Application rates

Rauschkolb and Mikkelsen ("Survey of Fertilizer Use in California—1973," UC Division of Agricultural Sciences bulletin, forthcoming) estimated common fertilizer application rates and percentages of land fertilized by area for individual crops in 1973. We derived weighted statewide application rates from these estimates. Thus, our estimates of application rates are based on the cropping pattern existing in 1973. A significant change in the location of crop production in California could produce a substantial change in fertilizer use without any change in fertilizer prices or planted acreage.

The acreage projections are based on increased average yields for most crops with the amount of increase dependent on recent trends. However, the interaction between fertilizer application rates and yields is not explicit. We assume that increased yields will require increased fertilizer applications and that our adjustments to the 1973 crop use rates will sustain increased yields.

Total fertilizer use

Estimated 1973 fertilizer use and projected 1985 use by nutrient and major crop category are presented in the table. We project a 98,000 ton (19.8 percent) increase in nitrogen, a 23,000 ton (13.6 percent) increase in phosphates, and a 6,000 ton (10.5 percent) increase in potash use in 1985. Approximately two-thirds of the increased nitrogen and 60 percent of the increased phosphates are for field crops. Just over one-half of the projected increase of potash is for bearing fruits and nuts. Nonbearing fruits and nuts show decreased use of all nutrients because of a projected decrease in nonbearing acreage.

The projected increase in the use of all three nutrients is 127,430 tons, which is 17.59 percent of reported 1973 sales in California. There are factors which could increase or decrease the projection. For example, increased crop income or increased crop acreage over that projected would tend to increase fertilizer use over the projection. Sharp increases in fertilizer prices could decrease projected usage.

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Post-harvest codling moth infestations on pears— a potential threat for next year's crop

Helmut Riedl ■ James E. DeTar

Fig. 1. Photograph of pear orchard after harvest.

The codling moth, *Laspeyresia pomonella* L., has been the key pest on pears for many years in California. At the present, two to three applications of azinphosmethyl or other broad-spectrum insecticides provide economic seasonal control of this insect. Without controls, however, the codling moth can build up very quickly, even if the density at the beginning of the season is very low.

Every year a certain amount of fruit remains on the trees after harvest due to uneven maturity, small size, and defects (insect damage, limb rub, etc.). In normal years not more than 1 percent of the total crop is left unharvested. In 1976, because of poor market conditions and an above-average crop, a considerable number of marketable, high-quality pears were not picked in many orchards. A survey of several pear orchards in Solano County showed that between 100 and 400 unharvested fruits remained on the trees at the beginning of August 1976 (fig. 1).

On an area basis this amounted to between 9,000 and 36,000 pears per acre. Since the last codling moth sprays are applied several weeks before harvest, this essentially unprotected reservoir of fruit provides a ready source for post-harvest codling moth infestations. Growers have expressed concern about these infestations and whether they result in larger overwintering populations and a magnified codling moth problem the following year. This research evaluates the extent and fate of post-harvest infestations in pear orchards.

Codling moth activity

Five commercial orchards located in Solano County were monitored with pheromone traps for codling moth activity. In late August and September egg and damage surveys were conducted to follow population build-up after harvest. Seasonal total trap catches varied between 9 and 115 which reflected large differences in population density among the orchards. The cumulative catch and post-harvest damage curves for two of the orchards are given in fig. 2. Damage is expressed as cumulative entries per tree (right hand scale) rather than percentages so that catches can be related to an absolute damage estimate.

Seasonal catches gave an accurate indication of post-harvest infestation levels (fig. 3). Although similar spray programs using three cover sprays were followed in these orchards, with only slight differences in dosage and timing, post-harvest damage levels varied from 4 to 67 entries per tree (fig. 3). Since these sprayed orchards in close proximity to one another were in an area that had few or no abandoned trees or unsprayed orchards, it seems likely the post-harvest infestations developed from indigenous populations. Apparently, populations are held at low sub-economic levels under these spray regimes but rapidly increase after the sprays are stopped.

