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VIRUSES DESCRIBED PRIMARILY
ON LEGUMINOUS VEGETABLE AND FORAGE CROPS

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Division of Mycology and Disease Survey serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

VIRUSES DESCRIBED PRIMARILY
ON LEGUMINOUS VEGETABLE AND FORAGE CROPS

By Freeman Weiss¹, for the Sub-Committee on Leguminosae,
of the Committee on Virus Classification and Nomenclature,
American Phytopathological Society

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FOREWORD

This is the second in a series of descriptive lists of plant viruses that is being compiled under the auspices of this Committee and issued as supplements to the Plant Disease Reporter. The first, VIRUSES DESCRIBED PRIMARILY ON ORNAMENTAL AND MISCELLANEOUS HOSTS, was issued as Supplement 150 in July, 1944.

In addition to descriptions of the typical viruses associated with Leguminosae, an annotated list of other viruses and of virus diseases and similar maladies occurring on this plant group is included.

Some viruses treated in this compilation as independent entities may be shown by later research to belong to a single species, or viruses considered here as identical may later prove to be distinct. It is not the function of this review to attempt to resolve problems that require further experimental research for their solution. Instead it is the aim to present an organized summary of the available literature, and it is hoped that this objective has been accomplished with sufficient completeness and accuracy to facilitate further research in this field.

In the listing of hosts or susceptibles those found infected in nature are indicated by an asterisk. An attempt has been made to employ virus names and names of diseases that conform to those used in the Review of Applied Mycology as issued by the Imperial Mycological Institute, January 1, 1944. In ascertaining geographic distribution outside the United States and Canada, free use has been made of the indexes and abstracts of the Review of Applied Mycology. The list is believed to be reasonably complete as of the present writing but notice regarding omissions will be welcomed.

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(ARACHIS) PEANUT ROSETTE VIRUS

Technical name(s):

Arachis virus 1 K. M. Smith 1937

Marmor arachidis Holmes 1939

Synonyms:

Groundnut Kräuselkrankheit (curl disease) virus Zimmermann 1907, 1913

Groundnut rosette Dodge 1923

Groundnut rosette virus Storey & Bottomley 1925

? Groundnut krulziekte (virus) Schwarz 1927

? Groundnut clump disease (virus) Sundararaman 1928

Peanut rosette virus Storey & Bottomley 1928

Groundnut "leprosy" (virus) Trochain 1931

Name of disease:

Peanut rosette

Geographic distribution: Throughout equatorial and southern Africa, wherever the crop is grown; also in **Java, Madagascar, and** probably India. Diseases of virus aspect, but not confirmed as rosette, have been reported also in Australia [R.A.M. 19: 459], Argentina [R.A.M. 13: 317], Brazil [Costa 1941], China [Yu 1939], Russia [R.A.M. 16: 750], and the United States [KenKnight 1942].

Host range:

LEGUMINOSAE -- *Arachis hypogaea L. (most vars., but Philippine White and Philippine Pink are resistant).Centrosema plumieri Benth.

Symptoms: Two distinct types of symptoms have been generally recognized, which may correspond to different viruses, or at least to different strains [Hayes 1932]. Several minor variations, originally described as different diseases, also have been noted [Hansford, Hargreaves, Trochain]. In one type, chlorotic rosette [Hayes; Portères & Leglieu 1938], transient yellow patches appear in the youngest leaves, which become flaccid; subsequent leaves exhibit persistent chlorotic or yellow spots, and are attenuated, pointed, undersized, and crinkled; petioles and internodes are shortened; flowers are small, sessile, and fail to open. In the green rosette type there is no chlorosis, the leaves are darker than normal green, are undersized and tend to be roundish. The chlorotic syndrome can be superimposed on the green rosette type, and vice versa, by grafting, which is believed to indicate that two distinct viruses are concerned [Brooks]. In a third type the leaves remain normal in color but are much reduced in area while becoming thickened; branches are thickened and curved. In a fourth type, "clump", none of the plant organs develop normally, possibly due to early infection. In all types seed formation is arrested. The "mosaic type" described by Storey and Bottomley differs from chlorotic rosette in showing a pronounced mottle and less severe stunting; it is believed to be an exceptional reaction of individual plants to the same virus.

Means of transmission: By grafting. By Aphis medicaginis Koch (A. leguminosae Theob.) with symptoms in 13 days. Not by juice inoculation, nor through soil or seed.

Properties: Not determined.

Literature:

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(MEDICAGO) ALFALFA DWARF VIRUS

Technical name(s):

Medicago virus 3 K. M. Smith 1937

Synonyms:

Alfalfa dwarf (little leaf) Weimer 1931

Alfalfa dwarf virus Weimer 1936

Name of disease:

Alfalfa (lucerne) dwarf
Pierce's disease of grape

Geographic distribution: United States (Ariz., Calif.); possibly New South Wales.

Host range:

LEGUMINOSAE -- *Medicago sativa L.

VITACEAE -- *Vitis vinifera L.

Symptoms: Appear first in roots, consisting of yellowish streaks in the peripheral layer of wood just beneath the cortex; in cross sections at an early stage the discolored tissue appears as a band or ring, later it may extend throughout the section. The discoloration extends into the crown and stem bases. In aerial parts the first symptoms are a general dwarfing and failure of leaflets to attain normal size, but there is no chlorosis or deformity; the green color may even be intensified. Ultimately only a few stunted stems are produced and death ensues [Weimer 1931].

Means of transmission: By grafting involving root tissue union and by the insertion of diseased (yellow) tissue from roots or crowns into stems. However, stem cuttings produce 35 to 80 percent of diseased plants; not by juice inoculation [Weimer 1936, 1937]. More recently it has been shown that leafhoppers of the subfamily Amblycephalinae ("sharpshooters") are able to transmit this virus and that the same virus causes the Anaheim or Pierce's disease of grapes, a relationship previously suspected because of the observed correlation in the natural incidence of the two diseases [Hewitt, Frazier, & Houston]. The following species, constituting all the members of this subfamily as yet tested, can transmit this virus, and no other leafhoppers among many species tested have been found to possess this property: Carneocephala fulgida Nott., C. triguttata Nott., Cuerna occidentalis Oman & Beamer, Draeculacephala minerva Ball, Helochara delta Oman, Neokolla circelata (Baker), N. confluens (Uhler), N. gothica (Sign.), and N. heiroglyphica (Say) [Frazier].

Properties: Unknown.

Remarks:

Although this is identified as an alfalfa virus, owing to its first having been recognized as a virus in association with this host, on the basis of economic importance of the disease it causes in cultivated grapes it might more properly be considered a grape or vine virus. On this latter host the disease has been known since 1844, and is said to have caused the destruction of 30,000 acres of vineyards by 1895; however, it was not shown to be transmissible until 1938. The origin of the virus, whether on alfalfa or grape, is unknown and apparently either plant can serve as a virus reservoir for the infection of the other. A similar relationship exists between potato and clover with respect to the potato yellow-dwarf virus,

the virus taking its common name from the host in which it causes the economically more important disease.

Literature:

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(MEDICAGO) ALFALFA MOSAIC VIRUS

Technical name(s):

- Medicago virus 1 K. M. Smith 1937
- Marmor medicaginis Holmes 1939
- M. medicaginis var. typicum Black & Price 1940

Synonyms:

- Alfalfa mosaic virus Weimer 1931
- Alfalfa ringspot virus Young 1934
- Alfalfa virus 1 Pierce 1934
- Alfalfa virus 2 Pierce 1934
- Medicago virus 2 K. M. Smith 1937
- Alfalfa mosaic virus 1 Zaumeyer 1938
- Chilli mosaic virus Kovačevski 1942
- Medicago virus 2 var. typicum (Black & Price) Kovačevski 1942
- Lucerne mosaic virus Imp. Myc. Inst. 1944

Name of disease:

- Alfalfa (lucerne) mosaic
- Also celery mosaic (in part), chilli mosaic, pea streak (in part).

Geographic distribution: United States, more commonly in the western part from Montana and Oklahoma to the Pacific Coast, occasional in the Central and Eastern States; Canada (Alta., Que.). Possibly in China.

Host range:

- ACANTHACEAE -- Thunbergia alata Bojer
- AIZOACEAE -- Tetragonia expansa Murr.
- AMARANTHACEAE -- Amaranthus caudatus L.
- APCYNACEAE -- Vinca rosea L.
- BALSAMINACEAE -- Impatiens balsamina L.
- BORAGINACEAE -- Cynoglossum amabile Stapf & Drum.
- CAPPARIDACEAE -- Cleome spinosa L.
- CHENOPODIACEAE -- Beta vulgaris L.
- COMPOSITAE -- Chrysanthemum sp.; Cichorium endivia L.; Helianthus annuus L.; Zinnia elegans Jacq.
- CUCURBITACEAE -- Cucumis sativus L.
- GESNERIACEAE -- Sinningia speciosa (Ladd.) Hiern
- HYDROPHYLLACEAE -- Nemophila insignis Benth.; Phacelia campanularia A. Gray
- LABIATAE -- Coleus blumei Benth.
- LEGUMINOSAE -- *Medicago sativa L.
- Cicer arietinum L.; Crotalaria intermedia Kotschy;
Dolichos lablab L.; Lathyrus odoratus L.; Lens esculenta Moench;
Lespedeza striata (Thunb.) Hook. & Arn.; Lupinus albus L., L. luteus L.; Melilotus alba Desr.; Phaseolus angularis (Willd.) W. F. Wight. P. aureus Roxb., P. calcaratus Roxb., P. lunatus L., P. mungo L., P. vulgaris L.; Pisum sativum L.; Soja max (L.) Piper; Trifolium incarnatum L., T. pratense L., T. repens L.; Vicia americana Muhl., V. faba L., V. sativa L., V. villosa Roth; Vigna sesquipedalis (L.) Fruwirth, V. sinensis (Torner) Savi ex Hassk.
- LOBELIACEAE -- Lobelia tenuior R. Br.
- MALVACEAE -- Lavatera trimestris L.
- NYCTAGINACEAE -- Mirabilis jalapa L.
- ONAGRACEAE -- Godetia amoena Lilja
- PAPAVERACEAE -- Eschscholzia californica Cham.
- PHYTOLACCACEAE -- Phytolacca decandra L.
- PLUMBAGINACEAE -- Limonium sinatum (L.) Mill.
- POLEMONIACEAE -- Gilia liniflora Benth.; Phlox drummondii Hook.
- POLYGONACEAE -- Rheum rhaponticum L.; Rumex crispus L.
- PRIMULACEAE -- Primula obconica Hance
- RANUNCULACEAE -- Aquilegia caerulea James; Delphinium cultorum Voss
- SCROPHULARIACEAE -- Antirrhinum majus L.; Cymbalaria muralis Gaertn. Mey. & Scherb.; Linaria macedonica Griseb.; Mimulus moschatus Dougl.; Nemesia strumosa Benth.; Penstemon sp.; Verbascum phoeniceum L.; Veronica longifolia L.; Zaluzianskya villosa Schmidt

SOLANACEAE -- *Capsicum frutescens L. (C. annuum L.)

Datura stramonium L.; Hyoscyamus albus L., H. niger L.;
Lycopersicon esculentum Mill.; Nicandra physalodes (L.) Pers.;
Nicotiana alata Link & Otto, N. glutinosa L., N. langsdorffii
Weinm., N. longiflora Cav., N. palmeri A. Gray, N. paniculata L.,
N. rustica L., N. sanderiae W. Wats., N. sylvestris Speg., N.
tabacum L.; Petunia hybrida Vilm.; Physalis peruviana L.; Salpiglossis sinuata Ruiz & Pav.; Solanum melongena L., S. nodiflorum
Jacq., S. tuberosum L.

UMBELLIFERAE -- (*?) Apium graveolens L.

Anthriscus cerefolium Hoffm.; Daucus carota L. var.
sativa DC.

Symptoms: In alfalfa, the earliest symptom is the appearance of small, greenish-yellow spots, often ringlike with green centers, and is followed by more extensive and diffuse chlorosis typically spreading along and adjacent to the veins; the leaves become crinkled, deformed and brittle; there is no necrosis but general dwarfing may occur; sometimes only the lower leaves are affected and symptoms are masked at high temperatures [Weimer 1934]. In beans, small, reddish-brown, primary lesions, without systemic effects, are induced; in peas, varying with the virus strain, the symptoms range from a mild chlorotic mottle to a severe mosaic and streak with marked stunting and necrosis. In Vicia faba, necrotic, reddish-brown, local lesions, followed by general necrosis; in tobacco, white flecks and rings on the inoculated leaves followed by systemic mottling with ringspot-like necrotic patterns. [Zaumeyer 1938]. Ultimately there is a marked diminution of virus concentration and "recovery" of the ringspot type [Ross 1941]. In Capsicum frutescens (chilli) a severe mosaic disease occurs under field conditions in Bulgaria [Kovačevski 1942]. A mosaic disease of celery is caused by this virus in California [Snyder & Rich].

Means of transmission: By inoculation of expressed juice, readily, with an incubation period of 8-10 days. Commonly by the pea aphid Macrosiphum (Illinoia) pisi (Kalt.) [Weimer, Zaumeyer]; also by Myzus persicae (Sulz.) for chilli mosaic in Bulgaria [Kovačevski]. Not by seed [Pierce].

