STRAINS OF *MYZUS PERSICAE* (SULZ.) ACTIVE AND INACTIVE WITH RESPECT TO VIRUS TRANSMISSION

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Summary

The inconsistent transmission of a persistent yellows virus disease of spinach by its vector, *Myzus persicae,* is described.

A study was made of the infective ability of viviparously produced progeny of individual apterae, selected at random from a stock colony. It was found that individual cultures varied in their capacity to transmit the virus, and that selected cultures retained their infectivity characteristic in successive controlled experiments.

It is postulated that inactive insects may occur more frequently in vector species than is at present realized, and could account for much of the variability which characterizes virus-vector relationships.

I. INTRODUCTION

In experiments with a yellows virus of spinach, which is transmitted by the green peach aphid, *Myzus persicae* (Sulz.), inconsistent transmission of the virus occurred over a period of two years. As the inconsistent results could not be related to variations in virus source, or in test plants, an explanation was sought on the basis of differences between individual aphids.

The virus, which has not yet been identified with any known virus, and which will be described elsewhere, is of the persistent type. It is frequently associated with a strain of the cucumber mosaic virus in a complex infection of spinach. The yellows and cucumber mosaic viruses may be separated readily from a complex infection by applying the long and short feed techniques respectively, to the common vector, *M. persicae.*

II. METHODS

The virus was originally isolated from spinach, and was maintained on that host. Test plants were spinach seedlings in the first or second true leaf stage of development. One line of seed of the variety Nobel was used in all experiments, unless otherwise stated. Aphids were transferred to test plants with a camel's hair brush, and were caged on the plants by means of small celluloid cylinders with muslin tops. The long cotyledonary leaves of the spinach plants were held in a vertical position by loops of electrical fuse wire, thus permitting the use of small-diameter cages without disturbing the aphids, or injuring the plants.

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The plants were sprayed with "Systox" systemic insecticide at the end of the transmission feed, and held in an insect-proof cage for the duration of the experiment.

III. Results

The variable transmission of the yellows virus by *M. persicae* first became apparent in experiments concerned with its persistency in that aphid. The results recorded in Experiment 1 are typical of those obtained from other experiments of this type.

(*a*) *Experiment* 1

In this experiment semi-mature non-infective apterae were given an acquisition feed of 24 hr, on one leaf of a spinach plant infected with the yellows virus. The aphids were carefully selected for uniformity of size from a vigorous colony on a healthy spinach plant. Eight groups, each of five aphids, were transferred serially, at 24-hr intervals, to healthy Nobel and U.S.D.A. 179590* spinach plants. The results and experimental details are recorded in Table 1.

Table 1

VARIABLE TRANSMISSION OF SPINACH YELLOWS VIRUS BY *M. PERSICAE*

Transfer No.	Transfer Date	Virus Persistence in *M. persicae* (days)	Infections Recorded							
			Nobel				U.S.D.A. 179590			
			1	2	3	4	1	2	3	4
1	13.v.53	0	−	−	+	−	−	+	−	−
2	14.v.53	1	−	−	+	−	−	+	−	−
3	15.v.53	2	−	−	+	+	−	+	−	−
4	16.v.53	3	−	−	+	−	−	+	+	−
5	18.v.53	5	−	−	+	−	+	−	−	−
6	19.v.53	6	−	+	+	−	−	+	+	−
7	20.v.53	7	−	−	+	−	−	+	−	−
8	21.v.53	8	−	−	+	−	−	−	−	−
9	22.v.53	9	−	−	+	−	−	−	−	−
10	25.v.53	12	−	−	−	−	−	−	−	−

(*b*) *Experiment* 2

The wide differences in infectivity between the groups of insects used in Experiment 1 suggested that some individuals were infective and others were not. The possibility also existed that many individual aphids did not possess the ability to transmit the spinach yellows virus. In order to gain evidence

* This accession was obtained through the courtesy of Dr. Paul G. Smith, University of California, U.S.A. In field trials at Burnley it was immune from infection with the cucumber mosaic virus but was highly sensitive to yellows.

for this hypothesis it was necessary to compare the infectivity of the progeny of a number of individual aphids. The mother aphids were selected as adult apterae from the stock non-infective colony used in Experiment 1. They were caged separately on each of the infected spinach plants listed in Table 2, which were selected from the above experiment.

