# THE TRANSMISSION OF BEAN YELLOW MOSAIC VIRUS BY SOME STRAINS OF THE APHID MYZUS PERSICAE (SULZER)

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TABLE OF CONTENTS


| | Page |
|---|---|
| INTRODUCTION | 1 |
| REVIEW OF LITERATURE | 2 |
| MATERIALS AND METHODS | 10 |
| The Plant Virus | 10 |
| The Aphid | 10 |
| The Plants | 11 |
| Definition of Terms | 12 |
| Testing Techniques | 14 |
| Statistical Methods | 14 |
| RESULTS | 16 |
| Development of Positive and Negative Colonies | 16 |
| Colonies from Field-Collected Apterae | 21 |
| DISCUSSION | 26 |
| SUMMARY | 30 |
| BIBLIOGRAPHY | 32 |
| APPENDIX | 34 |

# LIST OF TABLES


| TABLE | | Page |
|---|---|---|
| 1. | Transmission Rates of BYMV by Developed Positive and Negative Colonies . . . . . | 19 |
| 2. | Transmission Rates of Colonies 4 and 7 . . | 20 |
| 3. | Transmission Rates of Colonies Started from Field-Collected Apterae . . . . . | 22 |
| 4. | BYMV Transmission Rates of Colonies 2 and 8 . . . . . | 24 |

# THE TRANSMISSION OF BEAN YELLOW MOSAIC VIRUS BY SOME STRAINS OF THE APHID, *MYZUS PERSICAE* (SULZER)

## INTRODUCTION

The factors which influence the transmission rate of plant viruses by their insect vectors have been studied for about 25 years. Numerous factors have been discovered. One of these is inherited variation in the virus-transmitting ability of the vectors. Genetic variations in the ability to transmit plant viruses have been studied with several leafhopper species. Inheritance of susceptibility to a virus has been studied with a mosquito vector.

Nothing has been published on the genetic variation in the ability of aphids to transmit a non-persistent virus, such as bean yellow mosaic virus. Therefore, a study was made to determine if there were strains of *Myzus persicae* (Sulzer) varying in their ability to transmit bean yellow mosaic virus (BYMV).

## REVIEW OF LITERATURE

While working with the leafhopper, Cicadulina mbila Naude, and the streak disease of maize, Storey (15, p. 46-56) noted that certain individuals transmitted the virus while others did not. As a result of this observation he began to mate the leafhoppers selectively in order to obtain an active and an inactive strain. "Active" designated those leafhoppers which had the inherent potentiality to transmit the virus, and "inactive" designated the opposite inherent potentiality. The active line was carried to the F5 generation and the inactive line to the F6 generation to obtain pure strains.

A cross between an active female and an inactive male gave an entirely active progeny in the F1 generation, and in the F2 generation gave active females and both active and inactive males. The reciprocal cross, an inactive female and an active male, produced in the F1 generation only active females and inactive males. Both active and inactive males and females appeared in the F2 generation. Storey hypothesized that the male was heterozygous for sex, that the factor for activity was dominant to that for inactivity, and that this factor was linked with the sex chromosomes.

Later Storey (16, p. 483-484) discovered that if the virus were injected into the abdomen or leg of an inactive insect, it was transmitted in some cases. Also, some insects would become active if the wall of the intestine were pierced with a fine needle. The number which became active was never as great as the number of active insects in the active strain.

Fukushi (8, p. 149-151) found that certain individuals of the vector species, Nephotettix apicalis Motsch. var. cinciteps, and their progeny were never able to acquire and transmit the virus of the rice dwarf disease. It is regrettable that he did not attempt to develop an active and an inactive race.

In testing large numbers of beet leafhoppers, Eutettix tenellus (Baker), from stock colonies and field collections, Bennett and Wallace (2, p. 44-46) found individuals which failed to transmit the curly top virus to small beets. By successive selections and matings, strains of the leafhopper which differed in their efficiency to transmit the virus were developed. The percentage of infections resulting from test feedings on 20 successive plants by individual leafhoppers was used to measure the transmission efficiency of the leafhopper. The individuals which transmitted the virus to seven or less plants were considered

inefficient, while those that transmitted to eight or more of the 20 plants were considered highly efficient. The strain with the lowest transmission efficiency in the last generation had a transmission rate of 19.3 per cent, and the strain with the highest transmission efficiency had a transmission rate of 72.5 per cent.

