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I. A BACTERIAL DISEASE OF MELONS IN SOUTHERN ARIZONA

By J. G. Brown and Maryhelen Emmons

II. VIRUS DISEASES OF MELONS

By Paul D. Keener

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By J. G. Brown and Maryhelen Emmons*

INTRODUCTION

A disease mainly affecting cantaloupes (Plate I) but also damaging crops of honeydew melons (Plate II) and watermelons, occurred this season in southern Arizona. In the Salt River Valley, the disease on cantaloupes assumed almost epiphytotic proportions. It was found on a few cantaloupe vines in an isolated planting in Pima County. Although this blight caused less damage to honeydew melons, it severely affected some fields of that crop. The disease was primarily caused by a bacterium that is seed-borne. Secondary factors were the exceptionally dry weather that hastened water-loss from the infected foliage, and the abundant presence of insect carriers of the bacterial parasite.

Plate I.—Blighted cantaloupe field. Note sunburned fruits.

SYMPTOMS

Fields of cantaloupes, as a whole, early in the season, showed numerous dark spots caused by the infection, death, browning, and drying of leaves. With the growth of new leaves, the spots in a field became inconspicuous. At the time of our visit June 17, 1948, only a few fields presented a diseased appearance from a distance. By July 15, however, fields of badly infected cantaloupes (Plate I) that had not yet been disked up had predominantly dead, dried foliage that rustled in gusts of wind.

*Maryhelen Emmons, graduate student.

Plate II.—Blighted honeydew melons: dead, infected leaves and sunburned fruits are conspicuous.

Upon close inspection, affected plants showed the following symptoms: the first leaves were attacked, their browned and dried remains afterward lying in the center of the hill. Later the disease progressed outward, involving the younger leaves as they developed on the runners. Infections also occurred on the older leaves.

The earliest symptom observed was a small, brownish, water-soaked spot *either close to, or on,* the margin of the leaf. The infected area rapidly increased in size (Plate III, *A, a*) and often assumed the form of a wedge (Plate III, *B, b*) with the broad end at the margin of the leaf and the point toward the lower end of the latter. Eventually the whole or only a part of the leaf became infected. The leaf-stem (petiole, Plate IV) frequently became water-soaked or, in earlier stages of infection, had brown, depressed areas. Later the petiole dried and sometimes twisted, particularly when the leaf-blade was badly infected. The affected areas of the blade became dry and brittle, often later jagged and torn by the action of the wind (Plate IV, *B*). The leaves killed by the bacterium frequently remained attached to the vine by a tough, dried petiole (Plate IV, *B, d*), but some were separated and lay on the ground.

Buds (Plate IV, *A, c*) and flowers also were attacked and blighted, sometimes along the full length of a runner. The infected flowers turned brown and eventually dropped. The same type of floral infection was present in both honeydew melons and watermelons.

Numerous blighted young fruits (Plate V) appeared in the fields, that apparently resulted from previous floral infections. The affected fruits were first discolored yellow and later a light

