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Association of okra *(Abelmoschus esculentus* (L.) Moench) yellow vein mosaic incidence with population of its vectors under Kerala conditions

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ABSTRACT: One hundred and one accessions of okra (*Abelmoschus esculentus* (L.) Moench), collected from various parts of India, were scored for Yellow vein mosaic disease (YVM) incidence and population of two vectors of the disease during summer season during four stages of the crop. The accessions differed significantly for whitefly population during all the three stages of the crop (30, 50 and 70 DAS), while leaf hopper count showed significance only during 50 DAS. Time of infestation differed significantly for white fly at 30 DAS whereas in all other cases, time mean square was non-significant. Correlation coefficients of YVM incidence with vector population computed during different crop stages revealed that morning and evening population of both whitefly and leaf hopper (except for morning population with YVM during final harvest) at 30 DAS had significant association with disease occurrence from 50 DAS to final harvest. Besides, white fly population during both the time at 50 DAS also had influence on YVM incidence during final harvest.

KEYWORDS: okra, *Abelmoschus esculentus,* germplasm, yellow vein mosaic, vectors, whitefly, leaf hopper, *Bemisia tabaci*, *Empoasca devastans*, association, population

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is an important vegetable all over the world

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having a wide spectrum of uses. Yellow vein mosaic (YVM), the most destructive viral disease of okra, has become a serious limiting factor in the successful cultivation of this crop, which could reduce the yield by 30 to 70 per cent (Duzyaman, 1997). YVM virus belongs to the family *Geminiviridae* and YVM disease is caused by a complex virus consisting of the monopartite begomovirus and a small satellite DNA β component (Jose and Usha, 2003). Disease causes a reduction of leaf chlorophyll and the infected plants become stunted and produce small-sized pale yellow fruits (Gupta and Paul, 2001).

Spread of the virus, causing YVM, by whitefly (*Bemisia tabaci*) was established by Varma (1952) and later reported by many researchers (Ali *et al*., 2000). However, during rainy season, white flies were not common on the crop whereas okra leaf hopper (*Empoasca devastans* (Dist.)) was abundant on the diseased plants (Varma, 1955). Depending upon the stage of crop growth at which infection occurs, yield loss ranged from 50 to 90 per cent (Sastry and Singh, 1974). Any study regarding the magnitude and influence of vector population during various stages of crop growth on YVM disease development could not be found so far. Hence the current study was carried out to find out the interaction of genotypes with the vectors for YVM incidence and also to find out the association of the time of feeding by the vectors with the disease development.

MATERIALS AND METHODS

A germplasm collection of 101 okra varieties / genotypes obtained from various parts of India including known yellow vein mosaic (YVM) resistant varieties, varieties released by Kerala Agricultural University, types from NBPGR Regional Station, Vellanikkara and local collections formed the materials for the study. The genotypes were laid out in Randomised Block Design with three replications and ten plants per treatment per replication at spacing of 60 x 45 cm during summer season to evaluate the resistance of the accessions against YVM. Cultural and manurial practices were followed as per Package of Practices Recommendations of KAU (1996). The experiment was completely devoid of plant protection measures. A local susceptible variety was also grown all around the experimental area to ensure the adequate inoculum for heavy disease incidence as well as vector population. Scoring for disease incidence was done as per the rating scale (Table 1) by Arumugam *et al*. (1975) during four stages of the crop *viz*., 30 days after sowing (DAS), 50 DAS, 70 DAS and final harvest. Population of the two vectors of YVM disease *viz*., whitefly (*Bemisia tabaci*) and leaf hopper (*Empoasca devastans*), were recorded on the plants during 30 DAS, 50 DAS and 70 DAS stages of the crop. Since the leaves were dried, vector population could not be noticed during final harvest stage. The lower sides of the top three leaves in each plant were observed and the number of whiteflies and leaf hoppers were counted separately in the morning as well as evening of the same day. ANOVA was carried out for YVM scores taken on morning and evening populations of white fly and leaf hoppers during each crop stage. Two-factor ANOVA was done for various stages to study the interaction effects between genotypes and time for vector populations. Since genotype x time interaction mean square was non-significant, pooled error mean square was used for testing the significance among the genotypes. In

