Journal of
Entomology

ISSN 1812-5670

Academic
Journals Inc.

www.academicjournals.com

Journal of Entomology 11 (5): 283-290, 2014
ISSN 1812-5670 / DOI: 10.3923/je.2014.283.290

Efficacy of Selected Insecticides and Application Methods in Controlling *Aleurodicus dispersus* (Homoptera: Aleyrodidae) on Pepper Plants

Andi Nasruddin, Ahwiyah Eka Said, Muhammad Said Baco and Jumardi
Department of Plant Pests and Diseases, Faculty of Agriculture, Hasanuddin University, Makassar, South Sulawesi, 90245, Indonesia

Corresponding Author: Andi Nasruddin, Department of Plant Pests and Diseases, Faculty of Agriculture, Hasanuddin University, South Sulawesi, 90245, Indonesia

ABSTRACT

Spiraling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae), was detected for the first time causing serious damages on pepper in South Sulawesi Province of Indonesia in 2012. Farmers rely mainly on insecticide for its control however, this effort apparently failed to provide satisfactory control. The failure probably stemmed from inappropriate insecticide choice and application method. Thus, the purpose of the current study was to evaluate the efficacy of commercially available insecticides and application methods on suppressing the whitefly. Ten formulated insecticides with different active ingredients were evaluated in a field trial against the adult and nymphal whitefly. The same insecticides were also tried to determine their efficacy against the adult populations in a leaf-dip bioassay in the laboratory. Another field trial was conducted to compare the effectiveness of two different application methods; partial coverage spray practiced by farmers and full coverage spray. Fipronil, lambda-cyhalothrin, fenobucarb and imidacloprid consistently had the lowest numbers of adults during the trial. While, pipronil, lambda-cyhalothrin and imidacloprid had the least numbers of nymphs. Overall, however, all insecticides were highly effective in suppressing the whitefly populations with reduction levels ranging from 85.7% (cypermethrin) to 99.3% (imidacloprid) for the nymph and 87.8% (cypermethrin) to 99.7% (imidacloprid) for the adult. Laboratory bioassay results showed that all insecticides effectively controlled the adult whitefly with mortality rates from 80-100% 24 h and 100% 48 h after the insecticide application. The results of the field trial comparing two application methods showed that the partial spray coverage (farmers' method) failed to lower the whitefly population, while the full spray coverage method successfully suppressed the pest population. Therefore, the ineffectiveness of insecticides use so far was probably due to the inappropriate choices of insecticides and application method by the farmers.

Key words: Spiraling whitefly, *Aleurodicus dispersus*, insecticides, application method

INTRODUCTION

The spiraling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae), is a polyphagous species native to Caribbean Region and Central America. The insect has spread westward across the pacific and reached Southeast Asia (Waterhouse and Norris, 1989). The first detection of spiraling whitefly in Indonesia was recorded in 1989 in Java. The insect was reported attacking 22 plant species in 14 families, including ornamentals, shade and fruit trees in Java (Kajita *et al.*, 1991). Later study indicated that the spiraling whitefly infested 111 species of plants, belonging to 53 families in Java (Murgianto, 2010). The spiraling whitefly was also found on cassava, papaya, pepper, banana, hibiscus and ficus in West Java (Gniffke, 2011). A low population of the spiraling whitefly was reported on pepper (*Capsicum annum* L.) in West Java (Yuliani *et al.*, 2005). However, no reports of serious injury to pepper crops, due to the spiraling whitefly in Indonesia, were available until we found heavy crop damages due to immense whitefly infestations in 2012. The lower leaf surfaces were fully covered with developing whiteflies and waxy filaments produced by the immature stages. The leaves were cupped upwards and covered with sooty mold. Whitefly samples collected from pepper crops in Pinrang in 2013 were confirmed as *A. dispersus* (Nasruddin and Stocks, unpublished data).

Farmers rely mainly on insecticide use for the control of the spiraling whitefly. They currently spray every 2-3 days using a mixture of up to 5 insecticides to achieve a satisfactory control. This control practice is highly potential to detrimentally affect non-target organisms and the environment. Two major factors probably contribute to the ineffectiveness of the insecticide use. First, farmers' choices of insecticides are based on their own experiences in controlling other pests because no insecticide recommendations are available yet for the new pest. The second factor is the way the farmers apply the insecticide does not provide complete coverage of the plant leaves, especially the lower surface of the leaves. This is similar to the case when ineffectiveness of insecticide use occurred because aerially sprayed insecticides did not provide thorough coverage on the lower surface of cotton leaves (Johnson *et al.*, 1982). During the surveys, we observed farmers spraying their crops by directing the nozzle downwards and moving the boom from the top to the bottom leaves (Nasruddin, unpublished). Therefore, the lower leaf surface where the whiteflies mostly reside was most likely not completely covered by the spray.

