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STUDIES ON THE VIRUSES OF RADISH MOSAIC

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ABSTRACT

KIM, Woon Soo* & CHOI, Yae Chin**(University of Ill., U.S.A.* & Chunchon Agricultural Coll.**) Studies on the viruses of radish mosaic. Kor. Jour. Bot. VI (2):9—21, 1963.

A mosaic diseased radish collected from the suburb of Seoul, in November, 1961 was used for studing the host range, physical properties, purification, insect transmission, and electron microscopy.

A Japanese strain of radish mosaic (RPV) was also used with Korean strain of radish mosaic (KRMV) for a comparative study.

The two viruses, KRMA and RPV, were identified by the difference in host range, insect transmission and electron microscopy. The KRMA was severely infective on tobacco and *Nicotiana glutinosa*, while on Gomphrena globosa was immune to the virus. RPV produces necrotic local lesions on Gomphrena globosa but did not infect tobacco and *N. glutinosa*. Among varieties of radish, *Seoul*, *Akamaroo*, *Akanagea*, *Koong-Joong* showed more severe symptoms than *Simoo*, *Minong*, *Paek-soo*, which appeared to be fainly resistant. In a number of tests, it was found that the virus KRMA retained its infectivity until to a dilution of 1:2,000, heating at 58° C for 10 minutes, and aging *in vitro* for 7 days at room temperature. The RPV was not inactivated until it was diluted to 1:2,000, heated to 56$_0$ C, and aged for 6 days.

The KRMV was readily transmitted by the aphid (*Myzus persicae* Sulz). The virus RPV was not transmitted by the aphid in a number of tests. Partialy purified viruses using ammonium acetate buffer, salting-out by ammonium sulfate and centrifugation of high and low speed were highly infective. Electron micrographs showed that the KRMV paticles are of spherical particles whereas the RPV particles are rod-shaped.

INTRODUCTION

Since Tompkins(30) first noted the mosaic disease of radish in California, U.S.A. in 1939 similar diseases have been found in several other parts of the world. and a number of viruses or virus strains that cause mosaic symptoms in radish have been reported. Some of such viruses are Turnip mosaic

virus(29), Cabbage black ring spot virus(13), and Cauliflower mosaic virus(26), Works have already been made in the U.S. and other countries on Radish mosaic virus(7, 8, 24, 30); there have also been several reports from Japan on this virus(21, 25, 32). From a review of the literature, there are several viruses which attack radish crops (Table 1). .Ishiyama et al.(8) reported the stunt disease in radish from Japan: Severin(19), Kasai(9) and others (7, 8, 21, 30) reported that the transmission of this virus was done by aphids.

Takahashi (24) observed the particles of radish mosaic virus under the electron microscope and found that it is of rod-shape and about 25 x 120 mu in size. Tochihara(25) in Japan classified the isolated viruses from radish, by host range into three strains P.Q. and R. He made further studies on the p virus--host range, purification, electron microscopy. The physical properties of this virus vary among reporters. The radish mosaic virus (RMV), along with the tobacoo mosaic virus (TMV) and the potato virus X (PVX), is one of the most important pests to the main crops of Korea. To prevent the loss of the crops research works on the virus pathogens and on their control have been carried on in the U.S. and other countries of the world. Recently vegetable crops in Korea have decreased in yield by the virus pathogens; the damage in yield of radish and chinese cabbage amounts to over 40% yearly. Isolation of the virus and the discovery of the measure of its control would be an urgent problem in this country. In this study, some preliminary researches have been done on the host range, physical properties, transmission, purification, and the electron microscopy.

MATERIALS AND METHODS

A collection of six radish plants showing mosaic symptoms was made from important radish growing areas in the outskirts of Seoul. The Korean radish mosaic virus (KRMV) used in this study was isolated from these mosaicdiseased radish. The Japanese radish mosaic virus (RPV) was used as control; it was originally isolated from radish by Tochihara, at the National Institute of Agricultural Science in Japan. Saps from these diseased radishes were inoculated mechanically on the chinese cabbage (*B. pekinensis* Makino), turnip (*B. campestris* L). *Nicotiana glutinosa* L. tobacco (*N. tabacum* L.), radish (*Raphanus sativus* L.), cabbage (*B. oleracea* var. capitate), cucumber (*Cucumis sativus* L.), *Chenopodium Koreanse* Nakai and other hosts. Local lesion symptoms were produced on the inoculated leaves of chenopodium. From these lesions the KRMV was isolated. The RPV also produced a local lesion symptoms on the inoculated leaves of chenopodium. Both of the viruses KRMV and RPV have been maintained by successive inoculation on radish and turnip, which were kept in the wire net insect cages.