Properties: Filterability not demonstrated. Thermal inactivation 62-65° C [Pierce 1934; Zaumeyer & Wade 1935], higher for some strains, 65-70° and 70-75° [Zaumeyer 1938]. The "energy" of activation (E) value" is 75,000 cal. per mole between 50 and 62.5° C [Price 1940]. Dilution tolerance 1: 2000 [Pierce, Zaumeyer]; somewhat greater (1: 3000) for one strain [Zaumeyer 1938]. Longevity in vitro at 20° 4-5 days [Zaumeyer]; 8-9 days [Pierce]. No cross-protective relationships with the viruses of potato mottle, cucumber mosaic, or the Canada streak strain of potato aucuba mosaic [Black & Price, 1940].

A nucleo-protein having the properties of this virus was isolated by differential centrifugation [Ross 1940]; its mol. wt. was estimated at 2.1×10^6 , sp. gr. 1.48, sedimentation constant 74×10^{-13} , and the diam. of its spherical particles 16.5 m μ . Isoelectric point 4.6; stable in pH range 5.5 - 7.7.

Varieties and strains: (1) Potato calico virus (see also under Potato Viruses). This var., designated Marmor medicaginis var. solani Black & Price, differs from the type virus in its natural occurrence on potatoes [Porter 1931, 1935], and in producing stronger symptoms on potato, but milder ones on Nicotiana glutinosa, and on red and crimson clover [Black & Price]. The potato aphid Macrosiphum solanifolii (Ashm.) can transmit this virus [Porter 1935].

(2) Strains A and B. These strains were segregated from the type virus by Zaumeyer [1938] on the basis of the intensity of symptoms induced in several hosts, especially pea, broad bean, etc., though identical on alfalfa; strain B also has a higher thermal death point.

(3) Alfalfa viruses 1 and 2. The viruses originally identified as distinct types under these numbers [Weimer, Pierce] are regarded by subsequent investigators [Zaumeyer; Black & Price] as of no greater order of difference than strains, of which many minor variations occur in nature [Weimer, Zaumeyer, Valleau].

Literature:

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_____, and B. L. Wade. The relationship of certain legume mosaics to bean. Jour. Agric. Res. 51: 715-749. 1935.

(MEDICAGO) ALFALFA WITCHES'-BROOM VIRUS

Technical name(s):

Medicago virus 4 K. M. Smith 1937

Chlorogenus medicaginis Holmes 1939

Synonyms:

Alfalfa witches'-broom (virus) Richards 1929

Lucerne witches'-broom virus Edwards 1935

Name of disease:

Alfalfa (lucerne) witches'-broom.

Other names applied in Australia: spindle shoot, mistletoe, bunchy top, kurrajong [Edwards 1936].

Geographic distribution: United States (Idaho, Utah, Wash.); Canada (British Columbia); Australia (New South Wales, Queensland, Victoria); ? New Zealand.

Host range:

LEGUMINOSAE -- *Medicago sativa L.

Medicago hispida Gaertn., M. lupulina L.

Symptoms: General dwarfing; stems short, thin, numerous and bunched; leaves small, of abnormal round form, puckered, chlorotic at edge; flowers suppressed or few, sometimes virescent; seed rarely set. In late stages, decay of roots and crowns, and ultimate death. Symptoms sometimes masked in early spring growth but appear after first cutting [Edwards 1936].

Means of transmission: By grafting, using side (veneer) attachment of healthy scion to diseased root and vice versa [Edwards]; also by stem grafts but not by dodder union [Menzies]. Symptoms appear in the stock 2 months after shoot grafting, 5-6 months after root grafting. Not by juice inoculations, nor by insects as far as tested (including exposure to mass populations of alfalfa-infesting insects). Not seed-borne [Edwards]. Possibly by the leafhopper Scaphytopius acutus (Say) [Menzies 1944].

Properties: Unknown.

Remarks:

The assumed identity of the disease occurring in the U. S. with that in Australia is based upon the conclusions of Edwards who observed the dis-

eases in the field in the two countries.

Literature:

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 Jour. Australian Inst. Agric. Sci. 1: 31-32. 1935.
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 Menzies, J. D. Transmission studies with alfalfa witches'-broom.
 Phytopath. 34: 936. 1944.
 Richards, B. L. Witches' broom, cause unknown. U. S. Dept. Agri.
 Plant Dis. Repr. Suppl. 71: 309-310. 1929

(PHASEOLUS) BEAN COMMON MOSAIC VIRUS

Technical name(s):

- Phaseolus virus 1 K. M. Smith 1937
Marmor phaseoli Holmes 1939

Synonyms:

- (Bean) mosaic disease Iwanowski 1899
 Bean infectious chlorosis Clinton 1908
 Bean mosaic (virus) Stewart & Reddick 1917
 Bean mosaic virus Reddick & Stewart 1919
 Marmor mosaic (mottle mosaic) Merkel 1929
 Pocken Mosaik (blister mosaic) virus Merkel 1929
 Typical bean mosaic virus Nelson 1932
 Common bean mosaic virus Pierce 1934
 Bean virus 1 Pierce 1934
 Ordinary bean mosaic virus Costa & Forster 1941

Name of disease:

Common bean mosaic

Geographic distribution: Probably world-wide. Reports of "bean mosaic" are on record from all the continents and Australia, though often not discriminating between the common and the yellow types. Bean seed from 22 countries produced plants showing typical mosaic [Nelson 1932]. In the United States the incidence of common bean mosaic is greatest in the Northern and Western States.

Host range:

LEGUMINOSAE -- *Phaseolus calcaratus Roxb., *P. vulgaris L.

Lespedeza striata (Thunb.) Hook. & Arn.; Phaseolus acutifolius Gray var. latifolius Freem., P. aureus Roxb., P. lunatus L., P. lunatus var. macrocarpus Benth. (P. limensis Macf.); Vicia faba L., V. sativa L.

Based on insect transmission in the field Nelson [1932] listed P. aconitifolius Jacq., P. angularis (Willd.) Wight, P. coccineus L., P. mungo L., and Vigna sesquipedalis (L.) Fruwirth as addi-

tinal susceptibles. Zaumeyer & Wade [1935] found only varieties of P. vulgaris susceptible to this virus by juice inoculations. Natural infection of Phaseolus coccineus L. with a similar mosaic disease was reported in the U. S. by Gardner [1925] and in New Zealand by Chamberlain [1939]; in the latter instance the virus was seed-transmitted and is therefore considered identical with common bean mosaic virus.

Symptoms: Susceptible vars. of beans first show diffuse chlorosis and downward curling of leaves; later may show patchy chlorosis or a definite green mottle together with leaf distortion varying from blistering and puckering of surface to marked irregularities of form and reduction of size. Resistant vars. show only a faint chlorosis, transient mottle, or slight ruffling of leaves. Other organs (stems, pods, flowers) are not greatly affected as a rule though reduced in number and size. Symptoms are most evident in the temp. range 20-28° C; masking is more or less complete above 28° and below 15° [Fajardo 1930].

Disintegrative changes occurring in plastids and cytoplasm give rise to amorphous, granular cell inclusions but no typical inclusion bodies [Nelson 1932].

Means of transmission: By expressed juice, with aid of carborundum; incubation period 8 to 15 days. By grafting [Nelson 1932]. By the following aphids: Aphis rumicis L. (A. fabae Scop.), A. gossypii Glov., A. medicaginis Koch, A. spiraecola Patch, Brevicoryne brassicae (L.), Hyalopterus atriplicis (L.), Macrosiphum ambrosiae (Thos.), M. pisi (Kalt.), M. solanifolii (Ashm.), Myzus persicae (Sulz.), Rhopalosiphum pseudobrassicae (Davis) [Nelson 1922, Fajardo 1930, Zaumeyer & Kearns]. By seed, in variable proportions up to 50% (usually less than 10%) of the progeny of infected plants [Reddick & Stewart; Fajardo; Smith & Hewitt].

Properties: Not filterable through any grade of Berkefeld filter [Fajardo]. Thermal inactivation between 44° and 56° C [Fajardo]; 56-58° [Pierce; Zaumeyer & Wade]; in seeds the virus can withstand 65° for 24 hrs. [Fajardo]. Dilution end-point below 1: 1000. Longevity in vitro about 24 hrs.; in cut plants 96 hrs. if kept turgid but reduced to 48 hrs. by drying [Fajardo]; in seeds several to many (+30) years [Pierce & Hungerford].

Serological relations: No virus-specific precipitin reaction obtained [Chester 1937].

Remarks:

Certain vars. of beans are highly resistant to this virus, e. g. Robust, and some are completely immune since they show no symptoms when inoculated and the virus cannot be recovered from them. Examples of the latter type are the Corbett, Idaho, U. S. No. 5, and Wisconsin Refugee, and U. I. Great Northern vars. [Walker & Jolivette 1943].

However, a mosaic disease having symptoms typical of common mosaic has recently appeared on certain hitherto resistant vars. in New York; the

causal virus is seed-transmitted and is believed to be a strain of this virus or one closely related [Richards & Burkholder]

Literature:

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- Walker, J. C. and J. P. Jolivet. Productivity of mosaic-resistant Refugee beans. Phytopath. 33: 778-788. 1943.
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(PHASEOLUS) BEAN SOUTHERN MOSAIC VIRUS

Technical name(s):

Marmor laesiofaciens Zaumeyer & Harter 1943

Synonyms:

Bean-mosaic virus 4 Zaumeyer & Harter 1942

Southern bean-mosaic virus 1 Zaumeyer & Harter 1943

Name of disease:

Southern bean mosaic

Geographic distribution: United States (Calif., La., Md.; probably Colo., Idaho, Miss., and elsewhere).

Host range:

LEGUMINOSAE -- *Phaseolus vulgaris L. (no var. fully resistant though differing in symptom expression; those resistant to systemic infection can be considered commercially resistant).

Phaseolus lunatus L. (but not P. lunatus var. macrocarpus Benth. or Fordhook types); Soja max (L.) Piper (var. Virginia).

31 spp. representing 20 genera of Leguminosae and 4 other families were insusceptible.

Symptoms: Among bean varieties 2 distinct types of symptom expression occur which depend on a single genetic-factor difference, viz., systemic mottling and local necrotic lesions, the latter being dominant [Zaumeyer & Harter 1943 a]. In vars. that react with systemic mottling (recessive types), the degree of mottling ranges from mild to intense, the interveinal tissue being lighter green than that bordering the veins; puckering, blistering, distortion, and dwarfing similar to that in common mosaic also may occur. The pods also are mottled and sometimes distorted and undersized. The virus is distributed throughout the plant from roots to pods and seeds.

In vars. reacting with local lesions (dominant and heterozygous types), the leaves are more or less thickly covered with necrotic spots 1 to 3 mm in diam., circular, brownish-red, frequently with light centers. In some vars. a severe leaf- and stem-necrosis occurs [Zaumeyer & Harter 1944]. Symptoms expressed through a temp. range of 16° to 27° C, with optimum expression at 18°.

Means of transmission: By expressed juice with aid of carborundum. No insect vector is known.

Properties: Thermal inactivation at 95° C, dilution tolerance above 1 to 500,000; longevity in vitro at 18° at least 32 weeks. The temp. coefficient (Q₁₀) of inactivation of the virus is about 3.1, and the energy of activation (E) is about 27,750 cal. per mole. These values are close to those previously found for tobacco necrosis virus but are quite different from those of tobacco mosaic virus [Price 1944].

Immunological reactions: No antagonism shown to common mosaic virus of bean.

Strains: A virus closely similar in respect to the reactions induced in beans and in properties has been designated Marmor laesiofaciens var. minor (bean mosaic virus 4-A, southern bean mosaic virus 2) Zaumeyer & Harter. It differs from the type in the appearance of the local lesions in certain vars., and in causing more distortion and stunting in systemic infections; it is also transmitted through a small proportion of seed.

Literature:

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- Zaumeyer, W. J., and L. L. Harter. A new virus disease of bean. Phytopath. 32: 438-439. 1942.
- _____, and _____. Two new virus diseases of beans. Jour. Agric. Res. 67: 305-328. 1943.
- _____, and _____. Inheritance of symptom expression of bean mosaic virus 4. Jour. Agric. Res. 67: 295-300. 1943.
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(PHASEOLUS) BEAN YELLOW MOSAIC VIRUS

Technical name(s):

Phaseolus virus 2 K. M. Smith 1937

Synonyms:

- ? Sweet clover mosaic (virus) McLarty 1920
- ? Sweet clover mosaic (virus) Elliott 1921
- ? Sprenkelmosaik (speckle mosaic) virus Merkel 1929
- Yellow bean-mosaic virus Pierce 1934
- Bean virus 2 Pierce 1934
- ? Pea virus 2 Osborn 1935, 1938
- ? Pea mosaic virus 2 Zaumeyer & Wade 1935
- White sweetclover mosaic virus Zaumeyer & Wade 1933, 1935
- Yellow sweetclover mosaic virus Zaumeyer & Wade 1935
- Bean dwarf mosaic virus Costa & Forster 1941

Name of disease:

Yellow bean mosaic

Geographic distribution: United States (probably coextensive with cultivation of beans, specifically reported on beans in Colo., Idaho, Md., N. Y., Texas, Va., and Wis., and widely on sweetclover). Also in Brazil [Costa & Forster; Silberschmidt & Nobrega]; possibly in China as white sweetclover mosaic [Yu 1939]; and in Japan as red clover mosaic [Fukushi 1936].

