

FEEDING PREFERENCE OF *PENTALONIA NIGRONERVOSA* COQ. (HEMIPTERA: APHIDIDAE) FOR AND ITS COMPARATIVE DEVELOPMENT ON BUNCHY-TOP SUSCEPTIBLE ABACA VARIETY AND RESISTANT HYBRIDS¹

Henry T. Facundo and Augusto C. Sumalde²

ABSTRACT

Tests conducted in the greenhouse showed that the banana aphid, *Pentalonia nigronervosa* Coq. (Hemiptera: Aphididae), the only known vector of the abaca bunchy-top (ABT) virus, preferred to feed on the ABT-susceptible variety, Tinauagan Pula (TP) than on the resistant hybrids, Itolaus x Magsarapong #7 and Pacol x CES III-2. Their preference was already manifested during the very first monitoring schedule (0.5 hr), although the number of colonizing aphids on TP only became statistically greater than those on the two resistant hybrids at 4 hours.

P. nigronervosa exhibited better development and reproduction on TP, as manifested by its shorter nymphal development period, lower number of nymphal instars, longer reproductive period and higher fecundity, than on the resistant hybrids.

In a field experiment, *P. nigronervosa* colony establishment was more successful on TP than on the resistant hybrids. The resistance of the hybrids to the aphid vector may explain partly their resistance to the disease.

Key words: abaca bunchy-top virus, antibiosis, antixenosis, banana aphid, comparative development, feeding preference, host plant resistance, *Pentalonia nigronervosa* Coq., transmission, vector.

INTRODUCTION

Abaca (*Musa textilis* Nee) or Manila hemp, as it is known in international trade, is an important crop which is principally used for specialty paper, cordage and fibercraft. It is indigenous to the Philippines but is also found in Borneo, Indonesia and Central America. The Philippines supplied 30,176 metric tons of abaca per year or 73.3% of the world fiber requirement in 1981 to 1985, with the United States, United Kingdom and Japan being the major importers (FIDA, 1986). The abaca industry registered total export earnings of US \$ 47.5 M for the country in 1982 (de Castro *et al.*, 1988).

Some 17 diseases of abaca have been recorded by PCARR (1977). One of them, bunchy-top, is considered as the most destructive. Abaca bunchy-top (ABT) is a disease caused by a virus of undetermined morphology, but there are indications that this virus is similar to, if not identical with, the banana bunchy-top virus (Castillo and Martinez, 1961; Martinez and Castillo, 1965; Magnaye, 1979; Dale, 1987).

Received: 15 June 1998; accepted 12 October 1998.

¹Portion of the B. S. thesis of the senior author.

²Department of Entomology, University of the Philippines Los Baños, 4031 College, Laguna.

Since there is yet no direct control measure that is effective against the causal virus, controlling the aphid vector offers a good alternative. The only known vector of the ABT virus is the banana aphid, *Pentalonia nigronervosa* Coq. Several abaca hybrids with reported resistance to the disease have been developed by the Institute of Plant Breeding (IPB), University of the Philippines Los Baños. However, it is not very clear if the resistance is against the virus or against the vector. This study was conducted at IPB from March 1990 to March 1991, with the following objectives: (1) to determine the feeding preference of the aphid for an ABT-susceptible variety and two resistant hybrids; and, (2) to compare its development on these same test plants.

MATERIALS AND METHODS

Test insects. Clean or aviruliferous banana aphid, *P. nigronervosa*, was reared on healthy Abuab variety abaca plants. This particular variety was not included in the preference tests to eliminate the possibility of "induced preferences" (Hanson, 1983; Dethier, 1970). The aphids were allowed to multiply on the said abaca plants in a screened cage to protect them from parasites and predators, and to avoid contamination.