For the most part, plants to be tested were grown on compost soil in 3″–5″ earthen post. Plants were inoculated mechanically with a glass spatula after carborundum had been sprinkled on the leaves. The turnip variety Kanamachi and chenopodium were used for most of the green house studies.

Physical properties were determined in a manner similar to that described by Tochihara (25).

The aphids (*Myzus persicae* Sulz) used in the insect transmission studies were collected from the radish nursery in the vegetable farm and were manipulated by methods similar to those described by Tochihara (25).

In purification, the International Centrifuge Model PR-2 was used. Chinese cabbage harvested 20 days after inoculation was used for purification.

For the electron microscopy, Hitachi Model HS-6 electron microscope and Hitachi HUS-3 Vacuum evaporator were used.

Table 1. Viruses Infecting on Radish

Virus	Author and reference	Place found	Plant isolated	Symptoms on radish	Host range & differential hosts	Methods of transmission	Physical properties
Aster yellow virus	Severin & Frazier 1945*(2)	U.S. Calif.		Systemic infection	LIC *(1) Onion, Potato Celery	MCT IT	
Brassica nigra virus	Sylvester 1953	U.S. Calif.	Brassica nigra	SM*(3)	(−) Tobacco (−) Cabbage (+) Turnip	MCT IT: Aphid	TI: 60°c. DE: 1:10,000 AI: 96 hrs.
Broccoli mosaic virus	Caldwell & Prentice 1942	Devon-shire	Broccoli	SM	(+) Cabbage (+) Rape (+) Turnip	MCT IT: Aphid	TI: 75°c. DE: 1:2,000 AI: 7 days
Cabbage black ring virus	Tompkins, Gardner & Thomas 1937	U.S. Calif.	Cabbage	SM	(+) Chenopodium (+) Turnip (+) Tobacco (+) N. glutinosa	MCT IT: Aphid	TI: 59°c. DE: 1:1,000 AI: 3 days
Cabbage black ring spot virus	McClean & Cowin 1952-3	S. Africa	Cabbage	SM	(+) Poppy (+) Zinnia (+) Tobacco	MCT IT: Aphid	TI: 60°c. DE: 1:1,000 AI: 48 hrs.
Cauliflower mosaic virus	Tompkins 1934	U.S.	Cauli-flower	SM	(−) Tobacco (+) Turnip (+) Cabbage	MCT IT: Aphid	TI: 75°c. DE: 1:2,000 AI: 15 days
Chinese cabbage mosaic virus	Tompkins & Thomas 1938	U.S. Calif.	Chinese cabbage	SM	(+) All cruciferae (+) N. glutinosa (LL) (+) Tobacco (LL)*(4)	MCT IT: Aphid	TI: 73°c. DE: 1:5,000 AI: 3 days
Chinese rape mosaic virus	Wei et al. 1958	China	Rape	VC*(5)	(+) Ch. cabbage (−) cabbage,	MCT IT: Aphid	
Crucifer virus	Hoggan & Johnson 1935	U.S.	Horse radish & Turnip	VC	(+) Tomato (+) Tobacco (+) N. glutinosa	MCT IT: Aphid	TI: 54°c. DE: 1:1,000 AI: 2 days
Crucifer virus	Oliveira & Borges 1944	Portugal Lisbon	Papist spp.	SM	G9 : (−) N. glu. (+) Cab. G8 : (−) Cab. (+) Tob. G3 : (−) Tob. G1 : (+) N. glu.(+) C. semp. G5 : (−) C. semp. G4 : (+)N. glu. (+) Radish G7, 2, 6 : (−) Radish		
Crucifer virus	Dale 1948	Trinidad	Radish	SM	(−) Cabbage (+) Tobacco	MCT IT: Aphid	TI: 58°c. DE: 1:1,000 AI: 4 days
Crucifer virus	Hean 1949	S. Africa	Cauli-flower	VC	(+) Cabbage (+) Turnip	MCT IT: Aphid	TI: — DE: 1:50 AI: 2 days
Horse radish mosaic virus	Pound 1948	U.S. Wiscons.	Horse radish	VC	(+) Ann stock (+) Brassicae		
Malva yellows virus	Costa et al. 1959	U.S. Calif.	Radish		(+) Cabbage (+) Tobacco (+) Petunia (+) Zinnia (+) Hibiscus	MCT: (−) IT: Aphid Grafting (+)	

