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GROUNDNUT OIL TREATMENT FOR THE CONTROL OF *CALLOSOBRUCHUS MACULATUS* (F.) DURING COWPEA STORAGE

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Abstract—Groundnut oil at 5 ml/kg completely protected cowpea seeds in storage from *Callosobruchus maculatus* (F.) for up to 180 days. The treatment had no adverse effects on cooking time or taste of the cooked beans or on germination even after 6 months storage. The oil treatment prevented emergence of progeny rather than affecting oviposition or mortality of the adult weevils. Groundnut oil entered the egg of *C. maculatus* through the micropyle, and in 1 to 2 day old eggs, protoplasmic movement was stopped and the protoplasm coagulated. In 3 to 5 day old eggs, where the larvae were partially or fully formed, larval death occurred within minutes of the entry of the oil.

INTRODUCTION

The cowpea, *Vigna unquiculata* (L.) Walp., is an important pulse crop in West Africa and a major source of protein (STANTON, 1966). The Cowpea weevil, *Callosobruchus maculatus* (F.) is the most important pest of stored cowpeas and has a world-wide distribution. Severe losses due to this pest have been reported in several tropical and subtropical countries. For example, CASWELL (1968) found that cowpeas stored in traditional storage containers in northern Nigeria for 9 months suffered 32 and 87% damage (expressed as weight loss) when stored as unshelled and shelled cowpeas, respectively. Many insecticides and storage containers have been found effective for protecting cowpeas from the Cowpea weevil (SINGH and BENAZET, 1974), but at the farm level such inputs are expensive or difficult to obtain. Control involving materials of low cost and easily available in rural areas was therefore sought.

In India, split pigeon peas and other grain legumes are mixed with edible oils before storage in the home. The reason for this ancient practice is unknown. MITAL (1971) showed that cowpeas remained unattacked by beetles when treated with oil, but that such seeds lost their viability. SU *et al.* (1972) applied oils from the peel of 8 citrus fruits to the surface of cowpea seed, and adult *C. maculatus* exposed on the treated cowpeas failed to produce progeny. TAYLOR and VICKERY (1974) identified the principal component of citrus oil as limonene which was found to be a highly effective insecticide.

MATERIALS AND METHODS

Tests were conducted to find out if oils of groundnut, castor, coconut or palm kernel would protect cowpeas against Cowpea weevil.

'Prima' cowpea, a Nigerian improved variety susceptible to Cowpea weevil, was used. All seed samples were brought to 12% moisture content before use in a room at 27° ± 10°C, 65 ± 5% r.h. and a 12 hr L, 12 hr D photoperiod. Cultures were maintained in wide-mouth litre jars (STRONG *et al.*, 1968). The desired amount of oil was added to a known quantity of seed in a plastic bag, which was shaken to spread the oil uniformly. Detailed methods relating to particular tests are given with the results.

RESULTS AND DISCUSSION

Efficacy of different edible oils

Four dosages, 1, 3, 5 and 8 ml oil/kg seed were compared for each edible oil. Three pairs of 1-day-old Cowpea weevils were released in a plastic box (45 × 45 × 20 mm)

TABLE 1. PROTECTION OF COWPEA SEEDS AGAINST COWPEA WEEVIL INFESTATION AFFORDED BY VARIOUS EDIBLE OIL TREATMENTS

Dose ml oil/kg seed Edible oil	Relative protection = progeny as % of untreated control 1	3	5	8
Groundnut	81.5 a	94.5 a	100.0 a	100.0 a
Castor	77.0 a	90.0 a	99.0 a	100.0 a
Coconut	63.3 b	82.5 b	95.0 ab	100.0 a
Palm kernel	59.8 b	76.8 b	92.5 b	100.0 a

Means followed by a common letter are not significantly different at the 5% probability level. Comparison made only vertically.

with 40 cowpea seeds of a particular treatment. The efficacy of each treatment was determined by comparing numbers of F_1 progeny with those in the untreated control. Tests were repeated 4 times, each time with 4 replications. The data obtained were combined (Table 1). The control had an average F_1 emergence of 120 adults.

