Mortality of Cowpea Weevil[1] in a Low-Oxygen Atmosphere[2]

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ABSTRACT

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Various stages of *Callosobruchus maculatus* (F.) were exposed to a modified atmosphere (0_2 < 1%, CO_2 = 9–9.5%, balance principally N_2) produced by an exothermic inert atmosphere generator. The order of tolerance to the low 0_2 atmosphere was 21-day-old larvae = pupae > 14-day-old larvae > 7-day-old larvae > 1-day-old eggs > 3 day-old-eggs > adults. At 27°C, times of exposure for 100% mortality were 48 h for adults, 96 h for 1- and 3-day-old eggs, 120 h for 7- and 14-day-old larvae, and 192 h for 21-day-old larvae and pupae.

The cowpea weevil, *Callosobruchus maculatus* (F.) is among the most destructive pests of stored dried cowpeas, *Vigna sinensis* (L.) Endl. Infestation that occurs in the field before harvest may be carried into storage with the threshed cowpeas or the cowpeas may be attacked directly while in storage. The female weevil attaches her eggs to the surface of the cowpeas, and the newly hatched larvae tunnel directly into the cowpeas. The interior of the cowpea is virtually destroyed by the feeding activity of the developing larvae.

The principal method of controlling storage infestations is fumigation of bagged cowpeas with methyl bromide under gas-tight tarpaulins or in fumigation rooms. However, during long storage more than one fumigation may be necessary to protect against reinfestation. Thus, an alternate method of control that would not leave residues on the cowpeas would be desirable.

Studies have shown that low oxygen atmosphere produced by an exothermic inert atmosphere generator is effective against several species of stored product insects (Storey 1975a, b, c, 1977). Such a generated atmosphere, a potential residue-free alternative to conventional chemical fumigation, was tested against all stages of the cowpea weevil.

Materials and Methods

The inert atmosphere (oxygen < 1%, CO_2 9–9.5%, and the balance principally N_2) was produced in a pilot inert atmosphere treatment system, and the cowpea weevils were exposed to it at a flow rate of 25 cc/min in 0.47-liter jars as described by Storey (1975a).

Immature stages of the cowpea weevil were obtained by placing 25 adults from laboratory cultures on 50 g of blackeye cowpeas (ca. 12% moisture) for 24 h at 27°±1°C and 60% RH and then sifting the adults from the cowpeas. Development time from egg to emerged adult under these conditions was ca. 32 days. Jars containing eggs that were 1 or 3 days old, larvae that were 7, 14, or 21 days posthatch, pupae 28 days from egg deposition, and adults that were 3–5 days old were exposed to the inert atmosphere at 27°±1°C and 50±5% RH for 4–192 h. After the exposures, the jars containing the infested cowpeas were transferred to incubators maintained at 27°±1°C and 60±5% RH. Counts of adults emerging from treated and untreated samples began when the 1st emergence was observed in untreated controls (jars held in atmospheric air) and ended 21 days later. Data of mortality counts for immature stages were based on the relative number of adults emerging from treated and untreated samples. An avg of 406 adults/jar emerged from the control samples. Adult mortality was based on counts of 25 adults exposed in each test. All treatments (ages and exposure times) were replicated 3 times.

Results and Discussion

Table 1 shows mortalities resulting from exposure of the various stages of the cowpea weevil to the generated inert atmosphere. The order of tolerance to the low 0_2 atmosphere was 21-day-old larvae = pupae > 14-day-old larvae > 7-day-old larvae > 1-day-old eggs > 3-day-old eggs > adults. Endpoint mortality was 48 h of exposure for adults, 96 h for 1- and 3-day-old eggs, 120 h for 7- and 14-day-old

Table 1.—Toxicity of a low 0_2 atmosphere[a] produced by an exothermic inert atmosphere generator to different developmental stages of the cowpea weevil.[b]

Stage	Age (days)[c]	Avg % mortality after exposure of										
		4h	8h	12h	24h	48h	72h	96h	120h	144h	168h	192h
Eggs	1				32.2	70.9	99.8	100				
	3				50.8	96.5	99.9	100				
Larvae	7			2.9	59.7	84.2	92.0	99.9	100			
	14			0.0	0.0	2.6	83.6	93.6	100			
	21				0.0	0.0	35.8	57.7	86.0	96.7	98.0	100
Pupae	28						48.3	71.8	83.9	98.0	99.5	100
Adults	3–5	1.3	4	20.8	45.3	100						

[a] Composition, 0_2 < 1%, CO_2 9–9.5%, the balance principally N_2.
[b] Avg of 3 replicates.
[c] Mortality of immature stages based on an avg emergence of 406 adults from each untreated control sample; mortality of adults based on 25 adults exposed in each test.

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larvae, and 192 h for 21-day-old larvae and pupae. Thus, developmental stages of the cowpea weevil were more tolerant of the generated atmosphere than externally developing stored-product insects such as the confused flour beetle, *Tribolium confusum* Jacquelin duVal, the red flour beetle, *T. castaneum* (Herbst), Indian meal moth, *Plodia interpunctella* (Hübner), and almond moth, *Ephestia cautella* (Walker) (Storey 1975b and 1977) but they were similar in tolerance to internally developing species such as the lesser grain borer, *Rhyzopertha dominica* (F.) (unpublished data) and granary weevil, *Sitophilus granarius* (L.) (Storey 1975 c). Adults that emerged from immature stages of the cowpea weevil and survived 72- or 96-h exposures emerged 7–10 days later than the untreated controls; wings of some adults exposed as pupae appeared to be incompletely developed. Similar morphological abnormalities were reported by Storey (1977) when confused and red flour beetle pupae were exposed to the 0_2-deficient atmosphere.

The lethality of the generated low oxygen atmosphere to all life stages of the cowpea weevil suggests that this method of treatment is a possible alternative to chemical fumigation.

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