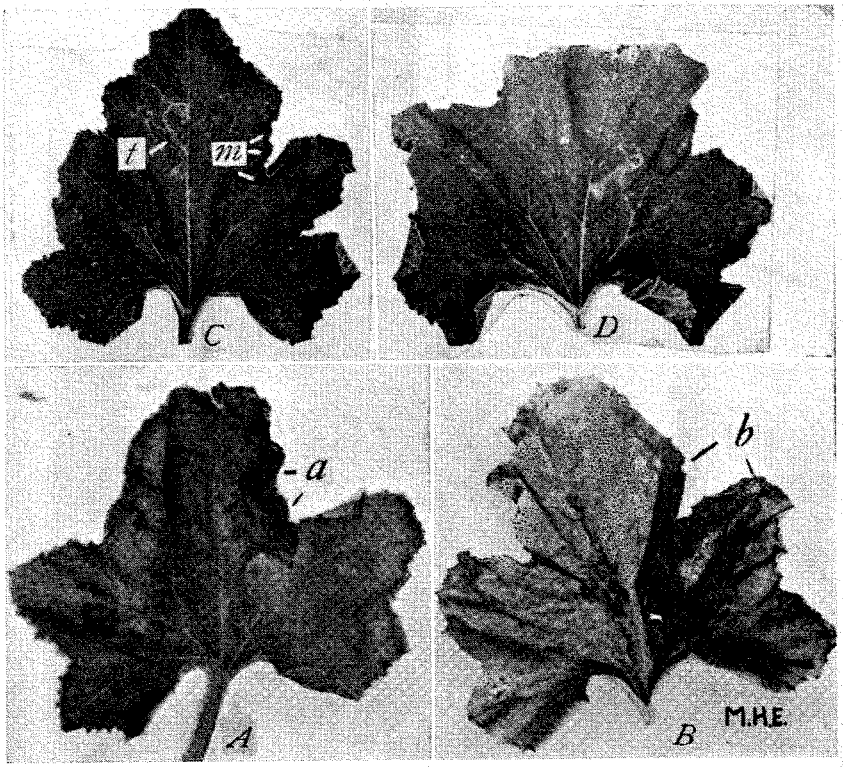

Plate III.—Leaves of honeydew melon: *A*. Early stage of marginal infection, *a*; *B*. Later stage with wedge-shaped blighted area, *b*; *C*. Leaf-miner tunnel, *t*, and marginal infection, *m*, independently developed; *D*. Healthy leaf with miner tunnel.

brown. Some young fruits showed a shrunken and shriveled area on the surface that was darker brown in color. The largest shriveled fruits were approximately 6 inches in length. Seeds of the infected fruits were normal in appearance but probably carried the bacterium of blight on the surface. Fruits selected for bacterial culture were shaded, therefore not sunburned.

Fields of honeydew melons and watermelons, as well as fields of cantaloupes, that appeared to be healthy from a distance often contained vines with blighted and discolored small fruits. Usually, too, such fields had plants with at least occasional, infected leaves.

STUDIES

Infected cantaloupe, honeydew melon and watermelon plants were early sent to the Department of Plant Pathology by County Agricultural Agent J. H. O'Dell and his assistants, who correctly surmised that an infection was present in the plants. Other specimens were collected by members of this Department shortly after

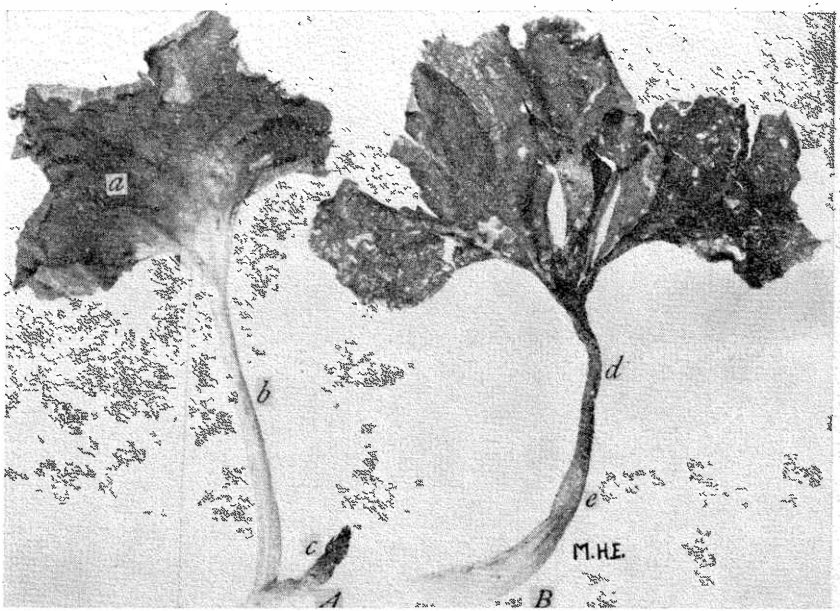

Plate IV.—Advanced stages of bacterial blight on leaves or honeydew melon plant. *A*. Browning and drying of leaf-blade. *a*; water-soaked spots on petiole, *b*; blighted bud, *c*; *B*. Later stage showing splitting of brown, dried leaf-blade; water-soaked and tough, drying part of petiole, *d*; and progressing infection, *e*.

the outbreak of the disease and at subsequent intervals; also by the authors of this bulletin on two field trips. The collected material, including leaves, flowers, fruits, and seeds, was promptly studied macroscopically and microscopically and also in cultures. Among the seeds procured were samples from lots left over from plantings of fields that later became infected.