Test plants. Seeds were obtained from mature fruits of the abaca bunchy-top (ABT) susceptible variety, Tinauagan Pula (TP), and resistant hybrids, Itolaus x Magsarapong # 7 (IM) and Pacol x CES III-2 (PC). The seeds were sown in separate seed boxes with sterilized soil. Seedlings were transplanted into individual clay pots with sterilized soil at three-leaf stage. To augment test plants from seeds, corms and/or suckers were also used. All test plants were enclosed in a nylon mesh cage inside the greenhouse to protect them from insects, especially aphids. Regular watering and periodic fertilization were done.

Feeding preference test. Twenty-one five-month old test plants, seven from each test variety/hybrid, were arranged randomly in a circular pattern around an aphid source. At least one leaf of each test plant was made to touch the aphid source and the other leaves touched the adjacent test plants. This aphid source was a platform topped with a round white cartolina (150 cm in diameter). On this was placed about 2500 aphids which were allowed to move freely. To minimize handling injury to the aphids, infested leaves were placed directly on the center of the platform. Monitoring of aphid number and activity on each test plant was done at 0.5, 1, 2, 4, 8, 24, 48, 72, 96, 120, 144, 168 hours after set-up. Follow-up monitoring was also done at 2, 4, 6, and 12 weeks after set-up to check colony establishment. Data were analyzed using Analysis of Variance and Duncan's Multiple Range Test.

Experiment on comparative development. Six-month old test plants, TP (12), IM (12), and PC (9), were arranged in a Completely Randomized Design in a greenhouse. Five adult aphids were confined to the underside of the youngest leaf of each test plant using plastic clip-on screened cages (22 mm in diameter, height of 7 mm). These were allowed to larviposit within 24 to 48 hours. Only one nymph for each plant was left to develop. Daily observation was done to monitor its growth and development. In cases of death or loss, adult aphids were again allowed to larviposit and the above procedure was followed. The number of instars, stadia, prelarvipositional, reproductive, and postpartural periods were noted. From these data, adult longevity, generation length and life span were computed. Fecundity was

also determined. To compare *P. nigronervosa* development on the three test variety/hybrids, data were analyzed using Analysis of Variance and Least Significant Difference Test.

Field experiment on colony establishment. Fifteen test plants, five from each test variety/hybrid, were arranged in a Completely Randomized Design in an open area. Fifty aphids were introduced onto the youngest leaves of each test plant. The number of thriving aphids was monitored weekly for thirteen weeks from December 1990 to February 1991. Analysis of Variance and Duncan's Multiple Range Test were used to compare colony establishment of *P. nigronervosa* on the three test variety/hybrids under field conditions.

RESULTS AND DISCUSSION

Feeding preference. Results of the feeding preference test are summarized in Table 1 and Fig. 1. Although Tinauagan Pula (TP) already had the highest mean number of aphids within 0.5 to 2 hours of monitoring, it was only at 4 hours after aphid release that the difference became statistically significant over Itolaus x Magsarapong #7 (IM) and Pacol x CES III-2 (PC). This trend continued except in the last monitoring in the twelfth week (2016 hours) when aphid population in TP decreased dramatically. Between the two resistant hybrids, PC had, on the average, more aphids per plant than IM in majority of the monitoring times. However, these differences were not statistically significant most of the time.

Aphids are said to touch leaf surfaces with the proboscis to make brief test probes. Chemicals of epicuticular waxes have been shown to affect feeding behavior in a number of ways for various insects. Some influence settling while others act as phagostimulants or feeding deterrents (Woodhead and Chapman, 1986). In this experiment, the first few hours can be considered as the probing period, which is then followed by settling of the aphid on an acceptable host plant to initiate feeding. The results suggest that TP is a more acceptable host than the two hybrids. Furthermore, because the aphids were free to approach any plant on the choice arena, initial high numbers on TP are suggestive of possible presence of a kairomone from TP and/or a repellent from IM and PC. These initial high numbers on TP were also observed in a choice test using excised leaves conducted in the laboratory, but not when excised bracts were used (Facundo, 1991).

