Journal of Root Crops, 2011, Vol. 37 No.1, pp. 48-53
Indian Society for Root Crops
ISSN 0378-2409

Whitefly [*Bemisia tabaci* (Genn.)] on Cassava: Seasonal Variation and Varietal Preference

A.V. Mary Josepha Shery[1] and C. A. Jayaprakas[2]

[1] Central Sericultural Research and Training Institute, Research Extension Centre Sub Unit, Wayanad, Central Silk Board, Kalpetta P.O. 673 121, Kerala, India
[2] Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram-695 017, Kerala India
Corresponding author: A.V. Mary Josepha Shery, e-mail: maryjosephasherry@yahoo.com

Received: 18 December 2010; Accepted: 16 March 2011

Abstract

A simple method was developed for the estimation of whitefly [*Bemisia tabaci (Genn.)*] population on cassava at Central Tuber Crops Research Institute, Thiruvananthapuram, India. The maximum number of late instars of whitefly was found on the 8th and 9th leaf from the top. The late instars of whitefly could be counted on the 8th leaf *in situ* without any aid. The nymphal count on the 8th leaf showed a significant correlation with the adult population of the previous month. The tender most leaf of the cassava plant took 20-22 days to become the 8th leaf from top. The life cycle of whitefly was completed in about 17-30 days with an average of 25 days. The time taken for the growth of the tender most leaf to the 8th leaf position and the development of the insect from egg to late instar synchronised. Each cassava leaf has on an average seven leaflets and there was a preference for middle leaflet (4th) for egg laying. Development and population build up of *B. tabaci* was seen affected by temperature and humidity and not by rainfall and sunshine. Significant seasonal variation and varietal preference were recorded in the population. The varietal preference changed according to season and the host preferred by adult and nymph also varied, which indicated that the preference of host for feeding and development were not the same.

Key words: *Bemisia tabaci*, cassava, population estimation, varietal preference

Introduction

Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is one of the major pests of cassava (*Manihot esculenta* Crantz). In Neotropics, 11 species of whiteflies have been reported from cassava. Feeding by whiteflies causes chlorosis, yellowing and leaf fall in cassava (Lal and Pillai, 1981). Yield loss due to cassava mosaic disease (CMD) transmitted by *B. tabaci* ranged from 44 to 90% in African countries and in India it is 10 to 88% (Narasimhan and Arjunan, 1974; Thankappan and Chacko, 1976; Nair and Malathi, 1987; Owor et al., 2004). Indian cassava mosaic virus (ICMV) and Sri Lankan cassava mosaic virus (SLCMV) are the two cassava mosaic geminiviruses reported from India. Biological characteristics of *B. tabaci* such as multivoltinism, high reproductive rate, broad host range and ability to migrate to great distances have increased the difficulty of developing sustainable management options for this pest (Gerling and Mayer, 1996). ICMV was also reported on bittergourd (*Momordica charantia*) (Rajanimala and Rabindran, 2007). Begomovirus closely related to ICMV has been reported from Jatropha (*Jatropha curcas* L.) (Narayana et al., 2007; Raj et al., 2008). To check the spread of CMD in cassava and to other host plants, proper control measures have to be taken. Sampling is a prerequisite before initiating control measures. Sampling of *B. tabaci* is usually done by counting adult and nymphal stages. Counting adults alone for the estimation of *B. tabaci* population is not enough as adults will fly away even by slight disturbance. The objective of the present study was to develop an easy and direct method for the sampling of the whitefly population on cassava to take up necessary control measures on time.

Materials and Methods

Six varieties of cassava viz., Sree Harsha, Sree Sahya, Sree Visakham, H-226, H-165 and H-97 maintained in the germplasm collection of Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram were selected for the investigation. Nymphal stages that could be seen *in situ* without any aid from the 8th leaf from top and adult flies from all leaves of the plant were counted with minimum disturbance to the plant. The late stage nymphs (3rd, 4th and pupal stages) were visible to the naked eyes on cassava leaves. Sampling was done for 12 months from November 2007 to October 2008 during the evening hours. To check the preference for leaflet, if any, sampling was done on all leaflets of the 8th leaf of 100 plants of the selected varieties at random. Sometimes, eight to nine leaflets were found in the cassava leaf, but generally it was seven. Hence the count from first seven leaflets from left to right only was taken for analysis. The weather parameters for the period viz., maximum and minimum temperature, relative humidity, rainfall and sunshine were noted. The range of the above parameters during the survey period was maximum temperature: 30-34.5^{o}C, minimum temperature: 23-26.5^{o}C, humidity: 63-74%, rainfall: 0-10 mm and sunshine: 6-9 hours.

