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EFFECT OF PHOSPHINE AND METHYL BROMIDE FUMIGATION ON EGGS AND LARVAE OF RICE MOTH *CORCYRA CEPHALONICA* S. A COMMON STORED GRAIN PEST

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Among the insect pests that attack stored groundnut, rice moth *Corcyra cephalonica* Stainton is most important. It is polyphagous in nature and cosmopolitan in distribution. Its ability to develop at low humidities ($<20\%$ RH) may account for its prevalence in the semi-arid tropics (SAT) over other stored product lepidopterous pests (Dick, 1987). The infestation in groundnut results in both qualitative and quantitative losses. *C. cephalonica* is the most common insect pest, often encountered during the visual examination of seed samples meant for export. Though this species is cosmopolitan in distribution and has attained economic importance in several crops, very limited work has been done with respect to its control by fumigation. Hence this study was undertaken to evolve effective, easy, and economic fumigation schedule to control this pest to ensure better sanitation of outgoing seed.

The test insects were obtained from a laboratory culture maintained on groundnut seeds (cv Robut 33-1) in glass jars (24 $\times$ 15 cm) covered with a fine mesh. The culture was maintained at a temperature of 24±2°C in a percival incubator. Four pairs of freshly emerged adult moths were transferred to plastic containers (15 $\times$ 12 cm) with 300 groundnut seeds and covered with a fine mesh. One hundred eggs or larvae were retained in these and rest were transferred back to the stock culture kept in the glass jar. Six treatments with different dosages and exposure periods with two common fumigants, phosphine (PH) and methyl bromide (MB), were selected and replicated thrice. To determine the effect of fumigants on eggs and larval stages of *C. cephalonica*, frseh eggs ($>$ 24 h old) and well grown larvae (20 days old) were subjected to fumigation at 25-30°C.

MB fumigation was carried out in a 1 m^3 chamber fabricated by M/s GBEA ltd, Altham, England. The following treatments were given under sustained vacuum conditions, i.e., 16 g/m^3 for 1,2, and 4 h; 32 g/m^3 for 2 and 4 h; and 40 g/m^3 for 1 h. Fumigation with PH was carried out in 1 m^3 size chamber fabricated by Physical Plant Services, ICRISAT Center. The dosages of 0.5 g a.i./m^3 for 3,4, and 5 days; 1.0 g.a.i./m^3 for 2 and 3 days; and 2.0 g.a.i./m^3 for 2 days were used in the present studies under normal atmospheric pressure (NAP). The observations on mortality of eggs and larvae were recorded after 2 weeks. After fumigation the seed samples were tested for their viability on moist filter paper in sterilized petri dishes. The results were subjected to statistical scrutiny using a randomized block design.

Methyl bromide: The studies on eggs revealed that there was no significant difference among the various treatments

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TABLE 1. Effect of methyl bromide fumigation on eggs and larvae of *Corcyra cephalonica* under sustained vacuum conditions.

Treatment[1]	Mortality (%)	
	Eggs	Larvae
16 g / 1 h	100.00	93.66
16 g / 2 h	100.00	97.66
16 g / 4 h	100.00	100.00
32 g / 2 h	100.00	100.00
32 g / 4 h	100.00	100.00
40 g / 1 h	100.00	100.00
CD at 5%	—	0.67
CV (%)	—	0.6%

TABLE 2. Effect of phosphine fumigation on eggs and larvae of *Corcyra cephalonica* under normal atmospheric conditions.

Treatment[1]	Mortality (%)	
	Eggs	Larvae
0.5 g a.i. / 3 days	94.00	91.33
0.5 g a.i. / 4 days	98.67	97.33
0.5 g a.i. / 5 days	100.00	99.33
1.0 g a.i. / 2 days	97.67	96.00
1.0 g a.i. / 3 days	100.00	100.00
2.0 g a.i. / 2 days	100.00	100.00
CD at 5%	1.35	1.02
CV (%)	1.3	1.0

1. 100 eggs and 100 larvae were exposed in each treatment replicated thrice.

vity will have to be balanced against the cost of finding alternative feed for livestock prevented from grazing the fields.

Earlier maturing cultivars offer an opportunity to manipulate competition gaps. In practice, however, the number of options is fairly limited. New cultivars will need to be screened to determine their consistency of performance in the existing cropping systems.