Population build-up on TP was markedly faster than on the two hybrids (Fig. 1). This difference might be due to the lack of feeding and/or ovipositional stimulants in the two hybrids and/or to the slower developmental rate of aphids on the hybrids. The latter hypothesis is supported by the data on comparative development as discussed in the next section. Faster population build-up on TP was also observed in a greenhouse experiment where 50 aphids were introduced onto the youngest leaves of test plants (thus aphids were not given a choice) and monitored for 12 weeks (Facundo, 1991).

The decline in aphid population in the twelfth week (2016 hours) might be due to the accumulation of exuviae and sooty molds, especially on TP test plants, that resulted in overcrowding of the preferred feeding sites and shelters (i.e. the bracts or crevices between the uppermost part of the leafsheaths and the pseudostem). Honeydew, a sugary excretion voided by aphids and some other homopterans on plant surfaces, favors the growth and proliferation of sooty molds (such as the case

Table 1. Mean number of aphids on each test variety/hybrid at different times after set-up in the feeding preference test.*

MONITORING SCHEDULE (hrs after set-up)	VARIETY/HYBRID		
	Tinauagan Pula	Itolaus x Magsarapong # 7	Pacol x CES III-2
0.5	18.14 a	6.57 a	7.14 a
1	21.00 a	9.00 a	9.71 a
2	20.29 a	4.43 a	4.29 a
4	23.71 a	3.71 b	3.14 b
8	26.86 a	5.29 b	4.86 b
24	19.00 a	5.00 b	4.86 b
48	33.71 a	5.86 b	16.29 ab
72	41.43 a	9.71 b	20.29 ab
96	50.14 a	7.14 b	20.14 ab
120	51.86 a	6.29 b	13.00 b
144	62.14 a	5.86 b	14.71 b
168	72.29 a	8.29 b	23.00 b
336	77.57 a	16.42 b	43.57 a
672	96.00 a	21.00 b	35.43 b
1008	158.57 a	48.14 b	73.86 a
2016	15.14 a	32.00 a	19.00 a

*Mean of seven replicates. Means with a common letter in a row are not significantly different at $\alpha = 0.05$.

of the lime aphid, *Eucallipterus tiliiae*, as reported by Carter and Nichols, 1986). *Pentalonia nigronervosa* was never found on areas covered with sooty molds and may, therefore, have sought alternative feeding sites. The abundance of exuviae indicates that a large population developed in that area (but see "Colony establishment in the field" below). Consequently, this deprived the aphids of favorable sites for larviposition and feeding, and may, therefore, have induced the aphids to emigrate to other sites on the same plant or to other plants.

Comparative development. *P. nigronervosa* had a faster development on TP than on the two resistant hybrids. This faster development is manifested in a significantly shorter total nymphal developmental period ≥ 4.78 days shorter, on average, and lower number of nymphal instars on TP than on the hybrids (range of 4 - 5 and 4 - 6, respectively) (Table 2). Although adult longevity and life span of the aphids on the test variety and hybrids were both insignificantly different, the reproductive period of the aphids on TP was significantly longer than on both resistant hybrids (on average, ≥ 6.77 days longer). Moreover, the mean total number of offspring for each female (fecundity) on the former was significantly higher than those females reared on the latter (8.92 vs. 4.33) (Table 2).