The pepper growers had an emergency need for information about quick and effective control measures against the insect. Therefore, the purpose of the current study was to evaluate the efficacy of selected insecticides against the spiraling whitefly in both field and laboratory experiments. We also compared the effectiveness between farmers' spraying method providing partial spray coverage and another method ensuring complete spray coverage for both upper and lower leaf surfaces.

MATERIALS AND METHODS

Field trial: An insecticide field trial was conducted in pepper growers' field in Padang Loang, Pinrang District from Feb to Mar 2013. In the field trial, application dosages used were in accordance to the label-recommended concentrations for respective insecticides as listed in Table 1. Insecticide treatments were arranged in a complete randomized block design with three replications. Each replication consisted of a plot of two rows wide and 10 m long, with plant spacing of 1.0 m between rows and 0.5 m within a row. In this experiment, pepper cv. Rusa was used, the same cultivar planted by the local growers, which was heavily infested by *A. dispersus*. The experimental plot was surrounded by commercial pepper plantations and left unsprayed for the first 10 weeks to build up high level of whitefly infestation. Spiraling whitefly infestation of the experimental plot occurred naturally. Insecticides were applied 11, 12 and 13 weeks after plant emergence, using battery-powered, knapsack sprayer (Agropower 3WBD-16LA) (Taizhou Taike Electronics Co., Ltd. Zhejiang, China).

Before each insecticide application, 20 compound leaves per plot were randomly selected for adult whitefly counts. The number of adult whiteflies was determined by directly counting the adults present on underside of the leaves. The same leaf samples were collected and separately placed in zip-locked bags (5×8 cm) and then brought back to our lab for nymph counts under a dissecting microscope.

Laboratory bioassay: An insecticide bioassay was conducted at the Laboratory of Insect in Relation to Plant Disease, Faculty of Agriculture, Hasanuddin University, Makassar, South Sulawesi, Indonesia. Adult spiraling whiteflies were collected from different farmers' fields in Padang Loang, Pinrang on May 3, 2013 and then brought back to our lab for insecticide bioassay 24 h after the collection. In this assay, the same commercially formulated insecticides and their respective recommended dosages were used (Table 1). Insecticide treatments were arranged in a completely randomized design with three replications. Three leaf disks (diameter 6 cm) were immersed into each insecticide diluted in distilled water. For control, the disks were dipped in distilled water only. The leaf disks were then individually placed into a plastic petri dish (diameter, 6.5 cm), lined with moist filter paper on its bottom. The dishes were left uncovered for 45 min to let the leaf disks air dry. Twenty adult whiteflies were collected from pepper leaves using a mouth aspirator and then placed into each dish. The dishes were kept in room temperature (27±1°C) with a photoperiod of 12:12 (L:D). Whitefly mortality in each dish was recorded 24 and 48 h after the initiation of the assay.

Effectiveness of partial spray coverage method and complete spray coverage method: Two weeks old pepper seedlings cv. Rusa were transplanted on June 15, 2013. Two treatments of insecticide spray methods were evaluated in this experiment. Treatments were arranged in a randomized complete block design with four replications and each replication consisted of a plot (four rows wide×10 m long) with 1 and 0.5 m between rows and within a row, respectively. First method was the local farmers' practice that provided partial insecticide coverage (lower leaf surface partially covered by insecticide). While, the second method ensured that both leaf surfaces receive thorough spray coverage; the nozzle was aimed to the lower surface of the lowest leaves and moved upwards to the top of the plant and then it was aimed to the upper surface of the top leaf and moved downward to the lowest leaf. Spray volume used was equivalent to 600 L ha^{-1} as oppose to famers' practice with spray volume of 300 L ha^{-1} but with the same amount of insecticide used for

Table 1: Insecticides and their active ingredients (a.i.) used in the field trial against *Aleurodicus dispersus* on pepper