Bennett and Wallace found that the degree of efficiency was inheritable and that strains below and above the average could be developed. The could find no evidence that a strain inherently lacking in the ability to transmit the curly top virus could be developed.

Black (4, p. 201-208) was able to breed races of Aceratagallia sanguinolenta (Prov.) active and inactive with respect to the transmission of potato yellow dwarf virus to crimson clover. Black's active and inactive races differed from Storey's in that of his active race only 80 per cent transmitted, and of his inactive race 2 per cent transmitted the virus in the last test. This occurred in spite of the fact that while developing the active race only leafhoppers which transmitted the virus were mated, and while developing the inactive race only leafhoppers which did not transmit were selected and mated. Only 30 per cent of the last group of hybrids transmitted the virus. Males resulting from crosses between inactive males

and active females had a significantly higher transmission rate than the females from such crosses and both the males and females from the reciprocal crosses.

Black proposed two genetic hypotheses to explain these differences. He suggested that sex-linkage was involved in the ability to transmit or that an autosomal gene or genes with a maternal (plasmatic) effect had a different degree of dominance in the two sexes. A simpler mechanism would be that a single incompletely dominant gene affecting the tendency of an insect to transmit was located on the sex chromosome. He suggested that the difference might have been due to inhibiting genes present on other chromosomes.

Day (5, p. 509-510) attempted to develop strains of Myzus persicae (Sulz.) differing in their ability to transmit the potato leaf roll virus. This was done to explain some of the differences recorded by various workers. A colony was initiated from field-caught alates, and later 205 aphids from this colony were used to start new colonies. Aphids from 20 of these colonies were tested. No differences in vector efficiency between colonies or between mature apterae and nymphs were found.

Day concluded that no difference in vector efficiency could be shown with the aphids available to him and that

the variability which occurs within any single colony makes it imperative that large numbers of aphids be used before any conclusions are made.

Stubbs (17, p. 69-71), working with a yellow virus of spinach and the green peach aphid, Myzus persicae (Sulz.), was the first to develop strains of aphids with different transmission rates. In his first experiment, aphids from different colonies transmitted the virus at different rates. In the second experiment, mother aphids were selected from a non-infective stock colony and placed individually on infected spinach plants. From each of the colonies selected from those which developed, five adult apterae were tested serially in daily transfers to a total of four healthy plants. This established the transmission rate for each colony. In the third experiment, one colony with a high rate of transmission was compared to a colony with a low rate of transmission. These two colonies retained the rate of transmission which had been established in the second experiment. In the fourth experiment, two more colonies, one with a high transmission rate and one with a low transmission rate, were used with the two which had been used in experiment three. Before the experiment was begun, these colonies were transferred to spinach plants infected from one virus source. Each of the three

groups of five aphids from each colony was serially tested on four plants. The two colonies with the high transmission rates retained these rates, while the two colonies with the low rates were unable to transmit the virus. Before Stubbs was able to make further experiments with these aphids, they were lost due to fungal attack and seasonal changes.

Frazier (7, p. 307-310) discovered differences in the rate of transmission of strawberry vein-banding virus between several colonies of Capitophorus fragaefolii (Ckll.). Six colonies of this species, four of pale aphids and two of dark aphids, were used during his experiments. The pale aphids were collected from commercial strawberry plants, and the dark aphids were collected from wild woodland strawberry plants. The dark aphids were morphologically similar to the pale aphids, but could be distinguished in the adult apterous form by the dark brown coloring of the abdominal dorsum. When tested, individuals from four of the colonies, two dark and two pale, were efficient vectors, but individuals from two of the pale aphid colonies failed to transmit.

Several aphid strains which differed in their ability to transmit beet yellows virus and potato leaf roll virus were isolated by Bjorling and Ossiannilsson (3, p. 1-2).

Most of the work was done with Myzus persicae, but strains of Aphis fabae were also isolated. From different localities, 85 strains of Myzus persicae were collected and tested for their ability to transmit the viruses. The transmission rates of these strains could be arranged in a series from 10 per cent to 80 per cent. Between some strains there was a significant difference. No relation could be found between transmission ability and the host plants from which the aphids were collected. Three facts supported the hypothesis that virus-transmitting ability was genetically determined. With beet yellows virus, certain aphid strains maintained their differences in transmission over a period of three years. In one of two crosses between different strains, the descendants differed significantly in virus-transmitting ability from their parent strains. For two standard strains, the differences were of the same magnitude with both beet yellows virus and potato leaf roll virus.