Radish mosaic virus	Tompkins 1939	U.S. Calif.	Radish	Chlorotic lesion	(+) Tobacco (LL) (+) Cauliflower (+) Turnip	MCT IT: Aphid B. Bra.	TI: 68°c. DE: 1:14,000 A:: 14 days
Radish stunt virus	Ishiyama & Mizawa 1943	Japan	Radish	VC VB*(6) EN*(7)	(+) Cabbage	MCT IT: Aphid	TI: 70°c. DE: 1:15,000 AI: 23 days
Radish mosaic	Takahashi 1952	U.S. Calif.	Radish	SM	(+) B. spp.		Rod-shape 25×120 mu
Radish mosaic virus	Horton 1956	U.S. Wiscons.	Radish	VC VB	G1, 3: LIC G2, 4, 5, 6: CR&NC*(8)	MCT IT: Aphid	TI: 70-80°c. DE: — AI: —
Radish mosaic virus	Raychaudhuri & Pathanian 1956	India	Radish	Necrosis & stunting	LIC	MCT IT: ?	TI: 85°c. DE: 1:10,000 AI: 17 days
Radish mosaic virus	Shimahama 1957	Japan	Radish	SM	Clsfd 5 groups by inf. to tobacco & cabbage	MCT IT: Aphid	
Radish mosaic virus	Tochihara 1959	Japan	Radish	VC	(+) Brassica spp. (−) Tobacco (−) Cabbage (+)	MCT IT: (±)	TI: 55-60°c. DE: 1:2,000 AI: 7 days Rod-shape
Rape mosaic virus	Ling & Yang 1940	China	Rape	VC	(+) Turnip (+) Ch. cabbage	MCT IT: Aphid	TI: 60-65°c. DE: 1:6,000 AI: 6 days
Stock mosic virus	Tompkins 1939	U.S.	Stock	SM	(+) M. incana	MCT IT: B. bra.	TI: 58-60°c. DE: 1:5,000 AI: 144 hrs.
Swede yellow mosaic virus	Kristensen 1957	Denmark	Swede		(+) Turnip (+) Radish (+) Ch. cabbage		TI: 75°c. DE: $1:10^6$ AI: 14 days
Turnip mosaic virus	Tompkins 1938	U.S. Calif.	Turnip	SM	(+) Cabbage (+) Ch. cabbage (+) Ann stock	MCT IT: Aphid	TI: 60-63°c. DE: 1:3,000 AI: —
Turnip yellow mosaic virus	Borges 1947	Portugal Lisbon	Turnip	Chlorosis of veins	(+) Mustard (+) Lepidium (+) Ch. cabbage	MCT IT: (−)	TI: 60°c. DE:1:200,000 AI: 9 days
Turnip yellow mosaic virus	Markham & Smith 1949	England Edinbur.	Turnip	SM	(+) Ch. cabbage (+) Cabbage	MCT IT: Beetle	TI: 70-75°c. DE: 100,000 AI: 14 days
Wasabia mosaic virus	Ohzima 1954	Japan Hokkaido	Wasabia radish	SM	(+) Turnip (+) Ch. cabbage (+) Napus	MCT IT: Aphid	T: 75°c. DE: 1:1,000 AI: 3 days

*1.....Limitted in cruciferae
*2.....Referenle number
*3.....Systemic mosaic
*4.....Local lesion symptom
*5..... Vein-clearing
*6..... Vein-banding
*7.....Enation
*8.....Cruciferae & non-cruciferae

EXPERIMENTAL RESULTS

Symptoms on radish; Seven to 14 days after inoculation the KRMV caused mosaic symptoms on the apical young leaf at temperatures ranging from 13 to 19° C. Slight vein-clearing and chlorotic lesions sometimes occur on the inoculated leaf 5 to 7 days after inoculation. Necrotic lesions and stunting of infected plants have not been known to occur either in the field or in the green house.

When the RPV was inoculated mosaic symptoms were produced 5 to 10 days after inoculation. Vein-clearing and chlorosis were sometimes observed on the leaves of infected radish. Stunting of the plant has not been observed during the experiment.

Symptoms on chinese cabbage; The KRMV infected on to the plant systemically and developed yellowish pin-points or chlorotic lesions around edges. Seven to 10 days after inoculation mosaic symptom appeared on a young leaf. Leaf distortion was observed sometimes on infected chinese cabbage plants a month after inoculation.

When the RPV was inoculated mosaic symptom appeared on a young leaf 5 to 7 days after inoculation. Leaf distortion was also observed 20 days after inoculation. No pin-points were developed.

Symptoms on turnip; The mosaic symptoms tend to be more pronounced on turnip with KRMV. After five to 10 days of inoculation the mosaic symptoms began to appear, the dark areas being often raised. Vein-clearing and vein-banding were sometimes observed clearly on the leaves developing after infection.

