PROTECTION OF STORED COWPEA SEEDS *Vigna unguiculata* (L) (Walp) FROM INFESTATION BY THE PULSE BEETLE *Callosobruchus maculatus* F. (BRUCHIDAE : COLEOPTERA)

BY

B. PURNAMMA

THESIS

Submitted in partial fulfilment of the requirement for the Degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Entomology
COLLEGE OF HORTICULTURE
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DECLARATION

I hereby declare that this thesis entitled "Protection of stored cowpea seeds Vigna unguiculata (L). (Walp) from infestation by the pulse beetle Callosobruchus maculatus F. (Bruchidae: Coleoptera)" is a bonafide record of work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,

4-10-1982.

B. Purnamma

B. PURNAMMA

CERTIFICATE

Certified that this thesis entitled "Protection of stored cowpea seeds *Vigna unguiculata* (L). (Walp) from infestation by the pulse beetle *Callosobruchus maculatus* (F.) (Bruchidae: Coleoptera)" is a record of research work done independently by Miss B. Purnamma under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. K.V. MAMMEN,
ASSOCIATE PROFESSOR OF ENTOMOLOGY
&
CHAIRMAN,
ADVISORY COMMITTEE,
COLLEGE OF HORTICULTURE.

Vellanikkara,
21-12-1982.

CERTIFICATE

We, the undersigned members of the Advisory Committee of Miss B. Purnamma, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology, agree that the thesis entitled "Protection of stored cowpea seeds Vigna unguiculata (L). (Walp) from infestation by the pulse beetle Callosobruchus maculatus (F). (Bruchidae: Coleoptera)" may be submitted by Miss B. Purnamma in partial fulfilment of the requirements for the degree.

Vellanikkara,
21-12-1982.

Dr. K.V. MAMMEN,
CHAIRMAN,
ADVISORY COMMITTEE.

21/12/82

Dr. C.C. ABRAHAM,
(MEMBER)

Dr. T.S. VENKITESAN,
(MEMBER)

Dr. A.I. JOSE,
(MEMBER)

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Introduction

INTRODUCTION

Next to cereals, pulses constitute the most widely used food materials of Indian diet and these offer perhaps practical means of solving protein malnutrition problems at the present stage of economic development in the country. Production and consumption of more pulses is now widely recognised to the the cheapest and most practical way of improving the nutrition of the common people.

The percapita availability of pulses in India was reduced from 70.4 g per day in 1956 to 39.1 g in 1981 due to rapid population growth, unstable production trends and also due to the pest problems in the field and under storage conditions.

Pulse beetles (Bruchids) the most predominent pests of stored pulses cause quantitative losses ranging from 10 to 15% of the produce besides imparting undesirable odours and flavours to the grains. Reports of the Pest Infestation Laboratory, London (Munro, 1966) revealed that the pulses are susceptible to damage by Bruchids before and after harvest and extent of loss being as high as 70 per cent.

Much emphasis has been given in recent years to evolve suitable methods of protecting seeds and grains in storage. The accepted maxim that prevention is better than cure is applicable in the case of reducing damage by the pulse beetles. Preventive measures include cleaning of the godowns or storage receptacles as well as seeds before storage, drying of the seeds to reduce moisture content, fumigation, mixing the seeds with inert dusts, insecticides etc.

A centrally sponsored programme of development of pulses is being implemented in India. The programme involves use of improved pulse seeds, treatment with rhizobial culture, adequate use of phosphatic fertilizers and timely crop protection coupled with protection of stored produce. It is of considerable importance that the availability of good quality viable seeds is ensured for the successful implementation of the programme.

The objective of the present study was to evaluate the relative efficacy of prophylactic treatments with some of the newer insecticides, inert dusts and botanical materials in reducing storage losses due to pulse beetles without adversely effecting the viability of seeds.

Review Of Literature

REVIEW OF LITERATURE

Bruchid beetles are considered as serious pests of pulses in storage damaging seeds of different varieties of pulses, namely, bengal gram *Cicer arietinum* (L), *Phaseolus* spp. including *Phaseolus aureus* (L) Roxb., *Phaseolus mungo* (L.), pigeon peas *Cajanus cajan* (L.), Millsp., Lentils *Lens esculenta*. M, Lathyrus *Lathyrus sativus* (L.), peas *Pisum sativum* L. and cowpea *Vigna unguiculata* (L.) (Walp). Out of five known species of *Callosobruchus* from India, *Callosobruchus chinensis* (L.), *Callosobruchus maculatus* (F.) and *Callosobruchus analis* (F.) are the most important species infesting stored pulse seeds (Raina, 1970).