The relationship between Rift Valley Fever Virus (RVF) and an insect host, Aedes aegypti (Linn.), has been preliminarily studied by Gillett and Cairns (9, p. 16-17). Though the mosquito is not a vector of the virus, it was chosen for this study because it is an excellent laboratory animal, RVF will multiply to a considerable extent

in some individuals, and the virus goes through a cycle similar to that which the yellow fever virus undergoes in the same species, in that it decreases to a vanishing point and subsequently in some individuals multiplies. As far as is known, the virus does not enter the salivary glands of the mosquito, and transmission does not occur. The virus is detectable in diminishing amounts for the first two days following the infective meal. It then becomes completely undetectable and in some ("susceptible") individuals in reappears several days later and multiplies, while in others ("insusceptible") it never reappears. Selective breeding was begun to develop susceptible and insusceptible strains. Many difficulties were encountered, mostly results of inbreeding. Therefore, the evidence secured from a line bred until the fifth generation was not considered to be sufficient to draw any conclusions.

Later Gillett and Mims (10, p. 7-8) discovered that the virus titer in the blood of the mice on which the mosquitoes fed varied, and, as a result, the number of mosquitoes in which the virus developed varied. The question as to the role of the varying titers is to be settled before any further attempts are made to continue the breeding experiments.

# MATERIALS AND METHODS

## The Plant Virus

The strain used in these experiments was isolated from a naturally infected clover plant collected near Geneva, New York, in 1954 (18, p. 1121) (19, p. 728-730). This strain of bean yellow mosaic virus had been maintained in broadbean, Vicia faba L., by means of aphid transfer since 1956.

## The Aphid

The green peach aphid, Myzus persicae (Sulzer), was used in all the experiments. To start the first experiment, aphids from colonies which had been maintained by K. G. Swenson for several years were used. The aphid colonies used during the second experiment were started from aphids collected from different fields around Madras, Oregon. One colony from the first experiment was included in the latter experiment.

In order to restrict the aphids to their own colony plants, cages were placed over each plant. These cages consisted of a wood frame to which a fine mesh plastic screen had been fastened on three sides and the top. The remaining side was covered by a sliding glass panel. Cut into the bottom piece was a circular hole through which

the plant projected. The soil level of each pot was brought up to the top in order to form a tight seal around the bottom of the cage and the top of the pot or can. To further confine the aphids, a piece of gauze was wedged in between the top of the wood frame and the sliding glass front.

To prevent contaminating adjacent colonies and to prevent the spread of the aphids to other greenhouse rooms, they were transferred only in the headhouse, a room separate from all others. The colonies were maintained or kept in one room of the greenhouse in which nothing but insect colonies were kept.

The Plants

The plants used for testing purposes were either the Dwarf Horticultural variety of the bean, Phaseolus vulgaris L., or the broadbean, Vicia faba L. Dwarf Horticultural bean was used for all of the experiments except one where, because damping off made it increasingly harder to grow them during the summer months, broadbean was used. All plants used were grown in either five- or six-inch clay pots, or number ten cans.

Aphids were reared on broccoli, Brassica oleracae L. These were started in small clay pots and then transferred to cans.

These plants were grown in a greenhouse room separated from the room in which insect colonies were maintained. This room was fumigated at intervals in order to kill any stray insects. Test plants which were placed in this room were inspected as frequently as was practical, and all plants showing definite symptoms were cut out and discarded. This was done in order to prevent the transmission of the virus by stray aphids. Usually test plants were thrown out within four to five days after the day on which the largest number of plants showed definitive symptoms.

Definition of Terms

Pre-acquisition starvation was the period during which the aphid was starved prior to being allowed to feed on the diseased source plant (20, p. 75-77). The feeding on the virus source plant (20, p. 83-84) was called the acquisition feeding (14, p. 29).

A test plant was the healthy plant on which the aphid was placed after it had fed on the source plant. It was this plant to which transmission of the virus was attempted (20, p. 84-85).

A test feeding was the period during which the aphid was allowed to feed on the test plant (14, p. 29).

A colony was a number of individuals of the same species on the same host plant. They may have developed

from one or several aphids.

