EFFECT OF A STICKER ON THE TOXICITY OF PENNCAP-M® AND FURADAN® TO HONEY BEES[1] WHEN THESE INSECTICIDES WERE SPRAYED ON FLOWERING ALFALFA[2,3]

Joseph O. Moffett,[4] Jack Harvey,[5] and Robert Cox[5]

(Accepted for publication August 4, 1986)

ABSTRACT

Adding an experimental sticker did not markedly reduce the toxicity of either Furadan® (carbofuran) or Penncap-M® (a microencapsulated formulation of methyl parathion) to honey bees. When sprayed on flowering alfalfa, these insecticidal formulations killed large numbers of bees in colonies located on the borders of the sprayed fields.

In a related study, Penncap-M, without the sticker, killed colonies placed adjacent to the treated field 5 hr after this spray was applied. In contrast, colonies placed next to a field 5 hr after it was sprayed with a combination of both the experimental sticker and Penncap-M lost only 11% as many bees as the colonies placed next to the field that was sprayed with only Penncap-M.

In the Furadan-treated fields, the alfalfa foliage had 873 times more carbofuran residue per gram than the honey samples. Freshly collected pollen from pollen traps had 15 times more carbofuran, and dead bees had 6 times more carbofuran than the honey samples.

In the Penncap-M-treated fields, the alfalfa foliage had 356 times more methyl parathion than the dead bee samples. Pollen contained 21 times more parathion per gram than the dead bees. Honey from the Penncap-M-treated fields was not analyzed.

Key Words: Hymenoptera, Apidae, *Apis mellifera,* insecticide residue, carbofuran, parathion.

J. Entomol. Sci. 21(4): 294-300 (October 1986)

INTRODUCTION

Insecticides have inadvertently killed honey bees since the use of insecticides began in the latter part of the nineteenth century. The first serious bee losses in the United States from insecticides occurred in the early 1870s when orchardists sprayed Paris green on apple and pear trees to control codling moths (Todd and McGregor 1952).

As the use of insecticides increased, the losses of honey bees from these chemicals also increased. In some areas, such as the Salt River Valley of Arizona, the use of insecticides virtually eliminated beekeeping (Moffett et al. 1978). Yet in

[1] Hymenoptera: Apidae.

[2] In cooperation with the University of Wyoming Agricultural Experiment Station as Journal Article #1380, and the Oklahoma Agricultural Experiment Station as Journal Article J-4863.

[3] Mention of a proprietory product does not constitute a recommendation by the USDA, or does it imply registration under FIFRA as amended.

[4] Research Entomologist, Plant Science and Water Conservation Laboratory, ARS, USDA, P.O. Box 1029, Stillwater, OK 74076.

[5] Formerly Research Chemist and Apiarist, respectively, Honey Bee Pesticides/Disease Research Facility, ARS, USDA, Box 3168, University Station, Laramie, WY 82071. Present addresses: University of Wyoming, Laramie, and USDA-ARS Honey Bee Research, 509 W. 4th Street, Weslaco, TX 78596, respectively.

many agricultural areas, beekeeping exists where insecticides are used. Farmers and orchardists frequently rent large numbers of honey bees to pollinate their crops. But even in these places, serious losses of honey bees from insecticides sometimes occur.

Adding an experimental sticker to insecticides reduced bee losses when Ross and Harvey (1981) sprayed Penncap-M® on flowering sunflowers in Wyoming. Beekeepers sometimes suffer severe losses when farmers spray either Penncap-M or Furadan® on alfalfa. Therefore, we tried to determine if adding this sticker reduced the mortality of honey bees when either pesticide was applied to blooming alfalfa. We selected southwestern Oklahoma because many farmers in this area grow alfalfa for seed. Consequently, flowering alfalfa fields were readily available.

MATERIALS AND METHODS

Six colonies were moved to the edge of each of the 5 experimental alfalfa fields 8 to 13 days before the first spray was applied. The minimum distance between fields was 13 km. This prevented bees of colonies adjacent to one field from visiting flowers from another treated field. The greatest distance between apiaries was 45 km.