Preliminary studies of the diseased leaves and their water-soaked petioles (Plate IV, *A, b; B, e*) disclosed the presence of clouds of bacteria oozing from the infected parts. Among these bacteria was a species that, up to the present stage of our studies, mostly agrees with the description of *Erwinia aroideae* (*Bacillus melonis*). This bacterium, isolated in pure culture and inoculated into parts of melon plants by the junior author, has attacked leaves, stems (Plate VI), and fruits of cantaloupe, also fruits of honeydew melon and cucumber, with resulting symptoms like those observed in the field.

A bacterium identical with the germ that attacked leaves, stems, and fruits of cantaloupe and fruits of honeydew melon and cucumber into which it was inoculated was also obtained in culture from seeds of cantaloupe (Plate VII, *A*) left over from planting this season's crop that afterward became blighted. It was likewise isolated from infected leaves and blighted flowers and

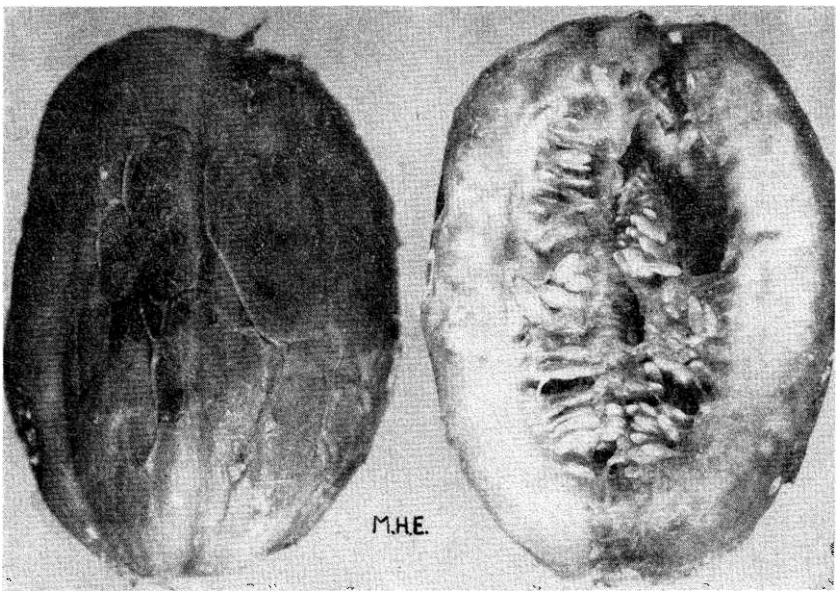

Plate V.—Naturally blighted and rotted young cantaloupe fruit split lengthwise, about natural size. It yielded bacterial colonies like the blighted leaves and other infected parts of the cantaloupe.

fruits, not only of cantaloupe but also of honeydew melon and watermelon. The presence of the bacterium on the left-over seeds is believed to explain the outbreak of the blight in the melon fields of the Valley.

DISCUSSION

That the melon blight that appeared this season in the Salt River Valley is bacterial appears beyond doubt. Most cultures of affected leaves and fruits gave bacteria only. The suspected bacterial parasite rotted certain melon tissues into which it was inoculated, including leaves, stems, and fruits.

