SEX PHEREMONE TRAPS DETERMINE IN

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FOR SEVERAL DECADES growers of pears and apples in California have controlled the codling moth by coating the fruit with chemical insecticides from petal fall through harvest. This preventive approach was necessary because growers lacked effective methods for determining codling moth activity and abundance in their orchards. While this approach has provided effective control, repeated applications of heavy dosages of broad-spectrum, persistent chemical insecticides have been expensive and disruptive to the environment. Beneficial organisms are destroyed which help regulate the abundance of other pests such as spider mites, aphids, and pear psylla. Released from their natural enemies, these pests frequently reach damaging levels, requiring additional pesticide treatments for their control.

Since 1968, a trap that can provide growers with the information necessary to determine the need for codling moth control has been under evaluation in California. The trap, known as a sex pheromone trap, utilizes five live virgin adult female codling moths housed in a small plastic cylinder cage with screened ends. This cage is suspended within a cylindrical one-gallon-size carton with the top half of each end removed. Male adult codling moths attracted to the trap by a pheromone emitted by the females, fly into the trap and are caught on a sticky plastic liner covering the bottom half of the carton (see cover photos). The captured moths are counted and the need for control is determined by the numbers found each day. Since few if any other insects are taken, there is small chance for misidentification of captured moths.

Although the sex pheromone trap was tested in a total of 13 counties in northern and central California, this report will be restricted to results obtained in El Dorado and Sacramento Counties.

TABLE 1. AVERAGE NUMBER OF MOTHS OF CODLING MOTHS CAPTURED PER TRAP PER YEAR IN EL DORADO COUNTY ORCHARDS*

	Pears						Apples					
	RH	KJ	CA	BT	NW	WP	RL	EL	HM	WP	MLO	ED
1968											43	17
1969	93	60	13	(3)†	4	64	23	12	53	93	19	56
1970	115	70	22	24	16	86‡	108‡	14‡	95	189	47	35
1971	91	72	17	61	-§	349‡	300‡	82‡	149‡	302‡	51	20

* Figures for all orchards represent the average catch for three traps for the season, except for ED and MLO orchards which had 1 trap in 1968 and 2 traps each in 1969, 1970, and 1971.

† Traps were not placed in the BT orchard until after most overwintered moths had emerged in 1969.

‡ Sprays for moth control were reduced or eliminated due to frost damage to crop.

§ Traps not operated.

El Dorado County studies

Early in the 1968 season sex pheromone traps were placed in two orchards (MLO and ED) in El Dorado County (table 1). The MLO orchard is a 13-acre commercial apple orchard where through 1967 codling moth and mites were controlled using the standard prophylactic chemical pesticide control programs (table 2). The ED orchard was a young, non-bearing high density planting of about four acres. Fruit production began in 1969 and gradually increased in productivity each succeeding year.

In 1969 five pear and five apple orchards were added to the study. These were commercial fruit production operations of 20 acres or more which used the standard prophylactic chemical pesticide programs for codling moth and mite control. However, the CA and RL orchards used only two standard applications for codling moth control each year, instead of three.

Throughout the study trapped moths were counted daily and the female moths replaced about weekly. Three traps were used in most orchards.

The female moths used in the traps were obtained from laboratory cultures maintained at the Division of Entomology, University of California, Berkeley. In 1969, moths were reared at Berkeley from larvae supplied by the USDA, Yakima, Washington.

Preliminary results

The number of male moths captured in the traps at the MLO orchard was low during 1968. (table 1). Consequently, the codling moth control program was reduced to two applications of one-half-dosage each of Guthion (azinophosmethyl) compared with three full-dosage applications used the previous year. Highly acceptable fruit, less than one per cent wormy, resulted at harvest, which indicated that the modified codling moth control program had been successful. Other benefits accrued immediately, as demonstrated by the reduction in the use of acaracides for mite control.

Major results

For the orchards brought into the program in 1969, the average number of male adult codling moths caught per trap per year for the three-year study was considered to be quite stable and low in the CA orchard; fairly stable and moderately

NEED FOR CODLING MOTH CONTROL APPLE AND PEAR ORCHARDS

low in the MLO and ED orchards and moderately high in the KJ and RH orchards. The number of moths captured increased from low to moderately high in the BT and EL groves and from moderate to heavy in the WP pear, RL, HM and WP apple orchards from 1969 to 1971.