The number of the alfalfa fields, the treatment applied, plus the size, type, and location of each field follows:

1. Furadan; 23 ha dryland; 12 km northwest of Hollis.
2. Furadan plus sticker; 9 ha dryland; 6 km southeast of Mangum.
3. Penncap-M; 8 ha irrigated; 7 km southwest of Gould.
4. Penncap-M plus sticker; 9 ha irrigated; 12 km southwest of Hollis.
5. Check (no treatment applied); 5 ha irrigated; 1 km west of Martha.

Treatments were applied aerially between 7 and 9 a.m. on 7/28 to the 4 treated fields and again a week later before 9 a.m. to 3 of the fields. Field 1 did not receive a second spraying because the alfalfa in this field had ceased flowering due to drought.

In the early afternoon of 8/4, ca. 5 hr after the last spray had been applied, 5 additional colonies were moved onto the borders of both fields 3 and 4. This was to determine the residual toxicity of Penncap-M to colonies moved into the field after the sprays had been applied.

During each application, 1.1 kg AI/ha of the insecticide in 18.7 liters of spray mixture was applied to the fields. To reduce foaming, 7.9 g of Red-Top® anti-foam was added to each 100 liters of the final spray mixture. In addition, each 100 liters of the specific treatments consisted of the following:

1. 12.5 liters of Furadan and 87.5 liters of water.
2. 12.5 liters of Furadan and 43.8 liters of both the sticker and water.
3. 20.0 liters of Penncap-M and 80.0 liters of water.
4. 20.0 liters of Penncap-M and 40.0 liters each of both the sticker and water.

The insecticides were mixed in a ground tank with water and the sticker, when used. Since the sticker had a tendency to clog the spray nozzles, we added a filter to the end of the hose used to fill the spray tank of the airplane from the mixing tank.

The commercial formulations of the insecticides were used. Furadan contains 40.64% (479 g/liter) of carbofuran (2-3-dihydro-2,2-dimethyl-7-benzofuranyl

methylcarbamate). Penncap-M is the microencapsulated formulation of methyl parathion and contains 300 g/liter of methyl parathion. Experimental sticker number 1253 developed by Pennwalt Corporation was used in this study.

On 7/21, pollen traps were placed underneath and dead bee traps on the front of each of the original 30 experimental colonies. Each day from 7/21 through 8/11, the dead bees in the traps were counted, and samples of the dead bees saved for analysis for pesticide residue. Samples of honey, pollen from the pollen traps, and alfalfa foliage were also collected for analysis of residues.

As the samples were collected, they were placed in an ice chest containing dry ice. Upon arriving in Stillwater on 8/21, the frozen samples were moved into a deep freeze and kept at -5°C. In October 1983, the samples were taken to the USDA-ARS Honey Bee Pesticides/Disease Unit Laboratory located at Laramie, WY, to be analyzed for insecticide residues.

We examined the colonies and counted both the frames of brood and frames of bees before the start of the study, between the first and second spraying, and 2 months after the second spray was applied. The colonies surviving the winter were also evaluated in the spring.

The samples from the Furadan-treated fields were extracted in a 4% solution of hydrochloric acid in a hot water bath at 80°C. Then, these samples were partitioned with equal amounts of ethyl acetate and iso-octane. The organic phase was evaporated and made up to 5 ml with 25% ethyl acetate in iso-octane. High pressure liquid chromatography was used to determine the amount of residue left in the samples.

The samples from the Penncap-M-sprayed fields were analyzed using the extraction, cleanup and gas chromatography procedures described by Ross and Harvey (1981).

RESULTS

Colonies exposed twice to either Furadan or Penncap-M sprays were severely damaged, but they managed to survive despite heavy losses (Tables 1 and 2). The dryland field receiving the Furadan-sticker spray ceased flowering after the first spray, due to drought, and was not sprayed again. This accounts for the small number of dead bees, 61 per colony, in this colony's dead bee trap the second week (Table 1).

The relative high losses in the check colonies the first week were caused from methyl parathion sprayed on nearby cotton fields. Two colonies became queenless in both of the Penncap-M tests, while one colony lost its queen in the Furadan study. The colonies exposed to Penncap-M had less dead bees in the dead bee traps than the colonies exposed to Furadan. Yet, the colonies exposed to Furadan appeared visually to suffer less damage than colonies exposed to Penncap-M.

Two weeks after the second spray, the brood counts of the colonies in all 4 treatments were not significantly different (Table 2). However, the number of frames of bees in the colonies exposed to the insecticides containing the sticker were more than 50% greater than in colonies exposed to the same insecticides without the sticker. Most of the colonies recovered sufficiently to survive the winter.