Host range:

LEGUMINOSAE -- *Melilotus alba Desr., *M. officinalis (L.) Lam.;
*Phaseolus vulgaris L.

Cajanus cajan (L.) Millsp.; Cicer arietinum L.;
Lathyrus odoratus L.; Lens esculenta Moench; Phaseolus angularis
 (Willd.) Wight, P. aureus Roxb., P. mungo L.; Pisum sativum L.
 (all tested vars. except Surprise and Wisconsin Early Sweet), P.
sativum var. arvense Poir.; Trifolium repens L., T. pratense L.;
Vicia americana Muhl., V. faba L. [Zaumeyer & Wade 1936].

The following were reported susceptible by Pierce [1934] but
 not by Zaumeyer & Wade: Lespedeza striata (Thunb.) Hook. & Arn.;
Lupinus albus L.; Phaseolus acutifolius Gray var. latifolius
 Freem.; Soja max (L.) Piper; Trifolium incarnatum L.

Symptoms: In snap beans, downward curling and reflexing of the lamina
 of trifoliate leaves, slight ruffling, brittleness, appearance of small
 yellow spots; secondary symptoms include a coarse yellow mottle and
 distortion of leaves, proliferation of stems and shortening of nodes,
 and general stunting; maturity is delayed and pod production much re-
 duced. Symptoms are masked at high temp., and are weakly developed in
 some vars., certain ones of which are resistant also to common mosaic,
 but no vars. are known to be immune [Pierce; Zaumeyer & Wade].

In pea and sweet pea, this virus induces a conspicuous veinal
 chlorosis and faint interveinal mottle, with slight ruffling and re-
 duction of size. In sweetclover it causes a veinal chlorosis with pat-
 terns ranging from a fine stippled mottle to large chlorotic patches
 [Zaumeyer & Wade].

It induces local necrotic lesions in Phaseolus aureus and P. mungo,
 and general necrosis in Cicer arietinum and Lens esculenta.

Means of transmission: By extracted juice, with aid of carborundum. By
 the aphids Macrosiphum pisi (Kalt.) and M. solanifolii (Ashm.) [Pierce
 1934; by Aphis rumicis L. [Zaumeyer & Wade]. Not by seed [Pierce],
 but seed transmission is claimed by Costa & Forster for their dwarf
 mosaic virus which they consider identical with this.

Properties: Filterability not demonstrated. Thermal inactivation at
 58-60° C; dilution tolerance 1:800 to 1:1000, longevity in vitro 24-48
 hrs. [Pierce; Zaumeyer & Wade].

Immunological and serological relationships: Not demonstrated.

Strains or related viruses: Several viruses having properties similar to
 those of yellow bean mosaic virus, but differing in specific host reac-
 tions, have been described as distinct viruses on various hosts. These
 include, besides sweetclover mosaic virus and pea mosaic virus 2 Zau-
 meyer & Wade, indicated as synonyms above, the following viruses as
 originally named: pea virus 2 Osborn, pea virus 4 Zaumeyer, and alsike
 clover mosaic virus 2 Zaumeyer. They are all infectious to some vars.
 of Phaseolus vulgaris, including those resistant to common bean mosaic,

and in general they induce a yellow mosaic in this host. They are uniformly infectious to Melilotus alba, and variably to other plants of the tribes Phaseolae and Trifoleae, but with no known hosts outside the Leguminosae. They may be regarded as strains of or closely related to yellow bean mosaic virus [Weiss 1939, Zaumeyer 1940]; possibly one form of sweet pea streak virus found in England also belongs to this group [Ainsworth 1940]. A relationship between pea mosaic virus 2 Zaumeyer & Wade and pea mottle virus also has been suggested [F. Johnson 1942].

Pending the definite allocation of these strains to certain virus species, and for the purposes of this preliminary list, it seems best to list them under the hosts on which they were first described.

Remarks:

This virus is readily distinguishable from that of common bean mosaic by its infectivity for peas, sweet pea, and certain vars. of beans (Robust, Corbett Refugee) which are resistant to the latter. Absence of seed transmission, although in question, is generally considered to be a reliable distinguishing characteristic. Although one of the viroses commonly found in sweetclover (Melilotus spp.) is caused by a strain of yellow bean mosaic virus, other viruses occurring in this plant are quite unrelated. The tobacco streak virus (see section on viruses of Nicotiana) has been transferred by dodder to Melilotus, causing a ringspot and mottle similar to an endemic disease of this plant in Kentucky, and was also returned to tobacco [Valleau 1941]. Conversely, streak virus was transmitted from naturally infected Melilotus in Ontario to tobacco, and vice versa [Berkeley & Phillips 1943]. However, the yellow bean mosaic virus studied by Pierce, which was sometimes obtained from sweetclover, was non-infectious to tobacco [Pierce 1935].

Literature:

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- _____, and B. L. Wade. The relationship of certain legume mosaics to bean. Jour. Agric. Res. 51: 715-749. 1935.
- _____, and _____. Pea mosaic and its relation to other legume mosaic viruses. Jour. Agric. Res. 53: 161-185. 1936.

(PHASEOLUS) LIMA BEAN MOSAIC VIRUS

Technical name(s):

Marmor cucumeris var. phaseoli Holmes 1939

Synonyms:

? Lima bean mosaic McClintock 1917

Lima bean mosaic virus Harter 1935

Name of disease:

Lima bean mosaic

Geographic distribution: United States, chiefly the Eastern and Southern States, also California. A mosaic disease of this host is reported also in Puerto Rico, Cuba, China, Sierra Leone.

Host range:

LEGUMINOSAE -- *Phaseolus lunatus L., *P. lunatus var. macrocarpus Benth.; the small-seeded types in general being susceptible, the large-seeded Fordhook sorts resistant.

Also infectious to Vicia faba L. and Vigna sinensis (Torner) Savi ex Hassk., but Phaseolus vulgaris L., Pisum sativum L., Lathyrus odoratus L., Soja max (L.) Piper, and Trifolium hybridum L. are insusceptible. Infectious also to representative other hosts of cucumber mosaic virus.

Symptoms: In lima bean, first vein clearing, then downward curving of the leaf blade and often of the shoot tip, death of the whole plant sometimes then ensuing; later symptoms consist of prominent yellow flecking and chlorotic mottling of foliage; pods not affected. In cowpea, minute necrotic lesions on inoculated leaves without systemic effects [Harter].

Means of transmission: By expressed juice; by the aphids Aphis gossypii Glov. and Myzus persicae (Sulz.). Not by seed [Harter].

Properties: Thermal inactivation at 70° C; dilution tolerance 1:10,000; longevity in vitro 8 days at 22° C.

Remarks:

On the basis of its infectiousness to Vicia faba, production of primary lesions in the form of chlorotic rings and circles on tobacco, and a somewhat lower thermal death point than the type and the celery strains of cucumber mosaic virus, the lima bean virus is designated as a strain [Harter]

Literature:

- Harter, L. L. Mosaic of lima beans (Phaseolus lunatus macrocarpus).
 Jour. Agric. Res. 56: 895-906. 1938
 McClintock, J. A. Lima bean mosaic. Phytopath. 7: 60. 1917

(PISUM) PEA COMMON MOSAIC VIRUS

Technical name(s):

- Pisum virus 2 K. M. Smith 1937
Marmor leguminosarum Holmes 1939

Synonyms²:

- ? Sweet pea mosaic (virus) Taubenhaus 1914
- ? Red clover mosaic (virus) Elliott 1921
- ? Clover mosaic (virus) Dickson 1921
- ? Field pea mosaic (virus) Dickson 1921
- ? Sweet pea mosaic (virus) Dickson 1921
- Garden pea mosaic (virus) Doolittle & Jones 1925
- Red clover mosaic (virus) Doolittle & Jones 1925
- Sweet pea mosaic (virus) Doolittle & Jones 1925
- ? Broadbean mosaic (Marmorier-Mosaik) virus Böning 1927
- Lupin sore-shin virus Neill 1934
- Common pea mosaic virus Zaumeyer & Wade 1935
- Pea virus 1 Zaumeyer & Wade 1935
- Red clover mosaic virus Zaumeyer & Wade 1935
- Marble pea mosaic (pea virus 2A) Stubbs 1935, 1937
- Speckle pea mosaic (pea virus 2B) Stubbs 1935, 1937
- (Corresponding names, Marmor-Mosaik and Sprenkel-Mosaik were applied by Merkel, 1929, to certain types of pea mosaic, but are not included here as synonyms, because they could apply with equal validity to the pea viroses caused by yellow bean mosaic virus or pea mottle virus.)
- Mild pea mosaic (pea virus 2C) Stubbs 1935
- Common pea mosaic virus Pierce 1935
- Pea virus 3 Pierce 1935
- Pea mosaic virus Chamberlain 1935, 1936
- Common pea-mosaic virus Murphy & Pierce 1937

Name of disease:

Common pea mosaic

Geographic distribution: United States (widespread, probably wherever peas are grown, this virus specifically identified in Calif., Colo., Idaho,

²Because of the confusion in literature regarding the identification of pea mosaic viruses, the names applied to this virus in all the principal studies of it are listed here even though duplicating previous names.

Mont., N. J., N. Y., Wis.); Canada (all provinces); Europe (British Isles, Germany, Holland); Australia; New Zealand; ? China; ? Japan.

Host range:

LEGUMINOSAE -- *Cassia corymbosa Lam.; *Lathyrus odoratus L.; *Lupinus albus L., *L. angustifolius L., * L. varius L.; *Melilotus alba Desr.; *Pisum sativum L.; *Trifolium hybridum L., *T. pratense L.

Cicer arietinum L.; Desmodium canadense (L.) DC.; Hovea trisperma Benth.; Lathyrus sativus L., L. tingitanus L.; Lupinus densiflorus Benth., L. hartwegii Lindl., L. luteus L., L. mutabilis Lindl., L. nanus Dougl.; Medicago arabica Huds., M. denticulata Willd., M. hispida Gaertn., M. lupulina L.; Melilotus officinalis (L.) Lam.; Phaseolus acutifolius Gray var. latifolius Freem.; Pisum sativum L. (44 vars. found susceptible, 21 were resistant, including Horal, Little Marvel, Perfection, Thomas Laxton, Wisconsin Early Sweet [Murphy & Pierce]), P. sativum var. arvense Poir.; Trifolium agrarium L., T. carolinianum Michx., T. dubium Sibth., T. glomeratum L., T. incarnatum L., T. procumbens L., T. reflexum L., T. suaveolens Willd.; Vicia faba L. var. major and var. minor, V. sativa L.

Not infectious to alfalfa (Medicago sativa), bean (Phaseolus vulgaris), cowpea (Vigna sinensis), soybean (Glycine max), white clover (Trifolium repens), or to any non-leguminous plants of 32 families tested. [Murphy & Pierce]

Symptoms: In peas, slight vein clearing, followed by conspicuous light or yellowish green, interveinal mottling in leaves and stipules, which become wrinkled, puckered, and twisted; apical parts rosetted, tendrils distorted, general stunting. In general there is more distortion and dwarfing than in other mosaic diseases of peas. Maximum expression of symptoms at 18-24° C, masked at 12-14° C [Stubbs]. In sweet pea, pronounced chlorotic mottling of leaves and striping of flowers. In broadbeans, a strong yellow-green mottle with dark green islands. In alsike, crimson, and red clovers, vein clearing followed by fine yellowish-green, interveinal, striping [Zaumeyer & Wade 1935; Murphy & Pierce 1937] and marked stunting [Chamberlain 1936]. In Cicer arietinum and Lupinus angustifolius, the virus causes top necrosis, sometimes becoming systemic, and general yellowing of foliage [Murphy & Pierce].

Means of transmission: By expressed juice, readily. By the aphid Macrosiphum pisi (Kalt.) [Doolittle & Jones; Stubbs; and others]; in New Zealand by Myzus persicae (Sulz.), Aphis citricidis (Kirk.), A. gossypii Glov., A. laburni Kalt., Cavariella aegopodii (Scop.), Macrosiphum rosae (L.), M. solanifolii (Ashm.), Capitophorus (Pentatrichopus) tetrarhodus (Walker), Rhopalosiphum pseudobrassicae (Davis) [Chamberlain 1936; Norris 1943]. Not by seed [Chamberlain; Murphy & Pierce] or very rarely [Zaumeyer & Wade; Norris].

Properties: Thermal inactivation at 60° C; longevity in vitro 2-3 days at

22° C [Murphy & Pierce]; dilution tolerance 1:1,000 - 1:1,500 [Stubbs].

Strains: Three strains differing in symptoms induced in peas but with similar host range and properties were distinguished by Stubbs.

Remarks:

Common pea mosaic virus can be distinguished from pea enation virus by absence of enations and inability to infect Moral and Perfection vars.; from yellow bean mosaic virus by usually more distinct mottling and distortion in peas and inability to infect beans; from pea mottle virus by usually milder symptoms in peas and inability to infect non-legumes.