Bacterial parasites in general cannot penetrate into uninjured plant parts but must enter through natural openings and wounds. The natural openings that are most numerous are the "breathing pores" or stomata present on the green parts of higher plants. Wounds are more or less abundant due to the activity of plant-feeding insects; this season they were particularly numerous. The insects that feed upon leaves and other plant parts that have already become bacterially infected are contaminated with the bacterial parasite, carry it either externally or internally or both, and thus spread the disease from infected to healthy plants.

That the bacterium causing the damage to melons was isolated from the surface of seeds of the same lot used in planting fields that later became diseased is important. That finding probably

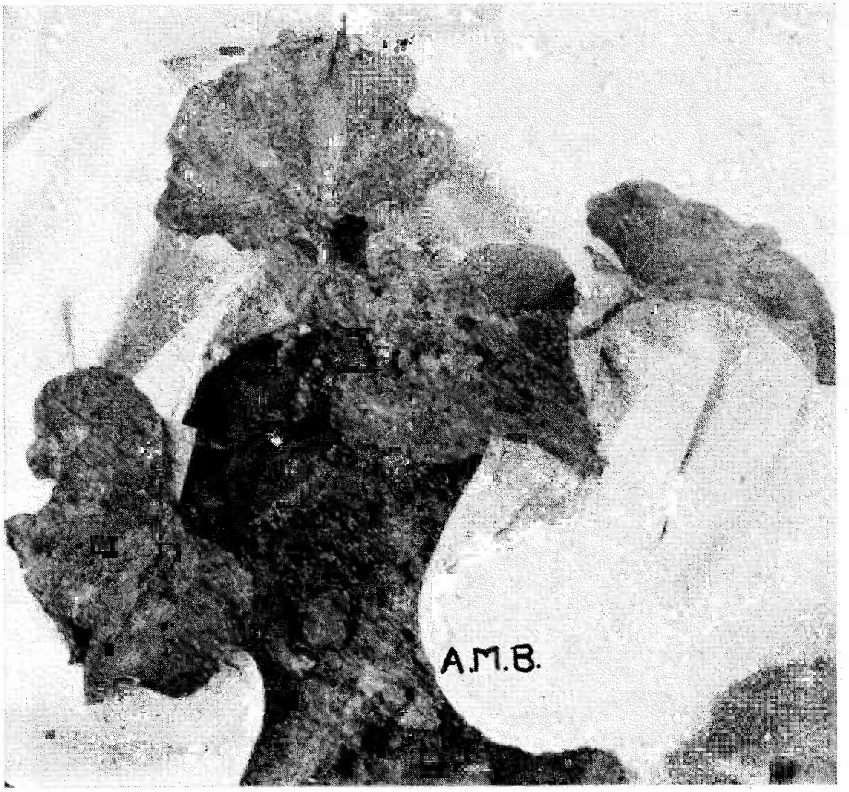

Plate VI.—Before inoculation this was a healthy cantaloupe plant. The blight bacterium is killing stem and leaves.

explains the manner in which the blight germ was first brought into the fields. From the seeds the bacterium reached the early leaves through the stomata and through minute cracks in the seedling received by it in forcing its way through the soil. Fortunately, the bacterium is apparently carried *only on the surface* of the melon seeds, *not inside* the seeds; therefore seed treatment with a good disinfectant such as solution of mercuric chloride, Semesan, or other satisfactory bactericide should prove valuable as a control measure.

If the bacterium of blight is absent there can be no bacterial blight regardless of the abundance of insects. Leaf-miner injury is only a secondary factor. Such injury was absent from by far the greater number of leaves of which those illustrated in Plates III *A*, *B*, IV, and VI are representative. Also there were many leaves with numerous clean, white leaf-miner tunnels, that were otherwise normally green, efficient manufacturers of food. On the other hand, some tunnels showed blight infection spreading outward from them. The leaf-miner larva is a carrier of the bac-