The values were transformed to $\sqrt{(x+1)}$ and statistical analysis was done using the SPSS software. The two tailed correlation with the adult and nymph was done using the Pearson correlation model. The correlation was done between the adult counts of *B. tabaci* in a month with the nymphal count of the succeeding month. Multiple regression was done separately with adult and nymph count as dependent variable and maximum and minimum temperature, humidity, rainfall and sunshine as independent variables. In the case of nymph, multiple regression was done with weather parameters of the corresponding month and the preceding month as independent variables. One way ANOVA was done for adult and nymph counts as dependent variable with month and varieties as factor. Significance of the nymphal count on the seven leaflets was also confirmed by one way ANOVA. Normality of the above data was checked and the out layers removed for more precision. The means were separated using Turkey test in all analysis.

Results and Discussion

Sampling of whitefly nymphs

In this study, the sampling was done during the evening hours. According to Ellsworth et al. (1995) sampling of whitefly can be done at any time of the day but a survey within 24 hours after rain may affect the counts. Active adult population was high in the tender leaves, resting and courting flies were found in the bottom yellow leaves with random spread at middle and lower leaves. Palaniswami and Pillai (1990) observed maximum population of the insect on the top leaves followed by the middle and lowest leaves. Nymphal count was more on the 8th leaf from top. The 3rd and 4th instars and pupae could be counted *in situ* with the naked eyes. According to Ohnesorge and Rapp (1986) adults or the last two larval instars including the so-called “pupae” were the stages easier to count than the eggs or early instars. *B. tabaci* completes its life cycle in about 17-30 days with an average of 25 days on cassava (Palaniswami and Pillai, 1990). The tender most leaf took 20-22 days to become the 8th leaf in actively growing cassava in the field and this coincides with the larval duration of the fly. The count of the late instars on the 8th leaf gives the direct count of the egg laid on the tender most leaf. The Pearson correlation of the adult count from the whole plant and nymphal count on the 8th leaf in the succeeding month from the same plant was found to be significant and had the same pattern on all six varieties studied ($P < 0.05$, $N = 264$). The above result supports the sampling of the nymphal count from the 8th leaf. The count of the nymphal stages from the older leaves will not give the correct data as it may have nymphs of the overlapping generations and pupal exuvia. *B. tabaci* deposits few eggs upon the leaf on which they emerge as adults and then move to newer growth (Byrne and Bellows, 1991). The female lays eggs while feeding and for feeding whitefly prefers tender leaves (http://creatures.ifas.ufl.edu/veg/leaf/silverleaf_whitefly.htm). The nymphal stages of *B. tabaci* on ground nut was very low on the terminal leaf one but reached maximum on leaves three, four and five and then gradually declined on older leaves (Lynch and Simmons, 1993). In cotton, the most frequently infected leaves were the 5-8th nodes (Melamed–Madjar et al., 1982; Butler and Henneberry, 1984). The adults collected using yellow sticky trap was used to predict the nymphs on the peanut leaf one week later. This relationship was weaker when the count was taken without any preference but a strong relationship was reported when 3-5 leaves were sampled for nymphs and more sticky traps were used for adult sampling (Lynch and Simmons, 1993).

Monthly variation

Monthly variation in the population was significant ($P<0.05$, $F=31.448$) and the maximum adult population was found in December followed by April (20.96 ± 3.28 and 19.6 ± 3.68) (Fig. 1). From June to September the population was very low and started increasing from October. Nymphal population was maximum in January and February (31.67 ± 1.50 and 31.96 ± 2.27) ($P< 0.05$, $F = 27.710$) and minimum in June to September and started increasing again from October. The highest population of *B. tabaci* was observed in February - March by Pillai and Daniel (1979) and Palaniswami et al. (1996), but Nair (1981) observed a peak in October-November.