Literature:

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- Pea-mosaic. Host range and methods of transmission. New Zealand Jour. Sci. & Techn. 18: 544-556. 1936.
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- Murphy, Donald M., and W. H. Pierce. Common mosaic of the garden pea, Pisum sativum. Phytopath. 27: 710-721. 1937.
- Neill, J. C. "Sore shin": a virus disease of blue lupins. New Zealand Jour. Agric. 49: 139-146. 1934
- Norris, D. O. Pea mosaic on Lupinus varius L. and other species in Western Australia. Australia Counc. Sci. & Ind. Res. Bull. 170. 1-27. 1943.
- Pierce, W. H. The identification of certain viruses affecting leguminous plants. Jour. Agric. Res. 51: 1017-1039. 1935.
- Stubbs, Merl W. Certain viroses of the garden pea, Pisum sativum. Phytopath. 27: 242-266. 1937.
- Taubenhaus, J. J. The diseases of the sweet pea. Delaware Agric. Exp. Sta. Bull. 106. 1-93. 1914
- Zaumeyer, W. J., and B. L. Wade. Relationship of certain legume mosaics to bean. Jour. Agric. Res. 51: 715-749. 1935.
- _____, and _____. Pea mosaic and its relation to other legume mosaic viruses. Jour. Agric. Res. 53: 161-185. 1936.

(PISUM) PEA ENATION MOSAIC VIRUS

Technical name(s):

Pisum virus 1 K. M. Smith 1937

Marmor pisi Holmes 1939

Synonyms:

Pea mosaic virus Osborn 1935

Enation pea mosaic virus Pierce 1935

Pea virus 1 Pierce 1935

(The above two names first published by Pierce were originally suggested by Stubbs)

Name of disease: Pea enation mosaic

Geographic distribution: United States (Calif., Idaho, N. J., N. Y., Wash., Wis.). Also in England [Ainsworth].

Host range:

LEGUMINOSAE -- *Lathyrus odoratus L.; *Pisum sativum L. (all tested vars., including Horal and Perfection); *Vicia faba L.Pisum sativum var. arvense Poir.; Soja max (L.) Piper; Trifolium incarnatum L.Melilotus officinalis (L.) Lam. is susceptible according to Stubbs; insusceptible, Osborn. Not transmissible to Phaseolus vulgaris L., Trifolium pratense L., or Medicago sativa L. [Osborn, Pierce, Stubbs], but Johnson & Jones reported vein clearing in alsike clover and alfalfa, and a mild mottle in Corbett Refugee bean and Lathyrus latifolius L.

Symptoms: In peas, vein-clearing followed by enlargement and fusion of chlorotic areas, which become flaccid and translucent, and on the lower leaf surface are surrounded by a ridge of proliferated tissue (enations); terminal growth retarded and distorted, sometimes severe top necrosis; older plants show wrinkling, dwarfing, and chlorotic spots; pods blistered and distorted [Osborn; Stubbs; Snyder], and also strongly mottled or calicoed [Linford]. Symptoms expressed through temp. range of 12-30° C [Stubbs]. In Vicia faba, conspicuous chlorotic spotting and striping usually along the veins, sometimes enations. In Trifolium incarnatum, small, yellowish spots on the upper surface, enations on the lower.

Means of transmission: By tissue union; by expressed juice with aid of carborundum; symptoms in 6-7 days [Stubbs]. By the aphids Macrosiphum pisi (Kalt.) and M. solanifolii (Ashm.) with an intervening latent period of 12 to 18 hours before the insects can infect. The virus is retained in active form and without renewal by M. pisi for at least 8 days, by M. solanifolii for 21 days [Osborn 1935, 1938]. Not seed-borne [Stubbs 1937], but contrary evidence presented by Johnson & Jones.

Properties: Thermal inactivation at 58° C [Pierce], 64-66° [Osborn 1938]. Dilution tolerance 1:2,000 [Stubbs]. Longevity in vitro 4 days [Osborn]. The enation mosaic virus studied by Johnson & Jones was difficult to transmit mechanically and was less tolerant of aging, dilution and heating.

Concentration of the virus to some degree is possible by ultracentrifugation but the sedimentation constants of the virus protein

thus obtained ($S_w 20^\circ = 76 \times 10^{-13}$, 112×10^{-13} , and 54×10^{-13} cm Sec.⁻¹ dynes⁻¹) were not appreciably different from those of normal protein [Loring et al.]

Remarks:

A strain of this virus differing from the type in causing crinkling, distortion, and necrotic spots in V. faba, and necrotic spots in T. incarnatum has been described; it is also more difficult to transmit mechanically [Osborn 1938]. The enation virus studied by Johnson & Jones in Washington also differs in minor respects.

Literature:

- Ainsworth, G.C. Identification of certain viruses found infecting leguminous plants in Great Britain. *Ann. App. Biol.* 27: 218-226. 1940.
- Johnson, Folke, and L. K. Jones. Two mosaic diseases of peas in Washington. *Jour. Agr. Res.* 54: 629-638. 1937.
- Linford, M. B. Pea diseases in the United States in 1928. U. S. Dept. Agric. Plant Dis. Rptr. Suppl. 67. 1-14. 1928.
- Loring, H. S., H. T. Osborn, and R. W. G. Wyckoff. *Proc. Soc. Exp. Biol. & Med.* 38: 239-241. 1938.
- Osborn, H. T. Incubation period of the virus of pea mosaic in the aphid, Macrosiphum gei. *Phytopath.* 25: 31. 1935.
- _____ Incubation period of pea mosaic in the aphid, Macrosiphum pisi. *Phytopath.* 25: 160-177. 1935.
- _____ Incubation period of pea virus 1 in the aphid Macrosiphum solanifolii. *Phytopath.* 28: 749-754. 1938.
- _____ Studies on pea virus 1. *Phytopath.* 28: 923-934. 1938.
- Pierce, W. H. The identification of certain viruses affecting leguminous plants. *Jour. Agric. Res.* 51: 1017-1039. 1935.
- Snyder, W. C. Pod deformation of mosaic-infected peas. *Phytopath.* 24: 78-80. 1934.
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(PISUM) PEA MOTTLE VIRUS

Technical name(s):

Marmor efficiens F. Johnson 1942

Synonyms:

- ? Pea virus 2 Zaumeyer & Wade 1935
- White clover mosaic virus, in part, Zaumeyer & Wade 1935
- ? White clover mosaic virus Pierce 1935
- ? White clover virus 1 Pierce 1935
- Pea severe mosaic virus Johnson & Jones 1937
- Trifolium virus 1 Weiss 1939
- Pea-mottle virus F. Johnson 1942

Geographic distribution: United States (Wash., ? Colo., Idaho, N. J., Va.).

Host range:

LEGUMINOSAE -- *Medicago lupulina L.; *Trifolium pratense L.,
*T. repens L.; *Pisum sativum L.

Cicer arietinum L.; Lathyrus latifolius L., L. odoratus L.; Lens esculenta Moench; Lupinus albus L., L. hirsutus L.; Medicago sativa L.; Melilotus alba Desr., M. officinalis (L.) Lam.; Phaseolus aureus Roxb.; P. lunatus L. (var. Henderson Bush), P. mungo L., P. vulgaris L. (all tested vars. including Great North-U. I. no. 1, Robust, and U. S. no. 5 Refugee); Pisum sativum L. (all tested vars. including Little Marvel and Perfection), P. sativum var. arvense Poir.; Trifolium hybridum L., T. incarnatum L.; Vicia faba L., V. sativa L.

Not infectious to Soja max (L.) Piper [Pierce], or to Vigna sinensis (Torner) Savi ex Hassk. [Johnson].

CARYOPHYLLACEAE -- Stellaria media (L.) Cyril.

CHENOPODIACEAE -- Spinacia oleracea L.

CUCURBITACEAE -- Cucumis sativus L.

SCROPHULARIACEAE -- Antirrhinum majus L.

Symptoms: In peas, delayed unfolding of leaves; vein clearing, presence of numerous, small, irregular, light-yellow spots on young leaves; slight dwarfing; pods not affected. In beans, vein clearing and numerous light-yellow spots. In alsike, red, and white clovers, light-yellow interveinal stripes. In spinach, dwarfing and mottling. In cucumber, light-yellow spots between veins [Johnson 1942].

Means of transmission: By dodder (Cuscuta campestris) [Johnson]. By extracted juice with aid of carborundum, with symptoms after 8 to 12 days [Zaumeyer & Wade; Johnson]. Not by pea aphid, Macrosiphum pisi (Kalt.) [Johnson].

Properties: Passes Berkefeld W filter; thermal inactivation at 60-62° C; dilution tolerance 1:10,000 but not 1:100,000; longevity in vitro or in dried pea leaves at least 31 days at 25° C.

Remarks: Together with pea wilt virus (see following) it causes systemic necrosis (streak) of peas. Though similar to some strains of cucumber mosaic virus in properties and symptoms on certain hosts, it is not infectious to tobacco or tomato [Johnson]. This virus also resembles bean yellow mosaic virus in its effects on beans and peas, in host range (except transmission to non-legumes) and in properties.

Literature:

Johnson, Folke. The complex nature of white-clover mosaic.
Phytopath. 32: 103-116. 1942

- Johnson, Folke, and Leon K. Jones. Two mosaic diseases of peas in Washington. Jour. Agric. Res. 54: 629-638. 1937.
- Pierce, W. H. The identification of certain viruses affecting leguminous plants. Jour. Agric. Res. 51: 1017-1039. 1935.
- Weiss, Freeman. A key to the typical viruses of leguminous crops. U. S. Dept. Agric. Plant Dis. Rptr. 23: 352-361. 1939.
- Zaunmeyer, W. J., and B. L. Wade. The relationship of certain legume mosaics to bean. Jour. Agric. Res. 51: 715-747. 1935.

(PISUM) PEA WILT VIRUS

Technical name(s):

Marmor repens F. Johnson 1942

Synonyms:

- White clover mosaic virus, in part, Zaunmeyer & Wade 1935
- ? White clover mosaic virus Pierce 1935
- ? Broadbean local-lesions virus Pierce 1935
- ? Pea mosaic virus 5 Zaunmeyer 1940
- ? Alsike clover mosaic virus 2 Zaunmeyer 1940
- Pea wilt virus F. Johnson 1942

Geographic distribution: United States (Wash., ? Colo., Idaho, Va.).

Host range:

LEGUMINOSAE-- *Trifolium pratense L., *T. repens L.

Lathyrus odoratus L.; Lens esculenta Moench; Lupinus albus L.; Medicago lupulina L.; Melilotus alba Desr.; Phaseolus aureus Roxb., P. vulgaris L. (all tested vars. including Great Northern U. I. no. 1, Robust, and U. S. no. 5 Refugee); Pisum sativum L. (all tested vars. including Little Marvel and Perfection), P. sativum var. arvense Poir.; Trifolium hybridum L., T. incarnatum L.; Vicia faba L., V. sativa L.; Vigna sinensis (Torner) Savi ex Hassk.

Soybean (Soja max) and all tested non-legumes insusceptible [Johnson].

Symptoms: In peas, wilting and death of inoculated leaves which remain attached to the stem, also extending to proximal lower leaves; in some varieties a transitory mottle in the apical leaves; stems grayish, plants dwarfed. In cowpeas, brown, necrotic, primary lesions, followed by diffuse, veinal chlorosis becoming systemic. In beans, a fine veinal chlorosis and diffuse mottle. In most Trifolium spp., a faint mottle, more conspicuous in T. repens, no symptoms in T. hybridum [Johnson].

Means of transmission: Neither by dodder nor by Macrosiphum pisi (Kalt.), but transmissible by extracted juice with aid of carborundum [Johnson].

Properties: Passes Berkefeld W filter; thermal inactivation at 58-60° C; dilution tolerance 1:100,000; longevity in vitro or in dried pea leaves at least 31 days at 25° C.

Remarks:

Together with pea mottle virus, causes a severe mosaic of white clover in nature, and of red clover and yellow sweetclover by artificial inoculation. A systemic necrosis of peas results from inoculation with a mixture of this and the pea mottle virus.

Literature:

Same as for pea mottle virus.

(PISUM) PEA AMERICAN STREAK VIRUS

Technical name(s):

Pisum virus 5 Zaumeyer ex Weiss 1939

Synonyms:

? Pea streak Linford 1929

Pea streak virus Zaumeyer 1937

Pea streak virus 1 Zaumeyer 1938

Name of disease: American pea streak

Geographic distribution: United States (Va., possibly Idaho, Mont., Wash.; also in Md., N. J., and other eastern States, although the relation of this virus to field examples of pea streak has not been demonstrated).

Host range:

LEGUMINOSAE -- Cicer arietinum L., Lens esculenta Moench, Medicago sativa L., Melilotus alba Desr., Pisum sativum L. (all tested vars. (40) including Horal, Little Marvel, Perfection, etc.); Soja max (L.) Piper; Trifolium incarnatum L., T. pratense L., T. repens L.; Vicia faba L. vars. major and minor, V. sativa L.

Bean (Phaseolus vulgaris L.), cowpea (Vigna sinensis (Torner) Savi ex Hassk.), lupine (Lupinus albus L.), sweet pea (Lathyrus odoratus L.), and all tested non-legumes insusceptible. [Zaumeyer 1938].

Symptoms: In peas, slight purplish discoloration of stems and stipules; leaflets curl downward, together with tendrils becoming distorted and twisted, veins prominent; apical parts rosetted; subsequently the stems develop secondary necrosis and the leaves wilt; sometimes only top necrosis with mild chlorosis in other parts. In Vicia faba, ringspot lesions on the inoculated leaves; stems, petioles and leaf veins streaked. In Trifolium spp. and Melilotus, systemic mottling. [Zaumeyer]

Means of transmission: By expressed juice, readily; by the pea aphid, Macrosiphum pisi (Kalt.).

