ity. If catches continue to be high, tree and ground fruit should be checked for entries to verify the size of post-harvest infestations.

A grower has several options to reduce a post-harvest infestation. As with many pests on fruit and nut crops, sanitation is good practice to restrict codling moth build-up during this period. To prevent further oviposition it is important to remove the remaining tree fruit and drop it to the ground where it can be readily destroyed by cultural measures such as flailing, discing, and post-harvest irrigation.

Larval mortality from the various sources mentioned above may substantially reduce the overwintering larval population. Assuming a larval mortality rate of 90 percent for the post-harvest period, only 7 of 67 larvae per tree would have survived in the orchard with the highest infestation in this study. If two-thirds of these mature larvae survived the dormant period, about 360 adult moths per acre would emerge the following spring. This certainly would be a sizable population which would pose a particular threat to growers who are unaware of this potential carry-over and who have become accustomed to the use of minimum spray programs with reduced dosages.

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Sunflower resistance to the sunflower moth

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The sunflower moth (*Homoeosoma electellum* Hulst.) will probably never be put on the endangered species list, but many California farmers would like to see it as extinct as the dinosaurs because of the damage it does to the sunflower crop. This pest has also caused extensive damage to sunflowers in Georgia, Kansas, Louisiana, Missouri, Nebraska, Texas, Minnesota, North Dakota, and in parts of Canada.

Newly hatched larvae feed on the pollen and other floral structures of the disk florets. Infestation can be detected by a silken webbing over the face of the sunflower head, and a very trashy appearance due to dead florets and frass. The larvae bore through the seedcoat of the achene (seeds) and feed on the developing kernel. Although damage to large plantings may vary from slight to 50 or 60 percent yield reductions, larval infestation of individual heads may cause 100 percent seed destruction.

Measures that provide limited moth control include cultural practices, especially early planting to avoid damage, and chemical control. Possible biological controls include predators, parasites, a pathogenic fungus, and the use of pheromones. Development of resistant plant varieties, the subject of this report, offers the greatest control potential.

Resistant sunflowers

Plant breeders in Europe and Russia have found sunflowers resistant to seed damage from a larva similar to that of the sunflower moth present in this country. These researchers believe a resinous or carbon layer (a phytomelanin layer) in the achene wall gives mechanical protection from larval penetration. Studies in California do not support the mechanical barrier concept, but indicate chemical resistance mechanisms may be important.

We have been working with two sources of resistance. One was obtained from the USDA, Agricultural Research Service at the Texas Agricultural Experiment Station and was selected from a line developed in Canada. The other came from a domestic variety x wild *Helianthus annuus* L. cross from a student's thesis study on the inheritance of branching. These two germplasm sources have provided slightly different damage estimates from natural infestation in the field, but progeny from crosses of the two sources have not shown additive resistance.

Ten seeds, from each of the resistant lines (including seeds with and without the phytomelanin layer), plus H2165 (our susceptible check) were collected from different stages of post-pollination development ranging from 1 to 40 days. Each sample was placed in Petri dishes containing six sunflower moth larvae. Three replications of each seed developmental stage and each larval instar stage on each type of seed were included.

TABLE 1. Percentage of Sunflower Seeds Damaged by Sunflower Moth Larvae

	Phytomelanin layer					
	Present			Absent		
	Larvae size*			Larvae size*		
Days after pollination	I	II	III	I	II	III
				percent		
1-3	4.5	10.0	22.1	21.5	32.1	40.2
5-7	3.2	10.3	27.4	20.4	30.0	40.2
9-11	2.0	10.0	20.0	14.4	26.0	35.0
13-15	0.0	5.4	15.3	11.4	18.1	31.9
40	0.0	0.0	3.8	0.0	1.5	13.0

Note: Seeds and larvae were confined in petri dishes.
*I = 1st or 2nd instar; II = 3rd or 4th instar; III = 5th instar.

TABLE 2. Estimated Seed Damage of Resistant and Susceptible Sunflower Lines Caused by Sunflower Moth Larvae

	Damaged seeds*			
	Field infestation		Artificial infestation	
	Phytomelanin layer		Phytomelanin layer	
Sunflower line	Present	Absent	Present	Absent
		average no.		
H2129	4.6 ab	14.0 ab	—	9.0 a
H2135	5.2 ab	15.4 b	2.3 a	
H2160	8.2 ab	16.0 b		
H2165 suscept.		68.0 c		23.5 b

*Based on counts of 5 replications per variety. Estimates not having a letter in common are significantly different at the 5% level of probability according to Duncan's multiple range test.

TABLE 3. Larval Growth of *H. electellum* on diets containing: (I) trachyloban-19-oic acid and (II) ( )-kaur-16-en-19-oic acid

Additive	Larval weight	
percent	mg	percent*
None	13.9	100
I. 0.5	8.5	61
1.0	6.7	48
2.0	2.5	18
II. 0.5	10.6	7.6
1.0	4.2	30
2.0	0.14	1

*Percent of control after 14 days.

Results

The results in percent damaged seeds (table 1) indicate the smallest larvae (first and second instar) were unable to penetrate seeds with the phytomelanin layer, but could penetrate those without, even up to older seeds of 13 to 15 days post-pollination development. On the other hand, the older larvae could penetrate all seeds, with or without the phytomelanin layer. However, an indication that something other than the phytomelanin layer contributes to resistance has shown up in field comparisons of resistant and susceptible lines—even those resistant plants without the phytomelanin layer show fewer damaged seeds than does the susceptible check (table 2).