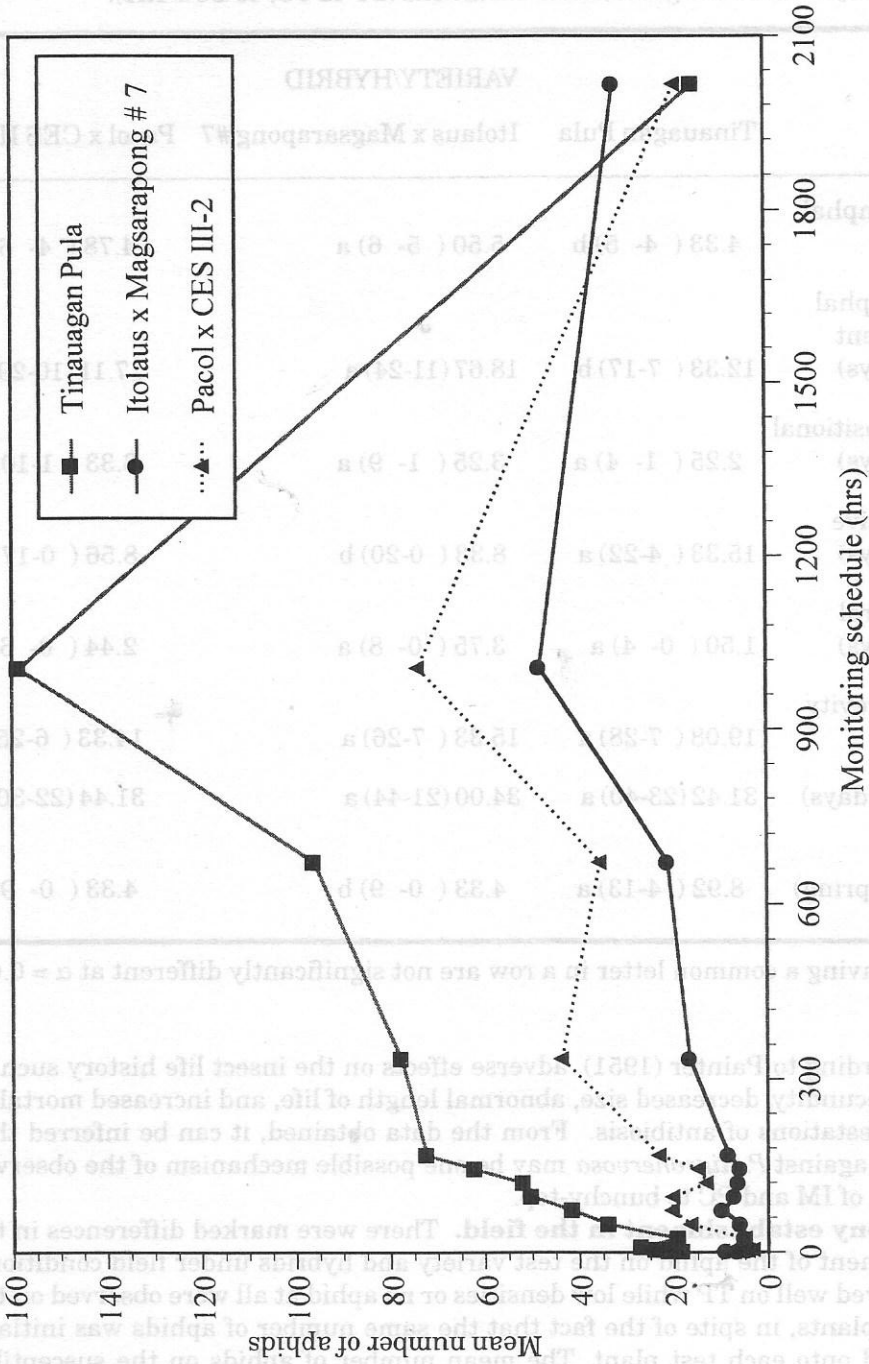


Figure 1. Mean number of aphids at different monitoring times showing preference for the abaca bunchy-top susceptible variety, Tinauagan Pula. For statistical significance, refer to Table 1.