Upon inoculation of RPV on turnip vein-clearing and vein-banding were produced on the newly appearing leaves of the infected plant 5 to 10 days after inoculation. Dark green areas were sometimes observed 20 days after inoculation. Under temperature of above 28° C. the symptoms were milder than under the temperatures ranging from 15 to 20° C.

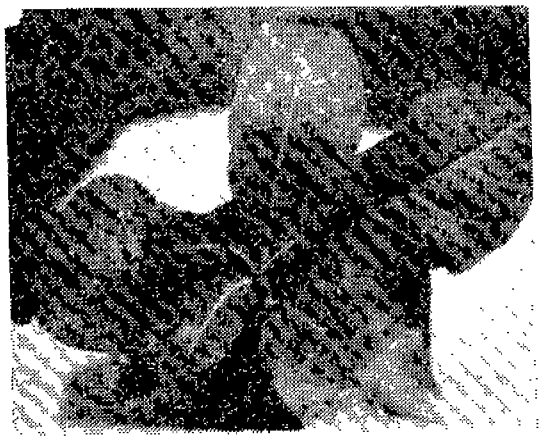
Symptoms on *Nicotiana glutinosa;* After 3 to 5 days of inoculation pin-point like lesions appeared on the leaves inoculated. After 5 to 10 days the infection became systemic with some stunting especially on the upper part of the plant. RPV did not infect on the plant.

Symptoms on chenopodium; Both KRMV and RPV caused local lesion on inoculated leaves 3 to 4 days after inoculation. After 7 to 10 days, the lesions have a tinge of red and rock quite distinct under the sun light. When inoculated on field grown chenopodium, or kept at high temperature above 28° C., the symptom started very slow taking more than two weeks. (Fig. 1)

HOST RANGE Fifty two members of cruciferae, Solanaceae, Cucurbitaceae, and other families of plants were tested for susceptibility to the two viruses. The plants tested and the results obtained are shown in table 2. Twenty-three members of plants were not susceptible to both the KRMV or RPV. None of the 7 Nicotiana species including *N. glutinosa* were susceptible to the RPV. KRMV was infective on Nicotiana species except to *N. rustica* L. *N. sandrae* L. *B. juncea* was susceptible to both KRMV and RPV.

The Pathogenicity to cabbages were very low with both of the viruses. KRMV was susceptible to *Cucurbita pepo* L., but it was not susceptible to RPV. *B. oleracea* var. capitata, succession, *B. oleracea* var. botrytis L., *Cucurbita moschata*, *Cucurbita pepo* L., *Cucumis sativus* L., *Impatiens balsamina* L., *Lycopersicum esculentum* Mill, *Zinnia elegans* Jacq were shown very mild infectivity to KRMV, but they

A



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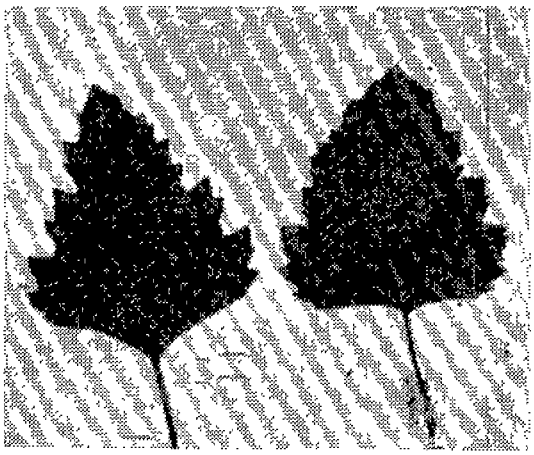

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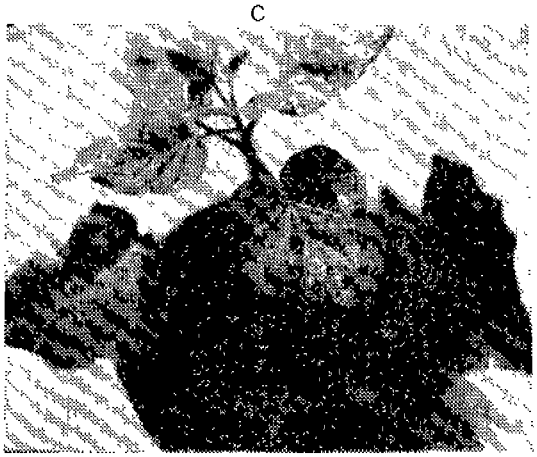


D

E

Fig. 1. Symptoms of KRMV on various hosts:

A. Chinese cabbage: infected (left) and healthy (right).

B. White Burley tobacco: systemic infection.

C. Chenopodium Koreanse Nakai,local lesions on inoculated leaf (right) and healthy (left.)

D. N. glutinosa L., systemic infection.

E. Radish; infected (left) and healthy (right).

were not susceptible to RPV. *Gomphrena globosa* L., was shown necrotic local lesion to RPV, but it was not susceptible to KRMV.

