Supplementation results (table 3) seem to indicate no advantage in ADG for either alfalfa-barley or straight alfalfa cubes over the pasture-only treatment at the levels fed. Supplementing three times per week with rolled barley (approx. 0.7 of body weight), however, resulted in a significant decline ($P < 0.05$) over either the pasture-only group or those supplemented with alfalfa cubes. This lower gain, while unexpected, might be explained as a disruption of the rumen flora of calves fed only three times per week, as this would be 40% of their diet as supplement on the day fed. No evidence of digestive upset was apparent, as the weight gains of the calves early in the season were comparable. An alternative explanation would be less rumen fill, since cattle on a high concentrate diet have less rumen fill than those on a high roughage diet.

Forage availability (as measured by height) indicated that the calves receiving supplements consumed less pasture. Even at the high stocking rates for the supplemented calves (9.9 animals per acre at the start of the grazing trial, decreasing to 6.3 animals per acre at the end of the grazing season), the pasture height remained equal for all supplementation treatments and was comparable with that of the yearling heifers (table 3) at the considerably lighter stocking rate (2.8 animals per acre). It was concluded that in all cases forage availability was not a limiting factor. Differences in per cent legume probably did not significantly influence either ADG or carrying capacity of the pastures.

Supplementation of young calves at 20% of expected dry matter intake, while not warranted by increased ADG of young calves, did permit an increase in stocking rate from 3.7 to 6.3 animals per acre.

Steers and heifers differed significantly in ADG in a manner similar to that found in the stocking rate trial. Sex of the calf did not influence the responses to supplementation.

No mid-season worm treatment was necessary. Pink eye occurred both years at orchardgrass flowering and seed set. It was greatly reduced when orchardgrass flower and seed stalks were clipped with a sickle-bar mower just above the vegetative part of the forage canopy.

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MOTH RESISTANCE ARMORED-LAYER SUNFI

ELMER C. CARLSON · ROBERT WITT

Sunflower varieties having plants with armored-layer seeds resulted in a high reduction of seed damage caused by larval feeding of the sunflower moth, *Homoeosoma electellum* (Hulst). Several sunflower lines were significantly more resistant to seed damage when the plants had armored-layer seeds than when the same lines had non-armored-layer seeds. The association of the armored layer with moth resistance was also shown by its significant reduction in the number of emerging adults. However, the same lines having plants with no armor still retained some resistance (compared with the check), which indicated that some chemical factors were also involved. Laboratory tests also indicated that the nature of resistance was partially chemical.

RECENT INVESTIGATIONS (1971) showed for the first time that some sunflower lines have an armored layer. The presence of this phytomelanin layer correlated with those lines having the least damage from sunflower moth larval feeding in open pollinated heads. Sunflower research in 1972 and 1973 was intensified in an effort to correlate the armored layer on sunflower seeds with resistance to larval feeding of the sunflower moth, *Homoeosoma electellum* (photo 1).

Field plantings of many sunflower lines and crosses were made in 1972 and 1973 to supply plants, heads, seeds, and pest animals for our investigations. Emphasis was placed on those lines that had been shown to exhibit an armored layer (photo 3), that had the least moth damage, and that were from available selfed seed from the 1969, 1970, and 1971 plantings.

Culture and method

A satisfactory culture and method was devised for laboratory rearing of the pest insect (photo 4). To obtain data on the resistance of sunflower lines to sunflower moth larvae, first instar larvae were transferred onto and in field-bagged heads. Six to 24 of these very small larvae were transferred from pint jars (kept cool) onto each selfed head, which was then re-bagged. This had to be done carefully and slowly to allow the larvae time to get a foothold in the small disc flowers. Many bagged heads were available, so two heads per line were used per introduction date.

Considerable data on head and seed injury and amount of damage due to sunflower moth larval feeding were also obtained from the open field-pollinated heads. A few heads at a time were cut and brought into the lab at several intervals, portions of which were then cut off and the seeds checked for light (scarring only) damage, severe damage (holes eaten through the seed coat and into cotyledons), and total number of seeds.

Laboratory experiments

Laboratory petri dish experiments were conducted on seeds from heads collected in the field, and subjected to first instar larval feeding. Several varieties having armored-layer seeds were tested using whole seed (florets + seed + pulp), seed + pulp (floret scar sealed with nail polish), florets alone, and seed alone. The whole seed obtained was cut carefully in groups of 15–24 from a head in order to preserve the florets on the seeds and to leave them intact in the pulp, since excised seeds left a crown scar and a slight hole at the apex. The laboratory cultured first instar larvae were able to search out these injuries and enter them instead of boring through the seed coat. The various types of seed used from each strain were placed on dry filter paper in the petri dishes, larvae were introduced, and all replicates were left about a month—or until adult moths had time to emerge (after larval feeding and pupation). The florets and seeds left alone were subjected to larval feeding in this manner for only two days, after which whole seed of fresh UC5 (the check) was added to insure survival of the remaining live larvae.