Properties: Thermal inactivation at 62-65° C; dilution tolerance 1:5,000; longevity in vitro 24 hours [Zaumeyer].

Remarks:

Alfalfa-mosaic virus, including several strains, also causes a streak disease of peas. Pea-streak virus can be distinguished from these by inability to infect beans and non-legumes, and by ability to infect the Horal var. of pea, which is immune to the alfalfa viruses. The pea streak virus is also less resistant to aging. The role of these viruses, together with that of the spotted wilt virus, in the natural incidence of pea streak is still uncertain, but in Idaho and Montana pea streak infection is often associated with proximity to alfalfa plants [Zaumeyer 1938].

Literature:

- Linford, Maurice B. Pea diseases in the United States in 1928.
U. S. Dept. Agric. Plant Dis. Rptr. Suppl. 67. 1-14. 1929
Weiss, Freeman. A key to the typical viruses of leguminous crops.
U. S. Dept. Agric. Plant Dis. Rptr. 23: 352-361. 1939.
Zaumeyer, W. J. Pea streak and its relationship to strains of alfalfa mosaic. *Phytopath.* 27: 144. 1937
_____ A streak disease of peas and its relation to several strains of alfalfa mosaic virus. *Jour. Agric. Res.* 56: 747-772. 1938

(PISUM) PEA NEW ZEALAND STREAK VIRUS

Technical name(s):

Pisum virus 3 Chamberlain 1939

Synonyms:

Pea-streak virus Chamberlain 1939

Name of disease: New Zealand pea streak

Geographic distribution: New Zealand

Host range:

LEGUMINOSAE -- **Pisum sativum* L.

Galega officinalis L.; *Lathyrus odoratus* L.; *Lotus hispidus* Desf.; *Lupinus angustifolius* L., *L. luteus* L., *L. mutabilis* Sweet; *Phaseolus vulgaris* L.; *Pisum sativum* var. *arvense* Poir.; *Soja max* (L.) Piper; *Trifolium arvense* L., *T. cernuum* Brot., *T. fragiferum* L., *T. glomeratum* L., *T. hybridum* L., *T. pratense* L., *T. repens* L.; *Vicia villosa* Roth.

CUCURBITACEAE -- *Cucumis melo* var. *cantalupensis* Naud., *C. sativus* L.; *Cucurbita pepo* L. (marrow), on all of which only local lesions were produced.

Symptoms: In peas, purple or purplish-brown spots on leaves and pods, purple streaking of stems, apical wilting, cessation of growth, death within 2-3 weeks.

Means of transmission: By expressed juice, readily. Insect vector unknown -- negative results with Thrips tabaci Lind., Myzus persicae (Sulz.), M. convolvuli (Kalt.) reported as Macrosiphum solani (Kalt.) [Chamberlain]

Properties: Passes "fine" grade Mandler filter; thermal inactivation at 78-80° C; dilution tolerance 1:1,000,000; longevity in vitro at least 41 days.

Remarks:

Distinguished from American pea streak virus by its properties in extracted juice and ability to infect beans (Phaseolus) and sweet peas; from alfalfa mosaic viruses (which also cause pea streak) by inability to infect alfalfa, and from pea wilt virus by property differences.

Literature:

Chamberlain, E. E. Pea-streak (Pisum virus 3). New Zealand Jour. Sci. & Techn. 20A: 365-381. 1939

(SOJA) SOYBEAN MOSAIC VIRUS

Technical name(s):

Soja virus 1 K. M. Smith 1937

Synonyms:

Soybean chlorosis (crinkling) Clinton 1916

Soybean mosaic C. R. Orton 1920

Soybean mosaic (virus) Gardner & Kendrick 1921

Soybean virus 1 Pierce 1935

? Soybean leaf curl (brown mosaic, yellow mosaic) virus Săvulescu et al 1936

Name of disease:

Soybean mosaic

Geographic distribution: United States and Canada (reported from many states and provinces, probably coextensive with cultivation of crop); Europe (Germany, Romania, Sweden); Africa (Uganda); Asia (China).

Host range:

LEGUMINOSAE -- *Soja max (L.) Piper

All other tested legumes insusceptible, though Heinze and Köhler [1940] produced obscure mosaic symptoms in inoculated leaves of certain bean (Phaseolus vulgaris) vars. and in Vicia sativa, and also, after an interval, returned the virus to soybeans; it did not become systemic in these plants. Vars. of soybeans differ in susceptibility, some tending to escape field infection but no true resistance has been demonstrated.

Symptoms: Leaves stunted, distorted, margins curled downward; surface puckered with dark green, puffy areas between veins, sometimes interveinal chlorotic spots; petioles and internodes shortened; pods stunted, flattened, less pubescent and more acutely curved than normal; pod setting delayed and suppressed, seeds few in number and undersized [Gardner & Kendrick 1921].

Means of transmission: By expressed juice through leaf rubbing and punctures [Gardner & Kendrick], aided by carborundum [Heinze & Köhler]; incubation period 6-13 days [Săvulescu]. By the following aphids: Myzus persicae (Sulz.) and M. convolvuli (Kalt.), (most commonly); also by Aphis gossypii Glov., A. rhamni Boy., A. rumicis L., Macrosiphum koehleri Börner (formerly reported as M. solanifolii (Ashm.)), Myzus circumflexus (Buckt.), M. ornatus Laing. There is no incubation period in the vector and the virus is not persistent [Heinze & Köhler]. Transmitted in seed of infected plants up to 25% and surviving in seed for 2 years [Kendrick & Gardner]; seed transmission sometimes 40% [Heinze & Köhler].

Properties: Thermal inactivation at 58° C [Pierce], 61° [Heinze & Köhler]; dilution tolerance 1:10,000 but not 1:100,000; longevity in vitro 3-4 days [Heinze & Köhler]. Filterability and serological reactions not determined.

Remarks:

Three forms of the disease were distinguished by Săvulescu et al. -- leaf curl, brown mosaic, and yellow mosaic; the first characterized by leaf distortion with little or no mottling, the second by brown spots along the veins and in the interveinal areas, the latter by yellow vein-banding and chlorotic mottling. A necrotic variant also was found by Heinze & Köhler.

The leaf-curl type of Europe corresponds most nearly in symptoms to the type described in America. Since several different viruses characteristic of Leguminosae may infect soybeans systemically [Zaunmeyer 1940] some of the different types described in this host may belong to different virus species rather than to strains of the common seed-borne virus.

Literature:

- Baudyš, E. Fytopathologické poznámky VII. Ochrana Rostlin 11: 178-197. 1931. Abst. in R.A.M. 11: 424. 1932
 Clinton, G. P. Report of the botanist for 1915. Connecticut Agric. Exp. Sta. Ann. Rept. 1915. 446-447. 1916.
 Gardner, M. W., and J. B. Kendrick. Soybean mosaic. Jour. Agric. Res. 22: 111-114. 1921.
 Heinze, K., and E. Köhler. Die Mosaikkrankheit der Sojabohne und ihre Übertragung durch Insekten. Phytopath. Zeitschr. 13: 207-242. 1940.
 Kendrick, J. B., and M. W. Gardner. Soybean mosaic: seed transmission and effect on yield. Jour. Agric. Res. 27: 91-98. 1924

- Pierce, W. H. The identification of certain viruses affecting leguminous plants. Jour. Agric. Res. 51: 1017-1039. 1935.
- Săvulescu, T., C. Sandu-Ville, A. Aronescu, and V. Alexandri. L'etat phytosanitaire en Roumanie en 1934-1935. Publ. Inst. Cerc. Agron. Romaniei 25. 1-97. 1936. Abst. in R. A. M. 16: 19. 1937
- Zaumeyer, W. J. Three previously undescribed mosaic diseases of pea. Jour. Agric. Res. 60: 433-452. 1940.

(TRIFOLIUM) ALSIKE CLOVER MOSAIC VIRUS

Technical name(s):

Trifolium virus 3 Zaumeyer & Wade ex Weiss 1939

Synonyms:

Alsike clover mosaic virus Zaumeyer & Wade 1935
 Alsike clover virus 1 Zaumeyer & Wade 1936
 Alsike virus 1 Wade & Zaumeyer 1938
 Alsike clover mosaic virus 1 Zaumeyer 1940

Name of disease:

Alsike clover mosaic.

Geographic distribution: United States -- Colo., Va. (Undetermined mosaic reported widely -- Idaho, Minn., Mont., N. Y., Pa.

Host range:

LEGUMINOSAE -- *Trifolium hybridum L.

Crotalaria mucronata Desv. (C. striata DC.); Lupinus albus L., L. angustifolius L.; Medicago sativa L.; Melilotus alba Desr.; Phaseolus vulgaris L. (all tested vars. except Great Northern U. I. no. 1); Pisum sativum L. (vars. Alaska, Laxton Progress, and Telephone, but not Horal, Perfection, Little Marvel or Wisconsin Early Sweet); Trifolium incarnatum L.; Vicia faba L.

SOLANACEAE -- All tested Solanaceae (Datura, Nicotiana spp., Petunia) insusceptible.

Symptoms: In alsike clover, a stippled interveinal chlorosis, becoming light yellow; sometimes irregular patterns of light and dark green, the latter following the veins; leaves undersized but not distorted. In beans, systemic light-green or yellow spotting and mottling, slight puckering and stunting, leaves not reflexed. In peas, systemic mottle and small chlorotic spots, without distortion or marked effect on size. In Crotalaria, conspicuous yellow spotting and blotching [Zaumeyer & Wade 1936].

Means of transmission: By extracted juice, with aid of carborundum [Zaumeyer & Wade 1936].

Properties: Thermal inactivation at 60-62° C; dilution tolerance 1:6,000; longevity in vitro 1-2 days. [Zaumeyer 1940].

Strains or related viruses: A second virus causing similar symptoms in alsike clover but different symptoms in peas and beans was designated alsike clover mosaic virus 2 Zaumeyer (Trifolium virus 3A Zaumeyer ex Weiss). It differs in causing wilting of basal (inoculated) leaves of peas followed by necrotic spotting, marked stunting and defoliation; pods also spotted and stunted. In beans it causes yellow spotting and reflexion of leaves, followed by marked chlorosis, puckering, and stunting. It was inactivated at 54-58° C but was infectious at 1:8,000 dilution [Zaumeyer 1940]. In some respects both alsike clover viruses resemble bean yellow mosaic virus (I.M.I list 1944). There is also a close parallel with white clover mosaic virus Zaumeyer & Wade 1935, involving two viruses, one causing mottling, the other wilt and necrosis in peas.

Alsike clover is also susceptible to common pea mosaic virus and may harbor it in nature [Murphy & Pierce 1937].

Literature:

- Murphy, Donald M., and W. H. Pierce. Common mosaic of the garden pea, Pisum sativum. Phytopath. 27: 710-721. 1937.
 Wade, B. L.; and W. J. Zaumeyer. Varietal reaction of pea to a virus from alsike clover. Phytopath. 28: 505-511. 1938
 Weiss, Freeman. A key to the typical viruses of leguminous crops. U. S. Dept. Agric. Plant Dis. Rptr. 23: 352-361. 1939
 Zaumeyer, W. J. Three previously undescribed mosaic diseases of pea. Jour. Agric. Res. 60: 433-452. 1940.
 _____, and B. L. Wade. The relationship of certain legume mosaics to bean. Jour. Agric. Res. 51: 715-749. 1935.
 _____, and _____. Pea mosaic and its relation to other legume mosaic viruses. Jour. Agric. Res. 53: 161-185. 1936.

(TRIFOLIUM) RED CLOVER VEIN-MOSAIC VIRUS

Technical name(s):

Marmor trifolii Holmes 1939

Synonyms:

- Red clover vein-mosaic virus Osborn 1937
 ? Pea streak virus 1 Zaumeyer 1938
 Trifolium virus 2 Weiss 1939

Name of disease:

Red clover vein mosaic

Geographic distribution: United States (N. J.); if pea streak virus 1 is identical, also in Va. Possibly in Germany.

Host range:

LEGUMINOSAE -- *Lathyrus odoratus L.; *Trifolium pratense L.; *Vicia faba L.

Trifolium hybridum L., T. incarnatum L., T. repens L., Melilotus alba Desr., Pisum sativum L. (including the vars. Horal and Perfection), P. sativum var. arvense Poir. [Osborn 1937].

If pea streak virus 1 is identical the following susceptibles are to be included: Cicer arietinum L., Lens esculenta Moench, Medicago sativa L., Soja max (L.) Piper, Vicia sativa L. [Zaumeyer 1938]. No infection of Phaseolus vulgaris L. or of non-leguminous plants [Osborn, Zaumeyer]. All tested vars. of peas (47) proved susceptible in some degree [Zaumeyer & Wade].

Symptoms: In red clover, a yellow color develops along the veins chiefly in new growth following cutting back; sometimes small yellow spots in interveinal areas but no mottling; little or no reduction in plant size or vigor. In other Trifolium spp., except T. incarnatum, the symptoms are similar; in the latter, marked stunting followed by death. In broadbean, necrotic spots and rings on the inoculated leaves, followed by systemic vein clearing, severe stunting, shoot necrosis and wilting. In peas, vein clearing, slight chlorosis (but no mottling), leaf curling, shoot distortion, stem streaking, and ultimately wilting and death.