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EFFECT OF SOIL CRUSTING ON SEEDLING GROWTH IN CONTRASTING SORGHUM LINES†

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SUMMARY

Seedling growth from sowing to emergence of two crust tolerant and two susceptible sorghum genotypes is described. Tolerant genotypes had longer mesocotyls with faster growth rates than the susceptible genotypes. The mechanism involved in crust tolerance appears to be that of avoidance by fast growth.

Desarrollo de plantas jovenes en suelos con capa exterior endurecida

RESUMEN

Se describe el desarrollo de las plantas jóvenes, desde la siembra hasta la emergencia, de dos genotipos de sorgo tolerantes a capas duras y dos tipos susceptibles a las mismas. Los genotipos tolerantes presentaron mesocotilos de mayor longitud y una mayor intensidad de crecimiento que los genotipos susceptibles. El mecanismo para lograr la tolerancia a las capas duras parece ser el evitarlas a través del rápido crecimiento.

INTRODUCTION

ı the semi-arid tropics, sorghum (*Sorghum bicolor* (L.) Moench) is frequently ·own in soils with a poor physical structure, which are prone to crusting or ıpping (Hoogmoed, 1983) with the result that poor seedling establishment is a ıajor problem (Peacock, 1979). Soil crusting results from compaction due to rain rops and the subsequent drying of the compacted surface (Cary and Evans, ɔ74). Considerable genetic variation exists in sorghum in its ability to emerge ırough the soil crust (Soman *et al.*, 1984; Maiti *et al.*, 1986). The purpose of this udy was to compare the growth and morphology of crust tolerant and sensitive enotypes of sorghum between sowing and emergence and to understand the ıechanism involved in differential emergence.

MATERIALS AND METHODS

he growth of crust tolerant and susceptible sorghum genotypes was compared, ısing a field technique described in Soman *et al.* (1984), in the 1987 and 1988 dry

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Table 5. Catches of *C. ignefusalis* male moths in water-oil traps with different surfactants

Surfactant	Total catch[a]	Mean catch per trap per night ± SEM
Motor oil (new)	1,134 (29)	39.1 ± 4.4a
Motor oil (used)	1,276 (29)	44.0 ± 5.1a
Lquid detergent	1,161 (30)	38.7 ± 3.6a
Soap	1,278 (30)	42.6 ± 4.7a
Vegetable oil	616 (30)	20.5 ± 2.8b

Means followed by same letter are not significantly different ($P > 0.05$; LSD test [SAS Institute 1987]).
[a] Number of trap nights in parentheses.

es of male *C. ignefusalis* moths. Traps with shade diameters of 8 and 21 cm caught significantly more male moths than traps with no shade or with shade sizes of 32 and 40-cm diameter ($F = 24.4$; df = 4, 20; $P < 0.001$) (Table 2). It is likely that with smaller shades, moths could more easily approach the pheromone dispenser without touching the oil-water surface and becoming caught, whereas shades larger than the tray discouraged moths from reaching the tray.

Effect of Trap Shade Height. Catches of male moths in standard traps with the shade at heights of 2, 5, 10, and 15 cm above the tray rim were compared. Significantly more moths were caught when the shade height was 2 or 5 cm than when the height was 10 or 15 cm ($F = 26.3$; df = 3, 15; $P < 0.001$) (Table 3). There was no significant difference in male moth catches among traps with shade heights of 2 and 5 cm or among traps with shade heights of 10 and 15 cm. The larger gaps between shade and tray may have allowed moths to escape without touching the oil-water surface.

Effect of Trap Shade Shape. The shades tested were a dish, a flat disk, a disk with a vertical edge, all in aluminum, and a plastic dish. Trap shade shape significantly affected trap catch ($F = 11.20$; df = 3, 15; $P < 0.001$). Traps with disk-shaped shades caught significantly less male moths than traps with dish-shaped shades or dish-shaped shades with a vertical edge (Table 4). Plastic and aluminum dishes were equally effective in these tests, but plastic can become brittle and deteriorate after prolonged exposure to sunlight; thus aluminum may be more durable for outdoor use.

Table 6. Catches of male *C. ignefusalis* moths in different trap designs

Trap design	Total catch[a]	Mean catch per trap per night ± SEM
Water-oil	842 (28)	30.1 ± 2.3a
Sticky board	288 (30)	9.6 ± 1.8b
Plastic funnel	32 (30)	1.1 ± 0.2d
Sticky delta	27 (28)	1.0 ± 0.3d
Sticky 3M	70 (30)	2.3 ± 0.4c

Means followed by same letter are not significantly different ($P > 0.05$; LSD test [SAS Institute 1987]).
[a] Number of trap nights in parentheses.