Table 2. Host range of two mosaic viruses of radish, KRMV (Korean strain) and RPV (Japanese strain).

Host	KRMV	RPV
althaea rosea cavanilles	0/5*	0/3*
Beta vulgaris L.	0/3	0/3
B. compestris	10/10	10/10
B. juncea L., Florida Broad Leaved	5/5	5/5
B. juncea L., Black mustard	5/5	5/5
B. juncea L., Yellow mustard	5/5	5/5
B. juncea Coss	5/5	5/5
B. napus L.	10/10	2/5
B. oleracea L.	1/10	0/3
B. oleracea var. *capitata*, Copenhagen	0/10	0/3
B. oleracea var. *capitata*, Succession	1/10	0/3
B. oleracea var. *capitate*, Yop-sim	0/5	0/3
B. oleracea var. *botrytis* L	1/10	0/3
B. oleracea var. *capitata*, Early round dutch	0/10	0/5
B. pekinsis	20/20	20/20
B. rapa L.	10/10	10/10
Callistephus chinensis Nees	0/5	0/3
Capicum annum L	0/5	0/3
Chenopodium Koreanse Nakai	10/10	5/5
Chrysanthemum coronarium L.	2/5	1/3
Citrullus vulgaris schrader	0/3	0/3
Cucumis melo L.	0/3	0/3
Cucumis sativus L.	1/10	0/8
Cucurbita moschata	1/3	0/3
Cucurbita pepo L.	5/5	0/3
Datura tatula L.	0/5	0/5
Gomphrena globosa L.	0/6	4/5
Impatiens balsamina L.	2/5	0/3
Lactuca sativa L.	0/10	0/5
Lagenaria vulgaris Seringe	0/2	0/2
Lycopersicum esculentum Mill	2/5	0/3
Malva olitoria Nakai	0/3	0/3
N. glutinosa L.	5/5	0/3
N. rustica L.	0/3	0/3
N. sandrae L.	0/3	—
N. tabacum L., Gold leaf	5/5	0/3
N. tabacum L., White Burley	5/5	0/3
N. tabacum L., Yellow special	3/3	0/3
N. tabacum L., Turkey	3/3	0/3
Petunia hybrida	3/4	3/3
Pharbitis Nill Choisy	0/5	0/3
Phaseolus vulgaris L.	0/6	0/5
Pisum sativum L.	0/6	0/5
Plantago major L.	0/6	0/3
Raphanus sativus L., Bom-moo	30/30	10/10
Soja maxMerill	0/5	0/3

Solanum nigrum L.	2/3	2/3
Spinacia oleracea L.	1/3	1/3
Taraxacum platycarpum	0/5	0.3
Vicia Faba L.	0/6	0/5
Vigna sinensis L.	0/5	0/ε
Zinnia elegasn Jacq	1/5	0/3

* Number of plants infected/Number of plants inoculated

VARIETAL SUSCEPTIBILITY in radish and Chinese cabbage.—With 16 varieeties of radish and Chinese cabbage tested, all were susceptible to KRMV and RPV, and the mosaic was most common on the plants, but 3 varieties of radish and one of Chinese cabbages showed more resistance to mosaic than the others. Radish varieties, Minong Early, Simoo (Tokinashi) were most resistant, while Paek-soo, and Extra Early (Chinese cabbage) were moderately resistant. (Table 3).

Table 3. Varictal Susceptibility Test

Radish and Chinesc cabbage variety		% of infection of 10 plants KRMV	RPV
Akamaroo 20 day	(radish)	100%	100%
Akanaga 20 day	(radish)	100	100
Chosun Moo	(radish)	100	100
Koong-Joong-Dae-Kun	(radish)	100	100
Minong Early	(radish)	20	30
Paek-Soo, Summer	(radish)	50	50
Seoul Bom-Moo	(radish)	100	100
Simoo (Tokinashi)	(radish)	40	30
White Icicle	(radish)	100	100
Chong Bang No. 9	(chinese cabbagc)	100%	100%
Chunpa Whasim	(chincsc cabbage)	100	100
Extra Early	(chincse cabbagc)	50	40
Kaesong	(chinese cabbagc)	100	100
San-Dong	(chinese cabbagc)	100	100
Seoul	(chinese cabbagc)	100	100
Spring No. 2	(chinese cabbage)	100	100

PHYSICAL PROPERTIES: Tolerance to dilution, thermal inactivation, and resistance to aging *in vitro* results are shown in Table 4. Both of the viruses, KRMV and RPV, were not inactivated at a dilution of 1: 2,000 In thermal inactivation tests——heating 10 minutes——the KRMV was not inactivated at 58° C. but the RPV inactivated at 56° C. In trials of resistance to aging *in vitro*, the KRMV aws inactivated in 7 days, and the RPV in 6 days.