When vigorous colonies had developed, groups of five adult apterae were transferred from each colony to healthy spinach seedlings, and serially transferred on three successive days to further test plants. The number of infections is recorded in Table 2.

Alate aphids were also examined from each colony, and their morphological characters were found to conform with those described for *M. persicae.*

TABLE 2

COMPARATIVE INFECTIVITY OF CLONAL CULTURES OF *M. PERSICAE*

Virus Source	Infections Recorded on Spinach				Vector Efficiency Rating
	Transfer Date				
	11.viii.53	12.viii.53	13.viii.53	14.viii.53	
Nobel T1/R3	+	+	+	+	100
Nobel T2/R3	+	+	+	+	100
Nobel T3/R4	+	−	+	−	50
Nobel T5/R3	+	−	−	−	25
Nobel T8/R3	+	+	−	−	50
Nobel T9/R3	+	+	+	+	100
U.S.D.A. 179590 T1/R2	+	+	−	−	50
U.S.D.A. 179590 T2/R2	+	+	+	−	75
U.S.D.A. 179590 T3/R2	+	+	−	−	50

(*c*) *Experiment* 3

In a further experiment the infectivity of aphids from Nobel colonies T1/R3 and T3/R4 was compared. Aphids from these colonies had shown high and low infectivity, respectively, in Experiment 2. In the experiment four groups of five alatae from each colony were placed on test seedlings and serially transferred on three successive days. The results (Table 3) showed that aphids from these colonies retained the same order of infectivity as exhibited in Experiment 2.

(*d*) *Experiment* 4

A final comparison of the infectivity of individual aphid colonies was made between colonies T1/R3, T2/R3 (high infectivity), T3/R4, and T5/R3 (low infectivity). Prior to the commencement of this experiment new colonies had been established on Nobel plants infected from the one virus source. Three

groups of five apterae from each colony were serially transferred to test seedlings as in Experiment 3. The infections recorded in Table 4 show that aphids from colonies T1/R3 and T2/R3 retained their infectivity, whereas those from colonies T3/R4 and T5/R3 were apparently unable to transmit.

It was the original intention of the author to maintain the above aphid colonies for further work with the spinach yellows virus, but they were inadvertently lost through fungal attack and an unfavourable environment during the summer period. However, an attempt will be made to select further active and inactive individuals from a field collection of *M. persicae* for the continuance of these studies.

TABLE 3

COMPARATIVE INFECTIVITY OF TWO CLONAL CULTURES OF *M. PERSICAE*

Transfer Date	Infections Recorded on Spinach							
	Colony T3/R4				Colony T1/R3			
	1	2	3	4	1	2	3	4
28.ix.53	−	−	−	−	−	+	+	−
29.ix.53	+	−	−	+	+	+	+	+
30.ix.53	−	−	−	−	+	−	+	+
1.x.53	−	+	−	−	−	−	+	+
Total infections	1	1	0	1	2	2	4	3

IV. DISCUSSION

The results obtained in the above experiments indicate that the aphid *Myzus persicae* is heterozygous for ability to transmit the spinach yellows virus. While these experiments do not prove conclusively the existence of this phenomenon, it would be difficult to suggest an alternative explanation.

In Experiment 2 the results could be explained on the basis that some virus source plants were a better source of virus than others. However, the fact that aphid cultures with high and low infectivity in this experiment retained their infectivity characteristic in succeeding experiments renders this explanation unlikely. Moreover, this explanation should not apply to Experiment 1, where all transfer aphids were given their acquisition feeding period on a single leaf of one infected spinach plant.