All oils gave protection, but groundnut and castor oil appeared to be superior to coconut or palm oil. Complete protection against the weevil was obtained by groundnut oil at 5 ml/kg and the other oils at 8 ml/kg. Groundnut oil treatment appeared particularly promising; even 1 ml/kg seed gave about 81.5% protection. In addition, groundnut oil was easier to mix with cowpea seeds than coconut or palm oil, and the laxative properties of castor oil are a disadvantage. Seeds treated with groundnut oil at 5 ml/kg were tested for cooking properties 6 months after treatment and no effect on cooking time or taste was found.

Test of groundnut oil treatment in conditions similar to farm storage

Cowpea seeds were treated at 5, 8, or 10 ml groundnut oil/kg. The test seed was exposed for Cowpea weevil infestation in 3 different 4 replication tests designed to simulate farm storage conditions.

Test 1. The treated seeds and untreated control were kept in paper bags containing about 2 kg seeds and left in a barn at the Institute in which cowpeas, maize and cassava were stored. Natural infestation was rapid in the untreated seeds, and almost 100% were damaged at 45 days. At 90, 135 and 180 days there was a mean of 1.2, 2.8. and 3.4 weevil emergence holes/seed respectively. None of the treated seeds had any infestation.

Test 2. Treated seeds were stored in cotton bags each containing about 5 kg and infested with 100 pairs of 1-day-old Cowpea weevils. The test was designed to find out if plastic bags as advocated by CASWELL (1973) could be replaced by cloth bags when cowpea seeds are treated with groundnut oil. Complete protection against infestation was observed in the 3 groundnut oil treatments during 180 days. The untreated control had 100% infestation at 100 days, with each cowpea seed having an average of 2.1 weevil emergence holes.

Test 3. This experiment differed from test 2 only in that at 40-day intervals the bags were opened and 100 further pairs of 1-day-old Cowpea weevils introduced to maintain a heavy infestation. Weevil emergence was recorded at 45, 90, 135 and 180 days after oil treatment. Complete protection against infestation was observed at the highest dosage of 10 ml oil/kg seed during the test period of 180 days. Some infestation (about 0.7%) was observed after 45 days in the seeds with lower dosages of oil but this infestation never increased significantly above the complete protection treatment during the experiment.

Fecundity of Cowpea weevils in oil-treated seeds

Four cloth bags containing 5 kg cowpea seeds were each infested with 100 pairs of 1-day-old Cowpea weevils 1 day after treatment with 5 ml groundnut oil/kg. Four untreated controls were similarly infested. All bags were closed and left in the rearing room. After 75, 135 and 150 days of storage, the bags were opened and the adult

weevils counted. The weevils did not reproduce in the oil treated seeds. The total progeny yield in the untreated control was 1,400 14,500 and 32,000 respectively at 75, 135 and 150 days after infestation. This illustrates the magnitude of insect multiplication and damage that can occur in unprotected seeds.

Effect of groundnut oil treatment on Cowpea weevil

The effect of oil treatment on the longevity of adult weevils, oviposition and number of progeny was studied. In laboratory tests, 1 pair of newly emerged weevils were released into a small plastic box containing 40 cowpea seeds, either untreated or treated at the 5 ml/kg level. The test had 8 replications. There was no significant difference in the longevity of the weevils between the 2 treatments. The mean number of eggs laid on the groundnut oil treated seeds (56.9) was significantly less than that on the untreated control (76.8). No progeny emerged in the groundnut oil treatment whereas 54 adult weevils emerged in the untreated control. Longevity of adult weevils was not affected (7.1 and 7.5 days respectively). Thus the oil primarily caused progeny mortality rather than reduced oviposition or adult mortality. Microscopic examination of the eggs laid on oil-treated seeds indicated that in most cases the embryo either did not develop or did so only partially.

The Cowpea weevil egg measures about 0.4 × 0.7 mm. The anterior end is rounded and the tapering posterior end has a micropyle and a small appendix-like structure. The head capsule is first noticeable on the 3rd day and larval development is completed in about 5 days at 30°C.