Tble 4. Physical Properties

Tolerance to dilution:							times
	0	10	100	1,000	2,000	5,000	10,000
KRMV:	10/10	10/10	10/10	10/10	5/10	0/10	1/10*
RPV:	10/10	10/10	10/10	10/10	5/10	0/10	0/10

* Number of plants infcctcd out of 10 plants in 3 trials on the Chenopodium Korcanse Nakai

Thermal inactivation:

	Control	55	56	57	58	59	60	62	65° C.
KRMV:	10/10	10/10	5/10	2/10	1/10	0/10	0/10	—	0/10*
RPV:	10/10	10/10	2/10	0/10	0/10	0/10	0/10	—	0/10

* Number of plants infected out of plants on the Chenopodium Koreanse Nakai

Aging in vitro: days

	0	1	2	3	4	5	6	7	8	9	10
KRMV:	8/8	8/8	8/8	7/8	7/8	5/8	2/8	1/8	0/8	0/8	0/3*
RPV:	8/8	8/8	8/8	8/8	6/8	2/8	2/8	0/8	0/8	0/8	0/8

* number of plants diseased out of 8 plants inoculated in 3 trials on the *Chenopodium Koreanse* Nakai

INSECT TRANSMISSION: The green aphid (*Myzus persicae* Sulz) was used as the test insect. After starvation of 2–3 hours, the aphids were allowed on the leaves of diseased plant. After 10 minutes feeding the aphids were transferred to healthy seedlings of turnip and other hosts, 5–10 aphids per plant. After 10 hours the aphids were killed by spraying insecticide.

The results of test are shown in Table 5. With the RPV, not a single infection was obtained in all tests, whereas the KRMV showed comparatively high degree of transmission.

Table 5. Aphid transmission test

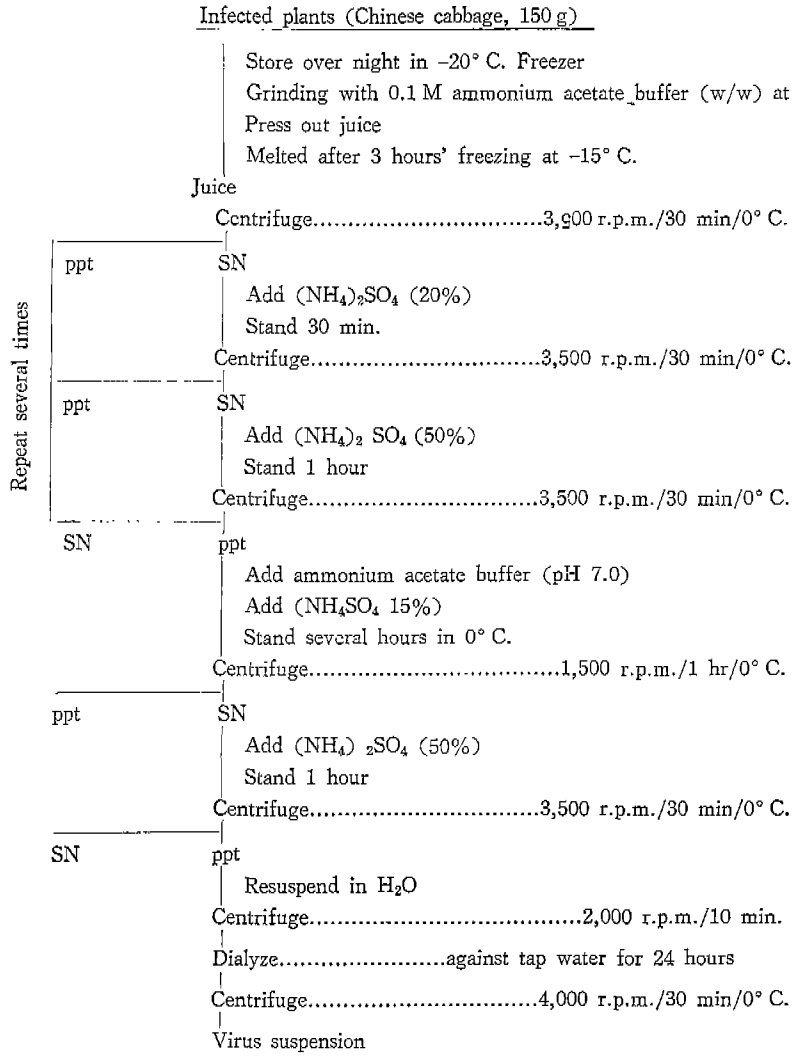
Host	KRMV	RPV
Chinese cabbage, Seoul	8/10*	0/7*
Radish, White Icicle	8/10	0/7
Turnip, Kanamachi	9/10	0/7
Tobacco, White Burley	3/3	—
Tobacco, Turkey	2/2	—

* Number of plants/infected Number of plants treated with aphids, 5–10 per plant.