A positive colony was one which had been propagated only by a single aphid which was able to transmit the virus.

A negative colony was one which had been propagated only by a single aphid which was unable to transmit the virus.

A strain was a colony of aphids with a rate of transmission significantly different from that of other colonies.

A non-persistent virus is one which is readily sap transmissible, retained by the vector for only a short period of time, and lacks a latent period in the vector. The efficiency of the vector is increased by short periods of fasting before the acquisition feeding and the vector efficiency decreases with increased acquisition feeding times (21, p. 543-546).

A persistent virus is one which has a definite latent period in the vector. Vector efficiency and vector retention of the virus are increased by increased feeding times on the source plant. The persistent virus is usually transmissible only by grafting or by the insect vector; if sap-transmissible, it is with difficulty (21, p. 543-545).

## Testing Techniques

A standard procedure was followed for all the transmission tests. The aphids were collected from colony plants and placed in 50-ml. Erlenmeyer flasks, where they underwent a minimum pre-acquisition starvation period of 30 minutes. The aphids from each colony were kept in separate flasks. After being starved for a sufficient length of time, they were placed on the last fully developed leaf of a source plant and allowed an acquisition feeding of 10 to 60 seconds. All those which did not naturally terminate their acquisition feeding within this period were discarded. After any aphid had completed its acquisition feeding within the prescribed length of time, it was placed on a test plant for one hour or more. All transfers were made by the camel's-hair brush technique.

## Statistical Methods

The analysis of variance was used to analyze the data from a transmission test between all of the colonies in either experiment (12, p. 198-208). In order to make further use of the calculations made in the analysis of variance, an individual degree of freedom (12, p. 226-233) was used to compare data from two colonies or to compare the data from one colony against the data from all the other colonies. When additional transmission tests were

made between only two colonies, the t-test (12, p. 96-99) was used to analyze for any significant differences in transmission rates. All the data were transformed, since they were small whole numbers. If no zeroes occurred, the numbers were transformed to their square root. If zeroes occurred, .5 was added to each number before the square root was extracted (11, p. 98).

# RESULTS

## Development of Positive and Negative Colonies

The aphids used in this experiment were derived from a stock colony which had been maintained in the greenhouse for four years. One hundred aphids taken from this colony were tested individually for ability to transmit the bean yellow mosaic virus. These aphids were starved for half an hour or more, fed on the virus source plant for 10-60 seconds, then transferred to healthy plants. After one to two hours on the healthy plants, each aphid which could be found was placed on a separate small broccoli plant.

Thirty-six of these aphids transmitted the virus. Colonies had been established on broccoli by most of these aphids. These were designated "positive colonies." Colonies established by the non-transmitters were designated "negative colonies."

In the second selection, one aphid was tested from each of 22 positive colonies and from each of 22 negative colonies. Five of the aphids from positive colonies and eight of the aphids from the negative colonies transmitted the virus. The colonies established by positive aphids which did not transmit and by negative aphids which transmitted were discarded. A small number of colonies were established by the remaining aphids.

In the third selection 40 aphids from two positive colonies and 40 aphids from three negative colonies were tested. Sixteen of the positive aphids and 13 of the negative aphids transmitted BYMV. Again only a small number of colonies were established by individual aphids.

One hundred aphids, 52 from six positive colonies and 48 from nine negative colonies were tested in the fourth selection. Thirty of the positive aphids and 26 of the negative aphids transmitted the virus. Colonies were established on small broccoli plants by the aphids which were tested.

In the fifth selection, 100 aphids, 62 from 17 positive colonies and 38 from eleven negative colonies were tested. Thirty-one of the positive aphids and 26 of the negative aphids transmitted the virus. From the colonies which were established, ten were chosen for a comparative transmission test.

For the transmission test, the colonies were renumbered 1 through 10. Colonies numbered 1, 4, 7 and 8 were negative colonies, and the other colonies were positive colonies. Colonies 4 and 8 were initiated by individual aphids from the same colony. Aphids from one colony established colonies 2 and 9, while colonies 6 and 10 were initiated by aphids from another colony (Appendix Figure 1).

The aphids which were tested underwent the prescribed pre-acquisition starvation period of at least 30 minutes, the acquisition feeding of 10-60 seconds, and the test feeding period of one hour. At the end of the test feeding period, the test plants were placed in the fumigator and fumigated with nicofume. Ten replicates of 50 plants each were used for a total of 500 plants. The results are presented in Table 1.