Trade name	Active ingridient	Rate[a] (mL L^{-1})	Manufacturer/supplier
Abacyper 30/125 EC	Abamectin+cypermethrin	2	PT. Dharma Guna Wibawa
Penalty 50 EC	Fipronil	0.5	PT. Dharma Guna Wibawa
Sidamethrin 50 EC	Cypermethrin	2	PT. Petrosida Gresik
Chlormyte 400 EC	Chlorpyrifos	1	PT. Agro Persada
Demolish 18 EC	Abamectin	0.5	PT. Dharma Guna Wibawa
Polydor 25 EC	λ-cyhalothrin	2	PT. Biotis Agrindo
Dharmabas 500 EC	Fenobucarb	2	Perusahaan Perdagangan Indo (Persero)
Trisula 450 SL	Monosultap	0.5	PT. Multi Sarana Indotani
Buldok 25 EC	β-cyfluthrin	2	Artha Buana Mandiri Surabaya
Providor 30 WP	Imidacloprid	1.0 g L^{-1}	Artha Buana Mandiri Surabaya

[a]Commercial formulation

both methods. Abamectin was used in this experiment with a recommended spray dose of 0.5 mL L^{-1} of water. The insecticide was applied weekly on August 22, 29 and September 5, 2013.

Before each insecticide application, the number of whitefly adults was counted on each of five plants randomly selected in each plot. For each plant, four fully developed upper and middle leaves were observed. The same number of plants was also observed for the number of whitefly adults in each of the plots sprayed with water only (untreated control). Since the whitefly adults were very sedentary, *in-situ* counts using a hand counter were possible to be done by gently flipping the leaves. The same leaf samples were taken to the laboratory for counting the immature under a binocular microscope (10-40x). The number of adults and nymphs were also estimated on the plants that were sprayed every 2-3 days (farmers' fields).

Data analysis: Adult and nymph counts and adult mortality were individually subjected to a one-way analysis of variance at p = 0.05. If a significant difference among treatments was detected, the treatment means were separated using a Tukey's test (p = 0.05) (BioStat, 2009).

RESULTS

Field trial: The numbers of adult and nymph whiteflies per 20 leaves for the insecticide treatments in the field trial are presented in Table 2 and 3, respectively. All insecticides tried were capable of maintaining the adult and nymph whitefly populations at the levels of significantly lower than the population levels on the unsprayed check plants during the trial. The number of adult and nymph whiteflies found on the control check increased during the study while, there was a tendency that for each insecticide used the number of adult and nymphal whiteflies found per plant decreased as the study progressed. Pipronil, lambda-cyhalothrin, FENOBUCARB and imidacloprid consistently had the lowest numbers of adults throughout the trial. While, pipronil, lambda-cyhalothrin and imidacloprid consistently showed the least numbers of nymphs among the insecticides tested. However, after three weekly applications, the numbers of whitefly per plant in

Table 2: Mean numbers of adult whiteflies per 20 leaves of pepper plants

	Whitefly numbers per 20 leaves (Mean±SE)				
	March				
Treatment	6	13	20	Overall mean	Reduction (%)[1]
Untreated control	79.7±11[a]	228.2±14.6[a]	339.9±32.5[a]	215.9	-
Farmers' practice[2]	3.4±1.0[d]	3.6±0.7[c]	6.2±0.6[c]	4.4	97.5
Abamectin+cypermethrin	30.1±4.6[bc]	6.7±1.2[bc]	2.3±1.3[c]	13.0	94.0
Fipronil	4.7±0.4[d]	13.8±3.1[bc]	1.0±0.5[c]	6.5	97.0
Cypermethrin	39.1±6.1[b]	28.1±7.3[b]	11.9±3.9[b]	26.4	87.8
Chlorpyrifos	16.1±3.7[bc]	2.2±0.7[c]	0.0±0.0[c]	6.1	97.2
Abamectin	17.1±3.5[bc]	12.2±1.6[bc]	2.0±0.5[c]	10.4	95.2
λ-cyhalothrin	1.0±0.0[d]	1.0±0.0[c]	0.0±0.0[c]	0.7	99.7
Fenobucarb	5.9±1.2[d]	12.3±1.0[bc]	2.0±0.3[c]	6.7	97.0
Monosultap	12.2±2.2[cd]	0.0±0.0[c]	12.0±4.7[b]	8.1	96.3
β-cyfluthrin	22.5±2.6[bc]	1.0±0.5[c]	4.9±1.2[c]	9.5	95.6
Imidacloprid	1.0±0.1[d]	1.0±0.1[c]	0.0±0.0[c]	0.7	99.7

