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A Gardona-Vapona Mixture for Control of Stored-product Insects in Railway Boxcars[1]

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ABSTRACT

Adult confused flour beetles, *Tribolium confusum* Jacquelin duVal, adult granary weevils, *Sitophilus granarius* (L.), adult lesser grain borers, *Rhyzopertha dominica* (F.), and *Trogoderma inclusum* LeConte larvae were exposed in railway boxcars to 3 dosages of a Gardona®: Vapona®, (2-chloro-1-[2,4,5-trichlorophenyl] vinyl dimethyl phosphate) : (2,2-dichlorovinyl dimethyl phosphate) formulation. Following application, some of the Vapona concentrations were monitored.

With few exceptions a 3.78 liter/boxcar application rate provided 80–100% mortality of the test insects. However, all dosages above 0.95 liter/boxcar resulted in a Vapona air concentration above the 1 mg/liter allowed for human exposure.

Virtually all of our foods move through distribution channels either in railway boxcars, trucks, or vessels. A survey by the Food and Drug Administration[4] revealed that the majority of food contaminations in transit involved boxcars and ⅔ of them were caused by insects and rodents.

Malathion is one of the most effective residual insecticides, but some stored-product insects are becoming resistant. Speirs et al. (1967), Dyte (1970), and Dyte and Blackman (1970 showed the resistance of certain strains of red flour beetles, *Tribolium castaneum* (Herbst) and at least 13 other species throughout the world.

Schesser (1967a, b, 1972) compared different insecticide and fumigant formulations using various application techniques. One promising combination that he used was a mixture of malathion and Vapona® (2,2-dichlorovinyl dimethyl phosphate). We substituted Gardona® (2-chloro-1-[2,4,5-trichlorophenyl] vinyl dimethyl phophate) for malathion to make a Gardona:Vapona mixture. Gardona has potential as a residual insecticide for some stored-product insects (Strong 1970).

MATERIALS AND METHODS.—Empty railway boxcars were retained for 9-day intervals in July, September, and October 1970 in Kansas City, Mo. These boxcars were ca. 12.0 m long, 2.9 m wide, and 3.0 m high. The sides, ends, and floor of each boxcar had ca. 126 m² of surface area.

An emulsifiable concentrate containing 454 g Gardona and 227 g Vapona per 3.78 liters was mixed with water to dilute Gardona to 2.5% and Vapona to 1.25%. The walls and floor of each boxcar were sprayed with 1 of 3 dosages to give the following intended residual deposit:

	Insecticide mg/m² surface	
Dosage	Gardona	Vapona
0.9 l	1.5 mg	0.7 mg
1.89 l	3.0 mg	1.4 mg
3.78 l	6.0 mg	2.8 mg

Applications were made with a stainless steel sprayer using 40 lb/in.² and a nozzle that sprayed a pattern ca. 0.9 m wide when held 1.8 m from the surface. All treated cars remained closed after treatment except for a ½-h aeration period 1 h after treatment and for ca. 15 min each time insects were placed in or removed from the exposure area.

Adult granary weevils, *Sitophilus granarius* (L.), adult lesser grain borers, *Rhyzopertha dominica* (F.), adult confused flour beetles, *Tribolium confusum* Jacquelin du Val, and *Trogoderma inclusum* LeConte larvae were exposed 1, 4, 8, 24, or 48 h in either metal-screen cages inserted into or taped to the exposed surface of the side liners or exposed on the surface of 239-cm² wooden boards on the floor. They were confined to the boards with inverted plastic petri dishes with a 25-mm diam hole for placing the insects and as a vent for insecticide vapors. Exposure periods on the simulated floor surface began 0, 2, 5, and 9 days following treatment.

Vapona concentrations in air were determined in October 1970 and June 1971. They were made by scrubbing 25 liters of air through 50 ml ethyl acetate which is a modification (Jay et al. 1964) of a technique developed by the U.S. Public Health Service.