Leaflet preference

Whitefly prefers middle leaflet, the 4th one of cassava leaf for egg laying. The number of nymphs in the seven leaflets gradually decreased from the middle to the margins. Nymphs present on 1-7 leaflets were 2.66 ± 0.28, 5.09 ± 0.45, 5.97 ± 0.54, 7.27 ± 0.76, 6.62 ± 0.65, 5.50 ± 5.58, 4.31 ± 0.50 respectively ($P< 0.05$, $F = 9.468$, $N = 90$) (Fig. 2). Lynch and Simmons (1993) reported statistically equal number of nymphal stages in four leaflets of peanut. Nair and Daniel (1983) found that leaf orientation such as erect, drooping and horizontal type showed variation in preference by the whiteflies. The erect type was more preferred. They opined that the better interception of light by these varieties might have provided congenial conditions for the whiteflies to feed. The erect position of the middle leaflet may be having the above advantage and could be the reason for the preference.

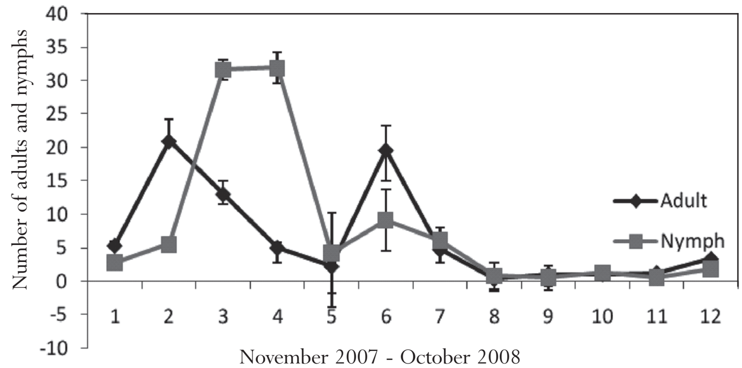

Fig.1. *Bemisia tabaci* adult and nymphal population (Mean ± SE) on cassava leaflets from November 2007 to October 2008

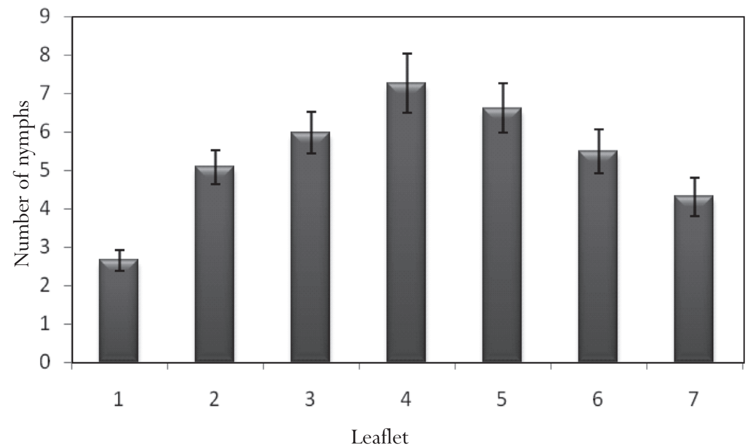

Fig.2. *Bemisia tabaci* nymphal population (Mean ±SE) on the seven leaflets of the cassava leaf

Effect of weather on whitefly population

Multiple regressions done with adult count showed that the temperature, humidity and sunshine had significant effect on the adult population, but rainfall had no effect ($R^2 = 0.275$ and $P < 0.05$, $F = 19.590$ and $N=264$). In the case of nymph, regression was done with weather parameters of the corresponding month ($R^2 = 0.373$, $P < 0.05$, $F = 30.648$, $N = 264$) and that of the preceding month ($R^2 = 0.347$, $P < 0.05$ $F = 27.414$, $N = 264$). The temperature had effect on the early nymphal stages, whereas humidity had weak effect. However, rainfall and sunshine had no role. In the late nymphal stages, temperature and humidity had effect, whereas rainfall and sunshine had no effect. According to Avidov (1956) climatic factors like temperature, wind, rainfall and relative humidity play a role in the *B. tabaci* population. Palaniswami and Pillai (1990), Pillai and Daniel (1979) and Lal and Pillai (1982) found that *B. tabaci* population was affected by maximum and minimum temperature and humidity, whereas rainfall had no effect on it. Naranjo and Ellsworth (2005) observed that heavy rains were able to dislodge whitefly nymphs from the leaves, but the rain protection experiment of Assimwe et al. (2006) showed no marginal difference in the nymphal population.

