INSECTICIDAL EFFECTS OF SELECTED SOAPS, OILS AND DETERGENTS ON THE SWEETPOTATO WHITEFLY: (HOMOPTERA: ALEYRODIDAE)

G. D. BUTLER, JR.[1], T. J. HENNEBERRY[1], P. A. STANSLY[2], AND D. J. SCHUSTER[3]

[1]USDA, Agricultural Research Service,
Western Cotton Research Laboratory,
Phoenix Arizona 85040

[2]University of Florida/IFAS,
S.W. Florida Research and Education Center,
Immokalee FL 33934

[3]University of Florida/IFAS,
Gulf Coast Research and Education Center,
Bradenton Florida 34203.

ABSTRACT

Efficacy against the sweetpotato whitefly (SPWF) *Bemisia tabaci* (Gennadius) of an insecticidal soap, two horticultural oils (one vegetable and the other petroleum based) and 15 detergents was evaluated under greenhouse conditions. Applications were directed to the underside of infested zucchini squash, tomato, or poinsettia leaves. Live nymphs were distinguished by their ability to deposit honeydew on water-sensitive paper held in contact. With the exception of 3 detergents, all materials evaluated at 1% concentration caused greater than 85% mortality of SPWF nymphs compared to applications of water. Similar results with 2 detergents and an insecticidal soap were obtained on infested cucumber leaves treated in the field in Florida. Saf-T-Side (mineral) Oil™, Natur'l™ (vegetable) oil, New Day™ liquid detergent or M-Pede™ applied with a mist blower reduced numbers of SPWF adults in heavily infested cucumber plots, although only Saf-T-Side Oil resulted in a significant reduction of nymphs.

RESUMEN

Se evaluaron bajo condiciones de invernadero 15 detergentes caseros, un jabon insecticida y dos aceites agricolas (uno derivado de algodon y el otro de petroleo) por su eficacia contra ninfas de la mosca blanca *Bemisia tabaci*. Las aplicaciones se hicieron a traves de asperciones dirigidas al enves de hojas de calabaza, zucchini, tomate y poinsettia. Las ninfas vivas fueron distinguidas por su abilidad de manchar el papel sensible al agua al hacer contacto con este. Con la excepción de 3 detergentes, se obtuvo una mortalidad mayor del 85% en materiales con una concentracion del 1% comparado con el agua. En el campo, en Florida, se obtuvo resultados similares con el jabon insecticida y 2 detergentes aplicados a las hojas de pepino. En parcelas de pepino fuertemente infestadas por *B. tabaci*, se observó reducciones en el numero de adultos despues de aplicaciones de los aceites agricolas "Saf-T-Side™, y "Natur'l"™, del detergente liquido "New Day"™ o del jabon insecticida "M-Pede"™, utilizando un aspersor motorizado de espalda. El tratamiento con aceite "Saf-T-Side" fue el unico que causó reduccion de ninfas.

Soaps and oils may have been among the first chemicals used to control insects (Puritch 1981). Although later replaced by synthetic organic compounds, increasing need for safer, environmentally compatible materials has renewed interest in the older-type insecticides. The mode of action of soaps, detergents and oils remains uncertain, but may involve removal of insect cuticle wax, physical action, repellency or cell membrane disruption (Hodgson & Kuhr 1990, Larew & Locke 1990).

Sweetpotato whitefly (SPWF), *Bemisia tabaci* (Gennadius), has developed resistance to all classes of commercially available insecticides (Forror 1990). Emulsions of cottonseed oil gave effective control of the sweetpotato whitefly in cotton in Israel and in India when good plant coverage on the underside of leaves was obtained with either air-assisted ground sprayers or hand equipment (Broza et al. 1988, Puri et al. 1991). Studies in India showed that an inexpensive laundry detergent, Nirma (Patel Detergents, Mehsana, India), also induced high mortality levels of immature SPWF stages. Additionally, promising results have been obtained with plant-derived oils and detergent combina tions for control of aphids, mites and SPWF on cotton and a number of vegetable crops (Butler & Henneberry 1990a,b). We conducted greenhouse studies in Arizona and field studies in Florida in 1991 with a wide variety of detergents, soaps, and oils to determine their effect on SPWF infestations of different host species.