PURIFICATION: After 3 weeks of inoculation, plants were harvested, partial washed, weighed in lots of 150 gm, wrapped in vinyl sack, and frozen, The frozen plants were passed through a mixer while still frozen with adding weight by weight of ammonium acetate buffer (pH 7.0). The juice was pressed from the macerate, and melted after 3 hours freezing at -15° C. This was then clarified by centrifuging it for 30 minutes at 3.500 r.p.m. To the supernatant liquid, while stirring, 20% of ammonium sulfate was added and, after standing for 30 minutes, centrifuged it for 30 minutes at 3.500 r.p.m. at 0° C. To the supernatant liquid, 30% of ammonium sulfate was added and, after standing one hour, centrifuged it for 30 minutes at 3.500 r.p.m. at 0° C. The precipitate was resuspended in ammonium acetate buffer (pH 7.0). one tenth of eolume to the original juice. This procedure was repeated until thebound components were removed.

To remove the dark pigmented material, involved the drop-by-drop addition of saturated ammonium sulfate solution to the virus concentrate at 20° C. until the first signs of opalescence be appeared. The preparation was chilled to 0° C. and allowed to stand for a few hours. Low speed (1.500 r.p.m./1 hr. /0° C.) centrifugation removed the brown precipitate. Saturating with ammonium sulfate (50%), the suspension was centrifuged for 30 minutes at 3.500 r.p.m./0° C. It was then resuspended in distilled water, dialyzed against tap water for 24 hours. Centrifuged at 4.00 r.p.m./30 min./0° C. The isoelectric point of the KRMV and RPV was around pH 4.0. (Table 6).

Table 6. Purification of KRMV and RPV



ELECTRON MICROSCOPY: For electron microscopy, Hitachi model HS 6 electron microscope was used. Purified viruses were mounted on 200-mesh wire grid that had been previously covered with a collodion membrane. Dried grids were shadowed with albuminium, and observed the shape of the virus particles. The KRMV particles, spherical in shape, were measured 55 mu in size. The RPV was about 650×12 mu in size with rod-shape.

DISCUSSION

The radish mosaic virus isolated from Korea (KRMV) causes severe mosaic symptoms on turnip, radish, mustard, chinese cabbage, rape, and tobacco; moderate symptoms were developed on *C. pepo* L., *C. coronarium* L., tomato and *Impatiens balsamina* L. and symptoms on cabbage were even milder. In physical properties, the thermal inactivation point of the virus was 58° C., dilution end-point, 1:2,000 and aging *in vitro*, 7 days. Like KRMV, the RPV severely infected upon radish, turnip, mustard,