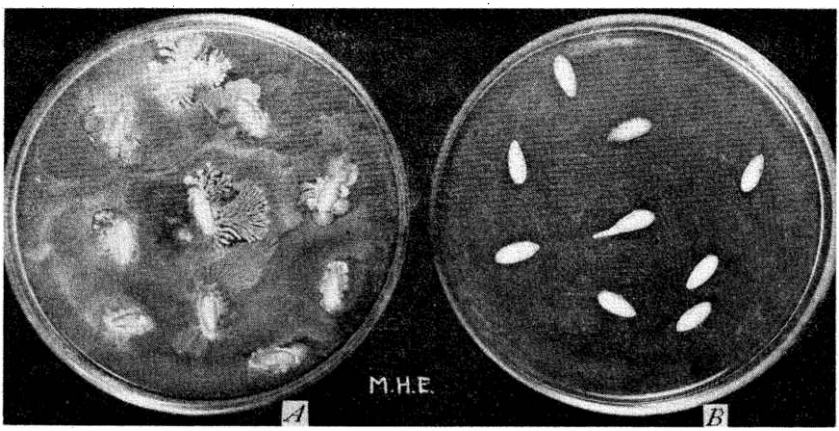

Plate VII.—*A*. Untreated cantaloupe seeds, from a lot left over after planting a field that later became infected, gave an abundant growth of bacteria when cultured. The white lobed form is the blight parasite. *B*. Seeds from the same lot, cultured after five-minute treatment with 1:1,000 mercuric chloride, gave no bacterial growth. Seed treatment at the cost of a few cents per acre would have prevented the blight so prevalent this year in fields of cantaloupes.

terium of the melon-blight when it feeds upon, or passes through, infected leaves: cultures of the insect gave the bacterium of melon blight. No leaf-miner injury was found in blighted flowers and young fruits. In those cases, bees probably carried the bacterium of blight.

The bacterium of melon blight was described from Vermont, by N. J. Giddings, in 1910, under the name of *Bacillus melonis*. There it had caused extensive damage in plantings of muskmelons. Prior to that description Townsend had described a rot-producing bacterium on the calla lily under the name of *Bacillus aroideae*. The two bacteria are now placed under the name of *Erwinia aroideae* in the latest manual (Bergey's *Manual of Determinative Bacteriology*, 6th ed., 1948) because they are believed by the authors to be identical. Listed as susceptible to attack by *Erwinia aroideae* are beet, broccoli, calla, cantaloupe, carrot, cauliflower, celery, citron, cucumber, eggplant, geranium, hyacinth, iris, onion, parsnip, potato, radish, rape, salsify, sweet potato, tobacco, tomato, and turnip. Cantaloupes and other melons should not follow any of the above-listed hosts that are crop plants, particularly where soft rots have been prevalent in them.

Other important control measures for bacterial blight of melons include, besides seed treatment, removal of debris from preceding crops and, particularly, deep plowing rather than disking of melon fields.

II. VIRUS DISEASES OF MELONS

By Paul D. Keener

INTRODUCTION

Several viruses are known to affect cantaloupes, honeydews, watermelons, and other cucurbits. In addition to curly top and certain other viruses, the most commonly encountered virus of melons in Arizona is the one causing the disease known as *mosaic*. Several strains (forms) of viruses are responsible for mosaic in melons and it is now believed that at least two or three of these occur with some regularity in the state. At times, melon viruses become sufficiently destructive as to greatly reduce yields or to wipe out entire plantings. During the season of 1948 symptoms of melon mosaic viruses were quite noticeable in numerous plantings in the Salt River and Yuma Valleys. A brief field survey was made in the Salt River Valley and surrounding territory during June and July, in order to determine the prevalence and severity of mosaic in cantaloupes and other melons.*