Before an additional transmission test was made on colonies 4 and 7, they were transferred to new colony plants. In this additional transmission test, 10 replicates of 10 plants each for a total of 100 additional plants were used. The results are presented in Table 2.

This test between the chosen developed colonies was made to determine any differences in transmission rates. The analysis of variance was used to determine significant differences between the colonies when compared as a group (Table 1). The differences were significant. When the individual degree of freedom was used, the results were significant for two colonies. This indicated that there was a difference between colonies 4, 7, and the other colonies with respect to the ability to transmit the virus.

The t-test was used to test for any significant differences in transmission rates between colonies 4 and 7 (Table 2). When the data for these two colonies from the

TABLE 1

Transmission Rates of BYMV by Developed Positive and Negative Colonies

| Colony | Number of plants infected | Per cent transmission |
|---|---|---|
| 1 | 20[1] | 40 |
| 2 | 18 | 36 |
| 3 | 22 | 44 |
| 4 | 31 | 62 |
| 5 | 23 | 46 |
| 6 | 20 | 40 |
| 7 | 14 | 28 |
| 8 | 17 | 34 |
| 9 | 21 | 42 |
| 10 | 20 | 40 |
| Average | 20.6 | 41.2 |

[1] Out of 50 inoculated.

Summary of analysis of variance

| Source of variation | Sum of squares | Degrees of freedom | Significance[2] |
|---|---|---|---|
| Replicates | 5.4354 | 9 | ** |
| Treatment | 1.6145 | 9 | * |
| Colony 4 X others | .9965 | 1 | ** |
| Colony 7 X others | .5148 | 1 | * |
| Colony 4 X 7 | 1.3247 | 1 | ** |
| Error | 6.1677 | 81 | |

[2] *: Odds 19:1 against differences being due to chance.
**: Odds 99:1 against differences being due to chance.
$\sqrt{\frac{1}{2} + X}$ transformation used.

TABLE 2

Transmission Rates of Colonies 4 and 7

| Colony | Results with group | Per cent infected | Plants infected in additional test | Per cent infected | Average per cent |
|---|---|---|---|---|---|
| 4 | 31[1] | 62 | 25[1] | 50 | 56 |
| 7 | 14 | 28 | 11 | 22 | 25 |

[1] Of 50 plants inoculated.

Summary of t-tests made

| Data | Calculated t-value | Degrees of freedom | Significance[2] |
|---|---|---|---|
| From the 2 tests | 4.9926 | 19 | ** |
| From the 100 plants in additional test | 2.3882 | 9 | ** |

[2] **: Odds 99:1 against differences being due to chance.

group test were combined with data from the test on the 100 additional plants, the difference was significant. The difference was also significant when the t-test was used to analyze only the data from the 100 additional plants.

The differences in the transmission rates between colonies 4 and 7 were almost the same in the two transmission tests. In the first test, the difference was 34 per cent, and in the additional test the difference was 28 per cent (Tables 1 and 2).

Colonies From Field-Collected Apterae

In late July, 1958, collections of aphids were made from various potato fields around Madras, Oregon. These were colonized on broccoli plants in the greenhouse. After seven colonies had developed, they were tested along with one colony, number 5, from the previous experiment in order to determine their transmission rates (Table 3). For convenience, these colonies were numbered 1 through 8.

The aphids were handled in the manner described in Materials and Methods. At the end of the test feeding period, the plants were fumigated and placed in the greenhouse. Five replicates of 96 plants each for a total of 480 plants were used (Table 3).

TABLE 3

Transmission Rates of Colonies
Started from Field-Collected Apterae

| Colony | Number of plants infected | Per cent transmission |
|---|---|---|
| 1 | 25[1] | 41.67 |
| 2 | 34 | 56.67 |
| 3 | 25 | 41.67 |
| 4 | 22 | 36.67 |
| 5 | 27 | 45.00 |
| 6 | 23 | 38.33 |
| 7 | 22 | 36.67 |
| 8 | 21 | 35.00 |
| Average | 24.88 | 41.46 |

[1] Out of 60 inoculated.