Table 7. Longevity of large and small polythene vial pheromone dispensers in water-oil traps

Exposure time, d	Large vials: Total catch[a]	Large vials: Mean catch per trap per night ± SEM	Small vials: Total catch[a]	Small vials: Mean catch per trap per night ± SEM
0	260 (24)	10.8 ± 1.8a	359 (24)	15.0 ± 1.7a
14	148 (23)	6.4 ± 1.4b	83 (24)	3.5 ± 0.7b
28	58 (22)	2.6 ± 1.1c	39 (24)	1.6 ± 0.4c
42	35 (21)	1.7 ± 0.6c	31 (24)	1.3 ± 0.4c

Means followed by same letter are not significantly different ($P > 0.05$; LSD test [SAS Institute 1987]).
[a] Number of trap nights in parentheses.

Effect of Surfactant Type. New motor oil, used motor oil, liquid detergent, refined vegetable oil, and soap were compared as surfactants. The soap treatment involved agitating a bar of soap in the water for 1 min until foamy. The type of surfactant significantly affected trap catches ($F = 15.3$; df = 4, 20; $P < 0.001$) (Table 5). The use of motor oil (used or new), soap, or liquid detergent resulted in significantly higher catches of male *C. ignefusalis* moths than the use of vegetable oil. Motor oil may reduce the evaporation rate of the water, but in villages, oil may not be as readily available as a bar of soap.

Comparison of Trap Designs. There was a significant difference in captures of male *C. ignefusalis* moths among trap types ($F = 115.1$, df = 4, 20; $P < 0.001$) (Table 6). The water-oil trap caught significantly more male moths than any of the other traps, followed by the sticky board trap and the wing trap. There was no significant difference in male moth catches between the funnel and delta traps, which caught the fewest numbers of male moths.

Longevity of Pheromone Dispensers. Samples of the standard and the smaller dispensers were exposed in traps for 14, 28, and 42 d before comparing with results with fresh dispensers. Exposure time of large or small pheromone dispensers before testing significantly affected trap catches ($F = 34.3$ [large], $F = 35.7$ [small]; df = 3, 15; $P < 0.001$) (Table 7). Traps baited with dispensers without previous exposure (control) caught significantly more male moths than traps with exposed dis-

Table 8. Comparison of attractiveness of large small polythene vial pheromone dispensers i traps

Dispenser	Exposure time, d	Total catch[a]	Mean catch per trap per night ± SEM
Large	0	452 (24)	18.8 ± 2.9a
Large	33	62 (24)	2.6 ± 0.5c
Small	0	276 (24)	11.5 ± 1.9b
Small	33	22 (24)	0.9 ± 0.2d

Means followed by same letter are not significantly different ($P > 0.05$; LSD test [SAS Institute 1987]).
[a] Number of trap nights in parentheses.

Table 9. Effect of trap height in relation to crop height on catches of male *C. ignefusalis* moths in water-oil traps

Trap ht, m	Crop ht, m: 0.44 Total catch[a]	0.44 Mean catch per trap per night ± SEM	0.79 Total catch[a]	0.79 Mean catch per trap per night ± SEM	1.31 Total catch[a]	1.31 Mean catch per trap per night ± SEM	1.63 Total catch[a]	1.63 Mean catch per trap per night ± SEM
0.10	400	16.7 ± 3.8a	236	9.8 ± 2.1a	89	3.7 ± 0.7a	297	12.4 ± 2.1a
0.50	129	5.4 ± 1.7b	137	5.7 ± 1.0b	34	1.4 ± 0.3b	190	7.9 ± 1.0a
1.30	4	0.2 ± 0.1c	18	0.7 ± 0.3c	5	0.2 ± 0.1c	39	1.6 ± 0.3b
2.00	0	0	1[b]	0.04 ± 0.04d	0	0	5	0.2 ± 0.1c

Means followed by same letter are not significantly different ($P > 0.05$; LSD test [SAS Institute 1987]).
[a] Number of trap nights was 24 for each experiment except as noted.
[b] Number of trap nights was 23.

pensers. Traps with dispensers exposed for 14 d before testing caught significantly more male moths than dispensers exposed for either 28 or 42 d. There was no significant difference in the numbers of male *C. ignefusalis* moths caught between traps baited with dispensers exposed for 28 and 42 d.