Table 1 contains a summary of the data obtained in 1972, separated according to presence or absence of the armored of

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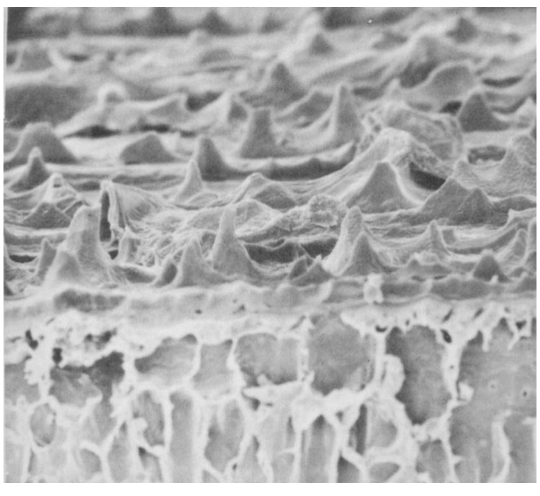
layer, which was determined at maturity by a chemical test. Larvae were introduced on many selfed heads that actually did not have armored-layer seeds, since this could not be determined at blooming time. The overall results from several lines showed that those heads having seed with a phytomelanin layer reduced the numbers of severely damaged seeds by over 97%, compared with seeds without an armored layer. Larvae were introduced in many heads of selections H2131 and H2135, all of which had this layer and zero seed damage. The moth-susceptible UC5 selection had no armored-layer seed at all (photo 3).

Damage reduced

Sunflower moth eggs and larvae were introduced again in 1973, in various numbers and at several different times onto selfed heads (bagged). Both eggs and larval introductions appeared comparable, and 12 to 24 per head appeared satisfactory. The overall results from several lines showed that the seed damage was reduced by 98.6% in those heads having armored-layer seeds.

The results from open pollinated heads in 1972 (table 1) showed that seeds having the armored layer reduced the severe damage incurred by 72% from those

Photo 1. Cross-section of thick black "armored layer" and spines of variety H2157, Pl.2. 490x



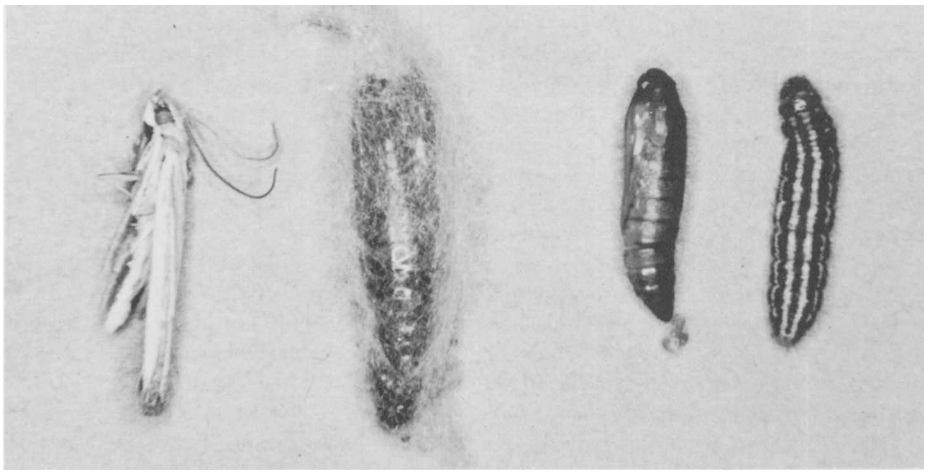


Photo 2. Sunflower moth adult to left, cocoon, pupa, and larva.

Photo 3. Normal seed to left, scarred seed, larval hole through hull, and black "armored-layer" seed to right (after chemical soaking) of a resistant line. Check seed on bottom row shows serious larval damage. White non-armored seed is shown after chemical treatment to right.

Photo 4. Sunflower moth larvae, cocoon, and pupa in laboratory culture.

with no armored layer. Seed damage was reduced by 83% when the best lines having this layer were compared to only the susceptible check line (UC5). Resistant seeds were only lightly scarred, and even severely damaged seeds had only small holes through the seed coat and very little cotyledon damage (1 to 1½ mm in diameter). The susceptible lines had large holes, with most of the cotyledon destroyed (⅛ to $^3/_{16}$ inch, as shown in photos). Also, in one instance, a larger number of moths emerged from the left-over head portion in the susceptible lines.

The overall data obtained from the open pollinated heads plucked for seed damage and adult counts in 1973 showed that H2052 was the only variety checked in large numbers in which only armored-layer seeds were present, and the damaged seeds amounted to only one per cent. H2059 had 17 heads with armored seeds versus two non-armored, and one per cent seed damage. Emerging adults were reduced overall by 76% in the heads having the armored seed, and the seed damage was reduced by 79%.