Varietal preference

Nair and Daniel (1983) reported the preference of whiteflies to H-226 and H-165 and opined that leaf texture and petiole colours were the two factors preferred by whitefly. In the present study the preference of host was found to vary in the months surveyed. In October and December more number of adults were found on H-165 followed by Sree Visakham, Sree Sahya, H-226, H-97 and Sree Harsha. In April, May, August and September, H-226 was preferred most. There was significant preference only in August and September, even though the population was less during those months ($P < 0.05$) (Table 1). In the months of February, July and November, Sree Sahya was preferred. In January and March, H-97 had maximum number of flies. Nymph number showed significant difference in the surveyed months, except January, April, July and August. The maximum number was found in H-97 during March, April and May ($P < 0.05$) and in Sree Harsha during November, December, January and February ($P < 0.000$) (Table 2). In February, Sree Sahya and Sree Harsha were equally preferred. Sree Visakham was preferred in June and October. In July, August and September maximum number was found on H-226. From this it can be concluded that the varieties preferred for feeding and development were not the same in the surveyed months and this might be due to the biochemical changes in the host plants. The biochemical changes and the number of eggs laid in preferred varieties need further investigation. Nair and Daniel (1983) found that H-226 was the variety which harboured more population followed by H-165 and H-97. Colvin et al. (2006) opined that adult flies preferred more cassava mosaic disease affected plants for feeding.

Conclusion

The sampling of the 8th leaf of actively growing cassava gave a reliable indication of the *B. tabaci* population. This can be done without much expertise and with minimum sampling error. The sedentary nature of the nymph rules out the error that could occur due to the flight of the adult. The varieties, H-226 and H-165 had more number of adults, whereas Sree Harsha, Sree Sahya and H-97 had more nymphal stages. The above preference changed with months. The *B. tabaci* showed preference to the middle leaflet (4th one). The *B. tabaci*

Table 1. Number of *Bemisia tabaci* (adults) (Mean±SE) collected from different varieties of cassava

Month	Sree Harsha	Sree Sahya	Sree Visakham	H-226	H-165	H-97	P value
Jan	11.25±3.15	12.75±3.94	10.5±3.12	5±2.61	15±3.63	23.5±7.59	0.111
Feb	8±3.08	8±3.08	2.5±1.04	4±1.68	2.5±1.19	4.5±1.32	0.437
Mar	1±0.41	1.5±0.65	0.25±0.25	2±1.15	2.25±0.75	6±3.39	0.117
Apr	14.25±4.57	19±13.35	26±14.67	33.5±6.27	18.25±2.5	6.75±4.61	0.248
May	1±0.71	6.75±2.4	1.5±0.65	9.25±3.59	3.25±1.32	6.5±1.94	0.060
June	0±0	0±0	1±0.71	0.5±0.29	0.5±0.29	0±0	0.213
July	0±0	2.5±1.89	0±0	1.75±1.18	1.25±0.48	0.75±0.48	0.342
Aug	0±0a	2±0.41ab	0±0a	2.75±0.85ab	0±0a	1.5±0.96ab	0.001
Sep	0±0ab	1±0.71ab	1±0.41ab	3±0.81b	1±0.41ab	0±0a	0.024
Oct	1±4.082	1.75±0.47	4±1.68	4±0.91	4.5±0.65	2.5±1.04	0.391
Nov	5.25±1.32	7±1.47	6.5±2.39	4.5±1.32	6±2.55	4±2.5	0.472
Dec	5.75±1.93	27±11.17	28.75±7.47	21.25±9.87	30±7.36	13±0.71	0.064

Letters of the same alphabet in the same row are homogeneous groups

Table 2. Number of *Bemisia tabaci* (nymphs) (Mean±SE) collected from different varieties of cassava