Comparison of Pheromone Dispensers. In a second experiment, the standard and the smaller dispensers were compared as fresh lures and as lures that previously had been exposed in traps for 33 d. Male moth catches were significantly different among dispenser types and exposure times ($F = 43.3$; df = 3, 15; $P < 0.001$) (Table 8). Large dispensers without previous exposure were significantly more attractive than large dispensers exposed for 33 d. Similarly, new, unexposed small dispensers were more attractive than small dispensers exposed for 33 d. Also, large dispensers were more attractive than small dispensers when new and after 33 d exposure. Thus, the larger dispensers are more effective than the small dispensers, and, although they retain some attractiveness for at least 42 d, they should be renewed at least every 2 wk.

Effects of Trap and Crop Heights. In a first experiment, traps were stacked vertically on one stake at heights of 0.1, 0.5, 1.3, and 2.0 m above ground level. This arrangement was replicated at six sites at least 100 m apart. For all crop heights, significantly more male moths were caught at trap heights of 0.10 and 0.50 m above ground level than in traps at 1.30 and 2.0 m ($F = 66.6$; df = 2, 10; $P < 0.001$ for crop height of 0.44 m; $F = 39.2$; df = 3, 15; $P < 0.001$ for crop height of 0.79 m; $F = 17.3$; df = 2, 10; $P < 0.001$ for crop height of 1.31 m; and $F = 35.5$; df = 3, 15; $P < 0.001$ for crop height of 1.63 m) (Table 9).

In a second experiment, traps were placed separately at the four heights given above in the standard experimental design. For all crop heights (0.99–2.93 m), there were no significant differences in catches of male moths among trap heights ($P > 0.05$) at three stages of growth with different moth densities (Table 10).

These results indicate that the positioning of traps for monitoring is not critical, regardless of the crop height or moth density. However, the different results with the two different arrangements of traps have not been reported before, although numerous studies using the second arrangement of traps and at different heights at different sites have been described for other species. For example, with the Mexican rice borer, *Eoreuma loftini* (Dyar), Shaver et al. (1991) found no significant difference in male catches in Unitraps placed 5 m within a field at heights of 0.46, 1.02, and 1.58 m, although traps at 2.14 m caught significantly fewer moths. For Pherocon 1C traps, they noticed no significant differences in catches at the different heights. However, when traps were placed at the edge of a field, more male moths were caught at

Table 10. Effect of trap height in relation to crop height on catches of male *C. ignefusalis* moths in water-oil traps, single traps at each site

Trap ht, m	Crop ht, m: 1.0 Total catch[a]	1.0 Mean catch per trap per night ± SEM	1.5 Total catch[a]	1.5 Mean catch per trap per night ± SEM	2.9 Total catch[a]	2.9 Mean catch per tra per night ± SEM
0.10	66	2.7 ± 0.5a	245	10.2 ± 1.7a	55	2.3 ± 0.4a
0.50	58	2.4 ± 0.4a	314	13.1 ± 1.9a	71	3.0 ± 0.5a
1.30	50	2.1 ± 0.4a	378	15.7 ± 3.3a	68	2.8 ± 0.4a
2.00	30	1.2 ± 0.4a	344	14.3 ± 2.7a	53	2.2 ± 0.4a

Means followed by same letter are not significantly different ($P > 0.05$; LSD test [SAS Institute 1987]).
[a] Number of trap nights was 24 for each experiment.

m. They also indicated in the discussion that moths were flying at 0.50–0.70 m above ground level during sexual activity, in agreement with the results that traps at that height caught most moths. Our studies suggest that such conclusions may possibly be misleading. *C. ignefusalis* male moths may fly to a trap between 0.1 and 2.0 m above ground level n a no-choice situation, but moths favor traps at).1–0.5 m when given a choice. It is possible that *C. ignefusalis*, a low flyer, conducts mate searching ınd sexual activity within 0.10 m and 0.50 m of ground level. However, it is also possible that interaction of the pheromone plumes from traps tacked at different heights at one site affect moth behavior.

Our study was done to develop and evaluate the parameters of an efficient pheromone-baited trap lesign for use with the *C. ignefusalis* synthetic pheromone for monitoring of pest populations by ubsistence farmers and national and international agricultural research stations in the Sahelian region of Africa. Criteria, thus, included availability and cheapness, while avoiding use of imported or specially-made items such as trap sticker or corrugated plastic sheeting. Our data has identified a water-oil trap consisting of materials that are readily available at a cost of less than U.S. $5. Because of he high average 24-h temperature of at least 30°C and the high volatility of the *C. ignefusalis* pheromone components, pheromone dispensers should be renewed at least every 14 d.

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