Table 1. YVM disease rating scale in okra

Sl. No.	Symptom	Grade	Disease **Score**
1	No visible symptom characteristic of the disease	Highly resistant	1
2	Very mild symptoms, basal half of primary veins remain green, mild yellowing of anterior half of primary veins, secondary veins and veinlets. Infection is also seen late in the season under field conditions	Resistant	2
3	Veins and veinlets turn completely yellow	Moderately resistant	3
4	Pronounced yellowing of veins and veinlets, 50 % of leaf lamina turn yellow, fruits exhibit slight yellowing	Susceptible	4
5	Petioles, veins, veinlets, and interveinal area turn yellow in colour. Leaves start drying from margin and fruits turn yellow	Highly susceptible	5

order to find out the association between YVM incidence and population of vectors, correlation coefficients were estimated between YVM scores and population of each vector during each crop stage and the results are furnished in Table 4.

RESULTS AND DISCUSSION

i) **Interaction between okra genotypes and vectors of YVM**

The 101 genotypes of okra were simultaneously scored for YVM incidence and for vector population of both white fly and leaf hopper in the morning and evening at various crop stages (Table 2). The four okra genotypes which could express highly resistant property throughout the crop phase included NBPGR / TCR – 2060 (T34), Parbhani Kranti (T85), Varsha Uphar (T86) and Selection-46 (T91). Interaction between the genotypes and the populations of each vector was examined separately, twice a day during three stages of the crop. During all the crop stages, interaction mean squares were non-significant for both vectors (Table 3).

The genotypes varied significantly for whitefly population during 30 DAS, 50 DAS and 70 DAS stages of the crop. However, leaf hopper count showed significance only during 50 DAS.

Though time of infestation differed significantly for whitefly at 30 DAS, time mean square was non-significant in all other cases.

