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# Seed Protectants for Healthy Exports

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**Abstract**

Dry formulations of three insecticides (chlorpyriphos, fenvalerate and carbaryl) were compared for their efficacy against rice moth, *Corcyra cephalonica* (Stainton) and groundnut bruchid *Caryedon serratus* Oliver, in the context of identifying a suitable alternative to aldrin. Fenvalerate 4 g/kg seed showed quick action and killed all the *Corcyra* eggs, and *Caryedon* grubs and adults, within 48 h. Chlorpyriphos and carbaryl were less effective, although the former showed high persistency. Fenvalerate and carbaryl were significantly superior to a range of rates of chlorpyriphos up to 180 DAT, and were on par with aldrin. For seed exports that require storage of 60 days or more, chlorpyriphos could be used as an effective replacement for aldrin. The chemicals tested had no deleterious effects on seed viability of pearl millet and groundnut up to 180 days at ambient temperature during storage.

## Introduction

Seed treatment, to disinfect and protect them from infestation during transit, is a pre-requisite for export. The commonly used seed dressing insecticide, aldrin, a cyclodiene compound with high persistence is effective against a wide range of insect species, but has recently been banned for use in agriculture due to environmental concern and fear of its accumulation in adipose tissue. It, therefore, is necessary to find an alternative seed treatment chemical to protect seeds against storage pests. The present studies were carried out to identify an effective substitute for aldrin.

## Materials and Methods

Three insecticides - chlorpyriphos 1.5D fenvalerate 0.4D and carbaryl 50 WP - were evaluated as seed protectants in comparison to aldrin 5% dust. The insecticides were tested @ 2, 4, and 6 g/kg seed with three replicates in each treatment, and evaluated against two common stored grain insect pests of quarantine importance *viz*; rice moth *Corcyra cephalonica* (Stn.) and groundnut bruchid, *Caryedon serratus* Oliver. Seed of pearl millet (*Pennisetum glaucum* L.) and groundnut, (*Arachis hypogaea* L.) were infested with freshly laid eggs (< 24 hold), 10-day old *Corcyra* larvae active adults (one day after emergence) and 10-day old grubs of *Caryedon.* Twenty individuals per replicate were used in each treatment, comprising 200 g of treated seeds. Mortality was recorded at 48 h after treatment (HAT), and later at 24 h intervals until total mortality was achieved.

The treated seeds were exposed to insects at periodic intervals (15, 30, 60, 120, and 180 days after treatment, DAT) to assess the efficacy of the insecticides over a period of time. A sample of 20 treated seeds was placed on water-soaked paper towels immediately after each insecticide treatment to study the effect on seed viability. A simple randomized block design was followed to analyze the data. The experiment was conducted under laboratory conditions at 25 ± 2°C.

## Results and Discussion

### Effect of seed treatment on *C. cephalonica*

All four insecticides tested resulted in 100% mortality of eggs and larvae within 72 h. Aldrin (6 g/kg seed) and fenvalerate at all doses were effective, causing 100% mortality in 48 h. Chlorpyriphos 2 g was on par with carbaryl 4 and 6 g, while 4 and 6 g of chlorpyriphos were on par

with aldrin 2 and 4 g at 48 HAT. Where eggs escaped mortality by 48 h the young larvae got killed within 72 h, in all treatments (Table 1).