The air was removed through a plastic hose inserted into the car with the end suspended 1.8 m above the floor. Gas chromatography was used to make the final determination on Vapona concentration.[5]

RESULTS AND DISCUSSION.—Fig. 1–12 present mortality data for each of the 4 insect species exposed to the 3 application rates. Only 5 exposures provided adequate control (80–100% mortality) of the adult confused flour beetles exposed to railway boxcars sprayed with 0.9 liter of the insecticide mixture (Fig.

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[4] Durham, J., G. Steele, F. Timko, S. Johnson and B. Walker. 1970. Final Study report from the AFDOUS Committee on Food Transportation.

[5] Shell Chemical Co. Analytical Method PMS - G - 914/68

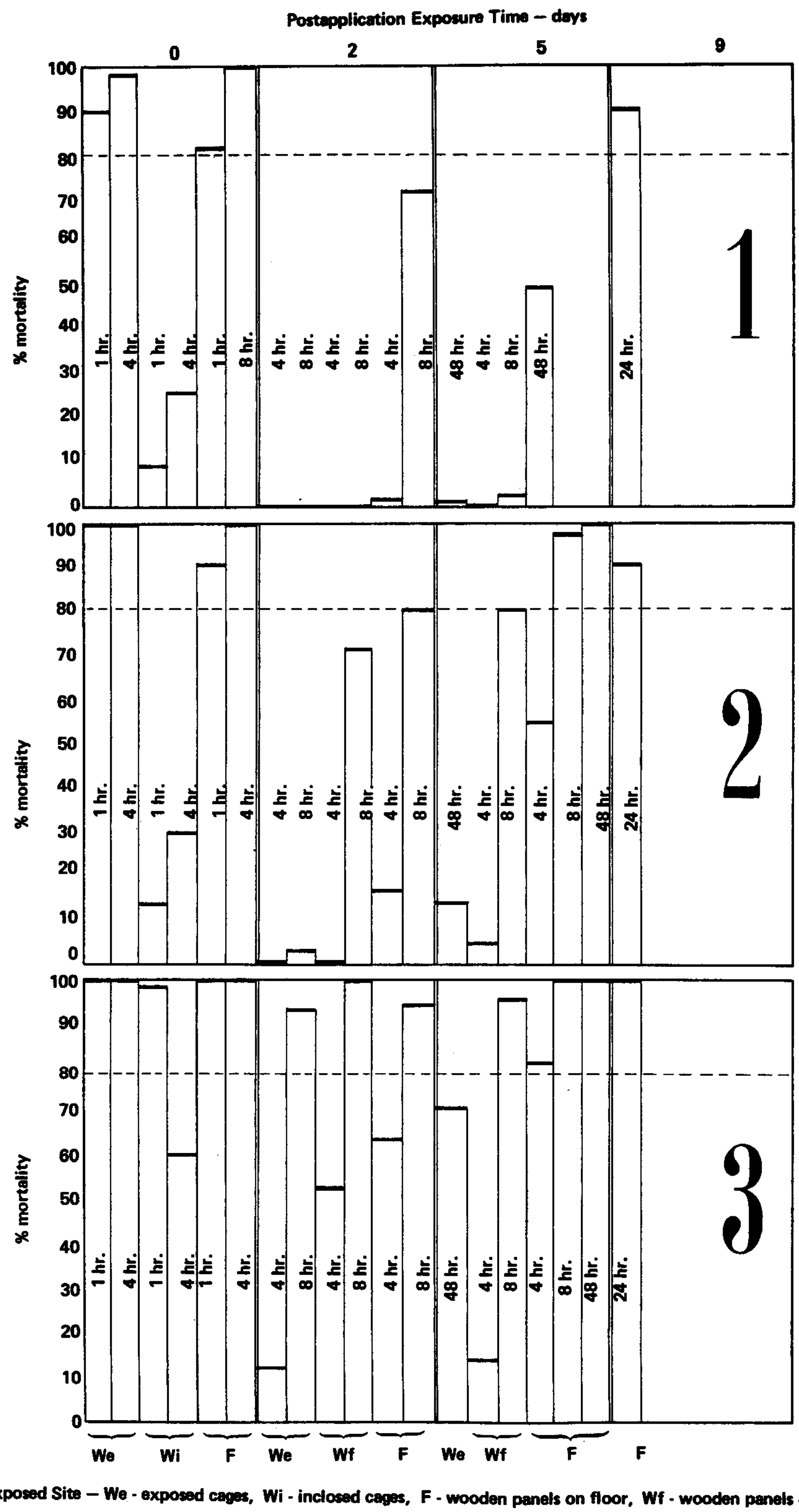

FIG. 1–3.—Mortality of adult confused flour beetles in boxcars sprayed with 0.90, 1.89, and 3.78 liters, respectively, with an emulsion containing 2.5% Gardona and 1.25% Vapona.