HOW TO RECOGNIZE MOSAIC

Sometimes no symptoms or evidence of infection appear to an observer in the field in melon plants affected with mosaic and other viruses. This "masking-of-symptoms" effect adds to the difficulty of determining the extent of infections, and indeed the very presence or absence of any viruses in a planting. When symptoms do appear (which is the usual situation with mosaic viruses), mosaic in melons may be easily recognized. Common forms of the viruses causing mosaics may infect melon plants at any age. Yellowish (chlorotic) discolored areas, variable in size and shape, appear on the leaves of affected plants in the form of a mottle (Plate VIII, arrows). Frequently, the leaf surfaces become puckered (Plate IX, arrows) and raised areas of dark-green tissue predominate. Leaves may become quite distorted and irregular in shape (Plate X). The leaf edges often become curled (Plate X), especially downwards. Symptoms of mosaic in melons usually appear first on young leaves (most recent growth) and consequently are often most noticeable at the tips of the vines (runners). If infection occurs at an early age in the life of a plant, dwarfing and stunting may result. As is usual in curly-top virus infections, sections of stem between the leaves (internodes) may become somewhat shortened as compared with those of normal plants. This results in more or less "bunching" of the leaves, particularly at the tips of the runners.

*The survey included general observations on the prevalence of *Erwinia aroideae* (*Bacillus melonis*), recently demonstrated by Dr. J. G. Brown, Head of the Department of Plant Pathology, and Miss Maryhelen Emmons, of this station, to be the cause of a blight in melons in this state.

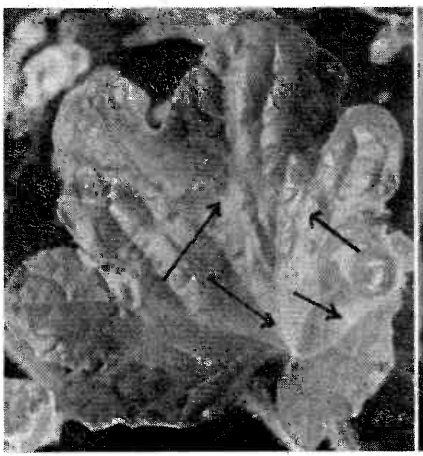

Plate VIII.

Plate IX.

On fruits, symptoms of melon mosaics may assume the form of a wartiness, in addition to the usual mosaic mottle. The symptoms, particularly in cantaloupes, become less severe as the fruits mature. Other symptoms such as reduction in size, and oddities in shape (form) may also occur in melon fruits. In the case of severe infections, the fruit pulp may lose color and the taste become altered.

Since symptoms are often difficult to discern, leaves should be shaded during examination in the field. Infections may be "spotty" in any particular planting or region; more mosaic being present in one area than in another.

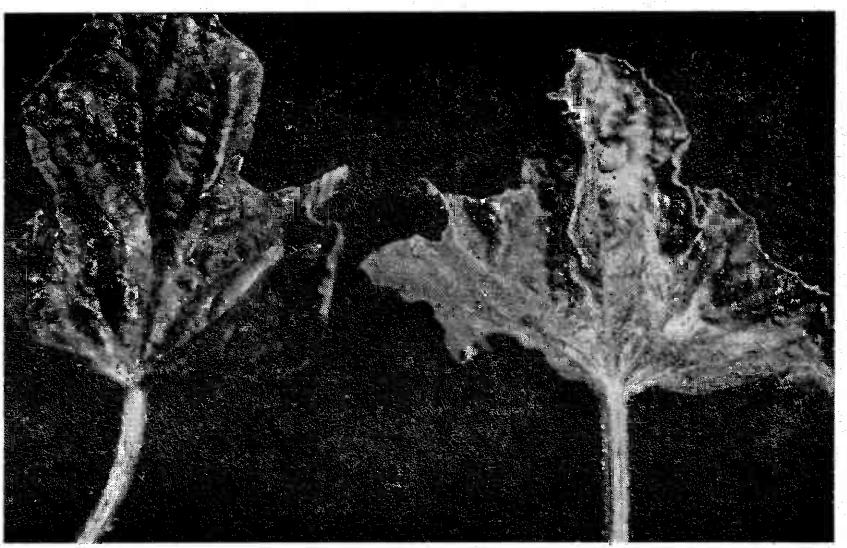

Plate X.