The rise in the number of moths captured in the WP pear, EL, HM and RL apple orchards was attributed to a sharp reduction in use of insecticides in 1970 and 71. This was due to spring frosts which caused a partial crop loss in 1970 and a total loss in 1971.

In those orchards with fruit to protect each year of the study, insecticide usage was based on trap catches and was reduced in every case (table 2). After the MLO orchard, the next greatest and most immediate reduction was made in the BT pear orchard. During 1969 only one full-strength application of Guthion was used, compared with three in 1968. In 1970 and 71 insecticide use increased slightly, mainly to protect against an apparent rise in moth abundance. However, a 4-acre section in the BTI orchard was kept under a reduced insecticide program (a single half-dosage application) in 1970 and 71 in an effort to find the lower limits of effectiveness for Guthion for adequate moth control. In both situations, harvested fruit never exceeded the one per cent worm level throughout the three-year study.

In both the KJ and RH orchards one trap captured three to four times more moths than the other traps throughout most of the season. In each case, the trap which captured the highest number of moths was closest to unsprayed (abandoned) apple or pear trees located on neighboring properties. These trees harbored codling moth populations producing moths which emigrated into the neighboring commercial orchards. Efforts to control the outside populations were made in 1970 and 71. This led to lower moth pressure in both the RH and KJ orchards in 1971 and consequently permitted reductions in the use of the insecticide for codling moth control in both orchards.

In the CA orchard the amount of insecticide used for codling moth control was first reduced in 1971 from two full-strength applications of Guthion to two one-half strength applications of Guthion. Although this reduction probably could have been made earlier in the program, caution was used because pesticide use had been low prior to the start of the trapping program.

In the WP apple orchard the use of Guthion for codling moth control was greatly reduced in 1971 compared with previous years despite the high number of moths captured in the traps. This was done in an effort to lower production costs as the orchard had suffered severe crop loss due to spring frosts. However, at harvest, it appeared that the lower limits for codling moth control had been exceeded as about one per cent wormy fruit was found in the orchard overall, with one block registering a high of ten per cent. The WP apple orchard was encircled by orchards which had not been sprayed for at least two seasons, and it is suspected that the moths migrating from these orchards contributed to the moth pressure in the WP apple orchard.

Effect on other insects

In addition to reductions in the use of Guthion for codling moth control, mite control programs were significantly altered in all the study orchards. In 1968, a total of 23 applications were made, and 18 contained an acaricide, whereas in 1971, a total of 16 applications were made and only 3 contained an acaricide. In two of the situations which employed acaricides in 1971, untreated blocks in the orchards indicated that the treatments were unnecessary. In the ED orchard artifical mite control was never needed because two species of predator mites, **Metaseulius occidentalis** and **Zezellia mali,** were present in ample numbers to control the phytophagous mites.

Many pear growers expressed concern that pear psylla populations would increase significantly if Guthion treatments were omitted or dosages reduced. This did not happen where overwintered psylla populations were adequately controlled during the dormant season. Orchards which suffered frost damage and were unsprayed during the 1971 foliage period showed no marked increase in psylla numbers, and in some cases there was actually a reduction. It appeared that when disruptive chemicals were not used, predators maintained populations of pear psylla at low levels during the foliage period.

The BTI block received only one insecticide application per year for codling moth control for the last three years of the study and during the last two years the one-half dosage of Guthion was used. In 1971, the only other pesticide materials applied were oil during the foliage period and oil plus polysulfide in the dormant season. Few pest species were observed in this block the past two seasons and none caused economic damage.

Pest control costs

In the El Dorado County study, insecticide costs in 1971 were $15 to $50 per acre less than in the year

TABLE 2. A COMPARISON OF PESTICIDE PROGRAMS AND COSTS PER ACRE THE LAST YEAR BEFORE TRAPS WERE USED (1968) AND ON THE THIRD YEAR WITH CODLING MOTH TRAPS (1971) IN EL DORADO COUNTY ORCHARDS*

