, Early White Flat Dutch, Extra Early White Milan, Large White Norfolk, Orange Jelly or Golden Ball, Purple Strap Leaf, Purple Top Strap Leaved Early, Purple Top Yellow Aberdeen, Seven Top, Shogoin or Japanese, Snowball, Southern Prize, White Egg, and White Milan. Of rutabaga varieties, the following varieties proved to be highly susceptible: American Purple Top, Hartleys Bronze Top, Large White, and Monarch or Tankard. The variety Long Island Improved was only slightly susceptible to infection.

By means of mechanical inoculation, the turnip mosaic virus from New York was transmitted to 18 species of plants representing 12 genera in 6 families, as follows:

Cruciferae:
- Cabbage (*Brassica oleracea* L. var. *capitata* L.).
- Cauliflower (*B. oleracea* var. *botrytis* L.).
- Rutabaga (*B. campestris* L. var. *napo-brassica* DC.).
- Turnip (*B. rapa* L.).
- Leaf or Chinese mustard (*B. juncea* Coss).
- Chinese cabbage (*B. pe-tsai* Bailey).
- Wild yellow mustard (*B. campestris* L.).
- *B. adpressa* Boiss.
- Shepherds-purse (*Capsella bursa-pastoris* Medic.).
- Annual stock (*Matthiola incana* R. Br. var. *annua* Voss).
- Dames violet (*Hesperis matronalis* L.).
- Virginian stock (*Malcomia maritima* R. Br.).
- Honesty (*Lunaria annua* L.).
- Chinese radish (*Raphanus sativus* L. var. *longipinnatus* Bailey).

Chenopodiaceae: Lambsquarters or white pigweed (*Chenopodium album* L.)
Resedaceae: Mignonette (*Reseda odorata* L.).
Begoniaceae: Fibrous-rooted begonia (*Begonia semperflorens* Link and Otto).
Verbenaceae: Garden verbena (*Verbena hybrida* Voss).
Solanaceae:
- Turkish tobacco (*Nicotiana tabacum* L.).
- *N. glutinosa* L.
- Petunia (*Petunia hybrida* Hort.).

In the family Cruciferae, all susceptible plants showed systemic infection. These include Winter Colma cabbage (fig. 2) with numerous chlorotic lesions which later became necrotic around the edges; February, April, Danish Perfection, Dryweather Danish Giant,

Early March, Early Snowball, and Super Snowball cauliflower with chlorotic to yellow lesions; Long Island Improved rutabaga with chlorotic lesions; Flat Turnip and Florida Broadleaf varieties of leaf or Chinese mustard with leaf mottling and rugosity; pe-tsai with coarse yellow vein banding and leaf distortion; *Brassica adpressa*, wild yellow mustard, and shepherds-purse with coarse mottling; Fiery Blood Red annual stock with coarse vein clearing, diffuse mottling, and occasional midrib distortion of leaves and flower breaking; dames violet with a fine type of mottling followed by small

FIGURE 2.—Early symptoms, consisting of small, diffuse, chlorotic rings, on Winter Colma cabbage leaf 27 days after artificial inoculation with the turnip mosaic virus in the greenhouse at 13° to 19° C.

necrotic lesions, raised dark-green islands, and marked bleaching; and Virginian stock, honesty, and Chinese radish with mottling.

Infection of lambsquarters or white pigweed was indicated by local, yellow lesions on inoculated leaves only. Later, these became necrotic, with some coalescence. Pronounced mottling of leaves characterized infection of mignonette, garden verbena, and petunia. Small chlorotic lesions appeared on leaves of infected fibrous-rooted begonia. Local chlorotic lesions which later became necrotic occurred only on inoculated leaves of Turkish tobacco and *Nicotiana glutinosa* (fig. 3). The virus was recovered from all infected plants except from lambsquarters, mignonette, and fibrous-rooted begonia.

No infection was obtained by mechanical inoculation in 53 species of plants representing 43 genera in 23 families, as follows:

Cruciferae:
Kale (*Brassica oleracea* L. var. *acephala* DC.).
Brussels sprouts (*B. oleracea* var. *gemmifera* DC.).
Sprouting broccoli (*B. oleracea* var. *botrytis* L.).
Kohlrabi (*B. oleracea* var. *caulorapa* DC.).
Rape (*B. napus* L.).
Black mustard (*B. nigra* Koch).
White mustard (*B. alba* Rabenh.).
Charlock (*B. arvensis* (L.) Ktze.).
B. integrifolia O. E. Schulz var. *chevalieri* R. Porteres.
Wallflower (*Cheiranthus cheiri* L.).
Evening scented stock (*Matthiola bicornis* DC.).