Materials and Methods

Greenhouse Studies at Phoenix, Arizona

Potted plants in a greenhouse were colonized with SPWF obtained from infested cotton and poinsettia plants. Leaves heavily infested with 2nd and 3rd instar nymphs were identified by visual examination, tagged and numbered. Individual leaves were then assigned to treatments in a randomized complete block design with 8 replications. One such experiment was carried out with zucchini squash, one with tomato, one with eggplant and two with poinsettia, each experiment using a different set of treatments.

The following is a list of tested materials by manufacturer ([L] = liquid; [P] = powder). All are detergents unless otherwise noted. Colgate-Palmolive Co., New York, NY: (1) Ajax™ (New) [P], (2) Palmolive™ [L]; ™Proctor & Gamble, Cincinnati, OH: (3) Cheer™ (Ultra) [P], (4) Crisco™ soybean oil (5) Dawn™ [L] (6) Ivory™ [L] , (7) Ivory Snow™ [P] (soap), (8) Joy™ [L], (9) Tide™ [L], (10) Tide™ (Ultra) [P]; Lever Bros., New York NY: All™ [P], (11) Dove [L]; Mycogen Corp., San Diego, CA: (12) M-Pede™ (soap, formerly called Safer Insecticidal Soap™) [L]; Stoller Inc., Houston, TX: (13) Natur'l Oil™ [L] (vegetable oil); Patel Detergents, Mehsana, India: (14) Nirma™ [P]; Planet Products Inc., Scottsdale, AZ: (15) Planet™ [L]; Brandt Chemical, Pleasant Plains, IL: (16) Saf-T-Side™ [L] (mineral oil); Tata Oil Mills, Ltd., Bombay, India: (17) Tata-OK™ [P]; Huish Chem. Co., Salt Lake City, UT: (18) White King™ [P]; Country Safe Corp., Everett WA: (19) Country Safe™; Life Tree Products, Sebastopol CA: (20) Life Tree™; Granny's Old Fashioned Products, Arcadia CA: (21) Power Plus™.

Liquids were tested at 10 ml per 1 liter of water spray (1%). Powders were also measured volumetrically except that 15 ml were used per liter of water. Treatments were applied to runoff with a small hand-held pump sprayer (Ultramist™, Delta Industries, Philadelphia, PA) directed at the underside of infested leaves. Leaves of control plants were sprayed with water.

Two days later treated leaves were collected to estimate the effects on SPWF nymphal survivorship. Each leaf was maintained in contact with a 26 x 38-mm or 36 x 52-mm piece of water-sensitive paper (Spraying Systems Co., Wheaton, Illinois) for 15 m by weigting with a 50 x 9-mm sand-filled plastic petri dish. Discrete drops of honeydew on

each paper were counted with the aid of a binocular microscope and considered evidence of living SPWF nymphs. Clusters or lines of drops produced by a single individual were counted as single drops (Melamed-Madjar et al. 1984, Butler & Henneberry 1990a&b). Data were subjected to analysis of variance procedures, and means were separated by the method of least significant differences contingent upon a significant F test.

Field Studies in Florida (Immokalee and Parrish)

At Immokalee, the effectiveness of 0.062, 0.125, 0.25, 0.5, and 1.0% concentrations of M-Pede™ insecticidal soap, New Day Dish Washing Liquid™ (Peck's Products, Chicago, Illinois) and APSA-80 Spray Adjuvant™ (Amway Corp., Ada, MI) were evaluated in a cucumber field heavily infested with SPWF. Individual leaves were assigned treatments as in the greenhouse studies using a randomized block design with 6 replications. Treatments were applied and evaluated as described above, and analyzed by regression (SAS Institute 1988).

At Parrish Florida, the effects of detergent and oil treated surfaces on alighting adult SPWF were estimated in a commercial cucumber field. Each of the test materials was sprayed individually on paper plates of 25 cm diameter with the hand-held sprayer. Adults were dislodged onto the wet treated surface of the plates by striking the overlying cucumber leaves. Water-treated plates served as controls. The number of adults trapped on the moist surfaces were counted immediately and again 2 h later to obtain percent mortality. Sets of three uncoated paper plates and three plastic-coated paper plates were treated with each material. Percent dead adults was calculated and trans¡formed to arcsines before subjecting to analysis of variance.