Summary of analysis of variance

| Source of variation | Sum of squares | Degrees of freedom | Significance[2] |
|---|---|---|---|
| Replicate | 3.212 | 4 | ** |
| Treatment | 1.161 | 7 | NS |
| Colony 2 X others | .8764 | 1 | * |
| Colony 8 X others | .1377 | 1 | NS |
| Colony 2 X 8 | .7477 | 1 | * |
| Error | 3.6226 | 28 | |

[2] NS: No significant differences.
*: Odds 19:1 against differences being due to chance.
**: Odds 99:1 against differences being due to chance.
$\sqrt{x}$ transformation used.

Colonies 2 and 8 were transferred to new colony plants before an additional transmission test was made. In this test between colonies 2 and 8, four replicates of 24 plants each were used for a total of 96 additional plants (Table 4).

This experiment was made to determine if there were any differences in transmission rates between any or all of the colonies started from field-collected apterae and the one colony which was used from the previous experiment.

The analysis of variance (Table 3) was used to determine if there were any significant differences among the colonies when tested as a group. The differences were not significant. The individual degree of freedom was used to test for differences between 2 and the other colonies, between 8 and the other colonies, and between colonies 2 and 8. The differences were significant between 2 and the other colonies, and between colonies 2 and 8, but were not significant between 8 and the other colonies.

To test for a significant difference in the transmission rates between colonies 2 and 8 the t-test was used (Table 4). When the data for these two colonies from the test between all the colonies were combined with the data from the test on the 96 additional plants, the difference

TABLE 4

BYMV Transmission Rates of Colonies 2 and 8

| Colony | Results with group | Per cent infected | Plants infected in additional test | Per cent infected | Average per cent |
|---|---|---|---|---|---|
| 2 | 34[1] | 56.7 | 30[2] | 62.5 | 59.6 |
| 8 | 21 | 35.0 | 18 | 37.5 | 36.3 |

[1] Out of 60 plants inoculated.

[2] Out of 48 plants inoculated.

Summary of t-tests

| Data | Calculated t-value | Degrees of freedom | Significance[3] |
|---|---|---|---|
| From the 2 tests | 5.0289 | 8 | ** |
| From the 96 plants in additional test | 6.1568 | 3 | ** |

[3] **: Odds 99:1 against the differences being due to chance.

was significant. The data from the 96 additional plants, when analyzed, showed a significant difference also.

The difference between the transmission rates of colonies 2 and 8 in the first test was 22.62 per cent (Table 3), and the difference in the additional test was 25 per cent (Table 4).

## DISCUSSION

A difference was found in the ability of different aphid colonies to transmit bean yellow mosaic virus (BYMV). In the second experiment, one colony's transmission rate was significantly different from that of the other colonies. In the first experiment, colonies 4 and 7 had transmission rates significantly different from the other colonies. These were two negative colonies, the first with the highest rate of transmission and the second with the lowest rate of transmission. Colony 8, a negative colony, had a transmission rate almost as low as colony 7. This was important because colonies 4 and 8 were started by individual aphids from the same colony (Appendix Figure 1). This would eliminate the possibility that the difference was genetic, since parthenogenetically reproducing aphids should produce genetically similar offspring.

K. G. Swenson* noted that in some of his experiments with BYMV and Myzus persicae (Sulzer) that aphids from different colony plants differed in their ability to transmit the virus. This could have been the cause of the differences reported here. The mean transmission rates of both the negative and positive colonies were

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* Personal communication.

almost the same, being 41 per cent and 42 per cent, respectively. This would indicate that the aphids of both groups were equal in the ability to transmit BYMV. Since the aphids for the first selection test came from a stock colony which had been maintained in the greenhouse for four years, genetic variation would be much less than that expected among colonies started from field-collected aphids. The aphids from both colony 4 and colony 7 were treated in the same manner throughout the transmission tests. There was only one factor which was not controlled, and that was the colony plant.

What causes the colony plant to affect the virus-transmitting ability of the aphids was not investigated, since this would be, in itself, another problem. To determine which of many things affect the plant and, in turn, affect transmission rates would be difficult. That there is something about the plant which affects the aphid's virus-transmitting ability has been shown. Because it is impossible to select definitely a particular factor as being the cause of the colony plant's effect on transmission rates, the hypothesis that the differences in virus-transmitting ability of aphids could be genetically determined cannot be completely disregarded. However, in the experiments reported here, it was not evident.