Table 2. Mean population of vectors on okra genotypes during three crop stages

Tr. No.	Genotype	YVM score				Whitefly						Leaf hopper					
		30 DAS	50 DAS	70 DAS	FH	30 DAS		50 DAS		70 DAS		30 DAS		50 DAS		70 DAS	
						M	E	M	E	M	E	M	E	M	E	M	E
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	NBPGR/TCR-1185	1.3	2.8	3.7	4.7	0.05	0.05	0.03	0.06	0.05	0.10	0.08	0.00	0.12	0.10	0.03	0.00
2	NBPGR/TCR-1943	1.0	3.5	3.7	5.0	0.08	0.16	0.38	0.50	0.08	0.16	0.16	0.08	0.38	0.42	0.08	0.00
3	NBPGR/TCR-1883	1.0	1.8	3.0	4.7	0.12	0.16	0.08	0.00	0.00	0.00	0.21	0.16	0.25	0.16	0.04	0.00
4	NBPGR/TCR-1948	1.0	1.5	2.5	4.0	0.12	0.08	0.29	0.41	0.21	0.25	0.25	0.16	0.42	0.50	0.21	0.41
5	NBPGR/TCR-2145	1.0	2.3	4.5	5.0	0.04	0.08	0.00	0.00	0.00	0.00	0.12	0.08	0.12	0.08	0.00	0.00
6	NBPGR/TCR-1674	1.0	2.8	3.2	4.7	0.04	0.08	0.16	0.00	0.16	0.16	0.20	0.24	0.58	0.65	0.13	0.00
7	NBPGR/TCR-1676	1.0	2.1	3.5	4.7	0.10	0.19	0.16	0.21	0.07	0.14	0.34	0.39	0.26	0.33	0.11	0.21
8	NBPGR/TCR-1581	1.0	3.0	3.3	4.6	0.27	0.21	0.29	0.41	0.06	0.04	0.27	0.00	0.57	0.56	0.18	0.08
9	NBPGR/TCR-1728	1.0	1.5	3.0	5.0	0.24	0.31	0.08	0.16	0.00	0.00	0.33	0.50	0.33	0.33	0.08	0.00
10	NBPGR/TCR-1981	1.0	4.0	4.5	5.0	0.04	0.00	0.32	0.24	0.08	0.00	0.29	0.08	0.61	0.50	0.33	0.16
11	NBPGR/TCR-1722	1.0	2.0	4.6	5.0	0.08	0.00	0.42	0.50	0.00	0.00	0.32	0.31	0.66	0.65	0.25	0.16
12	NBPGR/TCR-1828	1.0	3.8	4.2	5.0	0.32	0.31	0.59	0.50	0.08	0.00	0.31	0.31	0.70	0.83	0.16	0.00
13	NBPGR/TCR-1508	1.0	2.0	2.9	5.0	0.12	0.16	0.04	0.08	0.00	0.00	0.25	0.42	0.12	0.16	0.04	0.00
14	NBPGR/TCR-1507	1.0	2.8	3.6	4.8	0.06	0.11	0.14	0.05	0.03	0.00	0.19	0.16	0.31	0.28	0.06	0.00
15	NBPGR/TCR-2020	1.0	2.0	2.5	3.9	0.16	0.16	0.17	0.33	0.00	0.00	0.16	0.16	0.33	0.16	0.16	0.16
16	NBPGR/TCR-1498	1.0	2.0	3.0	4.8	0.24	0.31	0.38	0.50	0.04	0.00	0.16	0.31	0.42	0.50	0.08	0.00
17	NBPGR/TCR-1569	1.0	1.5	3.0	4.7	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.16	0.08	0.08	0.08
18	NBPGR/TCR-1533	1.0	1.8	3.2	5.0	0.20	0.31	0.16	0.16	0.04	0.00	0.08	0.08	0.29	0.42	0.13	0.17
19	NBPGR/TCR-1471	1.0	2.5	3.5	5.0	0.31	0.31	0.41	0.50	0.21	0.16	0.37	0.24	0.46	0.50	0.54	0.50
20	NBPGR/TCR-1963	1.1	2.8	3.5	4.5	0.08	0.00	0.24	0.31	0.04	0.08	0.37	0.41	0.46	0.41	0.00	0.00
21	NBPGR/TCR-1524	1.0	3.4	3.6	5.0	0.16	0.31	0.24	0.27	0.04	0.00	0.30	0.04	0.25	0.16	0.10	0.00
22	NBPGR/TCR-1929	1.0	2.3	2.7	4.7	0.00	0.00	0.54	0.58	0.21	0.33	0.29	0.33	0.55	0.67	0.21	0.25
23	NBPGR/TCR-1966	1.0	1.7	2.0	2.6	0.13	0.07	0.27	0.25	0.00	0.00	0.09	0.07	0.24	0.22	0.05	0.00