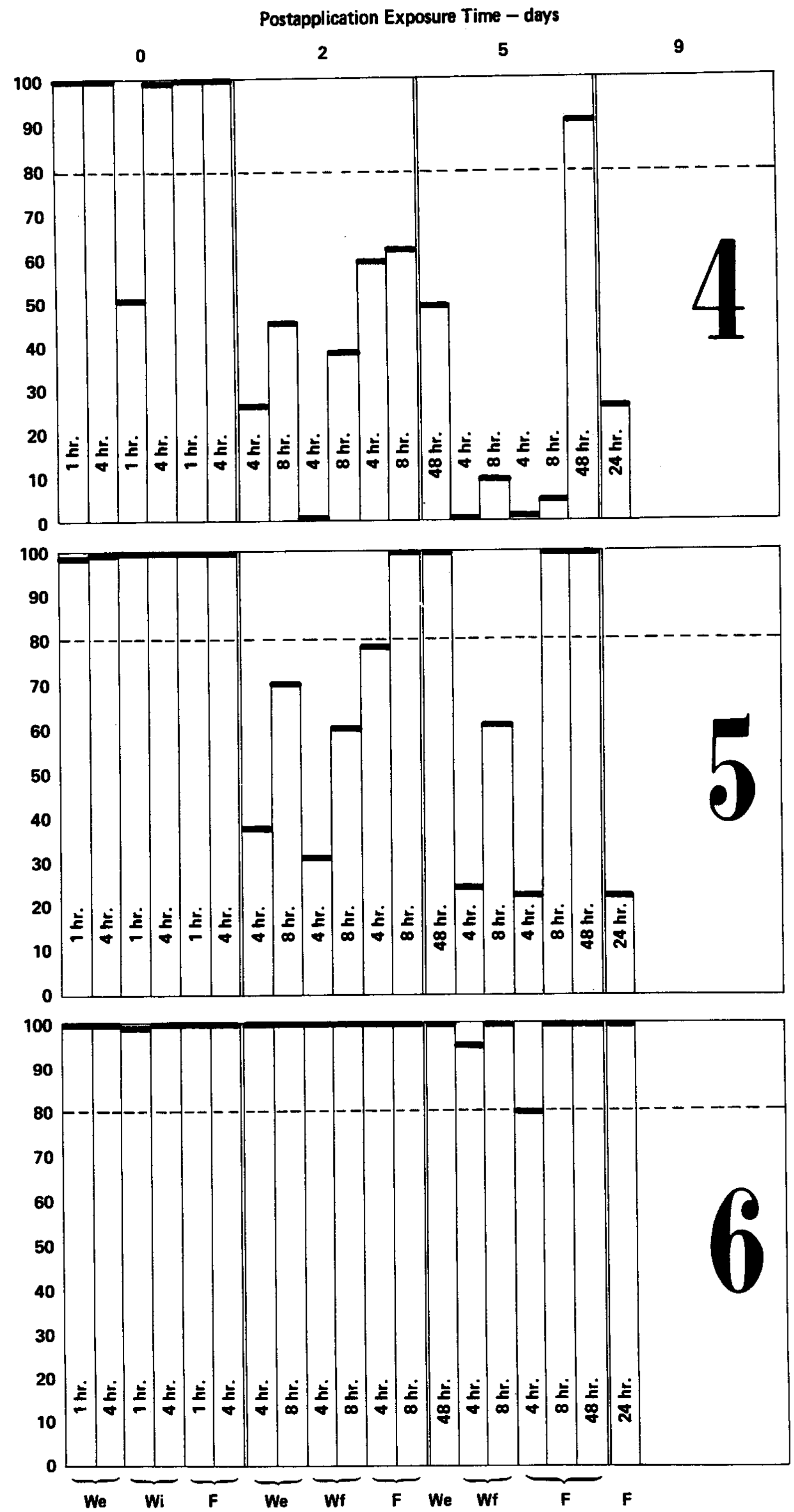

FIG. 4–6.—Mortality of adult granary weevils subjected to same conditions as Fig. 1–3.