**Table 1. Efficacy of insecticidal seed treatment on eggs and larvae of rice moth, *Corcyra cephalonica***

| Insecticide | Dosage (g/kg seed) | % morality after | | | | |
|---|---|---|---|---|---|---|
| | | 48 h Eggs | 48 h | 72 h | 96 h | 120 h |
| | | | Larvae | | | |
| Chlorpyriphos | 2 | 77 | 36.7 | 73.3 | 90.0 | 100.0 |
| Chlorpyriphos | 4 | 93 | 53.3 | 73.3 | 96.7 | 100.0 |
| Chlorpyriphos | 6 | 93 | 60.0 | 93.3 | 100.0 | 100.0 |
| Fenvalerate | 2 | 100 | 76.7 | 96.7 | 100.0 | 100.0 |
| Fenvalerate | 4 | 100 | 90.0 | 100.0 | 100.0 | 100.0 |
| Fenvalerate | 6 | 100 | 100.0 | 100.0 | 100.0 | 100.0 |
| Carbaryl | 2 | 63 | 26.7 | 43.3 | 73.3 | 100.0 |
| Carbaryl | 4 | 83 | 50.0 | 63.3 | 86.7 | 100.0 |
| Carbaryl | 6 | 77 | 63.3 | 76.7 | 100.0 | 100.0 |
| Aldrin | 2 | 87 | 56.7 | 86.7 | 100.0 | 100.0 |
| Aldrin | 4 | 97 | 90.0 | 100.0 | 100.0 | 100.0 |
| Aldrin | 6 | 100 | 100.0 | 100.0 | 100.0 | 100.0 |
| Control | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| S.Em ± | | 3.4 | 5.44 | 3.21 | 2.15 | 0.0 |
| CV (%) | | 7.1 | 15.3 | 3.5 | 4.2 | 0.0 |

Sample size: 20 individuals per treatment and mean of 3 replications

Fenvalerate and aldrin @ 4 and 6 g/kg seed resulted in 100% larval mortality in 72 h. The efficacy of chlorpyriphos and carbaryl was significantly inferior to fenvalerate and aldrin at lower dosages and shorter time period (48 h). However, all the treatments resulted in 100% mortality of larvae by 120 h (Table 1).

The efficacy of all seed treatments against eggs and larvae declined with time. At 15 DAT, there was no significant difference with regard to mortality of eggs, between 4 and 6 g of chlorpyriphos and aldrin, and 6 g fenvalerate while 2 g chlorpyriphos and 4 g fenvalerate (83%) and 4 and 6 g carbaryl (93%) were on par (Table 2). The differences were evident at 30 DAT, when chlorpyriphos and aldrin 6 g had greater effect and resulted in 100% mortality. There were no significant differences between 2 g aldrin (67%) and 6 g carbaryl (63%), 2 g aldrin and 2 g chlorpyriphos (47%). Fenvalerate at all doses resulted in minimum mortality (0-5%) at 120 DAT, and had no effect at 180 DAT (Table 2).

The effect of these chemicals on larvae was similar to that on eggs. Fenvalerate at all doses resulted in low mortality compared to other treatments at and after 60 DAT, while 4 and 6 g of chlorpyriphos and aldrin and 6 g of carbaryl resulted in more than 50% mortality. The differences among chlorpyriphos 4 g (40%), carbaryl 6 g (37%) and aldrin 2 g (43%) were not significant. At 180 DAT, chlorpyriphos (all dosages) was on par with aldrin 4 g (Table 2). All treatments were significantly superior to the untreated control at all stages of testing.

**Table 2. Efficacy of treated seeds at periodic intervals after treatment on eggs and larvae of *C. cephalonica***

| Insecticide | Dosage (g/kg seed) | % morality at days after treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Eggs | | | | | Larvae | | | | |
| | | 15 | 30 | 60 | 120 | 180 | 15 | 30 | 60 | 120 | 180 |
| Chlorpyriphos | 2 | 83 | 73 | 60 | 47 | 23 | 67 | 57 | 47 | 37 | 23 |
| Chlorpyriphos | 4 | 100 | 97 | 73 | 63 | 43 | 77 | 63 | 53 | 40 | 23 |
| Chlorpyriphos | 6 | 100 | 100 | 100 | 83 | 77 | 100 | 87 | 70 | 60 | 27 |
| Fenvalerate | 2 | 63 | 37 | 8 | 0 | 0 | 37 | 27 | 5 | 0 | 0 |
| Fenvalerate | 4 | 83 | 53 | 12 | 2 | 0 | 67 | 37 | 8 | 2 | 0 |
| Fenvalerate | 6 | 100 | 70 | 20 | 5 | 0 | 90 | 63 | 33 | 9 | 2 |
| Carbaryl | 2 | 70 | 53 | 33 | 8 | 3 | 63 | 43 | 27 | 13 | 7 |
| Carbaryl | 4 | 93 | 77 | 47 | 23 | 7 | 77 | 57 | 33 | 23 | 8 |
| Carbaryl | 6 | 93 | 83 | 63 | 53 | 50 | 93 | 83 | 57 | 37 | 17 |
| Aldrin | 2 | 90 | 83 | 67 | 47 | 43 | 90 | 77 | 73 | 43 | 37 |
| Aldrin | 4 | 100 | 100 | 87 | 67 | 47 | 100 | 90 | 73 | 47 | 27 |
| Aldrin | 6 | 100 | 100 | 100 | 77 | 63 | 100 | 100 | 93 | 67 | 43 |
| Control | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| S.Em ± | | 2.9 | 3.59 | 3.95 | 4.3 | 3.47 | 3.85 | 3.40 | 3.70 | 3.94 | 2.53 |
| CV (%) | | 6.1 | 8.7 | 13.3 | 20.5 | 21.9 | 9.0 | 9.8 | 14.5 | 23.5 | 26.7 |