At Parrish, Florida, the effectiveness of soap, detergent and oil treatments applied with a mist blower against both nymphs and adult SPWF was determined in three-row, 6 x 4-m plots in a commercial cucumber field after final harvest. Single plant rows were grown on raised beds mulched with plastic film. Treatments were Crisco™ soybean oil, Joy™ liquid detergent, New Day Dish Washing Liquid™, M-Pede™ Insecticidal Soap and Saf-T-Side (mineral) Oil™. The experiment was replicated four times in a randomized complete block design. Materials were applied with a Model 410 Solo™ Motorized Mistblower (Forestry Supplies, Inc., Jackson, MS) calibrated at 823 liters/hectare. Two 15.25 x 15.25-cm yellow sticky traps (Olson Products, Medina, Ohio) were placed horizontally on the bed surface of the middle row of each plot after sprays had dried. The numbers of trapped SPWF adults were counted after 1-h exposures. The number of adults per plot was estimated 24 h after treatments were applied by shaking five leaves from plants in the middle row of each plot over a black aluminum baking pan (33 x 24 cm) coated on the bottom with a thin layer of Natur'l Oil. The number of living immature SPWF on the underside of 5 leaves sampled at random from the middle row of each plot was estimated 48 h after treatment by using the water-sensitive paper metod. Data were subjected to analysis of variance and means were separated using LSD or Duncan's multiple range tests (SAS Institute 1988).

Results and Discussion

Greenhouse Studies

Results are presented as percent reduction compared to the water treatment, with treatments grouped according to the outcome of mean separation tests (Table 1). All treatments were significantly different from the controls ($P \leq 0.05$,). All materials tested with the exception of Planet on zucchini squash and All or Tata-OK on tomato, reduced SPWF nymphal populations more than 85% compared with water sprays.

TABLE 1. MEAN[1] PERCENT MORTALITY OF *BEMISIA TABACI* NYMPHS ON ZUCCHINI SQUASH, TOMATO, AND POINSETTIA (GREENHOUSE, PHOENIX AZ) ON DAY 2 FOLLOWING TREATMENT AS DETERMINED BY THE NUMBER OF HONEYDEW SPOTS ON WATER-SENSITIVE PAPER. MATERIALS LISTED IN SAME ORDER AS MEAN MORTALITY OF EACH TEST.

	Honeydew droplet reduction (%)[1]
Zucchini squash	
Dawn, Palmolive, Joy, Ivory, Dove, M-Pede	92-100[2] a
Planet	32 b
Control (water alone)	0 c
Tomato	
M-Pede, Liquid Tide, Natur'l Oil, White King, Nirma, Ultra Tide, Ultra Cheer, New Ajax, Ivory Snow, Saf-T-Side Oil,	86-99 a
All, Tata-OK	51-69 b
Control (water alone)	0 c
Poinsettia Test 1	
Liquid Tide, Saf-T-Side Oil, White King, Ivory Snow	95-98 a
Control (water alone)	0 b
Poinsettia Test 2	
Country Safe, Life Tree, Power Plus, Ultra Cheer	92-99 a
Control (water alone)	0 b

[1] Range of means for each material tested. Means followed by the same letter are not significantly different (LSD, $P \leq 0.05$).

[2] In comparison to numbers on water-sprayed infested leaves.

Field Studies in Florida

At Immokalee, the number of honeydew droplets observed on heavily infested cucumber leaves showed a significant negative linear response to detergent concentration (Table 2). Differences in slope between the three materials tested were not significant.

At Parrish, adult SPWF mortality on uncoated paper plates ranged from 92 to 95% after treatment with a 1% solution of Saf-T-Side Oil or with 2% or 4% solutions of soybean oil (Table 3). All materials tested at concentrations of 0.5% except for Saf-T-Side Oil were less effective. SPWF adults did not adhere to water-treated uncoated or

TABLE 2. PAREMETERS FROM REGRESSION OF HONEYDEW SPOTS AGAINST CONCENTRATION OF 3 DETERGENTS.