24	NBPGR/TCR-1998	1.0	2.3	3.0	4.7	0.29	0.41	0.08	0.16	0.16	0.16	0.29	0.41	0.25	0.16	0.25	0.33
25	NBPGR/TCR-1982	1.0	2.0	2.5	4.0	0.00	0.00	0.31	0.31	0.08	0.16	0.16	0.16	0.24	0.16	0.08	0.00
26	NBPGR/TCR-1999	1.0	2.5	4.0	5.0	0.16	0.16	0.59	0.67	0.25	0.33	0.42	0.16	0.42	0.50	0.16	0.16
27	NBPGR/TCR-2042	1.0	2.8	3.6	4.5	0.14	0.22	0.29	0.31	0.06	0.00	0.32	0.31	0.29	0.26	0.06	0.00
28	NBPGR/TCR-1955	1.0	3.8	4.2	5.0	0.03	0.03	0.28	0.31	0.02	0.00	0.13	0.03	0.28	0.34	0.02	0.00
29	NBPGR/TCR-2040	1.0	2.5	2.9	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.46	0.14	0.16	0.63	0.00
30	NBPGR/TCR-2168	1.0	3.3	3.9	5.0	0.35	0.53	0.12	0.16	0.00	0.00	0.39	0.39	0.12	0.16	0.04	0.08
31	NBPGR/TCR-1988	1.0	2.1	2.9	4.4	0.10	0.07	0.02	0.03	0.00	0.00	0.35	0.27	0.12	0.10	0.04	0.04
32	NBPGR/TCR-1999	1.0	2.4	3.3	4.9	0.16	0.14	0.02	0.00	0.00	0.00	0.19	0.10	0.15	0.14	0.03	0.00
33	NBPGR/TCR-2146	1.1	2.6	3.4	4.5	0.11	0.21	0.02	0.05	0.03	0.03	0.21	0.25	0.13	0.16	0.33	0.45
34	NBPGR/TCR-2060	1.0	1.0	1.0	1.0	0.05	0.07	0.00	0.00	0.07	0.11	0.16	0.14	0.20	0.03	0.33	0.23
35	NBPGR/TCR-2055	1.0	2.9	3.6	4.8	0.16	0.20	0.05	0.05	0.03	0.05	0.25	0.16	0.09	0.04	0.16	0.04
36	NBPGR/TCR-2048	1.0	2.0	2.7	3.8	0.16	0.16	0.05	0.06	0.02	0.03	0.12	0.13	0.12	0.20	0.00	0.00
37	NBPGR/TCR-2019	1.0	2.0	2.5	5.0	0.00	0.00	0.08	0.00	0.00	0.00	0.08	0.16	0.00	0.00	0.00	0.00
38	NBPGR/TCR-1871	1.0	3.1	3.9	4.7	0.37	0.54	0.18	0.20	0.29	0.41	0.49	0.62	0.31	0.45	0.32	0.33
39	NBPGR/TCR-1783	1.0	2.0	2.3	3.9	0.12	0.24	0.08	0.16	0.08	0.16	0.31	0.31	0.08	0.08	0.25	0.17
40	NBPGR/TCR-1777	1.0	2.3	3.1	4.5	0.08	0.16	0.03	0.05	0.03	0.05	0.30	0.16	0.10	0.14	0.17	0.11
41	NBPGR/TCR-1552	1.0	3.3	4.0	5.0	0.00	0.00	0.04	0.00	0.16	0.31	0.12	0.16	0.08	0.08	0.16	0.24
42	NBPGR/TCR-808	1.0	1.3	1.3	1.3	0.24	0.34	0.06	0.09	0.46	0.34	0.11	0.03	0.05	0.05	0.57	0.28
43	NBPGR/TCR-1957	1.0	1.5	1.9	2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.31	0.75	1.50
44	NBPGR/TCR-776	1.0	2.0	2.6	3.9	0.12	0.16	0.00	0.00	0.04	0.00	0.21	0.16	0.08	0.08	0.47	0.70
45	NBPGR/TCR-2235	1.0	2.0	3.5	5.0	0.08	0.11	0.03	0.05	0.03	0.00	0.03	0.00	0.08	0.11	0.22	0.33
46	NBPGR/TCR-760	1.0	3.0	3.9	4.8	0.15	0.16	0.03	0.03	0.00	0.00	0.28	0.20	0.15	0.17	0.05	0.10
47	NBPGR/TCR-128-A	1.1	2.7	4.0	5.0	0.47	0.65	0.16	0.31	0.00	0.00	0.58	0.71	0.19	0.22	0.03	0.05
48	NBPGR/TCR-2137	1.0	2.0	3.5	5.0	0.24	0.31	0.33	0.50	0.24	0.31	0.24	0.31	0.16	0.16	0.24	0.31
49	NBPGR/TCR-2177	1.0	3.5	4.3	5.0	0.19	0.22	0.14	0.28	0.00	0.00	0.45	0.52	0.11	0.22	0.08	0.16
50	NBPGR/TCR-2173	1.2	3.5	4.2	5.0	0.04	0.08	0.00	0.00	0.08	0.16	0.16	0.16	0.04	0.00	0.12	0.24