Sample size: 20 individuals per treatment and mean of 3 replications

**Effect of seed treatment on *C. serratus.***

At 24 HAT, 2 g aldrin and 4 g chlorpyriphos led to 87% mortality, while 6 g each of aldrin, chlorpyriphos, and fenvalerate resulted in 100% mortality. All treatments, irrespective of dosage, resulted in 100% mortality of grubs at 72 HAT (Table 3).

Chlorpyriphos and carbaryl each at 6 g and 4 and 6 g of fenvalerate and aldrin led to 100% mortality of adults in 24 HAT. The treatments with 2 g fenvalerate, 4 g chlorpyriphos and carbaryl led to 87% mortality in 24 HAT. All the treatments resulted in 100% adult mortality in 48 HAT (except 2 g chlorpyriphos) (Table 3). The treatments were significantly superior to the untreated control.

A clear decline in the efficacy of seed treatments was observed as time advanced. At 15 DAT, 2 g dosage of all treatments (except fenvalerate and carbaryl) killed more than 77% of grubs; and at 6 g all insecticides resulted in 100% mortality. At 60 DAT carbaryl 4 g was equivalent to aldrin 2 g (33%). Among the insecticides, fenvalerate followed by carbaryl declined in effectiveness more sharply than the others (Table 4). At 120 DAT aldrin 4 g and chlorpyriphos 2 g (27%), carbaryl 2 g and 4 g and fenvalerate 6 g (23%) caused equivalent egg mortality.

On adults, efficacy declined gradually after treatment. Fenvalerate at all dosages showed a more rapid decline than other treatments. All insecticides at a dose of 6 g resulted in complete kill at 15 DAT, while chlorpyriphos (2 and 4 g) led to 33% mortality of adults at 120 DAT, aldrin 4g and chlorpyriphos 6 g at 120 DAT recorded 53% mortality. At 180 DAT all treatments of chlorpyriphos and aldrin were on par, and mortality ranged from 23-57% (Table 4).

**Table 3. Efficacy of insecticidal seed treatment on grubs and adults of groundnut seed beetle *Caryedon serratus***

| Insecticide | Dosage (g/kg seed) | % mortality after | | | | |
|---|---|---|---|---|---|---|
| | | Grubs | | | Adults | |
| | | 24 h | 48 h | 72 h | 24 h | 48 h |
| Chlorpyriphos | 2 | 63 | 86 | 100 | 80 | 93 |
| Chlorpyriphos | 4 | 87 | 100 | 100 | 87 | 100 |
| Chlorpyriphos | 6 | 100 | 100 | 100 | 100 | 100 |
| Fenvalerate | 2 | 77 | 100 | 100 | 87 | 100 |
| Fenvalerate | 4 | 100 | 100 | 100 | 100 | 100 |
| Fenvalerate | 6 | 100 | 100 | 100 | 100 | 100 |
| Carbaryl | 2 | 57 | 77 | 100 | 77 | 100 |
| Carbaryl | 4 | 77 | 93 | 100 | 87 | 100 |
| Carbaryl | 6 | 93 | 100 | 100 | 100 | 100 |
| Aldrin | 2 | 87 | 100 | 100 | 97 | 100 |
| Aldrin | 4 | 97 | 100 | 100 | 100 | 100 |
| Aldrin | 6 | 100 | 100 | 100 | 100 | 100 |
| Control | | 0 | 0 | 0 | 0 | 0 |
| S.Em ± | | 3.47 | 1.51 | 0.0 | 3.31 | 0.93 |
| CV (%) | | 7.5 | 2.9 | 0.0 | 6.7 | 1.7 |

