Susceptibility of Varieties of papaya and Cucumber to the Papaya Mosaic Virus When Transmitted by the Green Peach Aphid[1]

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Papaya mosaic is a very destructive disease of papaya, *Carica papaya* L., in Hawaii. No effective control program has been developed other than complete eradication of diseased plants. Attempts to determine whether there is a genetic basis for resistance among the caricaceous plants revealed that several species of *Carica* were resistant to the papaya mosaic virus (Malaguti, Jimenez, and Horovitz, 1957; Capoor and Varma, 1961; Cook and Milbrath, 1971). However, no infraspecific taxon of *C. papaya* has been found to be resistant to this disease according to Cook and Zettler (1970) who tested 90 "accessions" of *C. papaya* from various papaya growing areas of the world. All these tests were conducted by means of sap inoculation and they possibly may not reflect the infectivity of the papaya mosaic virus when transmitted by means of aphid vectors.

Reviews by Swenson (1963, 1969) cite many examples of the variation in susceptibility of plant species and varieties to inoculation of plant viruses by aphids. With papaya mosaic virus, Namba and Kawanishi (1966) found that papaya, cucumber (*Cucumis sativus* L.), and watermelon (*Citrullus vulgaris* Schrader), which are important hosts of this virus in Hawaii, were equally susceptible to the virus when transmitted by the green peach aphid, *Myzus persicae* (Sulzer). In line with this finding, the present study was carried out to test the susceptibility of some infraspecific taxa of papaya and cucumber to the papaya mosaic virus when transmitted by aphids.

MATERIALS AND METHODS

The plants tested were papaya cultivars, Line 8, Kapoho Solo, and Waimanalo Solo; cucumber, variety Colorado Long, and genetical lines Lehua 64A1 and 70–A–68 provided by Dr. James C. Gilbert, Horticulture Department, Hawaii Agricultural Experiment Station. The genetical lines are resistant to cucumber and watermelon mosaic. The papaya plants tested were in the 4–6 leaf stage, and the cucumber plants in the two-leaf cotyledon stage. All plants were grown in sterilized soil in 3-inch plastic pots.

[1]Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Journal Series No. 1473.

The virus sources were leaves of young diseased Line 8 papaya plants. The leaves were excised and the petioles kept in water during the tests.

The vectors used were late-instar apterae of the green peach aphid. They were the progeny of a single female. Colonies of this female have been maintained in our greenhouse for many years on mustard cabbage, *Brassica juncea* (L.) Cosson. The aphids were kept without food in glass vials for at least 1/2 hour before the tests. Each aphid was watched with a hand lens and the feeding was timed with a metronome so that each aphid had an acquisition probe of 10–30 seconds on the virus source. One aphid was then placed on each of the test plants.

It was not feasible to test all the varieties of a plant species in one test period. Consequently one variety was selected as the standard to which the others were compared. Line 8 was the standard for papaya and Colorado Long for cucumber. One hundred plants per variety or a total of 200 plants were used per trial. Five trials were conducted per comparison. The trials were conducted on separate days using different virus sources.

Results and Discussion

Cucumber (Table 1). In all trials comparing Colorado Long and Lehua 64A1, there were more Lehua test plants infected than those of Colorado Long. In 4 trials the chi-square values indicated that the differences were significant. In the remaining trial the chi-square was 3.58 which almost reaches the 5% level. The sum of the chi-squares of the 5 trials and the pooled chi-square were large which further indicate that

TABLE 1. *Comparisons of the susceptibility of cucumber varieties to the papaya mosaic virus when transmitted by the green peach aphid.*

Trial	*Variety*		*Chi-square*
	Colorado Long	Lehua 64A1	
1	19[1]	28	3.58
2	32	54	18.61**
3	48	62	7.74**
4	54	67	7.06**
5	25	50	24.02**
Sum	178	261	61.01**
Pooled chi-square = 54.56**		Heterogeneity chi-square = 6.45	
	Colorado Long	70-A-68	
1	41	48	1.69
2	29	37	2.41
3	36	41	0.84
4	8	18	6.13*
5	58	50	2.26
Sum	172	194	13.33*
Pooled chi-square = 3.89*		Heterogeneity chi-square = 9.44	

[1] = number of test plants infected out of 100 tested.

differences do occur between the varieties and that there is a predominant tendency for the difference to be one way. The heterogeneity chi-square was not significant indicating the consistency of the results.

The tests provide strong evidence that differences do occur between Colorado Long and Lehua 64A1 in their susceptibility to inoculation of the papaya mosaic virus by the green peach aphid and that Lehua is more susceptible than Colorado Long.