Table 2. Development and reproduction of *P. nigronervosa* on the test variety and hybrids under greenhouse conditions (24-42 0C; 40-80% RH).*

	VARIETY/HYBRID		
	Tinauagan Pula	Itolaus x Magsarapong #7	Pacol x CES III-2
No. of nymphal instars	4.33 (4- 5) b	5.50 (5- 6) a	4.78 (4- 6) b
Total nymphal development period (days)	12.33 (7-17) b	18.67 (11-24) a	17.11 (10-29) a
Prelarvipositional period (days)	2.25 (1- 4) a	3.25 (1- 9) a	3.33 (1-10) a
Reproductive period (days)	15.33 (4-22) a	8.33 (0-20) b	8.56 (0-17) b
Postpartural period (days)	1.50 (0- 4) a	3.75 (0- 8) a	2.44 (0- 6) a
Adult longevity (days)	19.08 (7-28) a	15.33 (7-26) a	14.33 (6-25) a
Life span (days)	31.42 (23-40) a	34.00 (21-44) a	31.44 (22-30) a
Fecundity (no. of offspring)	8.92 (4-13) a	4.33 (0- 9) b	4.33 (0- 9) b

* Means having a common letter in a row are not significantly different at $\alpha = 0.05$.

According to Painter (1951), adverse effects on the insect life history such as reduced fecundity, decreased size, abnormal length of life, and increased mortality are manifestations of antibiosis. From the data obtained, it can be inferred that antibiosis against *P. nigronervosa* may be one possible mechanism of the observed resistance of IM and PC to bunchy-top.

Colony establishment in the field. There were marked differences in the establishment of the aphid on the test variety and hybrids under field conditions. They thrived well on TP while low densities or no aphid at all were observed on the resistant plants, in spite of the fact that the same number of aphids was initially introduced onto each test plant. The mean number of aphids on the susceptible variety was always greater than those of the two resistant hybrids in all monitoring times (Table 3 and Fig. 2). Results from this field experiment (Table 3) coincided well with those of the greenhouse experiments (Table 1 and Facundo, 1991) and those conducted in the laboratory (Facundo, 1991).

Table 3. Mean number of aphids on each test variety/hybrid at weekly monitoring in the field experiment on colony establishment.*

WEEK NO.	VARIETY/HYBRID		
	Tinauagan Pula	Itolaus x Magsarapong # 7	Pacol x CES III-2
1	30.40 a	17.60 b	13.00 b
2	42.80 a	13.20 b	8.00 b
3	44.40 a	14.60 a	10.00 ab
4	10.80 a	5.00 a	3.60 a
5	30.40 a	4.60 a	15.60 a
6	20.60 a	5.40 a	6.00 a
7	25.00 a	4.00 b	1.40 b
8	33.60 a	6.60 b	1.20 b
9	42.40 a	6.40 b	2.20 b
10	60.40 a	7.20 b	0.40 b
11	96.60 a	6.00 b	1.40 b
12	100.20 a	4.00 b	8.20 b
13	94.60 a	9.80 b	19.60 ab

*Mean of five replicates. Means having a common letter in a row are not significantly different at $\alpha = 0.05$.

The aphid population on TP in the field (Fig. 2) did not decline unlike that in the greenhouse (Fig. 1). High densities of exuviae and presence of sooty molds on the preferred sites (i.e. bract and young leaf) were less frequently observed in the field plants. Their build-up may have been limited by existing air currents in the field which was absent in the greenhouse. The wind was a vital factor in removing the expelled skin of the aphid from the preferred sites, that consequently reduced the possibility of crowding which was only observed in the greenhouse experiment. In the case of sooty molds, ants were available to tend the aphids as well as harvest their excreted honeydew (Way, 1963), and therefore, may have prevented honeydew accumulation on the plant surfaces. These mutualists were excluded from the plant in the greenhouse experiment.