One of these two hypotheses may explain the results Day (5, p. 510) obtained while attempting to establish strains of Myzus persicae which would differ in ability to transmit potato leaf roll virus. A new colony was started from field-collected alates. Two hundred five of these aphids were used to establish new colonies after being used in a transmission experiment. From these colonies, 20 were used in further transmission experiments. The results obtained in the transmission experiments on these 20 colonies were so inconsistent that no conclusions could be drawn. Since each colony had been started by just one aphid, all the aphids within one colony should have been genetically similar. If it were true that the individual aphid's ability to transmit a virus was genetically determined, such great discrepancies in the results from one colony would hardly occur, even though the colony was transferred to new colony plants. However, if the individual aphids' ability to transmit a virus were influenced by the colony plant from which it came, this would very adequately explain the differences in results obtained from one colony, especially when the colony was transferred to new colony plants.

The differing abilities of aphids to transmit a virus can influence the results obtained from transmission

experiments. To minimize the effect of individual differing abilities to transmit, one colony started from one aphid should be used in a transmission experiment. This would allow the worker to vary the other factors in order to determine their action or combined action upon the transmission of a virus.

## SUMMARY

A study was undertaken with the objective of determining whether there were strains of the aphid species, Myzus persicae (Sulzer), which differed in ability to transmit bean yellow mosaic virus (BYMV). The existence of such strains would answer many questions as to the cause of variation in transmission experiments.

In the first experiment, selection tests were started with aphids from a stock colony in order to obtain colonies with distinct differences in virus-transmitting ability. The colonies established by aphids which transmitted the virus were designated "positive colonies." "Negative colonies" were those established by aphids which did not transmit BYMV. After a series of five selections had been made, ten colonies were used in a comparative transmission test. Two colonies were significantly different from the rest with respect to the ability to transmit BYMV. These were negative colonies, one with the highest rate of transmission and the other with the lowest rate of transmission. The differences in virus-transmitting ability could have been caused by either of two factors, the colony plants or an inheritable factor. However, the results reported here showed the colony plants to be the cause of the differences.

Seven colonies were initiated by apterae collected from different potato fields around Madras, Oregon. To this group was added one colony from the previous experiment. Transmission tests were then made with these colonies. The transmission rate of one colony was significantly higher than the mean transmission rate of the other colonies. Considering the results obtained in the first experiment, to ascertain if the colony plants or a genetic factor caused the difference would be difficult. However, these results showed that variations in virus-transmitting ability of Myzus persicae (Sulzer) could occur in the field.

## BIBLIOGRAPHY

1. Adlerz, Warren C. Factors affecting transmission of bean yellow mosaic virus. Journal of Economic Entomology 52:260-262. 1959.

2. Bennett, C. W. and Hugh E. Wallace. Relation of the curly top virus to the vector, Eutettix tenellus. Journal of Agricultural Research 56:31-51. 1938.

3. Bjorling, K. and F. Ossiannilsson. Investigations on individual variations in the virus-transmitting ability of different aphid species. Socker Handlingar II 14:1-13. 1958. (published by the Swedish Sugar Corporation)

4. Black, L. M. Genetic variation in the clover leafhopper's ability to transmit potato yellow-dwarf virus. Genetics 28:200-209.

5. Day, M. F. The mechanism of the transmission of potato leaf roll virus by aphids. Australian Journal of Biological Sciences 8:498-513. 1955.

6. Dickson, R. C. A working list of the names of aphid vectors. Plant Disease Reporter 39:445-452. 1955.

7. Frazier, Norman W. Strawberry vein banding virus. Phytopathology 45:307-312. 1955.

8. Fukushi, Teikichi. Studies on the dwarf disease of rice plant. Journal of the Faculty of Agriculture, Hokkaido Imperial University 37:37-164. 1934.

9. Gillett, J. D. and H. J. F. Cairns. Rift Valley Fever virus--the relation between a virus and its mosquito host. In: East Africa High Commission Virus Research Institute Annual Report, no. 4. 1953. Entebbe, Uganda, 1954. p. 16-17.

10. Gillett, J. D. and C. A. C. Mims. Rift Valley Fever--relation between the virus and mosquito host. In: East Africa High Commission, East African Virus Research Institute Report, no. 5. January 1954 - June 1955. Entebbe, Uganda, 1955. p. 7-8.