The 5 colonies moved to the border of the Penncap-M-sprayed fields 5 hr after the last spray was applied sustained a tremendous loss. Three of these colonies died within a week, and the other 2 had only a handful of bees left (Table 3).

Table 1. Effect of aerial spraying of Penncap-M and Furadan, twice, with and without a sticker, on flowering alfalfa on colonies of honey bees, southwestern Oklahoma. 1983.

Time after 1st spray applied	Bees collected/colony from dead bee traps near fields sprayed with:				
	Penncap-M	Penncap-M + sticker	Furadan	Furadan + sticker	Check
1st week	2,670	3,038	5,046	4,228	727
2nd week	716	2,695	5,081	61	149
2-wk total	3,386	5,733	10,127	4,289	876

Table 2. Effect of aerial spraying of Penncap-M and Furadan, twice, with and without a sticker, on flowering alfalfa on frames of bees and brood 2 weeks after second spray was applied, southwestern Oklahoma. 1983.

Frames of	Strength of 6 colonies near fields sprayed with:				
	Penncap-M	Penncap-M + sticker	Furadan	Furadan + sticker	Check
Brood	19	23	25	26	40
Bees	49	76	49	82	116

Table 3. Influence of adding a sticker when spraying Penncap-M to flowering alfalfa on number of dead bees collected and methyl parathion residue of these bees from colonies moved adjacent to the field 5 hr after the sprays were applied, southwestern Oklahoma. 1983.

Days after spraying	Number of dead bees/colony moved near field sprayed with:		Methyl parathion residue (ppm) in dead bees from field sprayed with:	
	Penncap-M	Penncap-M + sticker	Penncap-M	Penncap-M + sticker
1	3,893	691	2.500	0.762
2	6,232	208	0.810	0.368
3	907	441	0.696	0.890
4	1,003	91	0.358	0.224
5	1,104	60	0.280	0.080
6	402	35	0.052	0.134
7	295	17	0.002	0.062
Total for week	13,836	1,544		

Dead bees were 1 - 2 inches deep on the bottom boards. Although we removed all the dead bees each day, the bees continued to die in large numbers, when it appeared there were few bees left to die. Five similar colonies unloaded at the field receiving the combined Penncap-M and sticker spray 5 hr after the last spray was applied suffered only moderate damage and wintered well.

The residue from the Penncap-M treatments was greatest on the alfalfa foliage and much smaller in the dead bees and pollen (Table 4). The foliage contained

Table 4. Residues of methyl parathion on foliage from fields of flowering alfalfa sprayed with Penncap-M both with and without a sticker and in dead bees and pollen taken from colonies adjacent to these fields, southwestern Oklahoma. 1983.

Days after spray applied	Methyl parathion in ppm in: Dead bees S*	Dead bees N*	Pollen S	Pollen N	Foliage S	Foliage N
Pretreatment	0	0	0	0.026	0	0
1†	0.202	0.883	2.342	2.168	172.765	186.875
2	0.042	0.177	0.860	0.942	171.895	77.945
3	0.028	0.122	0.080	0.275	60.575	41.085
4	0.018	0.072	0.020	0.042	55.655	7.300
5	0.015	0.045	0.065	0.043	18.760	0.815
6	0	0.002	0.025	0.008	11.600	0.260
----------Second Spray Applied----------						
1‡	1.230	1.582	1.907	2.177	210.100	194.070
2	0.458	0.117	1.513	0.263	154.800	83.470
3	0.085	0.048		0.063		21.085
4		0.050		0.033		1.550
5	0.140	0.012	0.040	0.002		0.290
6	0.030	0.002		0		0.060
7	0.005	0		0.002		0

* S = sticker added to spray mixture; N = no sticker added to spray mixture.
† 7/29
‡ 8/5

356 times and the pollen 21 times as much parathion residue as the dead bees.

The residue from the Furadan treatments was also highest in foliage (Table 5). The foliage contained 873 times as much carbofuran as honey samples. Pollen had 15 times and dead bees 6 times as much carbofuran as the honey did.

There were no consistent differences in the residues in dead bees or pollen between fields with and fields without the sticker added to the insecticides (Tables 3, 4, and 5). However, 4 - 7 days after the sprays were applied, the residue of both insecticides was several times greater on the alfalfa foliage in the fields where the sticker had been applied.