Means within a column followed by the same letter are not significantly different (p = 0.05, according to Tukey's test), [1]Reduction of adult population for each treatment relative to adult population in the untreated control , [2]Farmers' practice were sprayed every 2-3 days with a mixture of up to 5 insecticides

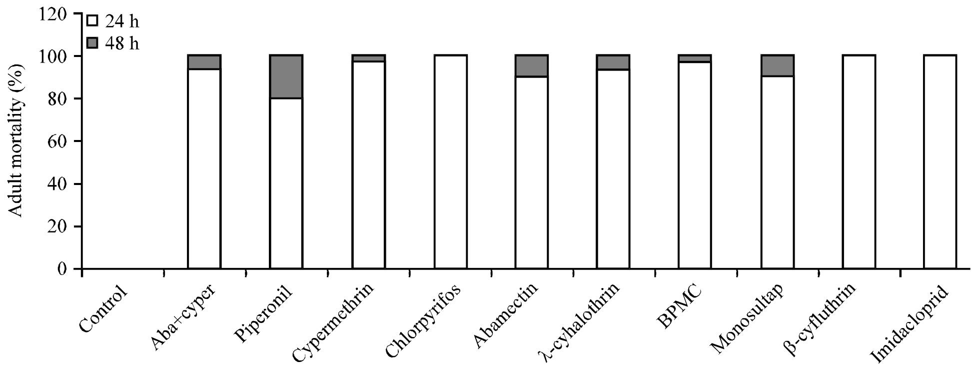

Fig. 1: Percent mortality of adult whiteflies after being exposed to insecticides for 24 and 48 h in a leaf-dip bioassay at a recommended rate for each insecticide. Significant differences (Tukey's test, p>0.05) are indicated by different letters for adult mortality after 24 h exposure. After 48 h exposure period, mortality reached 100% for all insecticides tested

Table 3: Mean numbers of immature whiteflies per 20 leaves of pepper plants

	Whitefly numbers per 20 leaves (Mean±SE)				
	March				
Treatment	6	13	20	Overall mean	Reduction (%)[1]
Untreated control	210.1±24.7[a]	546.6±28.6[a]	601.3±32.5[a]	452.7	-
Farmers' practice[2]	24.2±6[e]	5.0±1.1[d]	6.0±0.6[b]	11.7	97.4
Abamectin+cypermethrin	101.2±12.6[c]	21.0±2.2[c]	4.3±1.3[b]	42.1	90.7
Fipronil	17.8±2.1[f]	9.0±4.1[cd]	3.0±0.5[b]	9.9	97.8
Cypermethrin	120.1±15.4[b]	64.6±12.3[b]	9.6±3.9[b]	64.8	85.7
Chlorpyrifos	61.3±7.4[d]	12.0±1.7[cd]	3.0±0.0[b]	25.4	94.4
Abamectin	54.5±6.5[d]	16.5±2.6[c]	7.0±0.5[b]	26.0	94.3
λ-cyhalothrin	10.2±0.0[f]	5.0±1.0[d]	0.0±0.0[b]	5.1	98.9
Fenobucarb	24.3±3.1[e]	12.0±1.2[c]	4.5±0.3[b]	13.6	97.0
Monosultap	41.2±5.2[de]	21.0±2.4[c]	12.0±4.7[b]	24.7	94.5
β-cyfluthrin	67.5±9.2[d]	14.5±1.1[c]	6.9±1.2[b]	29.6	93.5
Imidacloprid	3.4±0.8[f]	6.5±0.6[d]	0.0±0.0[b]	3.3	99.3

Means within a column followed by the same letter are not significantly different (p = 0.05, according to Tukey's test), [1]Reduction of immature population for each treatment relative to immature population in the untreated control, [2]Farmers' practice were sprayed every 2-3 days with a mixture of up to 5 insecticides

all insecticide treatments were not significantly different (p>0.05) from the population in growers' fields, which was sprayed 2-3 times a week. Average reductions of whitefly populations due to the insecticide applications ranged from 87.8% (cypermethrin) to 99.7% (imidacloprid) for the adult and 85.7% (cypermethrin) to 99.3% (imidacloprid) for the immature (Table 2, 3).