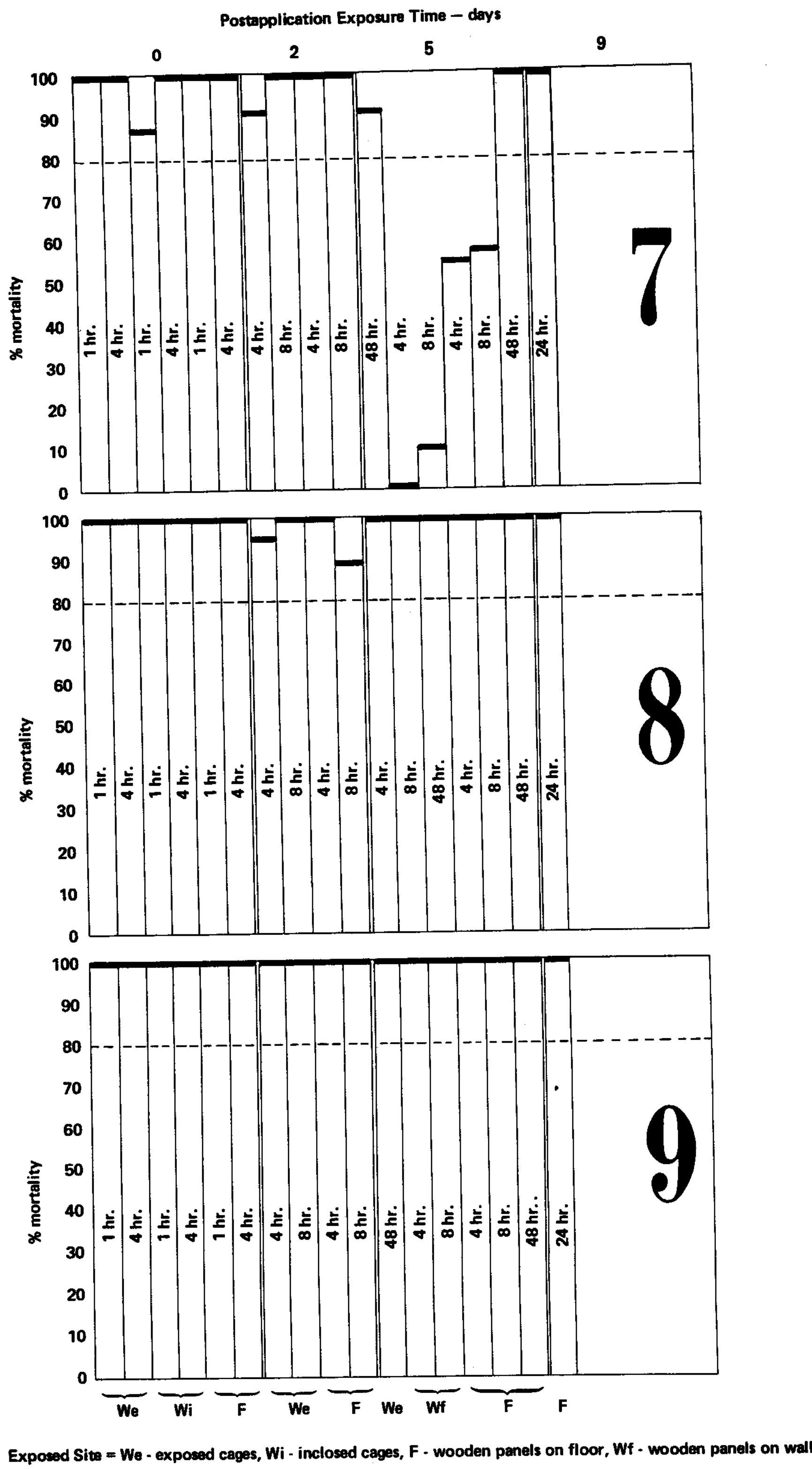

FIG. 7–9.—Mortality of adult lesser grain borers subjected to same conditions as Fig. 1–3.