Individual variation in ability to transmit was first recognized by Storey (1932) in the leafhopper, *Cicadulina mbila*. This characteristic has since been recognized for other leafhopper species (Black 1943; Kunkel 1951; Maramorosch 1953), but the author is aware of only one attempt (Bawden and Kassanis

1947) to apply the findings of Storey to aphid vectors of plant viruses. These workers suggested "that occasional individual *M. persicae* or other potato aphis may be vectors although the bulk of such species are not" vectors of potato virus C. Their experiments with *M. persicae,* collected from many different sources and hosts, and other species of aphids, failed to support this hypothesis. In further transmission experiments with potato virus Y they reported wide

TABLE 4

COMPARATIVE INFECTIVITY OF FOUR CLONAL CULTURES OF *M. PERSICAE*

Transfer Date	Replication No.	Infections Recorded on Spinach			
		Colony T3/R4	Colony T1/R3	Colony T5/R3	Colony T2/R3
19.x.53	1	−	+	−	+
	2	−	+	−	−
	3	−	+	−	+
20.x.53	1	−	+	−	+
	2	−	+	−	+
	3	−	+	−	+
21.x.53	1	−	−	−	−
	2	−	+	−	−
	3	−	−	−	−
22.x.53	1	−	−	−	−
	2	−	+	−	+
	3	−	−	−	+
Total infections		0	8	0	7

differences in efficiency between a number of aphid species. They suggested, as the simplest explanation of their results, that the low infectivity of some species might relate to the relatively few active individuals in those species. Unfortunately, they did not attempt to verify their hypothesis by an experimental study of individual insects.

Aphids, because of their shorter life cycle, and their capacity for both parthenogenetic and sexual reproduction, are more suitable insects than leafhoppers for a study of inherent variation in transmission ability. It is strange therefore that the infective variability of these insects has received so little attention from plant virologists.

It would appear unlikely that individual variation in ability to transmit specific viruses is a characteristic shared by only three leafhoppers and one

aphid vector. It is possible, however, that inactive insects may be in the minority where an efficient virus vector relationship has been established, but they could predominate where a less efficient relationship exists.

An analysis of the work of Costa and Grant (1951) with *Aphis citricidus*, the vector of tristeza virus of citrus, raises some interesting possibilities. Their results showed that there was little difference in the infective ability of one, five, or 25 aphids (16, 10, and 21 per cent. transmission respectively), yet the transmission rate rose to 77 and 88 per cent. when 50 to 100, and 100 or more aphids were used. They conclude that "a minimum of 25 aphids per plant was necessary to obtain a high percentage of transmission." The aphids used by these workers were obtained from field collections from sweet orange.

Similarly, with strawberry virus 3, Prentice (1949) and Prentice and Woollcombe (1951) consistently recorded low transmission rates, when the acquisition and transmission feeding periods were together longer than the latent period.

These examples are quoted because the author has had experience with both viruses, and the apparently low efficiency of their insect vectors. In an experiment recently concluded, groups of 10 adult *Pentatrichopus fragaefolii*, bred on a single virus source plant infected only with virus 3, infected less than 50 per cent. of the *Fragaria vesca* test plants. These aphids were given a transmission feed of 5 days.

In experiments with a virus complex responsible for the decline of Ellendale mandarin (Stubbs 1952), groups of 20 aphids bred on infected plants have transmitted the complex, under optimum conditions, to 20-80 per cent. of inoculated seedlings. Cultures of both species of aphids used in the author's experiments were established from the newly born progeny of a number of insects. The relative efficiency of individual insects from both species is now being investigated by the method described above.

With increasing attention being given by virus workers to the elimination of variables in work on vector relationships (Miller 1952; Sylvester 1953), it is contended that the matter of vector efficiency should receive prior attention. It is conceivable that precise experiments with a vector population, established unwittingly from a single individual with low or moderate capacity to infect, would produce uniformly false data in relation to a specific virus. Conversely, work with a mixed population might introduce a greater variable than the sum total of variables eliminated by refined techniques.

As a preliminary, therefore, to insect transmission work with any persistent virus, it is suggested that the infective capacity of individual insects should be determined by a method similar to that described above.

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