Month	Sree Harsha	Sree Sahya	Sree Visakham	H-226	H-165	H-97	P value
Jan	59.5±20.89	10.25±7.33	13±4.33	11.25±1.49	45.25±6.69	50.75±17.12	0.170
Feb	60±13.06c	60±13.05c	18.5±3.66ab	9.75±2.25a	45.5±5.85bc	16.75±8.37ab	0.000
Mar	2.25±1.60a	7.75±7.42a	0.75±0.75a	0.5±0.5ba	2.25±1.11a	11.5±8.29a	0.048
Apr	2.75±1.32	11±2.34	2.75±1.03	7.75±1.93	12.5±8.23	18±5.77	0.063
May	1±0.71a	1.25±0.25a	0±0a	10±5.15b	2.5±0.65ab	22±2.68c	0.000
June	0±0a	0±0a	4.25±1.65b	0.5±0.29a	0±0a	0±0a	0.000
July	0±0	0.75±0.48	0±0	1.5±0.65	0.75±0.48	0±0	0.054
Aug	0±0	1±0.41	1±0.71	2±0.41	1.5±0.65	1±0.41	0.668
Sep	1±0.41	1±0.41	0±0	1±0.58	0±0	1±41	0.041
Oct	0±0a	2±0.71ab	4±0.71b	1±0.41a	2±0.41ab	0.75±0.48a	0.008
Nov	16.5±5.31b	0±0a	0±0a	0±0a	0±0a	0±0a	0.000
Dec	27±5.2b	6±4.02a	0±0a	0±0a	0±0a	0±0a	0.000

Letters of the same alphabet in the same row are homogeneous groups

population changed with the weather parameters like temperature and humidity. A proper sampling was needed for the timely control of the insect vector to check the spread of viral diseases to more and more cultivated areas as the increase in population density resulted in the migration of the insects to new hosts.

Acknowledgement

The authors are thankful to the Director, Central Tuber Crops Research Institute, Thiruvananthapuram for providing facilities, Dr. Manoj Chacko, Department of Statistics, University of Kerala, Kariyavattom for helping in the data analysis and Dr. Paul De Barro, CSIRO, Australia for identifying the whiteflies. The first author is also thankful to the Member Secretary, Central Silk Board for granting study leave.

References

Asiimwe, P., Ecaat, J.S., Otim, M., Gerling, D., Kyamanywa, S. and Legg, J. P. 2006. Life-table analysis of mortality factors affecting populations of *Bemisia tabaci* on cassava in Uganda. *Entomol. Exp. Appl.* 1-8. DOI: 10.1111 / j.1570-8703.2006.00487.X.

Avidov, Z. 1956. Bionomics of the tobacco whitefly (*Bemisia tabaci* Gennad.) in Israel. *Ktavim*, **7**: 25-41.

Butler, G.D. and Henneberry, T.J. 1984. *Bemisia tabaci*: Effect of cotton leaf pubescence on abundance. *Southwest Entomol.*, **9**: 91-94.

Byrne, D.N. and Bellows, T.S.J. 1991.Whitefly biology. *Ann. Rev. Ent.*, **36**: 431- 457.

Colvin, J., Otim-Nape, W., Holt, J., Omongo, C., Seal, S., Stevenson, P., Gibson G.I., Cooter, R.J. and Thresh, J.M. 1999. Factors driving the current epidemic of severe cassava mosaic disease in East Africa. In: Fereres, A, (Ed.).VII International Plant Virus Epidemiology Symposium, International Society of Plant Pathology, Almeria, Spain. pp.76-77.

Colvin, J., Omongo, C.A., Govindappa, M.R., Stevenson, P.C. and Maruthi, M.N. 2006. Host plant viral infection effects an arthropod –vector population growth, development and behaviour: Management and epidemiological implications. *Adv. Virus Res.*, **67**: 419-52.

Ellsworth, P.C., Diehl, J.W., Dennehy, T.J. and Naranjo, S.E. 1995. (Rev.11/2000). Sampling sweet potato whiteflies in cotton. IPM series No. 2. Publ. No. 194023. University of Arizona, College of Agriculture and Life Sciences, Co-operative Extension, Tucson, Arizona. URL: http://cals.arizona.edu crops/cotton/insects/wf/sampl.html

Gerling, D. and Mayer, R. 1996. *Bemisia* 1995*:* Taxonomy, Biology, Damage and Management. Intercept, Andover, UK, pp. 577-603.