Laboratory bioassay: The results of the leaf dip bioassay showed that all insecticides tested effectively controlled the adult whitefly with mortality rates ranged from 80-100% and 100% mortality for all insecticides 24 and 48 h after the initiation of the assay, respectively (Fig. 1). No insect mortality was found in the control check 48 h after the insecticide application.

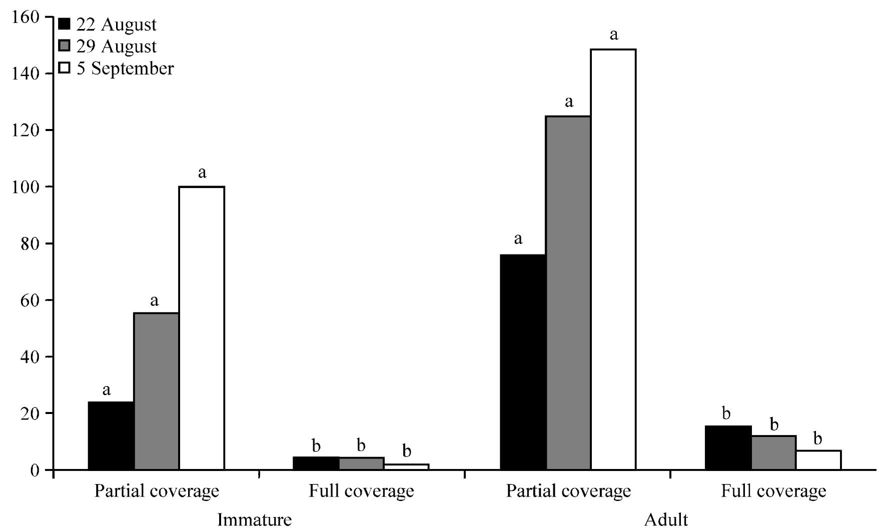

Fig. 2: Numbers of adult and immature whiteflies per 20 leaves after the application of abamectin using two methods of application: partial spray coverage and full spray coverage. Adult or nymph means with different letters are significantly different ($p<0.05$) for each date of insecticide application

Comparison between partial and complete spray coverage methods: For the partial spray coverage method (farmers' practice), the numbers of adults and nymphs constantly increased as the trial progressed. In contrast, the number of adults and nymphs in the complete coverage treatment tended to decrease during the course of the trial. For each application date, the number of adults or nymphs in the partial coverage treatment was significantly greater than in the complete coverage treatment ($p<0.05$) (Fig. 2).

DISCUSSION

During the first eight weeks after plant emergence, very few whitefly individuals (mostly adult) were found. This agreed with farmers' observation that high population of whitefly started after the first harvest, which is about 8-9 weeks after plant transplanting. It was not obvious from our observation whether the phenomenon was due to the first massive immigration of the giant whitefly at the location occurs at that particular time of the season or plants at this age are more suitable for the whitefly population to grow. This, of course, needs to be elucidated in further studies.

All weekly-applied insecticides were individually effective in suppressing the adult and nymph whitefly populations in the field. Similarly, all insecticides tested caused 100% adult mortality 48 h after the initiation of the bioassay. The results indicated that the spiraling whitefly had not developed resistant populations against the insecticides. The probable explanation for this is that the whitefly had become a problem on pepper in the area of experiment since 2011 or only two planting seasons prior to the study. Two seasons of heavy insecticide use probably did not provide a strong selection pressure, enough to elicit an establishment of resistant populations to the insecticides used. Besides that, the resistance could be slowed down by the use of insecticide mixture of up to 5 insecticide brand names by the farmers. Insecticide mixture is capable of slowing down the development of insect resistance to insecticides (Cloyd, 2010).

Imidacloprid and lambda-cyhalothrin were the most effective insecticides against both adult and nymphal whiteflies. This is in agreement with Cranshaw (2013) that the most effective insecticides against greenhouse whitefly were imidacloprid and pyrethrins or pyrethroid insecticides.