Statistical data

Table 2 presents the data differently and statistically for those varieties where 5 replicates could be run in 1973. In comparing only those counts of heads having armored-layer seeds, lines H2052 and H2059 were the most significant in reducing seed damage. In the next column the varieties having armored seed were all significantly better than some of the same varieties when they were non-armored. The third column showed that all varieties were significantly better than the check (UC5), whether armored or not. Thus, when the check was included in the statistical data, those plants segregating for non-armored seed were still superior to the check—indicating that some chemical also must have been present, and that this was a contributing factor in resistance.

When the data on severely damaged seeds and the adults were considered, those varieties having armored seeds were significantly better than when non-armored, except in one instance, and were better than the check. These data indicated also that those plants having non-armored seeds appeared to have retained a large amount of larval resistance, and that it was probably due to the presence of chemicals.

Laboratory data

Groups of whole seeds cut to preserve the florets on the seeds, and to leave them intact in the pulp, in laboratory tests showed 100% mortality of the larvae introduced and no seed damage in the varieties H2059, H2129, H2131, and H2135. Many larvae survived in the check (UC5). Although the mortality was 44.5%, seed damage was 82.8%. When florets were removed and crowns were sealed on seeds of line H2135, larval mortality was 100% and there was no seed loss. Larval mortality was 77.8% when they were allowed to feed on florets only for two days and then given access to whole check seed. Larval mortality was lower, and the seed damage was higher, when larvae fed on seed alone before transfer.

This indicated that the larvae were unable to penetrate the hull of the seed, or died while trying to feed on the first four varieties of whole seed. Many of the larvae feeding on florets or seed only were unable to transfer to susceptible seed or died, so that at least part of the nature of resistance must be chemical. The data also showed that each larva severely damages about nine seeds, after feeding primarily on the florets the first one or two days while in the first instar.

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TABLE 1. EFFECTS OF LARVAL FEEDING OF SUNFLOWER MOTH ON SEVERAL VARIETIES OF SUNFLOWER, DAVIS, 1972

	Bagged heads, larvae introduced				Open pollinated heads, field infested			
	Armored layer seeds		Non-armored layer seeds		Armored layer seeds		Non-armored layer seeds	
Variety	No. of heads	Avg. No. seeds damaged/head	No. of heads	Avg. no. seeds damaged/head	No. of heads	Avg. % seeds damaged	No. of heads	Avg. % seeds damaged
H2122	6	0.00	3	16.7	8	10	4	25
H2127	7	0.00	1	8.0	9	6	3	30
H2129	5	0.00	2	5.5	7	4	4	25
H2131	6	0.17	0	—	7	8	4	23
H2135	6	0.00	0	—	7	7	5	35
H2155	1	0.00	0	—	1	19	0	—
H2156	1	0.00	0	—	1	14	0	—
H2157	3	0.00	2	8.0	5	4	3	31
H2160	2	0.00	3	4.7	6	5	3	38
Average		0.02		8.6		8.6		31
% Reduction*	99.8					72.0		
H2165–UC5 check	0	—	0	8.0	0	—	8	42
% Reduction	97.5					79.5		

* Percentage reduction of damaged seeds by those heads having seeds with an armored layer.

TABLE 2. SIGNIFICANT DIFFERENCES BETWEEN SUNFLOWER VARIETIES IN RESISTANCE TO SUNFLOWER MOTH, DAVIS, 1973

		Open pollinated heads, field infested*					Selfed heads, larvae introduced	
		Average total number seeds damaged/head			Average number seeds severely damaged/head	Average number adults emerged/head	Average number total damaged seeds	Average number severely damaged seeds
		Armored only	Armored plus no armor	Armored plus no armor plus check				
Armored layer seeds	H2052	1.0 ab	1.0 a	1.0 a	0.6 a	5.6 a	0.0 a	0.0 a
	H2059	0.8 a	0.8 a	0.8 a	0.0 a	5.0 a	1.75 a	0.0 a
	H2127	—	—	—	—	7.2 a	0.0 a	0.0 a
	H2129	4.6 bc	4.6 a	4.6 ab	1.4 ab	8.4 a	—	—
	H2135	5.2 c	5.2 a	5.2 ab	1.6 ab	6.8 a	2.25 a	0.4 a
	H2160	8.2 c	8.2 a	8.2 ab	2.8 ab	9.8 a	—	—
Non-armored layer seeds	H2129	—	21.2 b	14.0 ab	9.8 c	23.8 b	9.0 a	1.4 a
	H2135	—	19.6 b	15.4 b	11.0 c	31.4 b	—	—
	H2160	—	19.4 b	16.0 b	7.4 bc	29.4 b	—	—
	H2165 (UC5)	—	—	68.0 c	33.0 d	61.6 c	23.5 b	11.8 b

* Based on counts of only those varieties for which five replicates could be run statistically, and comparing open and selfed heads with or without the armored layer (phytomelanin layer). Those varieties not having a letter in common are significantly different at the 5% level, according to Duncan's multiple range test.