11. Goulden, Cyril H. Methods of statistical analysis. 2d ed. New York, Wiley, 1952. 467 p.

12. Li, Jerome C. R. Introduction to statistical inference. Ann Arbor, Michigan, Edwards Brothers, 1952. 553 p.

13. Pierce, Walter H. Viruses of the bean. Phytopathology 24:87-115. 1934.

14. Simons, John N. and Edward S. Sylvester. Acquisition threshold period of western celery mosaic virus for four species of aphids. Phytopathology 43:29-31. 1953.

15. Storey, H. H. The inheritance by an insect vector of the ability to transmit a plant virus. Proceedings of the Royal Society of London B112:46-60. 1932.

16. _____ Investigations of the mechanism of the transmission of plant viruses by insect vectors. I. Proceedings of the Royal Society of London B113: 463-485. 1933.

17. Stubbs, L. L. Strains of Myzus persicae (Sulz.) active and inactive with respect to virus transmission. Australian Journal of Biological Sciences 8: 68-74. 1955.

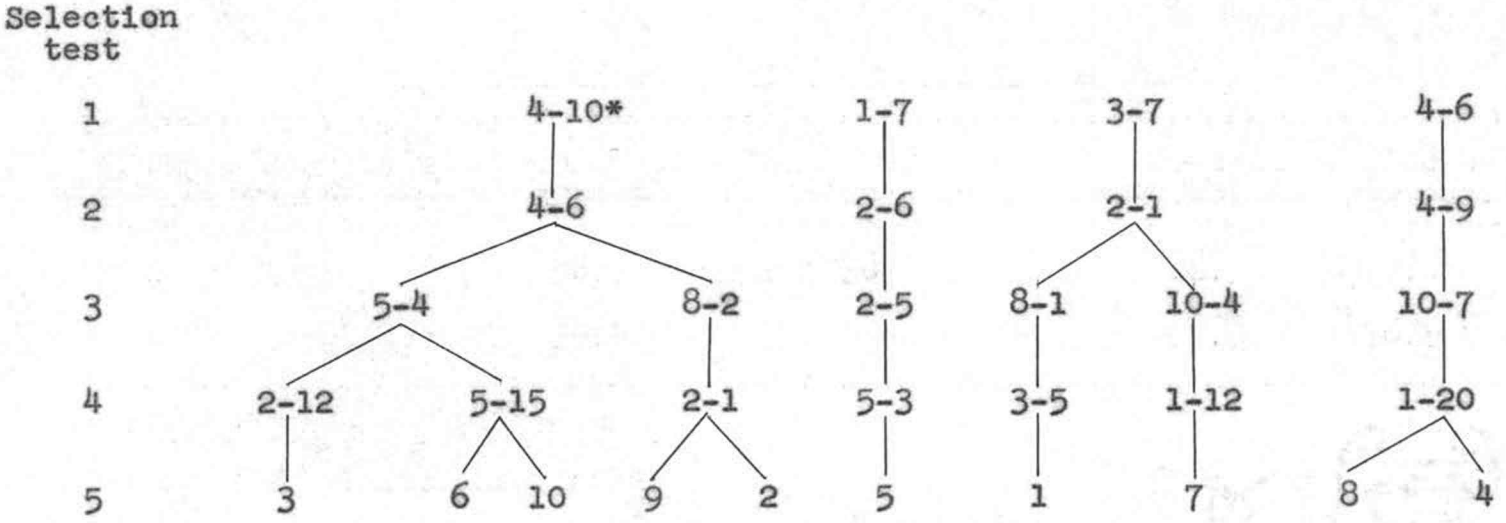
18. Swenson, K. G. Aphid transmission of a bean yellow mosaic virus. Journal of Economic Entomology 47: 1121-1123. 1954.

19. _____ Transmission of bean yellow mosaic virus by aphids. Journal of Economic Entomology 50: 727-731. 1957.

20. Sylvester, Edward S. Aphid transmission of nonpersistent plant viruses with special reference to the Brassica nigra virus. Hilgardia 23:53-98. 1954.

21. Watson, M. A. and F. M. Roberts. A comparative study of the transmission of Hyoscyamus virus 3, potato virus Y and cucumber virus 1 by the vectors Myzus persicae (Sulz.), M. circumflexus (Buckton) and Macrosiphum gei (Koch). Proceedings of the Royal Society of London B127:543-576. 1939.

# APPENDIX




* Code numbers to designate colony.

Figure 1. Lines of descent of the ten colonies on which the transmission test was made in experiment 1.