A possible explanation for this difference has been found at the Western Regional Research Center, Albany where researchers have isolated at least two substances which seem to contribute to sunflower moth resistance. These two substances, isolated from the florets of the sunflower by liquid and vapor phase chromatographic techniques, have been identified as diterpenoid acids. We have also found another sunflower line that seems to have an entirely different type of chemical, indicating that more variation may be available.

Sunflower moth larvae reared on artificial diets containing 2 to 3 percent diterpenoid acids do not grow and will remain in the first instar for long periods. A threshold concentration is required for these substances to be effective since low concentrations have only small effects on the larvae (table 3). Isolation studies have shown these substances are present in florets of all sunflowers, but at different concentrations in susceptible and resistant lines. Unfortunately we have been unable to coordinate data for chemical concentration and moth damage on the same head due to low populations of moths in the field at the proper time.

Infestation tests

In California we have used both natural and artificial infestation methods to test for plant resistance in the field. Natural infestation often fails to give reliable results due to insufficient adult moth populations or variability in number of moths during the growing season. Thus results vary by years, locations, or even areas in the same field, making our field tests insensitive to small differences in resistance.

Artificial infestation tests have consisted of placing ten first instar larvae or 10 to 25 freshly laid eggs on sunflower heads previously protected by kraft paper bags. An average of less than two of the ten larvae have survived per head, even on our most susceptible sunflowers; hatching percentage and larval establishment from the introduced eggs were also very limited. Since it has been difficult to have an adequate supply of larvae or eggs, and because extreme care is necessary to avoid injury when moving larvae or eggs, only a limited number of sunflower plants can be tested. Large scale infestation is essential since it appears that a sunflower line may be resistant to only one or two larvae per head, but susceptible to large numbers of larvae.

Growing sunflower plants in a greenhouse and subjecting them to a population of adult moths at the proper time would seem to be a feasible technique for development of resistant inbred lines and also for testing hybrids. Although techniques for rearing sunflower moths on artificial media have been known since the late 1960s, the vigor of our artificially reared moths declines rapidly, apparently due to small colony inbreeding, and we have not been successful in mass production of eggs or larvae. Diapause (dormancy) has been artificially induced by a combination of short daylight periods and lower temperature during the third to fifth instars. Larger colonies and development of techniques for storing diapausing pupae are needed. Also we need to be able to break diapause to make large numbers of adult moths available, when needed to coincide with plant development.

Development of sunflowers resistant to the sunflower moth appears possible based on presently available test results, but better technical procedures are needed for maximum progress.

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The adult sunflower moth is generally described as gray to brown, about 11 to 13 mm long, and with a wing spread of 21 to 27 mm. In California the female is larger than the male. Eggs are laid singly or in small clusters of 4 to 10 eggs, within or among sunflower disk florets, 3 to 6 days after the ray flowers open. The eggs are elliptical, finely reticulated, 0.63 to 0.80 mm long and 0.23 to 0.27 mm in diameter. When first laid the eggs are pearly white but after a day or two change to brownish yellow. Larvae, 1 to 1.5 mm long, usually emerge in 48 to 96 hours. Mature larval length is 16 to 18 mm, achieved about 19 to 28 days after hatching and passage through 4 or 5 instar stages. Mature larvae spin a silken thread, lower themselves to the ground, spin cocoons in the soil, and enter the pupal stage. Some reports indicate cocoons also can be found among or within the sunflower achenes. There may be one to four, or more, reproductive cycles each year. During early summer cycles, mature larvae spin light airy cocoons, but those going into diapause (overwintering) spin much heavier cocoons. Development of sunflower varieties or hybrids resistant to the seed-destroying larvae of the sunflower moth seems promising, but efforts have been stymied by erratic populations of moths in the field and difficulty in rearing moths for artificial testing for resistance.

Research briefs

UC Animal Behaviorist Ed Price, UC Davis, displays a lamb-kid pair being raised in isolation from other sheep and goats. As adults, they will be studied to determine how much each takes on the characteristics of the other.

Animal behaviorist Ed Price has paired sheep with goats and is raising each pair in isolation to determine the effects this will have on their behavior as adults. The objective: determine the relative influences of heredity and learning in the developmental process.

He also is looking for characteristics in bull calves that correlate with sexual motivation as adults. This would allow culling poor prospects without investing time and expense involved in raising them to maturity.

Another study is under way to determine the mothering ability of cows with twins compared with those having single calves.

Deer-sheep combination improves range use

There is little significant competition between deer and sheep for most kinds of range forage, a summary of 19 years of research, primarily at the Hopland Field Station, shows.

W. M. Longhurst and other wildlife and range scientists conclude that dual stocking of a range with deer and sheep makes more efficient use of all classes of forage than with either species alone.

The diet of deer consisted of approximately 60 percent browse, 20 percent forbs, and 20 percent grass. Sheep consumed 6 percent browse, 9 percent forbs, and 85 percent grass.

Deer and sheep overlap most in their diets when both are eating grass during the wet months of the year. There is minimal competition for browse and forbs, says Longhurst.