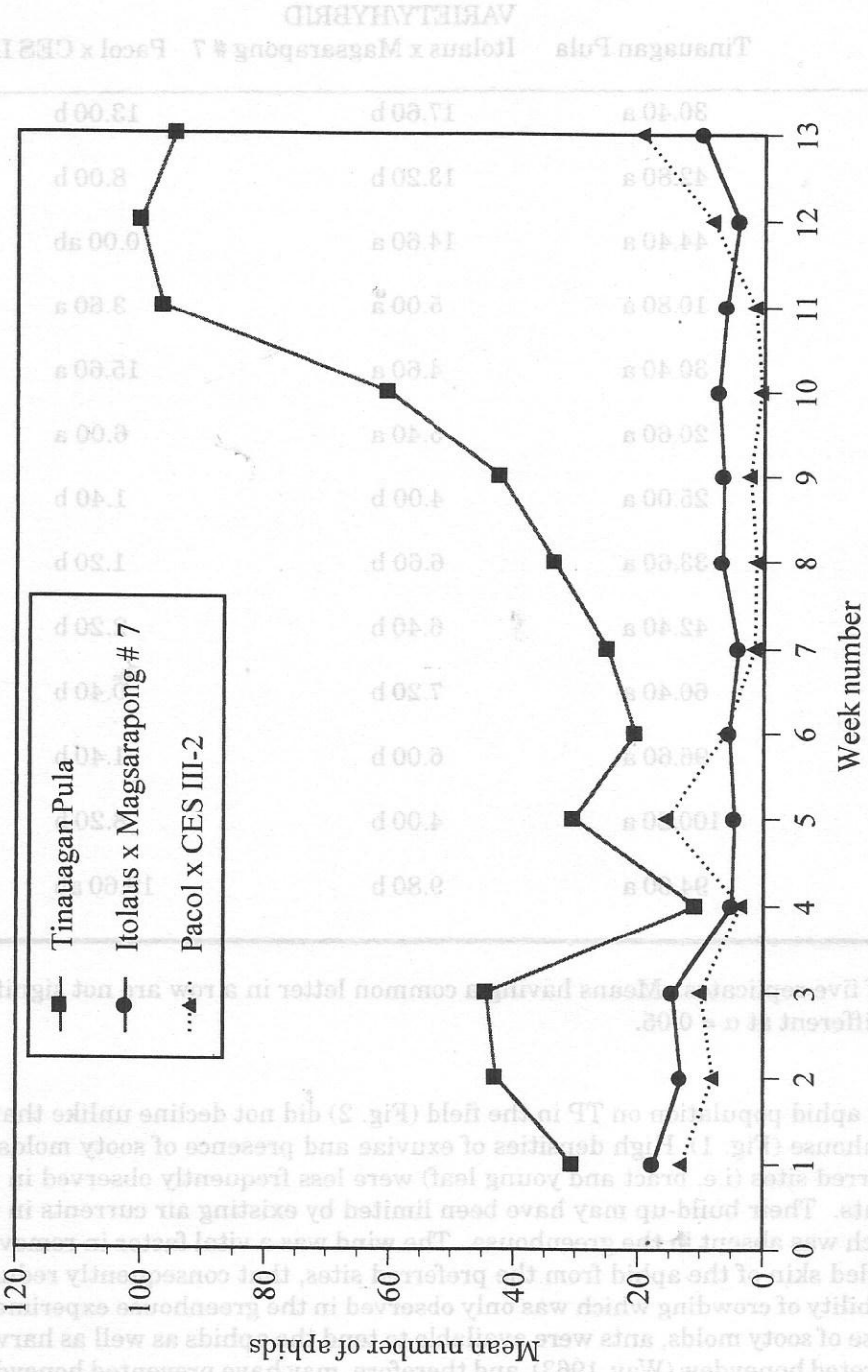


Figure 2. Mean Number of *P. nigronervosa* at weekly monitoring in the experiment to determine colony establishment on each test variety/hybrid in the field. For statistical significance, refer to Table 3.

The various feeding preference and comparative development experiments conducted in the laboratory, greenhouse, and field reported in this paper and by Facundo (1991) give strong indications that the resistance of the test hybrids to AET is due, at least in part, to antibiosis, or both antixenosis and antibiosis working against its vector, *P. nigronevosa*.