Means of transmission: By expressed juice, symptoms appearing in 10-12 days. By the aphid Macrosiphum pisi (Kalt.) with a variable often prolonged incubation period (14 days to 6 weeks). There is no latent period in the insect and the virus is retained for only a few hours [Osborn].

Properties: Thermal inactivation at 58-60° C; longevity in vitro 2-3 days [Osborn]. The pea streak virus is inactivated at 62°, tolerates dilution 1:5,000, and withstands aging in vitro less than 2 days [Zaumeyer].

Literature:

Osborn, H. T. Vein-mosaic of red clover. *Phytopath.* 27: 1050-1058. 1937.

Zaumeyer, W. J. A streak disease of peas and its relation to several strains of alfalfa mosaic virus. *Jour. Agric. Res.* 56: 747-772. 1938

_____, and B. L. Wade. Varietal reaction of pea to pea-streak virus 1. *Phytopath.* 27: 1009-1013. 1937

(TRIFOLIUM) SUBTERRANEAN CLOVER MOSAIC VIRUS

Technical name(s):

Synonyms:

Subterranean clover mosaic virus Aitken & Grieve 1943

Name of disease:

Subterranean clover mosaic

Geographic distribution: Australia (Victoria).

Host range:

LEGUMINOSAE -- *Trifolium subterraneum L.

Lathyrus odoratus L.; Lupinus angustifolius L.; Medicago hispida Gaertn. var. denticulata (Willd.) Urb., M. lupulina L., M. tribuloides Desr., M. arabica All.; Melilotus alba Desr., M. indica All.; Phaseolus lunatus L. var. macrocarpus Benth. (Henderson's Bush Lima), P. vulgaris L. (23 vars., including U. S. Refugee no. 5); Pisum sativum L.; Soja max (L.) Piper; Trifolium angustifolium L., T. glomeratum L., T. hybridum L., T. incarnatum L., T. minus L., T. pratense L., T. striatum L.; Trigonella ornithopodioides DC.; T. foenum-graecum L.; Vicia faba L. vars. major and minor.

Symptoms: On T. subterraneum, vein clearing, followed by systemic mottling, ruffling and distortion of leaves; general dwarfing and reduction of seed-set.

Means of transmission: By expressed juice with aid of carborundum. By aphids (not named). Possibly by seed.

Properties: Thermal inactivation at 60° C; dilution tolerance 1: 1,000; longevity in vitro 1-2 days.

Literature:

Aitken, Y., and B. J. Grieve. A mosaic virus of subterranean clover. Jour. Austral. Inst. Agric. Sci. 9: 81-82. 1943.

(VICIA) BROADBEAN COMMON MOSAIC VIRUS

Technical name(s):

Synonyms:

Broadbean mottle mosaic virus Böning 1927

Broadbean mosaic disease virus Fukushi, T. 1930

Broadbean common mosaic virus Yu 1939

Name of disease:

Broadbean common mosaic.

Geographic distribution: Europe (England; Germany); Asia (China, Japan).

A mosaic disease of broadbeans has also been reported in the United States, but the causal virus was designated pea virus 2 [Osborn 1937].

Host range:

LEGUMINOSAE -- *Vicia faba L.

Pisum sativum L., Trifolium incarnatum L., T. pratense L. (Böning); also Lathyrus odoratus L., and Phaseolus vulgaris L. [Imai, 1934].

Symptoms: Interveinal chlorotic mottling, downward curling of leaf margins and puckering of blades; loss of turgescence and general dwarfing; distortion and mottling of inflorescence [Böning].

Means of transmission: By expressed juice [Imai]. By the aphids Aphis laburni Kalt. (A. leguminosae Theob.), A. rumicis L., Macrosiphum pisi (Kalt.), Myzus persicae (Sulz.); symptoms in 6-10 days with A. laburni [Imai]. Not by seed [Böning]; however, a mosaic disease of V. faba (virus not identified) was reported seed-transmitted by Van der Meulen [1928].

Properties: Retained by porcelain filters; thermal inactivation at 63° C, dilution tolerance below 1:1000, longevity in vitro 23 days, in dried leaves 20 days; pH tolerance 3-9.5 [Murayama].

Remarks:

It has been suggested on the basis of symptoms and host relations that the common broadbean mosaic virus described by Böning is identical with common pea mosaic virus [Pierce, 1935; Zaumeyer & Wade 1936]. The broadbean mosaic attributed to pea virus 2 Osborn [1937], and possibly that studied in Germany by Merkel [1929], in Japan by Murayama [1938], and in China by Yu, appears to be due to a different virus which may be related either to yellow bean mosaic virus [Weiss 1939] or to pea mottle virus [E. Johnson 1942]. V. faba is systemically infected by most of the viruses described on Medicago, Phaseolus, Pisum and Trifolium [Zaumeyer & Wade 1936] except the broadbean local-lesion (pea wilt) virus [Pierce 1935; F. Johnson 1942].

Literature:

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(VICIA) BROADBEAN MILD MOSAIC VIRUS

Technical name(s):

Synonyms:

Broadbean mild-mosaic virus Yu 1939

Name of disease:

Broadbean mild mosaic

Geographic distribution: China (Chekiang and Kiangsu Provinces).

Host range:

LEGUMINOSAE -- *Vicia faba L.

Lathyrus odoratus L.; Melilotus alba Desr.; Medicago sativa L., Pisum sativum L. var. arvense Poir.; Trifolium pratense L., T. repens L.; Vicia sativa L., V. tetrasperma Moench, V. villosa Roth.

Not infectious to Phaseolus vulgaris L., Soja max (L.) Piper, or Vigna sinensis (Torner) Savi ex Hassk.

Symptoms: Slight vein clearing, fine chlorotic mottle, little or no distortion, slight elongation of leaves; pods undersized; under field conditions no stunting, distortion, or necrosis. In other hosts the symptoms consist of a mild diffuse mottle without distortion or necrosis.

Means of transmission: By extracted juice, with aid of carborundum; incubation period 10-24 days. By the aphids Aphis rumicis L. and Macrosiphum pisi (Kalt.). Not by seed.

Properties: Thermal inactivation at 55-60° C; dilution tolerance 1:1,500; longevity in vitro 2-3 hrs.

Remarks:

This virus differs from that of common broadbean mosaic, which occurs in the same area, only in the absence of leaf distorting and stunting effects -- a difference ordinarily considered of only strain magnitude but which may also indicate a different virus. The described symptoms resemble those reported by Zaumeyer & Wade [1936] as induced in this host by the white clover (pea mottle) and sweetclover mosaic (bean yellow mosaic) viruses. Since the identity of the virus or viruses concerned in common mosaic of broadbeans is uncertain, it seems inadvisable to designate this as only a strain of the latter.

Literature:

Yu, T. F. Mild-mosaic virus of broad bean. *Phytopath.* 29: 448-455. 1939

Zaumyer, W. J., and B. L. Wade. Pea mosaic and its relation to other legume mosaic viruses. *Jour. Agric. Res.* 53: 161-185. 1936

(VIGNA) ASPARAGUS-BEAN MOSAIC VIRUS

Technical name(s):

Synonyms:

Asparagus-bean mosaic virus Snyder 1942

Name of disease:

Asparagus (Yardlong)-bean mosaic

Geographic distribution: United States (Calif., Ind., Mich.)

Host range:

LEGUMINOSAE -- *Vigna sesquipedalis (L.) Fruwirth

? Phaseolus vulgaris L.

Other tested legumes and plants of different families were insusceptible [Snyder]

Symptoms: A coarse mosaic of light and dark green, the latter forming broad bands along the main veins and becoming rugose or puffy; downward rolling leaflets, sometimes leaf distortion, general dwarfing. Severely affected plants set little or no seed.

Means of transmission: By expressed juice, readily, with an incubation period of 9-28 days. By Macrosiphum pisi (Kalt.). By seed (30-40%).

Properties: Thermal inactivation at 55-60° C; dilution tolerance 1:1000 but not 1:3000; longevity in vitro 2 but not 4 days.

Remarks:

The similarity in symptoms, seed carriage, aphid transmissibility, and properties, of the viruses of common bean mosaic, cowpea mosaic, soybean mosaic, and asparagus-bean mosaic, though differing in host specialization, is noteworthy [Snyder].

Literature:

Snyder, W. C. A seed-borne mosaic of asparagus bean, Vigna sesquipedalis. Phytopath. 32: 518-523. 1942

(VIGNA) COWPEA MOSAIC VIRUS

Technical name(s):

? Cucumis virus 1 C K. M. Smith 1937

? Marmor cucumeris var. vignae Holmes 1939

(Strictly, the type form of this virus originated as a segregate or mutant of a strain of cucumber mosaic virus, and has not been definitely identified in nature. Since a naturally occurring virus in this host has properties similar in most respects to those of this strain, and no other name has been applied to it, it appears permissible to use this name.)

Synonyms:

- ? Cowpea mosaic (virus) Elliott 1921
- Cowpea mosaic virus C. E. Smith 1924
- ? Cucumber-mosaic virus Strain Y Price 1934
- ? Cucumber-mosaic virus Strain 9 Price 1935
- ? Cucumber-mosaic virus, cowpea-mottling strain Holmes 1937

Name of disease:

Cowpea mosaic

Geographic distribution: United States, probably throughout the range of cultivation of the host; also in Puerto Rico. A juice-transmissible mosaic of cowpea occurs in Trinidad [Briant & Martyn]. Mosaic disease of cowpea has been reported also in China, India, Sierra Leone, and Tanganyika

Host range:

LEGUMINOSAE -- *Vigna sinensis (Torner) Savi ex Hassk.

Phaseolus lunatus L. var. macrocarpus Benth., ? Vigna cylindrica (L.) Skeels (V. catjang Walp.)

Other Leguminosae and all tested plants of other families negative [McLean 1941], but the strain studied by Price [1934] was infectious to tobacco. All tested vars. of cowpeas susceptible, ranging from slightly to highly so.

Symptoms: Vein clearing, followed by chlorotic mottling, and usually convex cupping or arching of leaflets; in highly susceptible vars. there is marked leaf distortion, prominent mottling, flower-bud deformity, and general dwarfing; maturity is greatly delayed [McLean]. The strain studied by Price causes yellow primary lesions with or without a necrotic border, followed by a coarse, yellow, systemic mottle.

Means of transmission: By inoculation of expressed juice with incubation period of 8-12 days. By the aphids Aphis gossypii Glov., Macrosiphum pisi (Kalt.), M. solanifolii (Ashm.); Myzus persicae (Sulz.) [McLean 1941]. The reported transfer of a cowpea mosaic virus by the leaf beetle, Ceratomya bifurcata [Smith 1924] and by mealy bugs [Elmer 1925] was not confirmed for the virus studied by McLean. By seed [Gardner 1927]; up to 5% in highly susceptible vars. [McLean].

Properties: Thermal inactivation at 72-75° C; dilution tolerance 1:1000; longevity in vitro 48 hrs. [McLean].

Immunological relationships: The cowpea-mottling strain of cucumber mosaic virus studied by Price protects zinnia from the indicator necrotic strain of this virus [Price 1935]. No immunological relationships have been demonstrated for the cowpea mosaic virus of natural occurrence.

Remarks:

The relationship, if any, of the cowpea mosaic occurring in the U. S. with that reported in China [Yu 1939] and India [Vasudeva 1942] has not

been determined, although the symptom descriptions are similar. A vir-
osis of red gram (V. unguiculata = V. sinensis ?) occurring in Madras
Province, India, is reported to be transmissible by a leafhopper (Empo-
asca sp.) [Thomas].

Literature:

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II. OTHER VIRUSES AND VIRUS DISEASES OR SIMILAR MALADIES REPORTED ON LEGUMINOSAE

Viruses or virus diseases of leguminous plants not sufficiently charac-
terized for identification, or normally associated with other crops, inclu-
ding some diseases of physiological or unknown cause having virus-like
symptoms³.

Arachis hypogaea L. (peanut, groundnut)

MOSAIC. Found in Shangtung Province, China. Causes mottling and leaf
deformation but relatively little stunting [Yu, T. F. Phytopath.
29: 459-461. 1939].

NECROTIC SPOT. A disease of unknown nature, thought to be due to nu-
tritional deficiency, occurring in Georgia, perhaps also in Texas
and Virginia. Affected plants are usually chlorotic, sometimes
with mosaic-like patterns, and the leaves and petioles bear num-

³ See also the following viruses in PDR Suppl. 150: Laburnum variegation,
(Lathyrus) sweetpea streak, and Robinia brooming.

erous necrotic flecks and spots; dwarfing not consistently associated. [Jenkins, W. A. *Phytopath.* 31: 948-951. 1941].

PALE DWARF. Reported in Java. Distinguished from club-leaf dwarf (= rosette, q. v.). Characterized by pale undersized leaflets, and short petioles. Develops in juvenile stages, is associated with particular seed stocks; recovery usually occurs in later growth stages. Considered non-parasitic. [Hartley, C. *Phytopath* 27: 217-225. 1927].

RING SPOT. Occurs in Brazil. Characterized by appearance of yellow, circular lesions bearing necrotic flecks in young leaves; crinkling, upward rolling, chlorotic mottling and ring- and line-patterns in subsequent leaves; necrotic spots or streaks in stems; arrested growth. [Costa, A. S. *Biologico* 7: 249-251. 1941].

STUNT. A virosis causing vein clearing, a rosette appearance, and severe stunting, affected peanuts in southern Texas in 1942. It was readily transmissible by juice inoculation with aid of carborundum. [KenKnight, G. *Plant Dis. Rptr.* 26: 501. 1942].