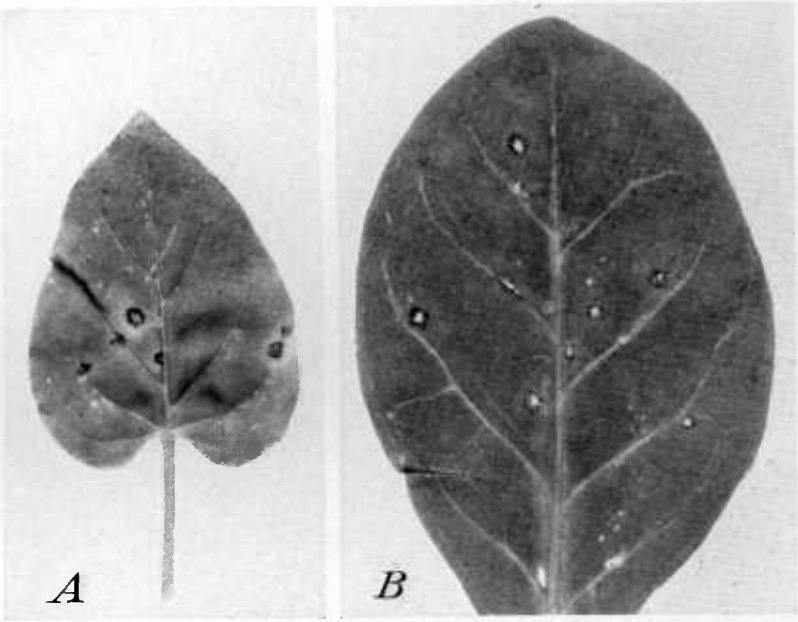

FIGURE 3.—Symptoms produced by the turnip mosaic virus by artificial inoculation in the greenhouse at 13° to 19° C.: *A*, Local chlorotic lesions on inoculated leaf of *Nicotiana glutinosa* which later became necrotic with tan centers; *B*, local necrotic lesions on leaf of *N. tabacum* var. Turkish.

Sweet alyssum (*Alyssum maritimum* Lam.).
Radish (*Raphanus sativus* L.) var. White Icicle and Crimson Giant Forcing.
Gramineae: Corn (*Zea mays* L.) var. Golden Bantam.
Polygonaceae: Rhubarb (*Rheum rhaponticum* L.).
Chenopodiaceae:
Sowbane or nettleleaf goosefoot (*Chenopodium murale* L.).
Spinach (*Spinacea oleracea* L.) var. Bloomsdale.
Caryophyllaceae:
Sweet-william (*Dianthus barbatus* L.).
Babysbreath (*Gypsophila paniculata* L.).
Ranunculaceae: Rocket larkspur (*Delphinium ajacis* L.).
Rosaceae: *Geum chiloense* Balb.
Leguminosae:
Garden pea (*Pisum sativum* L.) var. Alderman.
Broadbean (*Vicia faba* L.).

Tropaeolaceae: Garden nasturtium (*Tropaeolum majus* L.).
Euphorbiaceae: Castor-bean (*Ricinus communis* L.).
Violaceae: Pansy (*Viola tricolor* L.).
Onagraceae:
Clarkia elegans Dougl.
Godetia grandiflora Lindl.
Umbelliferae: Celery (*Apium graveolens* L.) var. Golden Self Blanching.
Plumbaginaceae: Everlasting or sea-lavender (*Statice latifolium* Kuntze).
Boraginaceae:
Forget-me-not (*Myosotis alpestris* Schmidt).
Common heliotrope (*Heliotropium peruvianum* L.).
Labiatae: Flowering sage (*Salvia farinacea* Benth.).
Solanaceae:
Solanum aviculare Forst.
Potato (*S. tuberosum* L.).
Tomato (*Lycopersicum esculentum* Mill. var. *vulgare* Bailey) var. Early Santa Clara Canner.
Currant tomato (*L. pimpinellifolium* Dunal).
Nicotiana langsdorfii Weinm.
N. rustica L. var. *humulis* Schrank.
Tobacco (*N. tabacum* L.) var. White Burley.
Jimsonweed (*Datura stramonium* L.).
Scrophulariaceae:
Snapdragon (*Antirrhinum majus* L.).
Penstemon or beardtongue (*Penstemon barbatus* Nutt.).
Dipsaceae: Mourning bride or pincushion flower (*Scabiosa atropurpurea.*).
Cucurbitaceae: Cucumber (*Cucumis sativus* L.).
Campanulaceae: Canterbury-bells (*Campanula medium* L.).
Lobeliaceae: *Lobelia hybrida* Hort.
Compositae:
Head lettuce (*Lactuca sativa* L. var. *capitata* Hort.) var. New York and Tom Thumb.
Dandelion(*Taraxacum officinale* Weber).
Annual marguerite (*Chrysanthemum coronarium* L.).
English daisy (*Bellis perennis* L.).
African marigold (*Tagetes erecta* L.).
French marigold (*T. patula* L.).
Winter Cape-marigold (*Dimorphotheca aurantiaca* DC.).
Gaillardia pulchella Foug. var. *picta* Gray.
Cineraria (*Senecio cruentus* DC.).

