ANTIBIOSIS TO CARIBBEAN FRUIT FLY (DIPTERA: TEPHRITIDAE) IMMATURE STAGES IN CARAMBOLA GERMPLASM

MICHAEL K. HENNESSEY[1], ROBERT J. KNIGHT, JR.[2], AND RAYMOND J. SCHNELL[1]
[1]USDA, Agricultural Research Service
Subtropical Horticulture Research Station
13601 Old Cutler Road,
Miami, FL 33158, USA

[2]University of Florida Institute of Food and Agricultural Sciences
Tropical Research and Education Center
Homestead, FL 33031

All cultivars of carambolas (*Averrhoa carambola* L.) grown in Florida are considered hosts of the Caribbean fruit fly [*Anastrepha suspensa* (Loew)] (Norrbom & Kim 1988). Fruits must be disinfested with cold, irradiation, or heat before they can be exported to nations having quarantine requirements. These treatments increase the cost of fruits and may decrease fruit quality. Resistant carambola cultivars have not been employed as a means for reducing losses to the pest by growers. Relaxation or elimination of postharvest quarantine treatment requirements may be possible for resistant cultivars.

Howard & Kenney (1987) determined that 'Golden Star' was less susceptible to Caribbean fruit fly than 'Arkin' or 'Fwang Tung' based on the numbers of eggs oviposited in harvested fruits. They ran their tests in cages using colony-reared flies and also found fewer and lower weights of pupae developing from 'Golden Star' fruits than from fruits of the other cultivars.

The present experiments were designed to identify antibiosis to Caribbean fruit fly eggs and larvae in some Florida carambola cultivar clones and seedlings from open pollinations or controlled crosses between various clones. Antibiosis (after Kogan & Ortman 1978) is due to fruit properties that adversely affect the metabolism of the growing fruit flies. Carambolas used in the experiments were from non-commercial research groves at the Miami National Clonal Germplasm Repository of the Subtropical Horticulture Research Station. Seedlings were derived from crosses described by Knight (1982) and Schnell & Knight (1989). Tree management included irrigation, fertilization, pruning, and mechanical and chemical weed control, but no insecticide application. Fruits were harvested between 16 December 1993 and 20 January 1994 as they became available.

Five clones and 11 seedlings described in Table 1 were bioassayed. A treatment consisted of one tree (cultivar or seedling) from one harvest date. For most clones and seedlings, only a single tree existed, therefore variability among trees was not assessed. 'Arkin' and 'Fwang Tung' were each bioassayed on two dates so effect of sam-

TABLE 1. CARAMBOLAS BIOASSAYED FOR ANTIBIOSIS TO CARIBBEAN FRUIT FLY AND MEAN (± SEM) PERCENTAGE ADULT EMERGENCE FROM FRUITS ARTIFICIALLY INFESTED WITH EGGS IN THE LABORATORY, MIAMI NATIONAL CLONAL GERMPLASM REPOSITORY, FLORIDA, 1993-94.