Detergent	Intercept (Mean (SEM)	Slope Mean (SEM)	R^2	P <
APSA-80	87.9 (22.1)	-102.4 (49.4)	0.12	0.046
M-PEDE	114.8 (15.5)	-111.0 (33.0)	0.25	0.002
NEW DAY	68.2 (13.0)	-87.5 (27.2)	0.24	0.003

plastic-coated plates used as controls, whereas all adults falling on plastic-coated plates treated with any of the soap or oil solutions adhered to the plates and died. Plastic-coated plates dried at a much slower rate than the untreated plates. These results may explain the observation that adult SPWF become active shortly after fields have been treated with these materials. Either the adults were not sufficiently wetted when flying through clouds of tiny droplets or the leaves did not remain wet with spray deposits long enough to entrap them. The results suggest that the effect of detergent on SPWF adults may be contingent on their physical immobilization in droplets and disappears upon evaporation.

Also at Parrish, Solo mist blower applications of New Day, M-Pede, Saf-T-Side and soybean oil significantly reduced the number of SPWF adults caught on sticky traps and in black pan samples in infested cucumber plots (Table 4). Sticky trap catches were reduced 50 to 70%, and numbers caught using the black pan sampling method were reduced 58 to 79%, as compared with plots treated with water alone. Nymphal populations were less affected than adults, with Saf-T-Side Oil (0.5%) being the only treatment causing significantly fewer honeydew droplets than the water control. No phytotoxicity was observed in any of the experiments described above.

TABLE 3. MEAN PERCENT MORTALITY OF *BEMISIA TABACI* ADULTS DISPERSED ONTO WET SPRAY DEPOSITS OF VARIOUS TREATMENTS ON PAPER PLATES. PARRISH, FLORIDA, MAY 14, 1991.

Treatment	Plates[1]	
	Uncoated[3] (%, $\sin^{-1}$%)	Plastic Coated (%, $\sin^{-1}$%)
Soybean Oil 4% [2]	95, 1.35 a	100, 1.57 a
Soybean Oil 2% [2]	95, 1.35 a	100, 1.57 a
Soybean Oil 1% [2]	68, 0.97 ab	100, 1.57 a
Soybean Oil 0.5% [2]	36, 0.64 bc	100, 1.57 a
Saf-T-Side Oil 1%	92, 1.28 a	100,1.57 a
Saf-T-Side Oil 0.5%	62, 0.91 ab	100, 1.57 a
New Day 1.0%	--	100, 1.57 a
New Day 0.5	46, 0.75 bc	100, 1.57 a
M-Pede 1%	66, 0.95 ab	100,1.57 a
M-Pede 0.5%	28, 0.56 c	100,1.57 a

[1] Means of 3 replications. Percentages transformed to arcsine before analyses. Means in a column followed by the same letter are not significantly different ($P \geq 0.05$, $N = 3$), Duncan's multiple range test.

[2] Treatment was prepared from a stock preparation of a 16:1 combination of Crisco™ soybean oil and Joy™ liquid detergent.

[3] Absorbed and dried rapidly so that SPWF adults did not adhere to the plates.

TABLE 4. MEAN NUMBER *BEMISIA TABACI* ADULTS ON YELLOW STICKY TRAPS OR COLLECTED IN BLACK PANS FROM FOLIAGE AND THE NUMBER OF HONEYDEW DROPLETS ON WATER SENSITIVE PAPER FROM FIVE CUCUMBER LEAVES FOLLOWING A SINGLE APPLICATION OF DIFFERENT TREATMENTS WITH A SOLO MOTORIZED MIST BLOWER. PARRISH, FLORIDA, MAY 15, 1991.

Treatment	Adults Collected		Number of honeydew droplets	Percent reduction compared to water
	Sticky traps	Black Pan		
Saf-T-Side Oil 0.5%	298 a[1]	55 a	260 a	56
New Day 0.5%	157 a	36 a	417 ab	29
Soybean Oil 0.5%[2]	214 a	72 a	449 ab	24
M-Pede 0.5%	263 a	72 a	559 b	5
Check (Water)	522 b	172 b	590 b	--

[1]Means in a column followed by the same letter are not significantly different ($P \geq 0.05$, $N = 4$), Duncan's multiple range test.