DISCUSSION AND CONCLUSIONS

Both Furadan and Penncap-M caused serious losses of honey bees when applied aerially to flowering alfalfa. Because of the severe loss of bees, these colonies did not store any more honey. However, the colonies recovered and developed sufficient strength to overwinter.

Penncap-M was still toxic to honey bees 5 hr after it was applied, as the 5 colonies moved into the field at this time died. Apparently more than 5 hr should elapse before bees can safely be exposed to fields sprayed with Penncap-M.

Table 5. Residues of carbofuran on foliage from fields of flowering alfalfa sprayed with Furadan both with and without a sticker and in dead bees, pollen, and honey taken from colonies adjacent to these fields, southwestern Oklahoma. 1983.

Days after spray applied	Carbofuran in ppm in: Dead bees S*	Dead bees N*	Pollen S	Pollen N	Honey S	Honey N	Foliage S	Foliage N
1†	3.333	6.367	4.550	10.183	0.217	0.133	268.90	307.60
2	2.500	1.900	4.267	6.600	0.267	0.233	181.75	203.50
3	1.417	1.217	3.317	1.500	0.183	0.100	171.60	95.15
4	0.100	0.467	1.517	0.316	0.083	0.033	89.70	12.80
5	0.467	0.083	1.000	0.233	0.017	0.017	61.15	1.10
6	0.250	0.033	0.067	0.033	0.050	0.017	6.00	1.20
----------Second Spray Applied----------								
1‡		3.317		11.517		0.167		337.25
2		1.300		5.100		0.233		203.05
3		0.367		1.233		0.100		91.10
4		0.483		0.717		0.033		14.40
5		0.083		0.233		0.033		4.10
6		0.033		0.033		0.017		4.00
7		0.033		0.050		0.017		1.00

* S = sticker added to spray mixture; N = no sticker added to spray mixture.
† 7/29
‡ 8/5

The use of the sticker gave mixed results in providing protection for the honey bees from the insecticides. Heavy losses of bees occurred in 2 of the 3 tests where it was involved. However, since the residues remained high on the alfalfa for several days when the sticker was used, the addition of the sticker to the insecticides may give longer and better control of the destructive insects. Therefore, possibly either lower dosages of insecticides would need to be applied or fewer applications would be required.

Initial residues were very low in honey. In this study, field applications of these insecticides did not pose a serious contamination problem for honey. The initial residue of freshly collected pollen is high enough that it should not be used. However, collections of pollen the first day or two after spraying are usually greatly reduced. Therefore, this residue normally would not be a serious problem when collecting pollen.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to the many people who helped make this study possible. First, we wish to thank William T. Wilson, Viola Gibson, and others associated with the Laramie Laboratory for their help in furnishing bees and in starting and conducting the experiment.

The Pennwalt Corporation generously helped finance this study. Ivan Gard of Pennwalt also gave valuable technical assistance.

A. J. Smith, Oklahoma Agricultural Extension Agent for Harmon County, contacted alfalfa seed growers on our behalf and was responsible for lining up three of the five fields used in the study. Don Peters of the Oklahoma Agricultural Experiment Station helped expedite the paperwork necessary for this test.

The five seed growers who made this study possible by letting us use their alfalfa fields are Tim Bullingham, Leroy Hudson, Ewell McDaniel, Don Petzold, and James Frederick Smith.

Darold Ketring of the Plant Science and Water Conservation Laboratory, ARS, USDA, Stillwater, Oklahoma, also deserves special thanks for the assistance he gave us on this report.

LITERATURE CITED

Moffett, J. O., A. Stoner, L. N. Standifer, and A. L. Wardecker. 1978. Reducing honey bee losses from insecticides. Amer. Bee J. 118: 724-47.

Ross, B., and J. Harvey. 1981. Penncap-M plus sticker applied to sunflower (*Helianthus annuus*) at Pine Bluffs, Wyoming — Effects on honey bees (*Apis mellifera* L.). Amer. Bee J. 121: 510-11, 516.

Todd, F. E., and S. E. McGregor. 1952. Insecticides and bees, pp. 131-135. *In* Insects, The Yearbook of Agriculture. U. S. Dept. Agric., Washington, DC.