Sample size: 20 individuals per treatment and mean of 3 replications

**Table 4. Efficacy of insecticidal seed treatment at periodic intervals after treatment on grubs and adults of groundnut seed beetle *Caryedon serratus***

| Insecticide | Dosage (g/kg seed) | % mortality at days after treatment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Grubs | | | | | Adults | | | | |
| | | 15 | 30 | 60 | 120 | 180 | 15 | 30 | 60 | 120 | 180 |
| Chlorpyriphos | 2 | 80 | 80 | 63 | 27 | 23 | 83 | 77 | 57 | 33 | 27 |
| Chlorpyriphos | 4 | 93 | 77 | 60 | 37 | 26 | 97 | 80 | 63 | 33 | 27 |
| Chlorpyriphos | 6 | 100 | 100 | 90 | 70 | 60 | 100 | 100 | 80 | 53 | 33 |
| Fenvalerate | 2 | 53 | 37 | 23 | 8 | 0 | 53 | 37 | 30 | 10 | 2 |
| Fenvalerate | 4 | 73 | 53 | 30 | 13 | 2 | 73 | 53 | 37 | 5 | 2 |
| Fenvalerate | 6 | 100 | 77 | 53 | 23 | 3 | 100 | 73 | 47 | 17 | 5 |
| Carbaryl | 2 | 77 | 57 | 40 | 23 | 5 | 67 | 47 | 33 | 20 | 7 |
| Carbaryl | 4 | 87 | 67 | 33 | 23 | 8 | 77 | 63 | 43 | 23 | 8 |
| Carbaryl | 6 | 100 | 87 | 53 | 37 | 23 | 100 | 83 | 57 | 33 | 20 |
| Aldrin | 2 | 87 | 57 | 33 | 13 | 7 | 87 | 67 | 53 | 40 | 23 |
| Aldrin | 4 | 100 | 73 | 47 | 27 | 13 | 100 | 90 | 73 | 53 | 33 |
| Aldrin | 6 | 100 | 93 | 87 | 53 | 30 | 100 | 100 | 90 | 70 | 57 |
| Control | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| S.Em ± | | 3.23 | 3.87 | 4.61 | 3.87 | 3.37 | 4.36 | 4.54 | 4.91 | 5.44 | 4.45 |
| CV (%) | | 6.9 | 10.2 | 16.9 | 24.6 | 37.6 | 9.5 | 11.8 | 16.7 | 31.3 | 41.2 |

Sample size: 20 individuals per treatment and mean of 3 replications

**Effect of seed treatment on seed viability**

**Pearl millet**

The viability of treated seeds at different exposure times in general was lower than that of the untreated control. Seeds treated with fenvalerate 2 and 6 g showed 91% viability after 15 DAT. Though there were some differences in seed viability after different exposure times in different treatments, the differences were not statistically significant. Higher dosages did not impair seed viability up to 180 DAT (Table 5).

**Table 5. Viability of pearl millet seed treated with different insecticides at periodic intervals**

| Insecticide | Dosage (g/kg seed) | % germination at days after treatment* | | | | |
|---|---|---|---|---|---|---|
| | | 15 | 30 | 60 | 120 | 180 |
| Chlorpyriphos | 2 | 89 | 87 | 77 | 75 | 72 |
| Chlorpyriphos | 4 | 89 | 88 | 72 | 71 | 77 |
| Chlorpyriphos | 6 | 83 | 87 | 65 | 69 | 75 |
| Fenvalerate | 2 | 91 | 87 | 71 | 79 | 79 |
| Fenvalerate | 4 | 88 | 91 | 79 | 81 | 81 |
| Fenvalerate | 6 | 91 | 87 | 73 | 75 | 81 |
| Carbaryl | 2 | 87 | 81 | 82 | 77 | 82 |
| Carbaryl | 4 | 85 | 82 | 79 | 73 | 75 |
| Carbaryl | 6 | 82 | 82 | 73 | 77 | 80 |
| Aldrin | 2 | 87 | 88 | 77 | 81 | 86 |
| Aldrin | 4 | 85 | 89 | 84 | 85 | 79 |
| Aldrin | 6 | 83 | 82 | 78 | 87 | 79 |
| Control | | 95 | 97 | 94 | 95 | 93 |
| S.Em ± | | 2.46 | 2.47 | 2.47 | 2.48 | 3.38 |
| CV (%) | | 4.9 | 4.9 | 4.3 | 5.4 | 5.9 |