In 4 trials comparing Colorado Long and 70-A-68 there were more 70-A-68 test plants infected than those of Colorado Long but only in one trial the chi-square test indicated that the difference was significant. This evidence for the predominant tendency of the difference to be one way, i.e., 70-A-68 more susceptible than Colorado Long was supported by the pooled chi-square which was significant. However, the heterogeneity chi-square almost reaches the 5% level of significance indicating that these differences may not be consistent. Thus it would be desirable to conduct additional tests to obtain more conclusive evidence to show that differences between these two varieties do exist.

Papaya (Table 2). In 3 trials comparing Line 8 and Waimanalo Solo there were more Line 8 test plants infected than those of Waimanalo Solo. In one of the trials the chi-square value indicated that the difference was significant. The pooled chi-square, however, was not significant indicating that there is no predominant tendency of Line 8 being more susceptible than Waimanalo Solo. In one of the 2 trials in which more Waimanalo Solo test plants were infected than those of Line 8 the chi-square was significant. It appears that the variations in susceptibility between

TABLE 2. *Comparisons of the susceptibility of papaya varieties to the papaya mosaic virus when transmitted by the green peach aphid.*

Trial	*Variety*		*Chi-square*
	Line 8	Kapoho Solo	
1	33[1]	41	2.32
2	25	27	0.12
3	30	17	11.07**
4	50	37	6.70**
5	15	14	0.02
Sum	153	136	20.23**
Pooled chi-square = 2.75		Heterogeneity chi-square = 17.48**	
	Line 8	Waimanalo Solo	
1	34	46	5.33*
2	52	49	0.25
3	38	28	4.48*
4	23	19	0.80
5	29	30	0.01
Sum	176	172	10.87
Pooled chi-square = 0.11		Heterogeneity chi-square = 10.76*	

[1] = number of test plants infect out of 100 tested.

the two cultivars are inconsistent and the large heterogeneity chi-square substantiates this. These trials provide no clear evidence that one cultivar is more suceptible to the papaya mosaic virus than the other when transmitted by the green peach aphid.

In 3 trials comparing Line 8 and Kapoho Solo there were more Line 8 test plants infected than those of Kapoho Solo. In two of these trials the chi-square values were significant. In the two trials where more Kapoho Solo test plants were infected the evidence for the differences were not significant. It seems that Line 8 is more susceptible than Kapoho Solo, but the pooled chi-square is not significant suggesting that there is no predominant tendency for one cultivar to be more susceptible than the other. Furthermore the heterogeneity chi-square was significant, indicating that the evidence for the differences were inconsistent. Here again the trials provide no clear evidence that one cultivar is more susceptible than the other to the aphid transmission of the papaya mosaic virus.

In interpreting the results of this study it must be remembered that the degree of susceptibility was based on the transmissibility of the virus to one test plant by one aphid. If more than one aphid were used per test plant the difference in the degree of susceptibility between the two compared varieties would be different. The probability of transmission increases exponentially with the increase in the number of aphids used per test plant as per formula $p = 1 - q^x$ were x is the number of aphids used in a group per test plant and q equals the probability of not obtaining an infection when one aphid is used (Sylvester, 1954). As the probability of transmission approaches 1.0 the difference in the susceptibility of the two varieties becomes smaller and eventually if enough aphids are used per test plant both varieties would have 100% transmission and there would be no evidence for a difference in susceptibility.

LITERATURE CITED

Capoor, S. P. and P. M. Varma. 1961. Immunity to papaya mosaic virus in the genus *Carica*. Ind. Phytop. **14:** 96–97. (Rev. Appl. Mycol. 41: 322, 1962).

Cook, A. A. and G. M. Milbrath. 1971. Virus diseases of papaya on Oahu (Hawaii) and identification of additional diagnostic host plants. Plant Disease Reptr. **55**(9): 785–788.

Cook, A. A. and F. W. Zettler. 1970. Susceptibility of papaya cultivars to papaya ringspot and papaya mosaic viruses. Plant Disease Reptr. **54**(10): 893–895.

Malaguti, G., H. Jimenez and S. Horovitz. 1957. Pruebas de transmision del mosaico de la lechosa a otras especies de Carica. Agronomia Trop. (Maracay, Venezuela) **7:** 23–31. (Rev. Appl. Mycol. **38:** 28, 1959).

Namba, R. and C. Y. Kawanishi. 1966. Transmission of papaya mosaic virus by the green peach aphid. J. Econ. Entomol. **59**(3): 669–671.

Swenson, K. G. 1963. Effect of insect and virus host plants on transmission of viruses by insects. Ann. New York Acad. Sci. **105**(13): 730–740.

Swenson, K. G. 1969. Plant susceptibility to infection by insect transmission. p. 143–157. In: Viruses, Vectors, and Vegetation. Edited by K. Maramorosch. Interscience Publishers, New York, London, Sydney, Toronto.

Sylvester, E. S. 1954. Aphid transmission of nonpersistent plant viruses with special reference to the *Brassica nigra* virus. Hilgardia **23**(3): 53–98.