[2]Treatment was prepared from a stock preparation of a 16:1 combination of Crisco™ soybean oil and Joy™ liquid detergent.

CONCLUSIONS

Oils of plant origin are readily available and used in small amounts as adjuvants in tank-mix pesticide formulations. Household cooking oils with dish washing detergents as emulsifiers have been shown to be effective for home garden use (Butler & Henneberry 1990a). However, edible oils may be too expensive to consider for large-scale agricultural use. Castor oil and neem seed oil, two non-edible but abundant oils in some countries such as India, may be very useful in agricultural programs (Puri et al. 1991). The use of less expensive petroleum oils is a comparatively recent development for insect control in vegetable production. Our results indicate that such products are at least as effective as their plant-derived counterparts.

The effectiveness of the large number of surfactants (soaps and detergents) in greenhouse and field tests indicates all may be similar in content and/or mode of action. M-Pede is a fatty acid salt specifically designed for insect control effective against SPWF nymphs. However, it shares with all soaps the disadvantage of precipitating in hard water. The results of our experiments show that a wide variety of dish and laundry detergents exist in every market place that can control SPWF effectively. These materials may be particularly useful in countries where natural oils are too expensive and suitable emulsifiers for them are not generally available.

The results of experiments with low concentrations of detergents indicate that 0.5% or even less applied directly to the leaf underside to runoff provided control. However, field tests with several of the more promising materials applied with a mist blower at 0.5%, gave poor control of SPWF nymphs. The underside of most leaves appeared to be covered thoroughly, but the deposits were extremely thin and evaporated rapidly. Also, adults were observed freeing themselves and flying away from the surface of rapidly drying paper plates sprayed with 0.5% detergent without any apparent adverse effect. These results indicate that not only is complete coverage the leaf underside required, but also adequate deposition to entrap adults and to kill the nymphs is necessary. A high gallonage requirement could limit the practicability and use of certain materials in some agricultural areas and on some crops. On the other hand, applications timed to coincide with humid conditions such as occur at night could reduce evaporation rate and thereby increase the efficacy of detergents.

ENDNOTE

Mention of a proprietary product does not constitute an endorsement by the U.S. Department of Agriculture or the University of Florida.

REFERENCES CITED

BROZA, M., G. D. BUTLER, Jr., AND T. J. HENNEBERRY. 1988. Cottonseed oil for the control of *Bemisia tabaci*on cotton, pp. 301 *in* Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, Louisiana. National Cotton Council, Nashville, Tenn.

BUTLER, G. D., Jr., AND T. J. HENNEBERRY. 1990a. Pest control on vegetables and cotton with household cooking oils and liquid detergents. Southwest. Entomol. 15: 123-131.

BUTLER, G. D., Jr., AND T. J. HENNEBERRY. 1990b. Cottonseed oil and Safer Insecticidal Soap: Effects on cotton and vegetable pests and phytotoxicity. Southwest. Entomol. 15: 257-264.

FORER, G. 1990. Whitefly management in Israel to prevent honeydew contamination, pp. 33-36 *in* Cotton production research from a farming systems perspective, with special emphasis on stickiness. Papers presented at a Technical Seminar 49 Plenary Meeting, International Cotton Advisory Committee, Montpelier, France.

HODGSON, E., AND R. J. KUHR. 1990. A brief history of insecticides. Research Perspectives. North Carolina State Univ. 8: 89.

LAREW, H. G., AND J. C. LOCKE. 1990. Repellency and toxicity of a horticultural oil against whiteflies on chrysanthemum. HortScience 25: 1406-1407.

MELAMED-MADJAR, V. A. NAVON, AND S. TAL. 1984. Honeydew staining to evaluate survival of tobacco whitefly nymphs after insecticide application. Phytoparasitica. 12: 157-161.

PURI, S. N, G. D. BUTLER, JR., AND T. J. HENNEBERRY. 1991. Plant-derived oils or soaps for the control of whitefly on cotton. J. Appl. Zool. Res. 2: 1-5.

PURITCH, G. S. 1981. Pesticidal soaps and adjuvants - what are they and how do they work? Proceedings of the 23rd Annual Lower Mainland Horticultural Improvement Assoc. Grower's Short Course, Abbotsford, B.C. Canada.