Treatment Cultivar/Seedling	Miami Accession No., Field Location	Emergence, %
'Golden Star' × 'Fwang Tung' seedling 7	25967, WA-4-4-11	61.0 ± 16.4a
'B-10'	26763, WB-1	43.0 ± 9.0ab
'Hew-1'	25129, WB-1	42.8 ± 13.3abc
'Fwang Tung', tested 20 Jan	22647, W2-2	42.0 ± 11.5abc
'Arkin', tested 20 Jan	25157, W2-2	42.0 ± 6.6abc
'Fwang Tung', tested 6 Jan	22647, W2-2	41.6 ± 17.2abc
'Golden Star' × 'Fwang Tung' seedling 5	25967, WA-4-3-32	40.0 ± 16.7a-d
'Golden Star' selfed seedling	25974, WA-4-2-32	32.0 ± 13.6a-e
'Arkin', tested 6 Jan	25157, W2-2	25.2 ± 7.2b-f
'Golden Star' × 'Fwang Tung' seedling 1	25967, WA-4-4-4	24.6 ± 5.0b-f
'Dah Pon' × open pollinated, seedling 1	25000, WA-4-2-6	24.0 ± 9.3b-f
'Golden Star' × 'Fwang Tung' seedling 3	25967, WA-4-4-18	21.6 ± 11.3b-f
'Golden Star' × 'Fwang Tung' seedling 2	25967, WA-4-1-134	16.4 ± 5.0b-f
'Demak'	21500, WA1-18-2	13.8 ± 7.5c-f
'Golden Star' × 'Fwang Tung' seedling 4	25967, WA-4-3-2	11.0 ± 6.0def
'Dah Pon' × 'Fwang Tung', seedling	25983, WA-4-2-134	5.4 ± 5.4ef
'Golden Star' × 'Fwang Tung' seedling 6	25967, WA-4-3-39	4.2 ± 4.2ef
'Dah Pon' × open pollinated, seedling 2	25000, WA-4-1-6	0f

Column means (n = 5) followed by the same letter do not differ ($P > 0.05$; Fisher's least significant difference test.)

pling date was also assessed for them. The other treatments were sampled on one date. Eighteen treatments, each comprising a cultivar or seedling and a harvest date, were bioassayed. Five fruits from one tree made up the five replicates of each treatment.

Bioassays were conducted on fruits within one h of harvest. Fruit quality was similar to that marketed from local packinghouses: at least 7.6 cm in length, 10-25% green in color (visual inspection), and free from rot, damage, and wild fruit fly infestations (visual inspection). A slice was cut from a fruit with a serrated knife; slices included peel and flesh, but not seeds. Slices served as the bioassay substrate and weighed 7.3 ± 1.3 g (mean ± SEM).

Caribbean fruit fly eggs used in bioassays were from a colony which had been maintained on an agar medium at the Miami USDA-ARS laboratory since 1971 (Hennessey 1994). Eggs were oviposited on waxed cheesecloth panels, washed from the panels with water, and incubated in a specimen chamber for three days (26 ± 2°C, 85 ± 10% RH, 13:11 [L:D], mean ± SEM) on paper towels moistened with an antifungal solution (sodium benzoate 0.07%).

Individual slices were placed in translucent, polypropylene specimen containers (120-ml). A piece of moist (antifungal solution) blotting paper containing 10 three-

day-old eggs was placed egg-side-down on the cut surface of each slice. The slice was misted with the antifungal solution (1 ml) and the container was sealed with a screw cap. Caps had a hole (1-cm diam) covered with organdy for ventilation. Controls consisted of agar diet (10 ml) inoculated with 10 eggs and misted with the antifungal solution. Five controls were bioassayed on each sampling date. Containers were placed in translucent, covered plastic boxes and held in the specimen chamber described above. Vermiculite (1 g) was placed in each container after four days to serve as a pupation medium. After seven days, pupae and prepupae were washed from the controls, placed in fresh vermiculite (1 g), and held until adult emergence in the specimen chamber. Prepupae and pupae were washed from treatments after 13 days (because they developed more slowly than controls) and held as above.

The percentage of eggs reaching adulthood from treatments divided by the percentage from the controls of the same sampling date was the criterion used for assessing antibiosis. The criterion was based on the report by Cowley et al. (1992) that defined a fruit fly host as a fruit from which reproductively viable adult flies could be reared from eggs oviposited into the fruit. Our method bypassed the oviposition process where antixenosis would have obscured antibiosis effects. PROC ANOVA (SAS Institute, 1992) was used to compare nontransformed percentages among the 18 treatments. Fisher's least-significant-difference (LSD) test ($P \leq 0.05$) was used to separate means after a significant ($P \leq 0.05$) F value was found. The SSN ranking selection procedure (Gibbons et al. 1974), which identifies the smallest subset that includes the best treatment, was also conducted as a separate test of means ($P \leq 0.05$).