Canavalia ensiformis DC. (jack-bean)

MOSAIC. Reported in Guam, Rhodesia, Sierra Leone, and Brasil. In the latter country the disease was definitely shown to be caused by a virus that was transmissible by sap inoculation to Lathyrus odoratus, Pisum sativum, and Soja sp., but not to Phaseolus vulgaris, Vicia faba, Lupinus albus, Vigna sinensis, Stizolobium aterrimum, among the Leguminosae, nor to Datura, Lycopersicon, Nicotiana, or Petunia in the Solanaceae. The symptoms consisted of interveinal chlorosis and vein banding, producing a mosaic pattern without blistering. The relation to other legume viruses is not known. [Silberschmidt, K., and N. R. Noberge. *Biologico* 8: 129-133. 1942].

Crotalaria spp.

CRINKLE (kronkelziekte). Occurs on C. anagyroides in Java. Characterized by apical shoot distortion, and thickening of veins and stems; no chlorosis. Etiology unknown, transmissibility not demonstrated [Schwarz, M. B. *Korte Meded. Inst. Plantenziek.* 5: 1-19. 1927. Abst. in R.A.M. 7: 380-381. 1928].

MOSAIC. A disease characterized by mottling, leaf distortion and blistering, stunting, and shoot proliferation occurred in test plots in Virginia on the following Crotalaria spp.: C. incana L., C. intermedia Kotschy, C. lanceolata E. Mey., C. maxillaris Klotsch, C. spectabilis Roth., C. striata DC. (= C. mucronata Desv.), and C. usaramoensis Baker. Communicable to Vicia faba by juice inoculation. [Johnson, H. W., and C. L. Lefebvre. *Phytopath.* 28: 10-11. 1938].

A mosaic disease of C. mucronata occurs in Puerto Rico; it is not seed-borne [Cook, M. T. *Phytopath.* 21: 124. 1931]. A mosaic disease of C. juncea L. has been reported in Japan, and of C. salsitiana Andr. in China.

A mosaic disease was induced in C. retusa L., C. spectabilis, and C. mucronata by artificial inoculation with one or another of the following viruses: pea mosaic 4 and 5, alsike clover mosaic 1 and 2. [Zaunmeyer, W. J. *Jour. Agric. Res.* 60: 433-452. 1940].

WITCHES'-BROOM (curly disease, krulziekte). Occurs on C. anagyroides H.B.K., C. juncea L., and C. verrucosa L. in Java. Characterized by chlorosis, shoot proliferation and attenuation, and weak pod formation. Etiology unknown, transmissibility not demonstrated. [Schwarz, M. B., loc. cit.].

Cyamopsis psoraloides DC. (guar).

TOP NECROSIS, streak. Appeared in an experimental planting in Oklahoma and caused heavy mortality. Symptoms consist of vein clearing, faint chlorosis of oak-leaf pattern, necrotic stippling, wilting and abscission of leaves; also necrotic stem lesions, stunting, and death. Symptoms masked in hot weather but return with cooler conditions. Rapid spread in the field. The virus is transmissible by sap inoculation, causing systemic necrosis in beans, and infecting cowpea, soybean, mungbean, petunia, and tobacco. Does not infect Nicotiana glutinosa, and its symptoms in petunia and tobacco differ from those of tobacco ringspot. [Chester, K. Starr, and W. E. Cooper. *Phytopath.* 34: 998. 1944]

Lathyrus odoratus L. (sweetpea).

MOSAIC. Probably the first described virosis of a legume, and also the first to be shown transmissible by needle puncture and by aphids. [Taubenhaus, J. J. *Delaware Agric. Exp. Sta. Bull.* 106. 1914]. The identity of the virus associated with the disease then described is not determinable now, as several viruses may cause a mosaic disease of sweetpea, but their symptoms have not been distinguished; these include the common and enation mosaic viruses of peas, pea virus 2 Osborn, pea mottle virus, yellow mosaic virus of bean, and some strains of alfalfa mosaic virus. In some instances the common pea mosaic virus (q. v.) has been specifically identified; this virus causes "breaking" of flower pigments as well as conspicuous yellowish-green mottling of foliage.

SPOTTED WILT. A streak-type of disease affecting sweetpeas in California was shown to be caused by the tomato spotted wilt virus [Snyder, W. C., and H. R. Thomas. *Hilgardia* 10: 257-262. 1936]. A similar disease has been reported in England.

STREAK. A symptom-complex associated with several different viruses. In England, one form of streak is attributed to a virus of the yellow bean mosaic type, q. v. Another form is caused by a strain of cucumber mosaic, and a streak disease is induced by inoculation with lettuce mosaic virus. [Ainsworth, G. C. Ann. Appl. Biol. 27: 218-226. 1940].

The streak virus of garden peas in America is not infedious to sweetpea, but the New Zealand pea streak virus, the pea wilt virus, and some strains of alfalfa mosaic virus cause a necrotic disease and also a systemic mottle in this host. The tobacco ringspot virus causes top necrosis, stem-breaking, and wilt of sweetpeas [Stubbs, M. C. Phytopath. 26: 242-266. 1936].

Lupinus spp.

BROWNING. A virosis of the streak type occurring on L. angustifolius L., L. albus L., and L. luteus L. in Germany and Holland. Formerly believed to be identical with sore-shin disease of L. angustifolius in New Zealand, subsequently shown to be caused in England and Germany by a strain of cucumber mosaic virus. [Köhler, E. Angew. Bot. 17: 277-286. 1935.; Spierenburg, D. Tijdschr. Plantenziek. 42: 71-76. 1936]

POCK MOSAIC (blister mosaic). Described on L. luteus in Germany. Characterized by presence of dark green blister-like areas covering both veins and interveinal tissue. [Merkel, L. Zeitschr. Pflanzenkr. 39: 289-347. 1929].

SORE SHIN A necrotic spot and stem-streak disease occurring in New Zealand, shown to be caused by a virus apparently identical with common pea mosaic virus, q. v. [Chamberlain, E. E. New Zealand Jour. Agric. 51: 86-92. 1935].

SPECKLE MOSAIC. On L. luteus in Germany. Characterized by dark green spots of irregular size and shape, unevenly distributed on a light-green background. [Merkel 1929].

Melilotus alba Desr. (white sweetclover), M. officinalis (L.) Lam.
(yellow sweetclover).

MOSAIC. May be caused by any of the following viruses, the symptoms of which have not been differentiated in this host: alfalfa mosaic, bean yellow mosaic, pea common mosaic, pea mottle, pea streak, pea wilt, and red clover vein mosaic. The virus originally described as white sweetclover mosaic virus [Zaunmeyer & Wade 1935] has been shown to be identical with bean yellow mosaic virus, q. v.

RING SPOT. Both white and yellow sweetclover are susceptible to tobacco ringspot virus and may harbor this virus in nature [Wingard, S. A. Jour. Agric. Res. 37: 127-153. 1928; Henderson, R. G. and S. A.

Wingard. Ibid. 43: 191-207. 1931; Young, P. A. Plant Dis. Rptr. 14: 125. 1930; Fenne, S. B. Phytopath 21: 891-899. 1931]. Besides the typical tobacco ringspot, a virosis having similar symptoms on sweetclover but differing from the typical form on tobacco has been reported. It causes in sweetclover a conspicuous veinal chlorosis, together with irregular chlorotic spot and line patterns, and pronounced puckering of leaves and general dwarfing. Transmissible to petunia and tobacco by juice inoculation. Probably a strain of tobacco ringspot virus. [Henderson, R. G. Phytopath. 24: 248-256. 1934].

STREAK. Circumstantial evidence that M. alba may harbor the tobacco streak virus was presented by Valteau [Phytopath. 30: 438-440. 1940]. In this host it causes general chlorosis, and also chlorotic and necrotic ring- and line-patterns. This virus is not transmissible to tobacco by juice-inoculation, but the tobacco streak virus was transmitted to sweetclover and returned to tobacco by dodder union [Valteau, W. D. In Kentucky Agric. Exp. Sta. Ann. Rept. 54: 15. 1941]. Similarly tobacco was infected with streak from sweetclover by patch-grafting, and a similar disease was induced in sweetclover by grafting with streak-infected tobacco, though the same virus was not used to complete the cycle. [Berkeley, G. H., and J. H. H. Phillips. Canad. Jour. Res. 21C: 181-190. 1943].

Phaseolus angularis (Willd.) W. F. Wight (adzuki bean).

MOSAIC. A mosaic disease of this host characterized by chlorotic mottling and puffiness in the leaves, and general dwarfing, was reported in Japan. [Matsumoto, T. Phytopath. 12: 295-297. 1922]. A relationship with common bean mosaic has sometimes been assumed, this species having been reported as a suspect of that virus [Nelson 1932] but was found insusceptible to both common and yellow bean mosaic viruses by Pierce, 1935.

Phaseolus vulgaris L. (bean, snap bean, French bean, etc.)

BEAN VIRUS 3. A virus believed to be distinct from the common and yellow bean mosaic viruses, found in a hybrid of Stringless Green Refugee X Wells Red Kidney in Colorado. The original symptoms consisted only of a mild chlorosis without malformation, but inoculation to Stringless Green Refugee resulted in marked chlorosis of a calico pattern, and reduction of leaf size without distortion. No stock of the virus is now known. [Zaumeyer, W. J., and B. L. Wade. Jour. Agric. Res. 51: 728. 1935]

BIG BUD. A characteristic phyllody occurring on snap bean, lima bean, soybean, and alfalfa in the Pacific Northwest (Idaho, Oreg., Wash.) was tentatively attributed, on the basis of external and internal symptoms, to the tomato big-bud virus, but the transmissibility of

this virus to leguminous plants has not yet been demonstrated. [Dana, B. F. *Phytopath.* 30: 866-869. 1940].

BLACK ROOT. A suspected virosis of bush and pole types of snap beans, possibly also of lima beans, observed in Georgia, also in Colorado, Idaho, and Oregon, especially on the Blue Lake variety. Causes incipient wilt in apical portions followed by permanent wilting of part or all of the plant. Sometimes accompanied by chlorosis, and typically by a brownish to purplish discoloration in the vascular system of roots, stems, leaves and pods. Transmissible by hypodermic needle injection of juice; possibly also by seed. [Jenkins, W. A. *Jour. Agric. Res.* 60: 279-288. 1940].

CUCUMBER MOSAIC VIRUS. A strain of this virus, designated strain 408, was obtained from naturally infected beans in Wisconsin. By artificial inoculation (expressed juice) it caused mottling, leaf distortion, stunting, and streak in beans, no tested variety being immune. [Walker, J. C., and D. C. Whipple. *Phytopath.* 28: 22. 1938]

CURLY TOP. The beet curly-top virus causes an endemic disease of beans in the western United States. Symptoms consist of vein clearing, downward curling and puffiness of leaves which may be darker green than normal, brittleness of tissue, stunting of pods and whole plants.

LEAF WILT. A virosis experimentally induced in snap beans, var. Stringless Green Refugee, by juice inoculation from symptomless Lathyrus pusillus L., attributed to a specific virus, the bean leaf-wilt virus. Symptoms limited to the inoculated primary leaves which wilt and dry up without necrotic lesions. Transmitted by Myzus persicae (Sulz.). Thermal inactivation at 48-50° C; dilution tolerance above 1:1000; longevity in vitro over 24 hrs., in dried leaves 30 days. [Johnson, J. *Jour. Agric. Res.* 64: 443-454. 1942]

ONE-SIDED VARIEGATION. Observed in hybrid beans derived from Corbett Refugee. A foliar variegation characterized by marked deficiency of chlorophyll causing white or yellow streaks, sometimes on only one side of a leaf, and marked deformation and reduction in size of leaves and pods. It is thought to be the same abnormality as that noted by Harrison & Burkholder, and Horsfall et al., which was at first attributed to a virus. Genetic studies indicate that the Corbett Refugee var. exhibits 2 types of hereditary variegation, one of which is controlled by 2 complementary factors with segregation into 15 normal to 1 variegated in the F₂ generation. Other types of variegation in beans also have been reported. [Harrison, A. L., and W. H. Burkholder. *Plant Dis. Rptr.* 20: 290-291. 1936; Horsfall, J. G., W. H. Burkholder, and O. A. Reinking. *Plant Dis. Rptr.* 21: 318-319. 1937; Reinking, O. A. *Plant Dis. Rptr.* 24: 37-40. 1940; Wade, B. L. *Jour. Agric. Res.* 63: 661-669. 1941; Walker, J. C., and J. P. Jolivet. *Phytopath.* 33: 778-788. 1943; Zaumeyer, W. J. *Phytopath.* 28: 520-522. 1928, *Jour. Agric. Res.* 64: 119-127. 1942].

RED NODE. A disease of suspected virus nature (possibly related to yellow bean mosaic) occurs in Colorado, Idaho, Montana, and Wyoming. It is characterized by a reddish discoloration of the stem nodes and leaf veins, together with malformation of the leaves, general dwarfing, and premature ripening. Pod production is diminished, and those present often bear reddish, sunken lesions. The seeds are shriveled and bear reddish, depressed lesions, but so far as tested they produce normal plants [Virgin, W. J. *Phytopath.* 33: 743-745. 1943].