Lal, S.S. and Pillai, K.S. 1981. Pests attacking cassava (*Manihot esculenta* Crantz.) in Southern India. *Trop. Pest Mgmt*, **27**: 480-491.

Lal, S.S. and Pillai, K.S. 1982. Ecological studies on whitefly *Bemisia tabaci* (Genn.) infesting cassava in Kerala. *Entomon.,* **7**: 101-102.

Lynch, R.E. and Simmons, A.M. 1993. Distribution of immatures and monitoring of adult sweetpotato whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae), in peanut, *Arachis hypogaea. Environ. Entomol.,* **22** (2): 375-380.

Melamed-Madjar, Y., Cohen, S., Chen., Tam, S. and Rosilio, D. 1982. A method for monitoring *Bemisia tabaci* and timing spray application against the pest in cotton fields in Israel. *Phytoparasitica,* **10**: 85-91.

Nair, N.G. 1981. Relationship between cassava mosaic disease spread and whitefly (*Bemisia tabaci* Genn.) population under different insecticide treatments. *J. Root Crops*, **7**: 15-19.

Nair, N.G. and Daniel, R.S. 1983. Preference of *Bemisia tabaci* (Genn.) to cassava varieties and their reaction to CMD. *J. Root Crops*, **9**: 45-49.

Nair, N.G. and Malathi, V.G. 1987. Disease severity and yield loss in cassava (*Manihot esculenta* Crantz.) due to Indian cassava mosaic disease. *J. Root Crops,* **13** (2): 91-94.

Naranjo, S.E. and Ellsworth, P.C. 2005. Mortality dynamics and population regulation in *Bemisia tabaci*. *Entomol. Exp. Appl*., **116**: 93–108.

Narasimhan, V. and Arjunan, G. 1974. Effect of mosaic disease on cassava. Tapioca Research Station Report. Salem, Tamil Nadu, India, pp.10.

Narayana, A.D.S., Ramaswamy, K.T., Shankarappa, K.S., Maruthi, M.N., Lakshminarayana Reddy, C.N., Rekha, A.R. and Keshava Murthy, K.V. 2007. Distinct begomovirus closely related to cassava mosaic viruses cause Indian Jatropha mosaic disease. *Int. J. Virology,* **3** (1): 1-11.

Ohnesorge, B. and Rapp, G. 1986. Monitoring *Bemisia tabaci:* a review. *Agric. Ecosyst. Environ.,* **17**: 21-27.

Owor, B., Legg, J. P., Okao-Okuja, G., Obonyo, R. and Ogenga-Latigo, M.W. 2004. The effect of cassava mosaic geminiviruses on symptom severity, growth and root yield of a cassava mosaic virus disease-susceptible cultivar in Uganda. *Ann. Appl. Biol.,* **145** (3): 331-337.

Palaniswami, M.S. and Pillai, K.S. 1990. Bio-ecology of *Bemisia tabaci* G. on cassava. *J. Root Crops,* **17** (special issue): 169-173

Palaniswami, M.S., Radhakrishnan Nair, R., Pillai, K.S. and Thankappan, M. 1996. Whiteflies on cassava and its role as vector of cassava mosaic disease in India. *J. Root Crops,* **22** (1): 1-8.

Pillai, K.S. and Daniel, R.S. 1979. Monthly variations in the population of whitefly (*Bemisia tabaci*) the vector of cassava mosaic disease. *J. Root Crops*, **5**: 8-10.

Raj, S.K., Snehi, S.K., Kumar, S., Khan, M.S. and Pathre, U. 2008. First molecular identification of a begomovirus in India that is closely related to cassava mosaic virus and causes mosaic and stunting of *Jatropha curcas* L. *Australasian Plant Disease Notes*, **3**: 69-72.

Rajanimala, N. and Rabindran, R. 2007. First report of Indian cassava mosaic virus on bittergourd (*Momordica charantia*) in Tamilnadu, India. *Australasian Plant Disease Notes,* **2**: 81-82. doi:10.1071/DNO7033.

Thankappan, M. and Chacko, C.I. 1976. Effect of cassava mosaic on the different plant parts and tuber yield in cassava. *J. Root Crops,* **2***: 45*-47.