The catch-damage relationship in fig. 3 can be used to predict the level of post-harvest infestations. However, it applies only to orchards that have had standard spray programs. If, for instance, the average cumulative catch per trap reached 40 moths at harvest time, post-harvest infestations could exceed 20 entries per tree if enough fruit remains on the trees (fig. 3). After harvest, fruit can be found in various stages of maturity and decay on both the trees and the ground. A careful examination of 1200 tree-borne and fallen fruit from each orchard clearly revealed the ovipositional behavior of the coddling moth. Without exception, freshly laid eggs were found only on tree fruit which was still firm and green or only slightly yellowed.

There was no evidence of oviposition on fallen fruit even when still green. This selective ovipositional behavior insures that larvae complete development before the fruit decays. Young larvae as well as adults seem to discriminate between stages of fruit maturity. In laboratory experiments they attacked firm fruit much more readily than yellow, soft fruit.

Two factors limit continued population development at the end of the season. First, larval diapause commences in the beginning of August and second, the fruit favorable for oviposition and larval development slowly decreases due to maturation, drop, and decay. After harvest, the remaining fruit slowly drops to the ground and then decays in about 20 days.

Figure 4 shows fruit drop as a function of time in orchards which received so-called 'stop-drop' sprays 2 weeks before harvest. These sprays are routinely applied in commercial orchards to delay premature fruit abscission and drop. Although this is a necessary cultural practice, it may prolong exposure of unharvested fruit to codling moth attack and thus increase the potential post-harvest infestation.

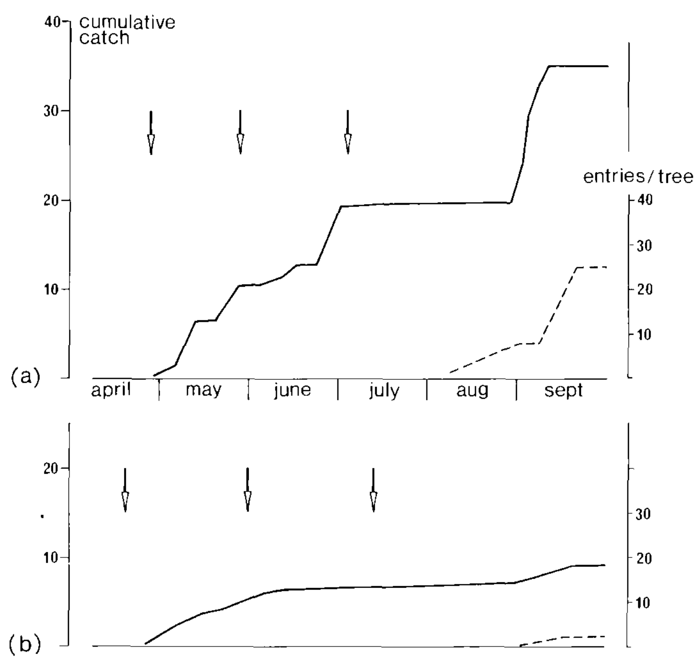


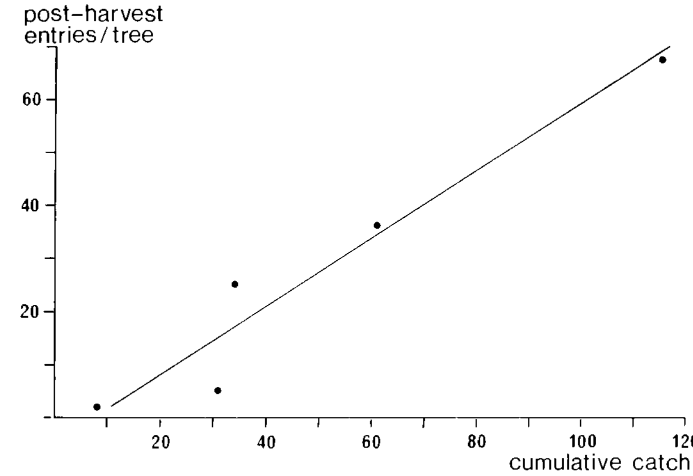
Fig. 2. Cumulative pheromone trap catches and post-harvest codling moth infestations in two commercial pear orchards (Solano County) with (a) medium and (b) low moth populations. Arrows indicate spray applications.