Subsequent inoculations to turnip with extracted juice from inoculated plants of the above-mentioned plant species failed to cause infection.

PROPERTIES OF THE VIRUS

Determinations were made on longevity in vitro, inactivation temperature, and tolerance to dilution, and the results are given in table 1.

Virus samples consisted of 2 cc of undiluted juice, from recently infected turnip plants, in small, thin-walled test tubes. In determining resistance to aging in vitro, samples were stored at a constant temperature of 22° C. Resistance to heating was determined by heating virus samples in a thermostatically controlled water bath for 10 minutes. Virus dilutions were made with distilled water. Immediately following a specific treatment, young Purple Top White Globe turnip plants were then tested for infectivity by mechanical inoculation.

The turnip mosaic virus was found to be infective for 48 hours after aging in vitro, but was inactivated after 72 hours. The virus was infectious after heating for 10 minutes at various temperatures not exceeding 60° C., but was inactivated at 63° C. A dilution tolerance

of 1:3,000 was established. In each of the three tests, 25 noninoculated turnip plants served as controls and they continued healthy throughout.

TABLE 1.—*Longevity in vitro, inactivation temperature, and tolerance to dilution of the turnip mosaic virus*

[Five trials on 25 plants in all cases]

LONGEVITY IN VITRO, 22° C.

Age (hours)	Plants infected	Age (hours)	Plants infected
	Number		*Number*
0	25	96	0
24	13	120	0
48	2	144	0
72	0	168	0

INACTIVATION TEMPERATURE (10 MINUTES)

Temperature (°C.)	Plants infected	Temperature (°C.)	Plants infected
	Number		*Number*
50	17	65	0
55	10	70	0
60	2	(1)	21
63	0		

TOLERANCE TO DILUTION

Dilution	Plants infected	Dilution	Plants infected
	Number		*Number*
0	25	1:2,000	4
1:10	20	1:3,000	4
1:100	17	1:4,000	0
1:500	7	1:5,000	0
1:1,000	8		

[1] Not treated.

DESCRIPTION OF THE TURNIP MOSAIC VIRUS FROM NEW YORK

Transmitted in greenhouse tests by means of the cabbage aphid (*Brevicoryne brassicae*) and the green peach aphid (*Myzus persicae*). Transmissible by mechanical inoculation, using expressed juice with or without powdered carborundum. Incubation period 13 to 21 days when Purple Top White Globe turnips were used. Resistance to aging in vitro between 2 and 3 days. Inactivation temperature between 60° and 63° C. for 10-minute exposure. Tolerance to dilution approximately 1 to 3,000. White turnip (*Brassica rapa* L.) and certain other vegetable and ornamental crucifers are susceptible. On turnip, early symptoms consist of diffuse mottling of the leaves; later, irregular-shaped, raised dark-green islands are scattered on a markedly chlorotic background. Slight distortion and rugosity of leaves in late stages of infection. Local necrotic lesions produced on *Nicotiana glutinosa* and *N. tabacum*. Chinese radish susceptible, but not ordinary radish.

COMPARISON OF THE TURNIP MOSAIC VIRUS FROM NEW YORK WITH CERTAIN OTHER CRUCIFER VIRUSES

In a recent paper (*16*) the writer briefly compared the symptoms produced on certain cultivated crucifers by the cauliflower mosaic and turnip mosaic (from New York) viruses. When sprouting

broccoli, cabbage, cauliflower, kohlrabi, radish, and turnip seedlings were inoculated with the cauliflower mosaic virus, early symptoms were manifested by vein clearing (*16, fig. 3, C*; fig. 1, *A*) (fig. 4). The turnip mosaic virus, however, produced different symptoms on infected plants: Cabbage, chlorotic rings later becoming necrotic; cauliflower, pale-green to yellow lesions (*16, fig. 5, A, B*). As shown in this paper, a coarse leaf mottle characterizes infection of turnip. Sprouting broccoli, kohlrabi, and radish were not infected by the turnip mosaic virus. On annual stock, the cauliflower mosaic virus caused a coarse vein clearing of the leaves (*16, fig. 4, A, B, C*) but not flower breaking; the turnip mosaic virus induced not only coarse vein clear-

FIGURE 4.—Vein-clearing symptoms produced by the cauliflower mosaic virus on Purple Top White Globe turnip leaf by artificial inoculation in the greenhouse at 13° to 19° C.

ing and diffuse mottling but also flower breaking. No infection was obtained with the cauliflower mosaic virus on *Nicotiana glutinosa* and Turkish tobacco (*16*), whereas the turnip mosaic virus caused necrotic lesions to form on inoculated leaves of both *Nicotiana* species. These viruses can also be further differentiated by comparing their properties.