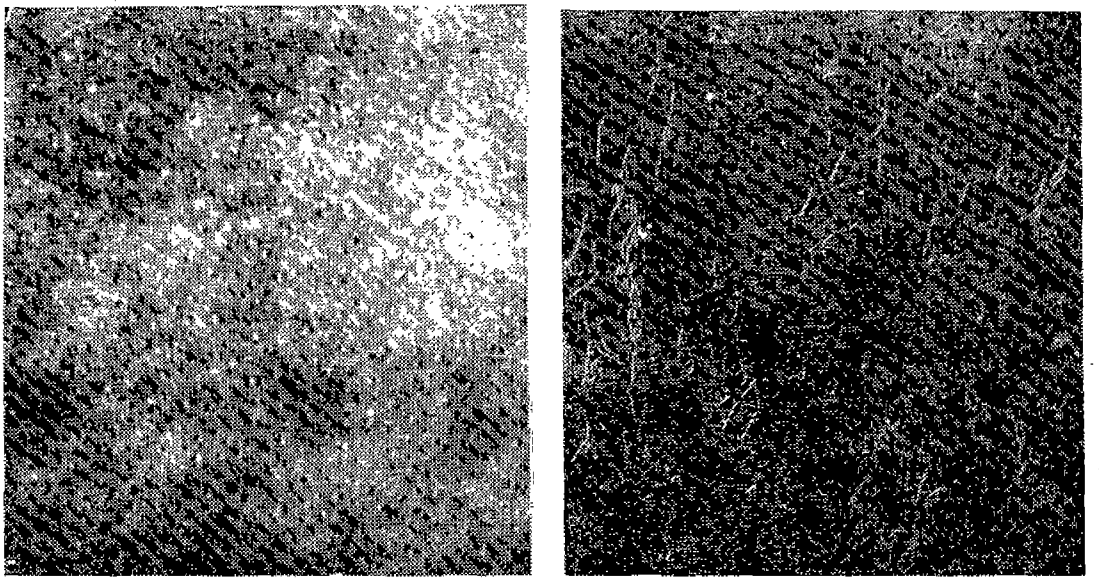


Fig. 2. Electron micrographs of KRMV & RPV; spherical (×15,000) KRMV and *rod-shape RPV.* (×15,000)

chinese cabbage and rape, but on cabbage its infectivity was mild as in the case of KRMV. KRMV infected on tobacco, but RPV showed no infection. The phylsica properties of RPV were found 56° C. in thermal inactivation point, 1 : 2,000 in dilution end-point, and of days in aging *in vitro*, which are similar to those of KRMV.

In the tests of insect transmission it was found that the KRMV was readily transmitted by the peach aiphids, whereas RPV was not.

The shape of virus particles of KRMV was spherical, while those of RPV are rod-shaped. Thus, KR MV is quite different from RPV in many respects.

According to the report by Tompkins et al. (27), the infectivity of cabbage black ring virus was severe on cabbage, turnip and tobacco, but that of KRMV was quite mild on cabbage. The thermal inactivation point of cabbage black ring virus was of 59° C., which is similar to KRMV, but the dilu tion end-point of the virus was 1 : 1,000 and aging *in vitro* was only 3 days, which is different from KRMV. Furthermore the black ring virus is of rod-shape.

According to another report by the same author (28) on the chinese cabbage mosaic virus, it infected on tobacco and Nicotiana glutinosa, but in physical properties, dilution end-point was of 1 : 5,000 and aging *in vitro* 3 days, thermal inactivation point 73° C., which are quite different from KRMV.

Dale's Crucifer virus (4), also infected on tobacco, but not on cabbage. In the physical properties of the virus, thermal inactivation point was of 58° C., dilution end-point 1 : 1,000 and aging *in vitro* 4 days, which is not exactly same as KRMV.

There are several more reports on the radish mosaic virus; i.e. Tompkins, (30) radish mosaic virus, Ishiyama and Mizawa's (8) stunt disease of Japanese radish, Takahashi's (24) Rod-shaped virus of radish mosaic, Horton's (7) Radish mosaic virus, and Raychaudhuri's (18) mosaic disease of radish, but their host ranges and physical properties are different from those of KRMV.

Crucifer viruses have been classified into several groups according to the pathogenicity on the Nicotiana genus and cabbages (32).

Tsujiya ot al. (32) classified the crucifer viruses into 5 groups on the basis of host range differences. Considering no pathogenicity to cabbage, the KRMV may belong to the 4 th group.

Pound and Walker (16, 17) classified the crucifer viruses into 2 major groups, turnip mosaic group and cauliflower mosaic group on the basis of host range, physical properties and temperatures affecting infection. If we are to follow them, KRMV may belong to turnip mosaic group, considering for positive pathogenicity to tobacco.

As to the shape of virus particles infecting on cruciferous plant; Takahashi's (23, 24) Brassica nigra virus (12 x 700 mμ), Radish mosaic virus (12 x 754 mμ) etc. are all of rod-shape, but KRMV is spherical, diameter being about 55 mu.

From the above observations the writer belive that the KRMV isolated in this work, is a new strain of radish mosaic virus. For the purpose of distinction the author will name the virus as the Korean Radish Mosaic Virus (KRMV).

摘 要

日本農林省 農業技術研究所에서 보내온 "무 모자이크 바이러스" (RPV)와 韓國의 서울 近郊의 菜蔬園에서 病에 걸린 "무"를 蒐集하여 그로 부터 分離한 "무 모자이크 바이러스" (KRMV)를 對照로 하여 宿主範圍 및 症狀, 物理的 性質, 昆虫傳染 및 電子 현미경 觀察등으로 檢討하였다. 이두 바이러스, KRMV와 RPV는 서로 다른 系統이라는 것이 밝혀졌다. 卽

1. 宿主範圍에서 KRMV는 담배 植物에 感染性이 있으나 RPV는 그에 感染性이 없다.
3. KRMV는 昆虫傳染이 되나 RPV는 되지 않았다.
3. KRMV 粒子는 球形이며 RPV는 棒狀이었다.
4. 物理的 性質은 大體로 비슷하였다.

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