Larval survival during post-harvest period

Experiments suggested high larval mortality once the fruit had dropped and began to decay. Only about 25 percent of all entries resulted in mature larvae. Possibly larvae drown as the fruit interior deteriorates and liquifies. Another source of mortality was caused by heat exposure in dropped fruit. On a clear day with maximum air temperatures of 89°F the temperature in fruit rose to 114°F exposed to full radiation on the soil surface (fig. 5).

There can be significant mortality with prolonged exposure at this temper-

Fig. 3. Relationship between seasonal cumulative catch per trap and post-harvest damage.



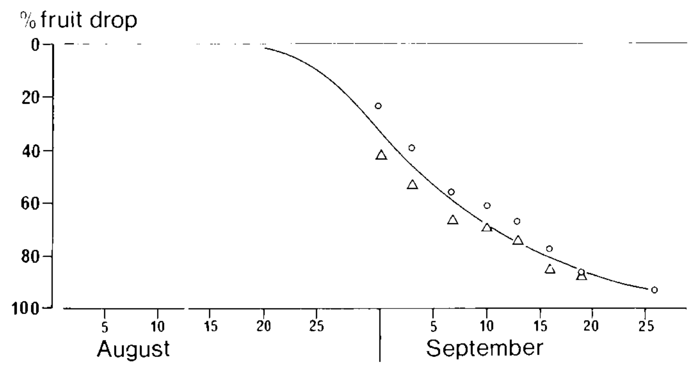
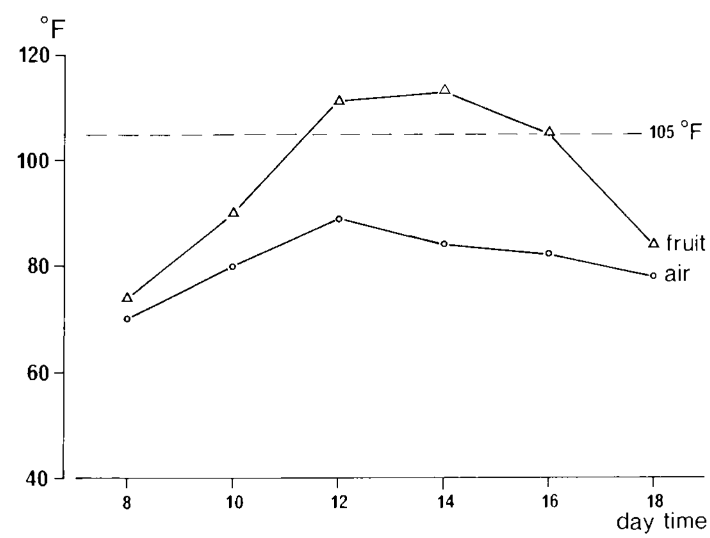


Fig. 4. Schedule of post-harvest fruit drop on two pear trees.

Fig. 5. Diurnal temperature profile in unshaded dropped fruit and in a standard weather shelter on a clear day.



ature. Preliminary laboratory work revealed that young larvae in apple thinnings suffered 25 per cent and 52 percent mortality after 6 hours exposure to 105°F and 110°F respectively. In the field only a certain proportion of the larvae will die due to heat, depending on the microclimate and shading beneath the tree.

Larval survival in fallen fruit is affected by cultural practices. Post-harvest irrigation will speed up fruit decay and deprive larvae of a suitable food source. Discing of the soil after harvest will destroy much of the fallen fruit and cause high larval mortality.

Natural enemies may contribute significantly to population regulation during the post-harvest period. The egg parasite *Trichogramma* sp. became very noticeable in three of the five orchards. Population increase of the parasite was significant only 4 weeks after application of the last broad-spectrum spray.

Practical considerations

It now should be common practice to place pheromone traps in every orchard and maintain a seasonal monitoring program for codling moth. This will help growers to spray according to need by using critical catch levels. It also will be a valuable aid to evaluate the effectiveness of seasonal control programs. From cumulative trap catches at the time of harvest one can determine the potential for post-harvest codling moth infestations if large amounts of fruit are not picked. If the cumulative catch at harvest exceeds 20 moths, traps should be maintained after harvest to keep close check on post-harvest codling moth activity. 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.