51	NBPGR /TCR-2228	1.0	3.0	1.9	5.0	0.02	0.04	0.00	0.00	0.02	0.04	0.10	0.04	0.06	0.12	0.00	0.00
52	NBPGR /TCR-2192	1.0	1.5	3.5	5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	NBPGR /TCR-2187	1.0	1.3	2.5	4.3	0.11	0.22	0.00	0.00	0.11	0.16	0.33	0.65	0.14	0.22	0.16	0.21
54	NBPGR /TCR-1753	1.0	3.0	3.3	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.31	0.08	0.16	0.08	0.00
55	NBPGR /TCR-1899	1.0	4.0	4.0	5.0	0.08	0.16	0.16	0.16	0.00	0.00	0.41	0.50	0.25	0.50	0.08	0.16
56	NBPGR /TCR-2061	1.0	2.7	4.2	5.0	0.11	0.21	0.00	0.00	0.16	0.31	0.16	0.11	0.05	0.05	0.24	0.31
57	NBPGR /TCR-2048	1.0	2.5	3.2	4.5	0.04	0.08	0.00	0.00	0.00	0.00	0.08	0.08	0.12	0.08	0.29	0.33
58	NBPGR /TCR-2235	1.0	3.0	3.3	4.2	0.23	0.46	0.00	0.00	0.00	0.00	0.24	0.31	0.16	0.31	0.00	0.00
59	NBPGR /TCR-1966	1.0	2.3	2.7	4.0	0.29	0.41	0.08	0.16	0.12	0.08	0.00	0.00	0.12	0.08	0.16	0.16
60	NBPGR /TCR-1975	1.0	1.5	2.5	4.2	0.31	0.46	0.16	0.31	0.08	0.00	0.80	0.87	0.60	0.73	0.84	1.37
61	NBPGR /TCR-1956	1.0	3.0	3.0	4.7	0.04	0.08	0.08	0.16	0.21	0.25	0.04	0.08	0.25	0.25	0.46	0.41
62	NBPGR /TCR-1934	1.0	5.0	5.0	5.0	0.08	0.16	0.16	0.16	0.16	0.16	0.40	0.80	0.17	0.00	0.16	0.16
63	NBPGR /TCR-1904	1.0	1.0	4.0	5.0	0.00	0.00	0.00	0.00	0.24	0.31	0.00	0.00	0.00	0.00	0.33	0.50
64	NBPGR /TCR-1479	1.0	1.5	3.5	5.0	0.00	0.00	0.00	0.00	0.24	0.31	0.00	0.00	0.00	0.00	0.08	0.16
65	Peechi Local	1.0	2.1	2.2	3.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.00	0.00
66	Kanhangad Local	1.0	1.0	1.5	1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.17	0.33	0.30	0.00
67	Chittarikkal Local	1.0	2.5	3.7	4.9	0.25	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.16	0.00	0.00
68	Mavungal Local	1.1	3.3	4.4	5.0	0.08	0.16	0.00	0.00	0.00	0.00	0.16	0.16	0.08	0.16	0.08	0.16
69	Eranakulam Local	1.0	1.0	1.5	1.9	0.04	0.08	0.04	0.08	0.00	0.00	0.00	0.00	0.04	0.08	0.08	0.16
70	Mananthavady Local	1.0	2.9	3.3	3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	Pudukad Local	1.0	1.0	1.0	1.1	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.04
72	Kollam Local-1	1.0	1.0	1.0	1.2	0.02	0.00	0.12	0.03	0.18	0.16	0.33	0.16	0.18	0.16	0.26	0.10
73	Kollam Local-2	1.0	1.8	3.0	4.7	0.11	0.11	0.00	0.00	0.06	0.11	0.03	0.00	0.00	0.00	0.12	0.19
74	Kilikolloor Local	1.0	1.3	1.7	2.2	0.00	0.00	0.02	0.00	0.02	0.04	0.00	0.00	0.06	0.12	0.52	0.87
75	Kattayikkonam Local	1.0	2.3	2.4	2.6	0.00	0.00	0.00	0.00	0.08	0.16	0.00	0.00	0.33	0.41	0.32	0.33
76	Kazhakkoottam Local	1.0	2.3	3.5	4.4	0.11	0.22	0.02	0.03	0.08	0.16	0.07	0.07	0.06	0.07	0.09	0.12