ACKNOWLEDGEMENTS

We would like to thank the following institutions and individuals: the Institute of Plant Breeding, through its abaca varietal improvement program, for providing the facilities and part of the experimental materials; LIPRA Philippines, Inc. for the thesis support to HTF; Edith Lomerio of FIDA in Bicol for providing part of the test materials; Merdelyn Caasi-Lit for her invaluable suggestions for the improvement of this study; Terry Solivas, Melvin Ebuenga, and Celia Medina for their help in the statistical analyses; and Helen Juanillo, Liza Canlas, Maritz Salinas, Joel Mora, Nars Bajet, Luz Sison, Dante Facundo, and Maggie Diaz, for the various assistance extended during the conduct of the experiments.

LITERATURE CITED

- CARTER, C. I. and J. F. A. NICHOLS. 1986. The lime aphid, *Eucallipterus tiliæ*, p. 342. In B. Juniper and R. Southwood (eds.), *Insects and the Plant Surface*. Great Britain: Edward Arnold (Publishers) Ltd.
- CASTILLO, B. S. and A. L. MARTINEZ. 1961. Occurrence of bunchy-top disease of banana in the Philippines. *FAO Plant Prot. Bull.* 9: 74-75.
- DALE, J. L. 1987. Banana bunchy-top: an economically important tropical plant virus disease. *Adv. Virus Res.* 33: 301-325.
- DE CASTRO, N. L., M. L. SARDIDO, J. B. ALINO, JR., and N. R. DEOMAMPO. 1988. Abaca. *Commodity Industry Analysis # 2*. Los Baños, Laguna: Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, 42 p.
- DETHIER, V. G. 1970. Some general considerations of insects' response to the chemicals in food plants, pp. 21-28. In D. L. Wood, R. M. Silverstein, and M. Nakajima (eds.), *Control of Insect Behavior by Natural Products*. New York: Academic Press.
- FACUNDO, H. T. 1991. Feeding preference for and comparative development of *Pentalonia nigronervosa* Coq. (Homoptera: Aphididae) on bunchy-top-susceptible abaca variety and resistant hybrids. B. S. thesis. Laguna, Philippines: University of the Philippines Los Baños, 65 p.
- FIBER INDUSTRY DEVELOPMENT AUTHORITY. 1986. World abaca fiber exports (1981-1985). *The Situationer*, 1-7.
- HANSON, F. E. 1983. The behavioral and neurophysiological basis of food plant selection by lepidopterous larvae, pp. 3-23. In K. F. Harris and K. Maramorosch (eds.), *Aphids as Virus Vectors*. New York: Academic Press.
- MAGNAYE, L. V. 1979. Studies on the identity and relationship of the abaca and banana bunchy-top virus in the Philippines. M. S. thesis. Laguna, Philippines: University of the Philippines Los Baños, 112 p.
- MARTINEZ, A. L. and B. S. CASTILLO. 1965. An evidence for the similarity of banana and abaca bunchy-tops. [Abstract] *Philipp. Phytopathol.* 1: 35-36.
- PAINTER, R. H. 1951. *Insect Resistance in Crop Plants*. Kansas: Kansas State University Press, 520 p.
- PHILIPPINE COUNCIL FOR AGRICULTURE AND RESOURCES RESEARCH. 1977. The Philippines recommends for abaca, 71 p.
- WAY, M. J. 1963. Mutualism between ants and honeydew-producing Homoptera. *Ann. Rev. Ent.* 8: 307-344.
- WOODHEAD, S. and R. F. CHAPMAN. 1986. Insect behavior and the chemistry of plant surface waxes, pp. 123-135. In B. Juniper and R. Southwood (eds.), *Insects and the Plant Surface*. Great Britain: Edward Arnold (Publishers) Ltd.