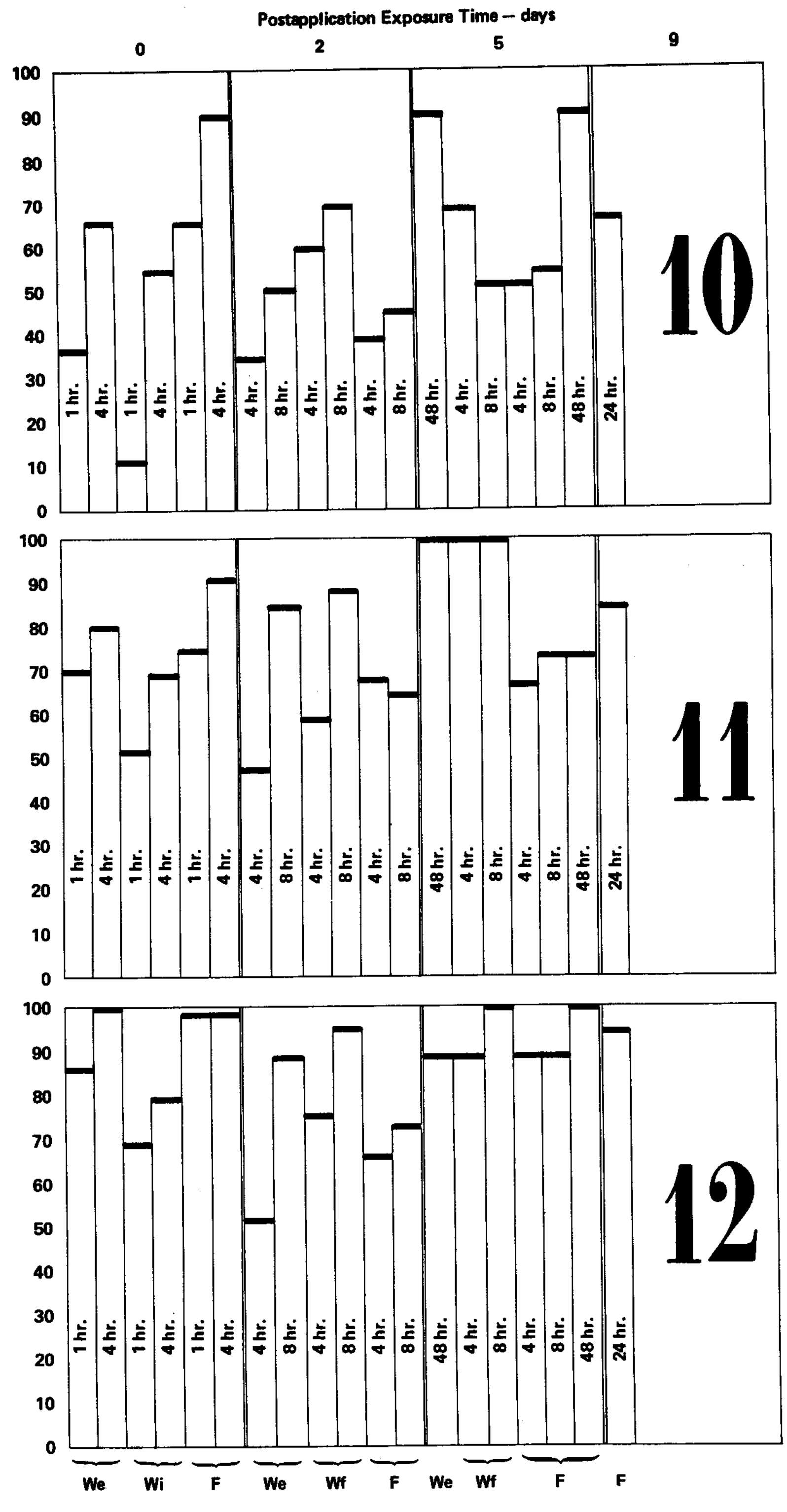

FIG. 10–12.—Mortality of *Trogoderma inclusum* larvae when subjected to same conditions as Fig. 1–3.

1). Increasing the dosage to 1.89 liters improved its effectiveness as anticipated (Fig. 2) but doubling the dosage to 3.78 liters appears necessary to obtain the desired kill in the majority of the exposure sites (Fig. 3). At this high dosage, only the 4 h exposure of confused flour beetles in cages inserted in the interior wall lining of the railway cars failed to produce more than 80% mortality.

Adult granary weevils appeared equally or more susceptible than adult confused flour beetles following the exposures to the Gardona:Vapona formulation (Fig. 1, 2, 3 vs. 4, 5, 6), e.g., the 3.78-liter dosage provided, with 3 exceptions, 100% mortality of the weevils.

Similar increase in mortality was noted for adult lesser grain borers (Fig. 7, 8, 9) compared to adult granary weevils (Fig. 4, 5, 6) as even the 1.89 liter dosage killed 100% of the borers except for a 4 h exposure in exposed cages and an 8 h exposure on floor panels 2 days after insecticide application.

Increasing the Gardona:Vapona dosage from 0.9 to 3.78 liters generally did not increase the mortality of *T. inclusum* (Fig. 10, 11, 12) as much as was noted for any of the other 3 species of test insects. Mortality following exposure to the 3.78-liter application was similar to the results with confused flour beetles and would support the selection of the maximum tested application rate for obtaining the desired insect control.

Temperature ranges in the boxcars during the replicated bioassays were 25–43°C in July, 16–26°C in September, and 8–21°C in October. Corresponding ranges in RH for the same periods were 34.0–48.6%, 70.0–86.7%, and 38.5–76.5%. The high temperatures in July caused high check mortalities but no other correlations between mortalities, temperature, and RH were noted.