Our results also suggested that the inappropriate application method used by the farmers, in which the spray covered only the upper leaf surface, was the main reason why the use of insecticide by the farmers so far was less effective. The partial spray coverage did not kill most of the whiteflies, especially the immature stages that mostly occupy and grow on the lower leaf surface (Botha *et al*., 2000; Banjo, 2010). This condition was similar to the ineffective coverage of aerially applied insecticides on the underside of cotton leaves that allowed the whitefly population to grow and secrete honeydew (Fullerton, 1982; Johnson *et al*., 1982; Prabhaker *et al*., 1989). Insecticides applied directly on the underside of cotton canopies provided effective control on eggs and larval stages up to 48 h after the insecticide application (Prabhaker *et al*., 1989).

CONCLUSION

All insecticides tested in the field experiment effectively suppressed both adult and nymph populations of *A. dispersus*. In addition, laboratory bioassay showed that after 48 h, the applications of the insecticides, all treated adult whiteflies were dead in all treatments but none in the control. These results suggested that the spiraling whitefly populations found in Padang Loang were still susceptible to all insecticides tested. Full coverage spray method was far more effective in controlling the spiraling whitefly on pepper than the farmers' method. Our results are invaluable for pepper growers in terms of the availability of information about effective insecticides with different mode of actions that can be used in rotation. Therefore, an integration of the rotation of effective insecticide and full coverage spray method will provide satisfactory control of the spiraling whitefly, while preventing or delaying the establishment of resistant populations against the insecticides.

ACKNOWLEDGMENT

The study was funded by the Institute for Research and Extension, Hasanuddin University, Makassar Indonesia; Project No. 80/UN4-LK.26/2012.

REFERENCES

Banjo, A.D., 2010. A review of on *Aleurodicus dispersus* Russel. (spiralling whitefly) [Hemiptera: Aleyrodidae] in Nigeria. J. Entomol. Nematol., 2: 001-006.

BioStat, 2009. Statistical Analysis Program. AnalystSoft Inc., USA.

Botha, J., D. Hardie and G. Power, 2000. Spiraling whitefly, *Aleurodicus disperses*: Exotic threat to Western Australia.. Fact Sheet No. 18/2000, Agriculture Western Australia, Western Australia, July http://archive.agric.wa.gov.au/objtwr/imported_assets/content/pw/ins/pp/hort/fs01800.pdf.2000

Cloyd, R.A., 2010. Pesticide mixtures and rotations: Are these viable resistance mitigating strategies? Pest Technol., 4: 14-18.

Cranshaw, W.S., 2013. Greenhouse whitefly. Fact Sheet No. 5.587, Colorado State University, U.S. Department of Agriculture and Colorado Counties Cooperating, USA.

Fullerton, D., 1982. Effects of plant coverage in whitefly control. Arizona Agric. Exp. Stat. Rep., 56: 117-118.

Gniffke, P.A., 2011. Integrated Disease Management (IDM) for anthracnose, *Phytophthora* blight and whitefly-transmitted geminivirus in chilli pepper in Indonesia. Final Report No. FR2011-22, Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia.

Johnson, M.W., N.C. Toscano, H.T. Reynolds, E.S. Sylvester, K.R. Kido and E.T. Natwick, 1982. Whiteflies cause problems for Southern California growers. California Agric., 36: 24-26.

Kajita, H.S., I.M. Samudra and A. Naito, 1991. Discovery of the spiraling whitefly *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) from Indonesia, with notes on its host plants and natural enemies. Applied Entomol. Zool., 26: 397-400.

Murgianto, F., 2010. The host range kutukebul *Aleurodicus destructor* Mackie, *Aleurodicus dispersus* Russell and *Aleurodicus dugesii* Cockerell (Hemiptera: Aleyrodidae) in District Dramaga Bogor Regency and others in the surrounding area]. Master's Thesis, Institut Pertanian Bogor (IPB), Bogor Agricultural University, Indonesia, (In Indonesian).

Prabhaker, N., N.C. Toscano and D.L. Coudrie, 1989. Susceptibility of the immature and adult stages of the sweetpotato whitefly (Homoptera: Aleyrodidae) to selected insecticides. J. Econ. Entomol., 78: 983-988.

Waterhouse, D.F. and K.R. Norris, 1989. Biological Control: Pacific Prospects, Supplement 1. Australian Centre for International Agricultural Research, Canberra, Australia, ISBN-13: 9780949511980, Pages: 123.

Yuliani, P. Hidayat and D. Sartiami, 2005. Identification of whiteflies (Hemiptera: Aleyrodidae) from several host plants and their population growth. J. Entomol. Indonesia, 3: 41-49.