RING SPOT. Natural infection of beans by tobacco ringspot virus has been reported in Germany, causing grayish-green to brown depressed spots on the pods but none on leaves. [Kotte, W. *Mitt. Biol. Anst. Berlin* 59: 61-64. 1939]. Previously shown susceptible to artificial inoculation with this virus, the symptoms consisting of circular, necrotic, bordered spots on leaves, followed by systemic necrosis. [Pierce, W.H. *Phytopath.* 24: 87-115. 1934].

RUGOSE MOSAIC. Differs from common mosaic in severe crinkling of foliage without mottling under field conditions, though a yellow mottle and general chlorosis developed in the greenhouse. The pods may show a roughened surface at an early stage of development. Seed-transmitted to same extent as common mosaic. Observed only in Refugee var. in California. [Nelson, Ray. *Michigan Agric. Expt. Sta. Tech. Bull.* 118. 50-56. 1932].

WITCHES' BROOM. A disease of unknown cause reported from Arizona affecting snap beans and lima beans. Affected plants show excessive multiplication of branches, marked wrinkling and great reduction in size of pods. [Hoyman, W. G. *Phytopath.* 34: 505-506. 1944].

YELLOW NECROSIS. A virosis experimentally induced in snap beans, var. Stringless Green Refugee, by juice inoculation from symptomless *Sesbania macrocarpa* Muhl.; attributed to a specific virus, the bean yellow-necrosis virus. Symptoms consist of general yellowing, or vein clearing, mild chlorosis, and necrotic spotting of secondary leaves. Soybean (*Glycine max*) and pea (*Pisum sativum*) also susceptible but the latter not systemically infected. Not transmitted by *Myzus persicae* (Sulz.). Thermal inactivation at 49° C; dilution tolerance 1:100,000 to 1:500,000; longevity in vitro over 48 hrs., in dried leaves over 12 days. [Johnson, J. *Jour. Agric. Res.* 64: 443-454. 1942].

YELLOW. A disease affecting snap beans and lima beans, also cowpeas and *Canavalia ensiformis* in Haiti; probably the same disease affects beans and cowpeas in Puerto Rico. Associated with the presence of a leafhopper *Empoasca fabalis* DeLong, but whether due to direct feeding injury or a virus is unknown. Not transmissible by juice or through seed. [Smith, R. C., and H. D. Barker. *Jour. Econ. Ent.* 23: 842-847. 1930]

Pisum sativum L. (garden pea).

CUCUMBER MOSAIC VIRUS. Two strains of this virus, designated 408 and 729, were obtained from naturally infected peas in Wisconsin. By inoculation of expressed juice both viruses infected peas, the former causing mottling of young leaves and mild streaking, the latter causing leaf necrosis. [Walker, J. C., and O. C. Whipple. *Phytopath.* 28: 22. 1938]

PEA VIRUS 2 Osborn (*Pisum virus* 4 Osborn ex Weiss, 1939). Originally distinguished from pea virus 1 (pea enation mosaic virus) by absence of enations and presence of conspicuous blotchy mottling in pea leaves, and by transmission without an incubation period in the insect vector [Osborn 1935, 1937]; subsequently related to common pea mosaic virus by various authors [Stubbs 1937, K. M. Smith 1937]. As further shown by Osborn [1937, 1938] it is infectious to many vars. of beans, Phaseolus vulgaris, (but not to Great Northern U. I. no. 1), causing a yellow-spot type of mosaic, thus distinguishing it from common pea mosaic virus. It differs from bean yellow mosaic virus in slightly higher thermal death point (62° C) and longer survival in vitro (4 days) [Osborn 1937]. It differs from pea mottle virus in being non-infectious to Perfection peas and to Great Northern U. I. no. 1 beans. Other susceptibles are: Lathyrus odoratus, Pisum sativum var. arvense, Melilotus alba, Trifolium incarnatum, T. pratense, and Vicia faba. It appears to belong to the bean yellow-mosaic and pea-mottle group of viruses but cannot definitely be referred to either. [Osborn, H. T. *Phytopath.* 25: 31. 1935; *Id.* 27: 589-603. 1937; *Id.* 28: 17-18. 1938; Weiss, F. *Plant Dis. Rptr.* 23: 352-361. 1939].

PEA MOSAIC VIRUS 4 (*Pisum virus* 4A Zaumeyer ex Weiss 1939). Obtained from mosaic-infected peas in Colorado. Distinguished in general from other pea-mosaic viruses by mild chlorotic mottling without leaf distortion in peas. It causes yellow halo-like spotting and reflexing of leaves of beans (Phaseolus vulgaris), followed by mottling, puckering, and distortion, thus placing it in the group of yellow-mosaic viruses of this plant. It is infectious to Crotalaria spectabilis Roth., C. mucronata Desv. (C. striata DC.), Lupinus albus L., L. angustifolius L., Medicago sativa L., Melilotus alba Desr., Trifolium incarnatum L., T. pratense L., Vicia faba L. Thermal inactivation at 62-65° C; dilution tolerance 1:8000; longevity in vitro at 20° C 1-2 days. It differs from pea virus 2 Osborn in symptoms on peas, in failure to infect Corbett Refugee bean; and from bean yellow-mosaic virus in failure to infect Great Northern U. I. no. 1 and Wisconsin Refugee beans. [Zaumeyer, W. J. *Jour. Agric. Res.* 60: 433-452. 1940; Weiss, F. *Plant Dis. Rptr.* 23: 352-361. 1939].

PEA MOSAIC VIRUS 5, PEA STUNT MOSAIC (*Pisum virus* 6 Zaumeyer ex Weiss 1939). Obtained from mosaic-infected peas in Colorado. Distinguished from other pea mosaic viruses by extreme stunting and only

slight mottling in Telephone and Dwarf Telephone vars., stems discolored, internodes shortened, apical parts rosetted and necrotic, ultimate wilting and death. In beans, small yellow spots and a diffuse blotchy mottle, with only slight distortion and size reduction. Infectious to all hosts listed for pea mosaic virus 4 except Trifolium pratense, and in addition infects Crotalaria retusa. Thermal inactivation at 60-62° C; dilution tolerance 1:8000; longevity in vitro at 20° C less than 24 hrs. It differs from bean yellow-mosaic virus in symptoms induced in peas and in inability to infect red clover; from pea wilt virus in inability to infect Perfection peas, white clover (T. repens), and especially in low resistance to aging. [For literature see preceding virus.]

RING SPOT. Peas inoculated with tobacco ringspot virus develop top necrosis, stem streaking, sometimes necrotic ring spots on leaves, and die prematurely. [Stubbs, M. C. *Phytopath.* 27: 242-266. 1937].

SPOTTED WILT. A streak disease of peas was shown to be caused in Hawaii by pineapple yellow-spot (tomato spotted-wilt) virus [Linford, M. B. *Phytopath.* 26: 114. 1936], in Wisconsin [Whipple, O. C. *Phytopath.* 26: 918-920], and in California [Snyder, W. C., and R. H. Thomas. *Hilgardia* 10: 257-262. 1936.]. Whether this virus or the typical legume viruses are the principal agents in the field occurrence of pea streak in the United States is not yet determined.

Soja max (L.) Piper (soybean)

TOP NECROSIS, BUD BLIGHT, STREAK. Characterized by distortion, brittleness, and necrosis of the shoot tip, necrotic stippling of young and bronzing of old leaves, general stunting, blighting of buds, and marked reduction in number and size of pods. Frequently reported in the Central and Southern States since 1942. Caused by a virus of the tobacco ringspot group, as first shown by Sampson and confirmed by F. Johnson. Transmissible by sap inoculations to soybean (with symptoms in 7 days), to cowpea, and to Turkish tobacco. [Johnson, F. *Plant Dis. Rptr.* 27: 86-87. 1943; Melhus, I. E. *Ibid.* 26: 431-432. 1942; Sampson, R. W. *Ibid.* 26: 382. 1942.]

Trifolium incarnatum L. (crimson clover)

MOSAIC. The following viruses may cause a mosaic disease in this host, aside from pea enation mosaic virus, which induces enations on the lower leaf surface; the symptoms of the different viruses have not been differentiated: alfalfa mosaic, bean yellow mosaic, pea common mosaic, pea enation mosaic, pea mottle, pea streak, pea wilt, pea mosaic viruses 2, 4, and 5, and red clover vein mosaic.

YELLOW DWARF. Crimson clover is a useful experimental host of both the New Jersey and New York strains of the potato yellow-dwarf virus (described in the Potato Virus Section, to be issued next). Two additional viruses that cause similar symptoms in this host and are transmitted by agallian leafhoppers have been identified as the big-vein and club-leaf viruses. These, together with the 2 strains of potato yellow-dwarf virus, are grouped in a new virus genus Aureogenus, the big-vein virus as A. magnivena Black, and the club-leaf virus as A. clavifolium Black. These 2 viruses have not been transmitted to any other hosts. [Black, L. M. Proc. Amer. Phil. Soc. 88: 132-144. 1944].

Trifolium pratense L. (red clover)

MOSAIC. May be caused by several different or sometimes by a combination of viruses. The red clover mosaic virus studied by Doolittle & Jones (1925) and Zaumeyer & Wade (1935) has been identified as common pea mosaic virus (q. v.), probably also the virus of red clover and sweetclover described by Elliott (1921) is of this type. From mosaic-infected red clover, Pierce (1937) obtained bean yellow mosaic, alfalfa mosaic, and white clover mosaic viruses, the latter since shown to consist of pea mottle together with pea wilt viruses. [For literature citations see the descriptions of these viruses.]

From red clover plants exhibiting a yellow venal chlorosis a virus was transferred through dodder to tobacco, in which it induced a mosaic pattern characteristic of the cucumber mosaic virus in this host. [Valleau, W. D. In Kentucky Agric. Exp. Sta. Ann. Rept. 54: 15. 1941.]

An unclassified red clover mosaic virus has been reported in Japan [Fukushi, T. Jour. Sapporo Soc. Agric. Formosa 30: 339-418. 1939]. It is infectious to Phaseolus vulgaris, Pisum sativum, Trifolium hybridum, T. incarnatum, and Vicia faba. Transmissible by juice and by the following aphids: Aphis fabae Scop., Myzus convolvuli (Kalt.), Macrosiphum kondoi (Shinji), in which it is non-persistent. Considered most nearly like pea virus 2 Osborn (q. v.) among the described viruses of legumes.

RING SPOT. A virosis observed in Kentucky, characterized by presence of small, yellowish, irregular rings, with necrotic borders, on leaves and stems. Possibly due to yellow ring-spot virus of tobacco but transmission tests to tobacco were negative. Not seed-borne. [Johnson, E. M. Phytopath. 23: 746-747. 1933.]

YELLOW DWARF. The potato yellow-dwarf virus causes vein clearing and leaf yellowing in red clover, suggestive of a mosaic disease; the symptoms are transient but the virus persists. Red clover is a natural overwintering host of the virus and an important food plant of the vector.

Trifolium repens L. (white clover)

MOSAIC. Originally attributed to a white clover mosaic virus Zaumeyer & Wade 1935 (probable synonyms, white clover virus 1 Pierce 1935 = Trifolium virus 1 K. M. Smith 1937) it has been shown that 2 viruses, each separately able to cause a mild mosaic disease in this host together cause the severe mosaic common in nature. See pea-mottle and pea-wilt viruses. [Johnson, F. Phytopath. 32: 103-116. 1942.]

A virus of white clover characterized by yellowish patches on the leaves was transmitted mechanically to tobacco causing ring and line patterns; likewise to beans, causing mottling and necrotic spotting, and to garden pea causing a mottle and streak. [Valleau, W. D. In Kentucky Agric. Exp. Sta. Ann. Rept. 54: 15. 1941.] The ability to infect tobacco distinguishes this virus from the pea mottle and pea wilt viruses, which jointly induce one form of white clover mosaic.

Vicia faba L. (broadbean, horsebean)

ALBICATION. A non-transmissible variegation characterized by white marginal banding of young leaves; other types of variegation also have been reported.

LEAF ROLL. Two types, one characterized by upward curling of leaf margins, the other by occurrence of pale foliar spots less distinct than in true mosaic; also by leaf thickening, and color changes from gray to yellow. Reported non-infectious. [Böning, K. Forsch. Geb. Pflanzenkr. & Immun. 4: 43-111. 1927.]

LOCAL-LESION VIRUS. So-named because it causes brown, necrotic, local lesions, without systemic effects in this host; obtained originally from mosaic-infected red clover. [Pierce, W. H. Jour. Agric. Res. 51: 1017-1039. 1935.] Resembles pea streak virus 1 [Zaumeyer, loc. cit.]; probable synonym of pea wilt virus [F. Johnson. Phytopath. 32: 103-116. 1942].

ROSETTE. A suspected virosis of the severe leaf-curl or stunt type occurs in China near Nanking. [Yu, T. F. Phytopath. 29: 459-461. 1939.]

VEIN MOSAIC. Distinguished from common mosaic by chlorotic vein-banding, the interveinal areas retaining normal color; sometimes epidermal hypertrophy; necrotic stripes in leaves and stems occur in the cortical but not the vascular tissues. Attributed to a combination of viruses [Böning, loc. cit.]; however the described symptoms resemble those of red clover vein-mosaic virus in this host [Osborn, H. T. Phytopath. 27: 1051-1058. 1937.], and of pea streak virus 1, which may be identical [Zaumeyer, W. J. Jour. Agric. Res. 56: 747-772. 1938].