* Mean of 3 replications

**Groundnut**

The percentage germination ranged from 79-98% at different periods (15-180 DAT) irrespective of the dose, and in all cases was close to germination levels in the untreated control (Table 6). Higher dosages did not reduce seed viability over prolonged periods. The effects on viability were similar even at different doses. It appears that storage after seed treatment had no effect on viability of groundnut seeds (Table 6).

Insecticidal seed treatment of groundnut and pearl millet showed that chlorpyriphos could be effective against storage pests, maintaining seed health without impairing seed viability.

The results on efficacy (Table 1 and 3) indicated that all the chemicals tested at all the doses (2, 4, and 6 g/kg seed) were on par with aldrin at 72 HAT against eggs and grubs (*Corcyra/ Caryedon*); at 120 HAT on *C. cephalonica* larvae; and at 48 HAT on *C. serratus* adults. Among the insecticides, fenvalerate at different doses resulted in higher mortality initially, but its efficacy declined from 30 DAT onwards, with lowest kill at 180 DAT. Chlorpyriphos, aldrin, and carbaryl showed more persistence.

**Table 6. Viability of groundnut seed treated with different insecticides at periodic intervals**

| Insecticide | Dosage (g/kg seed) | % germination at days after treatment* | | | | |
|---|---|---|---|---|---|---|
| | | 15 | 30 | 60 | 120 | 180 |
| Chlorpyriphos | 2 | 89 | 97 | 90 | 89 | 89 |
| Chlorpyriphos | 4 | 96 | 96 | 85 | 85 | 91 |
| Chlorpyriphos | 6 | 96 | 97 | 86 | 85 | 92 |
| Fenvalerate | 2 | 96 | 97 | 95 | 94 | 91 |
| Fenvalerate | 4 | 98 | 98 | 92 | 88 | 90 |
| Fenvalerate | 6 | 97 | 97 | 90 | 88 | 88 |
| Carbaryl | 2 | 92 | 95 | 89 | 86 | 79 |
| Carbaryl | 4 | 89 | 87 | 88 | 84 | 87 |
| Carbaryl | 6 | 88 | 90 | 83 | 89 | 83 |
| Aldrin | 2 | 95 | 92 | 90 | 88 | 92 |
| Aldrin | 4 | 90 | 89 | 89 | 84 | 89 |
| Aldrin | 6 | 85 | 87 | 84 | 87 | 90 |
| Control | | 93 | 90 | 90 | 95 | 89 |
| S.Em ± | | 2.03 | 1.44 | 2.32 | 1.72 | 1.73 |
| CV (%) | | 3.52 | 2.7 | 4.5 | 3.4 | 3.4 |

* Mean of 3 replications

The present findings are in agreement with those of Bandhopadhyay and Ghosh (1984), Yadav and Jha (1985), and Grace Suchitra *et al.*, (1989), who studied the efficacy of pyrethroids against *Sitophilus oryzae L., Rhizopertha dominica* (Fab.) and other stored product pests, and reported quick knockdown effect, and decrease in efficacy over time. Pawar and Yadav (1982) and Bareth and Gupta (1989) reported greater persistence of organophosphorus insecticides (chlorpyriphos, fenitrothion and malathion) than pyrethroids (fenvalarate and deltamethrin) as seed protectants against *Cadra cautella* Walker *and Corcyra cephalonica* Stainton.

Viability of treated pearl millet and groundnut seeds (Tables 5 and 6), measured at periodic intervals, was sustained irrespective of the dose and the chemical. Germination was more than 72% in pearl millet, and more than 79% in groundnut at 180 DAT and was comparable to the untreated control. The reports of Narsimhulu and Kameswara Rao (1989) and Ramzan and Chahal (1989) on the viability of groundnut and wheat also indicated no deleterious effects of grain protectants on seed viability.

Taking into consideration the greater persistence and relatively high mortality, chlorpyriphos (2-6 g/kg seed) is suggested as a seed treatment for maintaining the seed health of seeds for export.

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