There were a few differences in the Vapona air concentrations resulting from the 1.89 and 3.78-liter applications, especially within 2 h after treatment. Increases in Vapona air concentrations at both application rates 3 h and 30 h after treatment probably resulted primarily from the continued vaporization of Vapona residues from the sprayed surfaces and an increase in the rate of this vaporization as the air temperatures climbed the afternoon following application, respectively. However, the apparent effect of air temperature appeared short lived as the Vapona air concentration failed to develop 24 h later.

Results of the repeat Vapona air concentration experiment conducted in June 1971 generally confirmed the 1970 data for the 3.78-liter application rate and also illustrated that 0.95 liter/boxcar would not produce Vapona concentrations above the allowable limit set by the American Conference of Governmental Industrial Hygienist (Anon. 1968). A Vapona concentration of 1 μg/liter (skin) of air has been established by the American Conference of Governmental Industrial Hygienist as the safe threshold for human beings based on an exposure of 40 h/wk. "Skin" refers to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by air borne sources or by direct contact.

Vapona concentrations above 1 μg/liter still may be safe for the designed use in this study since the applicator would not be exposed to such concentrations 40 h/wk. In addition, when exposed to suspect concentrations, the applicator could protect himself by wearing the recommended respiratory equipment. Vapona concentration also could be reduced by cross ventilating the railway cars for extended periods, a procedure not practiced during this experiment.

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