77	Nedumangad Local	1.0	1.0	1.0	1.1	0.00	0.00	0.08	0.16	0.00	0.00	0.00	0.00	0.11	0.22	0.08	0.05
78	Goureesapattom Local	1.1	1.4	1.7	3.6	0.00	0.00	0.00	0.00	0.03	0.03	0.17	0.00	0.13	0.10	0.03	0.03
79	Kakkamoola Local	1.0	1.0	1.5	2.5	0.00	0.00	0.02	0.04	0.02	0.00	0.00	0.00	0.06	0.08	0.06	0.04
80	Arka Anamika	1.1	2.2	3.5	4.3	0.00	0.00	0.02	0.00	0.16	0.31	0.16	0.05	0.04	0.00	0.05	0.04
81	NBPGR/TCR-874	1.1	3.5	4.0	5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.04	0.08	0.16	0.16
82	MDU-1	1.0	1.1	1.3	1.9	0.10	0.00	0.08	0.00	0.04	0.04	0.21	0.16	0.04	0.08	0.08	0.12
83	NBPGR/TCR-985	1.0	2.0	2.9	4.2	0.04	0.07	0.35	0.70	0.19	0.34	0.13	0.00	0.08	0.12	0.00	0.00
84	NBPGR/TCR-893	1.0	2.2	2.9	3.9	0.04	0.00	0.08	0.05	0.25	0.14	0.03	0.00	0.15	0.19	0.21	0.25
85	Parbhani Kranti	1.0	1.0	1.0	1.0	0.39	0.40	0.02	0.03	0.11	0.22	0.18	0.08	0.19	0.31	0.38	0.70
86	Varsha Uphar	1.0	1.0	1.0	1.0	0.00	0.00	0.33	0.16	0.23	0.00	0.00	0.00	0.50	0.67	0.39	0.31
87	Salkeerthi	1.1	2.8	4.3	4.8	0.08	0.08	0.00	0.00	0.12	0.08	0.24	0.24	0.28	0.31	0.53	0.46
88	Aruna	1.0	3.0	3.8	5.0	0.03	0.00	0.24	0.31	0.03	0.05	0.11	0.00	0.08	0.16	0.03	0.00
89	Arka Abhay	1.0	1.0	1.5	2.3	0.06	0.00	0.00	0.00	0.04	0.08	0.18	0.12	0.06	0.12	0.02	0.00
90	Selection-13	1.0	1.0	1.0	1.1	0.03	0.00	0.00	0.00	0.00	0.00	0.12	0.05	0.10	0.19	0.11	0.22
91	Selection-46	1.0	1.0	1.0	1.0	0.08	0.05	0.00	0.00	0.00	0.00	0.35	0.30	0.03	0.05	0.15	0.05
92	Anakkomban-I	1.0	1.1	1.5	2.1	0.06	0.11	0.00	0.00	0.00	0.00	0.16	0.05	0.05	0.05	0.11	0.22
93	Anakkomban-II	1.0	1.0	1.9	3.2	0.03	0.00	0.00	0.00	0.00	0.00	0.13	0.05	0.11	0.11	0.03	0.05
94	Kiran	1.0	2.1	3.4	5.0	0.11	0.05	0.00	0.00	0.06	0.00	0.17	0.00	0.09	0.00	0.00	0.00
95	Kannur Local Red	1.0	1.5	2.0	4.0	0.03	0.00	0.00	0.00	0.00	0.00	0.08	0.11	0.08	0.11	0.03	0.00
96	Nileshwaram Local	1.0	1.0	3.0	5.0	0.16	0.16	0.04	0.08	0.10	0.12	0.10	0.08	0.04	0.04	0.08	0.12
97	Pananchery Local	1.0	3.0	3.0	5.0	0.00	0.00	0.00	0.00	0.07	0.14	0.18	0.12	0.16	0.16	0.24	0.24
98	Kalavoor Local	1.0	1.5	3.0	4.5	0.08	0.00	0.00	0.00	0.08	0.16	0.27	0.11	0.14	0.14	0.33	0.16
99	Balussery Local	1.0	4.0	4.5	5.0	0.06	0.08	0.12	0.20	0.16	0.16	0.04	0.04	0.17	0.25	0.10	0.12
100	Koyilandy Local	1.0	4.0	3.9	5.0	0.07	0.05	0.03	0.05	0.11	0.16	0.04	0.00	0.12	0.19	0.28	0.19
101	Payyannur Local	1.0	2.5	5.0	5.0	0.12	0.16	0.18	0.22	0.09	0.10	0.28	0.28	0.31	0.36	0.06	0.12
	Mean	1.0	2.2	3.0	4.1	0.1	0.13	0.11	0.13	0.07	0.08	0.18	0.17	0.19	0.21	0.17	0.17
	SE	NS	0.7	0.6	0.6	-	-	0.15	0.19	-	-	-	-	0.19	0.24	-	-
	CD	NS	1.8	1.7	1.5	NS	NS	0.39	0.05	NS	NS	NS	NS	0.51	0.62	NS	NS