To test whether the groundnut oil was acting as an ovicide, approximately 1 μl of oil was placed at the anterior end of 1, 2, 3, 4 and 5 day-old eggs laid on untreated seeds. There was no ovicidal effect, and the embryo developed and hatched normally. However, when the drop of oil was placed at the posterior end, the oil entered the egg through the micropyle. Within a few minutes protoplasmic movement stopped and the protoplasm coagulated in 1-to-2-day-old eggs. In 3-to-5-day-old eggs, where the larva had formed partially or fully, larval death was noticed within some minutes. Therefore, the oil had a toxic effect on the protoplasm and also on the fully formed embryo.

The action of the oil within the egg may be due to both chemical toxicity and the physical properties of the oil. Changes in surface tension (which could lead to protoplasm coagulation) and in oxygen tension within the egg are likely. The amount of oil on a seed is less than 1.0 mg when 5 ml of oil is added per kg of seed. Assuming a seed weight of 15 g/100 seeds and that the seeds are approximated by spheres 6.4 mm in diam. this represents a surface film about 0.006 mm thick. The amount of oil in contact with the egg would be only 20 μg, which implies a specific action of the oil.

Effect of oil treatment on cowpea seed germination

Cowpea seeds were treated with either groundnut, castor, coconut or palm oils at 5 ml/kg. The oil-treated seeds and control (8 replicates) were left in paper bags in a barn (see earlier) for 6 months. At the end of this time, the percentage infestation was determined by counting seeds with emergence holes. Untreated seeds had 100% infestation, significantly higher than the other treatments (Table 2). Slight infestation in the castor, coconut and palm oil treatments was not significantly different from that in the groundnut oil treatment. The oil-treated seeds and control were then planted in soil in the glasshouse. The seeds treated with edible oils germinated well, i.e. more than 83% (Table 2). There was no seedling emergence in the infested control.

In another experiment, cowpea seeds were treated with 5 and 10 ml/kg of the different edible oils. The seeds were stored in the rearing room with the control and were kept free from infestation. Germination tests were conducted at 4-monthly intervals for 1 year. No difference in germination was noticed in the treated and untreated seeds for up to 1 year, all germination being 83 to 86%. These results are contrary to those of MITAL (1971), where cowpeas treated with the same oils as used here lost viability.

TABLE 2. EFFECT OF EDIBLE OIL TREATMENT ON SEED INFESTATION BY COWPEA WEEVIL AND ON SEED VIABILITY, MEASURED BY GERMINATION AFTER 6-MONTH STORAGE

Treatment	Weevil infestation (%)	Seed germination (%)
Groundnut oil	0.0 a	84 b
Castor oil	5.0 a	84 b
Coconut oil	11.6 a	80 b
Palm kernel oil	16.4 a	76 b
Control	100.0 b	0 a

Means followed by a common letter are not significantly different at the 5% probability level. Comparison made only vertically.

CONCLUSION

Our observations indicate that Cowpea weevil can be readily controlled by mixing 5 ml groundnut oil with 1 kg of seed. Groundnut oil is one of the most commonly used cooking oils in West Africa, India and several other tropical countries and is thus readily available in rural areas. The cost of groundnut oil treatment appears to be almost negligible when compared with the losses in untreated cowpeas. It has no bad effects after storage on cooking and taste. It also eliminates the possibility of food contamination when insecticides are mixed with seeds in storage.

The main purpose of this study was to find a low-cost method for cowpea weevil control. Current prices prevailing in Ibadan (Nigeria) are U.S. $0.36/kg for cowpea seeds and $1.60/l for groundnut oil. Therefore the cost of treating 1 kg of cowpea seeds with 5 ml of groundnut oil would be $0.008. This treatment would prevent a loss of 30% of the cowpeas, i.e. an increase of market value of about $0.11. This gives a cost-benefit ratio of nearly 11, but the true benefit is higher since the farmer would be able to obtain a considerably higher price than $0.36/kg for cowpeas stored for 4–6 months.

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