Recently, Tompkins and Thomas (*18*) have described a mosaic disease of Chinese cabbage in which it was shown that this virus can readily be differentiated from the turnip mosaic and cauliflower mosaic viruses on such hosts as cabbage, Chinese cabbage, cauliflower, and turnip.

It is believed the evidence submitted in the present paper is sufficient to differentiate the turnip mosaic virus from other viruses recently described (*16, 17, 18*).

DISCUSSION

A review of the literature on turnip mosaic (*1, 4, 5, 6, 7, 9, 11, 12, 13, 19*) and rutabaga mosaic (*2, 6, 8, 14, 19*) indicates a lack of agreement on the part of the workers concerned, specific examples of which may be cited. Although it seems to be generally agreed that the principal symptom of the disease on turnip consists of leaf mottling, additional symptoms unlike in any two instances are given by several writers (*1, 2, 4, 5, 7, 9, 12*). All but Gram (*5*) reported infection by mechanical means. Concerning insect transmission, Schultz (*12*) proved the green peach aphid was a vector; Pape (*9*) considered the tarnished plant bug was responsible for natural spread of the disease in Germany; while Hoggan and Johnson (*7*) and Chamberlain (*1*) found that both the green peach and cabbage aphids were efficient vectors. In studies on the rutabaga mosaic virus, Clayton (*2*) stated the green peach aphid gave unsatisfactory results, but transmission occurred by means of the cabbage aphid. Schultz (*12*), Clayton (*2*), and Chamberlain (*1*) reported negative results in tests for seed transmission but no data were given by others. According to Gardner and Kendrick (*4*), the incubation period for artificial infection ranged from 16 to 26 days while Clayton (*2*) records 3 to 5 weeks. Schultz (*12*) reported a period of 12 to 20 days for the green peach aphid.

Relative to host range, Gardner and Kendrick (*4*) and Chamberlain (*1*) were unable to infect radish. Unfortunately, other workers failed to test this plant for susceptibility. Conversely, Gram (*5*) observed infection of radish. Infection of rutabaga was reported only by Gram (*5*), Clayton (*2*), and Chamberlain (*1*); the description of symptoms differs in the latter two instances. There is no close agreement concerning symptoms on such hosts as Brussels sprouts and cauliflower based on the studies of Clayton (*2*) and Chamberlain (*1*). Clayton (*2*) found that cabbage was practically immune, Hoggan and Johnson (*7*) observed chlorotic rings, and Chamberlain (*1*) noticed only a faint mottle on the leaves. The writer (*16*) has previously reported light-green to yellow lesions which become necrotic around the edges with age. Spinach and currant tomato were reported as hosts by Hoggan and Johnson (*7*), but the writer has failed to obtain confirmatory results. To date, data on the properties of a turnip mosaic virus have been published only by Hoggan and Johnson (*7*). They used tobacco as a test host and since the writer used turnip a satisfactory comparison cannot be made.

Inevitably these differences have led to such questions as: Was the same turnip mosaic virus, or the same rutabaga mosaic virus, under the consideration by the different workers; are the turnip mosaic and rutabaga mosaic viruses identical? It is believed satisfactory answers to these questions cannot be given on the basis of available information and that any definite conclusions would not be justified.

SUMMARY

A mosaic disease of turnip, prevalent on Long Island, N. Y., is described.

Turnip mosaic is characterized by coarse vein clearing of the leaves in early stages of infection followed by conspicuous mottling with raised islands, crinkling, and stunting of the plants.

Under greenhouse conditions the turnip mosaic virus was readily transmitted by *Myzus persicae* and *Brevicoryne brassicae*. The virus was also transmitted by mechanical inoculation using carborundum as an abrasive; the incubation period ranged from 13 to 21 days. In longevity tests, the virus was active at the end of 2 days but inactivated after aging for 3 days at 22° C. Its inactivation temperature lies between 60° and 63°. A tolerance to dilution of 1 to 3,000 was established.

The host range includes 18 species of plants representing 12 genera in 6 families; 11 species belong to the family Cruciferae and include cabbage, cauliflower, rutabaga, leaf or Chinese mustard, pe-tsai, annual stock, dames violet, Virginian stock, honesty, and Chinese radish.

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