Mean emergence varied between 0.0% and 61.0% among treatments (Table 1). Differences among treatments were significant ($F = 2.67$; df = 17, 72; $P = 0.002$). The 'Dah Pon' × open pollinated seedling 2, from which no flies emerged, was more antibiotic ($P \leq 0.05$; LSD) than 'Golden Star' × 'Fwang Tung' seedlings 5 and 7, 'B-10', 'Hew-1', 'Fwang Tung' (6 and 20 January), 'Arkin' (20 January), and the 'Golden Star' selfed seedling. It did not differ significantly ($P > 0.05$), however, from nine other treatments (Table 1). The LSD and SSN procedures agreed except that the SSN included the 'Golden Star' selfed seedling among the subset of treatments (11) which included the best treatment (smallest mean; SSN upper limit = 37.9). Sampling date effects were not significant ($P > 0.05$; LSD) for 'Arkin' or 'Fwang Tung' treatments.

The accessions 'Dah Pon' × open pollinated seedlings 1 and 2, 'Golden Star' × 'Fwang Tung' seedlings 1, 2, 3, 4, and 6, 'Dah Pon' × 'Fwang Tung' seedling, 'Arkin', 'Demak', and 'Golden Star' selfed seedling warrant further host resistance screening. Further resistance screening may include methods proposed by Cowley et al. (1992), including laboratory and field oviposition trials (antixenosis), natural field infestation levels, and sampling for detection of flies where and when fruits are harvested. They may also include factoring of variability among trees, and factoring of variability among commercial cultivation methods. Cultivars or seedlings demonstrating high resistance to the Caribbean fruit fly may be promoted and grown in Florida for export. If those identified as highly resistant are not commercially valuable, attributes conferring resistance in them could be identified and introduced into commercial cultivars through breeding or other methods.

SUMMARY

Resistance in carambolas to the immature stages of the Caribbean fruit fly was demonstrated. Cultivars or seedlings demonstrating resistance should be considered for promotion and production in Florida.

REFERENCES CITED

COWLEY, J. M., R. T. BAKER, AND D. S. HARTE. 1992. Definition and determination of host status for a multivoltine fruit fly (Diptera: Tephritidae) species. J. Econ. Entomol. 85: 312-317.

GIBBONS, J. D., I. OLKIN, AND M. SOBEL. 1974. Selecting and ordering populations: a new statistical methodology. John Wiley & Sons, New York, New York.

HENNESSEY, M. K. 1994. Depth of pupation of Caribbean fruit fly (Diptera: Tephritidae) in soils in the laboratory. Environ. Entomol. 23: 1119-1123.

HOWARD, D. F., AND P. KENNEY. 1987. Infestation of carambolas by laboratory-reared Caribbean fruit flies (Diptera: Tephritidae): effects of fruit ripeness and cultivar. J. Econ. Entomol. 80: 407-410.

KNIGHT, R. J., JR. 1982. Response of carambola seedling populations to Dade County's oolitic limestone soil. Proc. Florida State Hort. Soc. 95: 121-122.

KOGAN, M., AND E. F. ORTMAN. 1978. Antixenosis-a new term proposed to define Painter's "nonpreference" modality of resistance. Entomol. Soc. America Bull. 24: 175-176.

NORRBOM, A. L., AND K. C. KIM. 1988. A list of reported host plants of the species of *Anastrepha* (Diptera: Tephritidae). USDA-APHIS-PPQ Bull. 81-52.

SAS INSTITUTE, INC. 1992. SAS®, version 6.04. SAS Institute, Cary, North Carolina.

SCHNELL, R. J., AND R. J. KNIGHT, JR. 1989. Variation in isozyme alleles in *Averrhoa carambola* L. Proc. Interamerican Soc. Trop. Hort. 33: 127-132.

◆◆◆