"CONTROL" OF MELON MOSAICS

The term control when applied to the disorders known as mosaics of melons, is rather misleading. Virtually no single foolproof method of control is known. It has already been shown that infections in a planting may originate with infected seeds. Even though a very small percentage of seed in any particular lot may harbor these viruses, the first prerequisite to adequate alleviation of the diseased condition is the *securement and planting of disease-free seed.* Comparatively disease-free seed stock is available on the market from reputable growers and such material should be utilized.

Insects such as aphids (plant lice) are capable of spreading the melon mosaic viruses from seed-initiated centers of infection and from wild weed hosts which may also harbor these viruses. Since noncultivated noxious plants afford reservoirs of infection for many viruses (including those causing melon mosaics) as well as for the insects which carry them, the use of disease-free seed *alone* is not the final answer to the mosaic problem. For control to even approach adequacy, the use of disease-free seed should be supplemented by other procedures such as eradication, where practical, of the wild weed hosts of these viruses, and other sanitation practices. In small plantings, melons which appear to be infected (determined by the appearance of symptoms) should be cut out. The cut out vines, if situated near to, or adjoining, healthy plants should *not* be removed but allowed to *die in place.* Certain strains of mosaic viruses are easily transmitted through mere contact of the specific virus with a healthy plant.

Disease resistance is of course the ultimate aim in combating parasitic diseases of plants. Melon plants resistant to the mosaic viruses may become available in the future but as yet are not sufficiently recognized to form a suitable basis for the control of these disorders.

Mosaics apparently "build up" in severity in regions in which melons are grown from year to year. This appears to be especially true in the case of honeydews. This may result in greater prevalence and severity of mosaics on melons in future years in Arizona.

THE RELATIONSHIP OF VIRUS TO SEED

Whereas *Erwinia aroideae* (*Bacillus melonis*), the cause of a blight of melons in this state, may be carried *on seed surfaces,* melon mosaic viruses may be borne *within* the seeds. Thus, any surface sterilizations performed to control the bacterial parasite ordinarily will not affect the viruses *within* the seed tissues. No methods of eliminating viruses from seeds of melons are feasible, excepting those which aim to select seeds from assumedly normal, healthy plants. Selection of seed free from disease is practiced on a commercial scale.

OTHER VIRUSES OF MELONS IN ARIZONA

(a) Variant of common mosaic—This form believed to be seed-borne was observed in 1947 in a 60-acre planting of Imp. (45) cantaloupe, north of Tolleson. It appears to be a strain of common mosaic, first described from the east. Symptoms assume the form of a vein-banding.

(b) Curly-top virus—Symptoms of this virus have been frequently noted on cantaloupes, watermelons, squashes, and other cucurbits in the state.

(c) Yellow-net virus—This disease, recently described* probably occurs on cantaloupes and watermelons. The virus is transmitted by an aphid, *Myzus persicae,* which is found within our range. Symptoms resembling those described for this virus were observed in the state in 1948 on cantaloupes and watermelons in Deer Valley and in the region of Buckeye.

Among other commercially-important crop plants (other than melons, and other cucurbits) which may be affected with strains of melon (cucumber) mosaics, are:

Celery—A strain of cucumber mosaic was observed on this crop in Arizona, during the 1947 season. Of interest is the fact that Southern Celery Mosaic virus is a strain of cucumber mosaic.

Tomato—Cucumber mosaic virus on this crop produces symtoms which cause the leaves and leaflets to assume a "shoestring-like" form. Several records of the disease have been made in the state and the condition is commonly referred to as "Fern-leaf."

Pepper—

Lettuce—Melon mosaics have never been observed on this crop in Arizona. Reports indicate that lettuce may be experimentally infected but that infection does not occur naturally in the field.

In addition to the above crop plants, spinach (on this host cucumber mosaic virus causes a disease known as spinach blight), tobacco, beans, and even bananas are capable of becoming infected with strains of cucumber mosaic viruses. Numerous ornamentals, including Zinnias, are also susceptible. Zinnias are also quite susceptible to curly-top virus.

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*Sylvester, Edward S. The yellow-net virus disease of sugar beets. *Phytopathology* 38 (6): 429-439, June 1948.