Orchard		Pesticide Programs: Codling moth 1968	Codling moth 1971	Mites 1968	Mites 1971	Cost per acre 1968	1971	Diff.
MLO†	apple	GGG	gg	ACC	A	$ 70	$ 33	$ 37
ED†	apple	N	gg	P	P	0	14	14†
WP	apple	GGG	gggg	AAA	P	73	36	37
BT	pear	GGG	Gg	ACC	OO	109	59	50
BTI	pear	GGG	g	ACC	OO	109	22	87
RH	pear	GGG	GGg	OCC	COO	55	39	16
KJ	pear	GGG	Ggg	OCC	COO	83	53	30
CA	pear	GG	gg	OC	OO	40	25	15
NW	pear	GGG	ggg	OCC	OOO	62	37	25

* Each letter designates one application of pesticide: G is for 1/2 lb. and g is for 1/4 lb. Guthion 50% wettable powder per 100 gallon; N means no applications; A is for acaricide; O is for Oil 1 gal/100 gallons; C is for acaricide plus oil; and P is for control by predator.

† In the MLO and ED orchards the pre-trapping data is period information for 1967; the trapping program began in 1968. The ED orchard was a young non-bearing orchard in 1967 and came into production during the course of this study.

before traps were used. Most of the decrease was in the cost of insecticides for codling moth control and the remainder was in materials used for mite control. Further reductions in pest control expenditures appeared possible as indicated by the cost of pesticides used in the CA, ED and BTI orchards in 1971.

Sacramento County pilot study

The success of the El Dorado County codling moth sex pheromone trap program prompted six pear orchard enterprises in Sacramento County to jointly finance a similar study for their area. A pilot program was initiated in 1971 using 6 paired-block arrangements. In each paired block arrangement an effort was made in one of the blocks to maintain the normal commercial insect control program which included a standard prophylactic codling moth control program. In the other block, codling moth control was applied only when needed as indicated by the numbers of male moths captured in the sex pheromone traps. One sex pheromone trap was employed in each block and additional traps were scattered throughout the remainder of the orchards.

In addition to the sex pheromone traps, leaf samples were collected weekly to determine population levels of harmful and beneficial mite species. Samples were taken by beating periodically to assess the abundance of pear psylla, other pests and beneficial species.

The average number of male adult codling moths captured per trap month was low in three pear orchards and moderate to high in the three others. Because of the low to moderate codling moth population levels, it was immediately possible to reduce either the number of applications or the dosage of Guthion needed for codling moth control.

Good populations of predator mite species were found in four orchards, making post-harvest control of phytophagous mites unnecessary. Also, despite the elimination of as many as four psylla sprays in the integrated control blocks, psylla populations did not increase except where oil was not used on the foliage prior to harvest.

In the paired block arrangements the average cost per acre for pest control in the integrated control blocks was $74 compared with $147 in the standard block.

The preliminary results were so encouraging that the growers frequently followed a similar program in the balance of their orchards. Because of the overkill of codling moth in previous years and the establishment of integrated control during the first season of this project, substantial savings were realized. The average cost per acre was $98 ($67 for pesticides, $31 application costs) compared with $156 ($111 for pesticides, $45 application costs) in 1970. The net reduction was $58 per acre or a total of $64,800 for 1100 acres of commercial pears.

At harvest, the fruit from all orchards was as free from insect damage as in any previous year of intensive pesticide use.

Conclusions

These studies demonstrated that the codling moth sex pheromone trap was a highly useful tool for monitoring the abundance of male adult codling moths in apple and pear orchards in El Dorado County and pear orchards in Sacramento County. The traps have the advantages of being simple to operate and can be located where desired.

It was further demonstrated that the need for insecticide applications to control codling moth could be determined through proper interpretation of trap catch data. In all orchards, except one, in Sacramento County, it was possible to reduce the amount of insecticide and the number of applications used for codling moth control. This in turn led to a reduction in the use of pesticides for the control of phytophagous mites and pear psylla. Above all, savings were realized in all the orchards in the program.

The major disadvantage of the sex pheromone trap was the need for a continuous supply of fresh, live, virgin female moths. This problem may have been solved with the development of a synthetic attractant by scientists at Cornell University. During preliminary field studies conducted in 1971 the synthetic attractant appeared to effectively duplicate the effects of the pheromone produced by the female moth. Further studies will be conducted to adequately determine the effectiveness of the artifical codling moth sex attractant.

Although traps baited with either live females or the synthetic attractant are available to growers, the grower is warned to employ them with extreme caution. Proper interpretation of trap catch data is difficult and should be undertaken only by individuals knowledgeable in the population dynamics of the codling moth.

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