Table 3. ANOVA for vectors and YVM incidence

Vectors	Mean square				
	Genotype (df=100)	Time (df=1)	Interaction (df=100)	Error (df=202)	Pooled error (df = 302)
Whitefly					
30 DAS	0.045**	0.329**	0.017	0.033	0.028
50 DAS	0.081**	0.152	0.014	0.031	0.025
70 DAS	0.032**	0.071	0.015	0.024	0.021
Leaf hopper					
30 DAS	0.094	0.069	0.044	0.073	0.064
50 DAS	0.110**	0.339	0.020	0.046	0.038
70 DAS	0.121	0.000	0.082	0.109	0.100

** Significant at 1% level

ii) **Association of YVM incidence with vector population**

Correlation coefficients of YVM incidence with populations of whitefly and leaf hopper were estimated at various stages of the crop *viz*., 30 DAS, 50 DAS, 70 DAS and final harvest (Table 4). YVM incidence at the three stages (except at 30 DAS) was significantly and positively correlated with the morning (0.209, 0.224 and 0.196 respectively) and evening (0.236, 0.251 and 0.210 respectively) populations of whitefly at 30 DAS. YVM incidence during last harvest exhibited positively significant correlation with morning (0.208) and evening populations of whitefly during 50 DAS also.

Morning population of leaf hopper at 30 DAS had significant positive correlation with disease incidence at 50 DAS (0.276) and 70 DAS (0.230). Evening count of leaf hopper had influence on YVM incidence at 50 DAS (0.301), 70 DAS (0.278) and final harvest (0.257).

It was clear from the association analysis that morning and evening populations of both whitefly and leaf hopper at 30 DAS had significant influence on the development of YVM from 50 DAS to final harvest. This indicates the fact that feeding by the vectors during the initial stage of crop growth, especially at 30 DAS, leads to the incidence and development of YVM disease throughout the crop phase. Moreover, whitefly count (both morning and evening) during 50 DAS also influenced the disease expression during the final phase of the crop. Bhagat *et al.* (2001) also arrived at similar conclusion that YVM disease development occurred at its maximum during 35 – 45 DAS of the crop. As evident from the table, population of both vectors at 70 DAS and leaf hopper count also at 50 DAS had no correlation with the disease incidence.

Table 4. Association of YVM incidence with its vector population

Vectors and time	Correlation coefficients with YVM incidence			
	30 DAS	50 DAS	70 DAS	Final harvest
Whitefly				
30 DAS				
Morning	0.045	0.209*	0.224*	0.196*
Evening	-0.002	0.236*	0.251*	0.210*
50 DAS				
Morning	-0.111	0.162	0.121	0.208*
Evening	-0.113	0.146	0.121	0.210*
70 DAS				
Morning	-0.030	-0.088	-0.071	-0.080
Evening	-0.025	-0.084	-0.014	-0.021
Leaf hopper				
30 DAS				
Morning	0.050	0.276**	0.230*	0.187
Evening	0.021	0.301**	0.278**	0.257**
50 DAS				
Morning	-0.042	0.146	0.074	0.171
Evening	-0.045	0.133	0.068	0.153
70 DAS				
Morning	-0.002	-0.096	-0.118	-0.082
Evening	-0.007	-0.052	-0.054	-0.029

*Significant at 5% level ** Significant at 1% level

The degree of Okra mosaic virus (OKMV) and the population of its vectors *viz.*, *Podagrica unifoma* (Jac.) and *Podagrica sjostedti* (Jac.) at different growth stages of okra plants was studied using a netted barrier method and it was suggested that protecting okra plants up to 28 days after germination reduced the spread of OKMV by checking both vectors (Fajinmi and Fajinmi, 2010).

However, no information could be traced out from the available literature, regarding the magnitude and influence of vector population during various stages of crop growth on YVM disease development. Hence this study is the first stepping stone in this arena of research.

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