Biology and Ecology of pulse beetles

Fletcher (1914) described the pulse beetles and their nature of damage. Short thick bodied beetles attack pulses such as grams, lab-lab, beans and peas. The larvae burrow inside the seeds and destroy the internal contents leaving a characteristic large round exit holes.

Comparative biology of *Bruchus chinensis* (L) and *Bruchus analis* (F.) was studied by Rahman *et al.* (1943).

They found that a single pulse seed contain only one larvae of B. analis and as many as 8 larvae of B. chinensis. The fecundity range of both the species were recorded as 4 to 14 and 11 to 150 eggs respectively. In B. chinensis the egg, larval and pupal stages ranged from 4 to 16, 10 to 38 and 4 to 28 days respectively whereas in B. analis., the corresponding periods were 1 to 18, 8 to 43 and 5 to 36 days depending upon the season. The number of generations per year ranged from 8 to 9 and 9 to 10 respectively for both the species.

Metcalf and Flint (1962) reported that pulse seeds which are infested by Bruchus pisorum (L) are often reduced to mere shells.

Pulse beetles lay eggs on the mature pods in the field and the young ones bore into the seeds and are thus carried into the store (Pruthi, 1969).

Raina (1970) studied the comparative biology of C. maculatus, C. chinensis and C. analis. All the three species were active from early spring to late autumn and overwinter in larval stage. Immediately after their emergence, the adults were able to mate several times. Females laid oval translucent eggs on the surface of the seeds and the average number of eggs laid were 128, 78 and 96 respectively. The incubation period of eggs were 5, 3 and 4 days respectively at 30°C and 70 per cent relative humidity and the percentage of hatching ranged from 94 to 99 for all the three species. The larvae after emergence bored vertically into the seed, turned at right angles and then pushed forward horizontally, feeding on the cotyledons. The larvae moulted four times before pupation. The combined larval and pupal period averaged 20, 18.8 and 23.5 days and the development from egg to adult occupied an average of 24, 22.3 and 28.5 days respectively for the three species.

In studies on the effect of temperature and humidity on the fecundity of B. chinensis, Ouchi (1936) observed that the maximum number of eggs were laid at 29.7°C and 93% RH.

Miyake and Odera (1939) reported that the number of days required to complete development from oviposition to adult emergence at 20, 30 and 37°C were 51.3, 18.9 and 21.5 respectively for C. chinensis and 109, 23.3 and 23.6 respectively for C. analis.

Effect of temperature and relative humidity on the biology of C. chinensis was studied by Arora and Singh (1970). A single male could mate with as many as 18 females at 25 to 30°C and 50 to 90% RH. The highest number of eggs laid per female (91) was at 30°C and 90% relative humidity and the lowest (32) at 25°C and 50% RH.

Bato and Sanchez (1972) reported that at a mean temperature of 83.6°F and 67.7% relative humidity, the duration of egg, larval and pupal stages of C. chinensis in green gram seeds with 14.79 per cent moisture were 4.62, 12.48 and 3.94 days respectively. The longevity of adult males and females were 2 to 14 and 2 to 22 days respectively.

Weight loss due to the infestation of C. maculatus varied with the host based on the number of eggs laid. Black eyed cowpea Vigna unguiculata was most preferred for oviposition. The extent of weight loss of seeds infested with the pulse beetle after storage for five months on black eyed cowpea, fetriate cowpea and lentils were 50, 44 and 45 per cent respectively (Koura-Elhalfwy, 1971).

Gundu Rao and Wilbur (1972) estimated that the extent of damage in wheat by adult feeding of Rhyzopertha dominica Fabr. was about 19.4, 12, 9.5 and 6.5 per cent kernel during first, second, third and fourth week respectively after adult emergence.

Sample testing of cowpeas V. unguiculata from the markets of Frote and Brazil by Basto, (1973) showed that in 27.8 per cent of the samples, 5 per cent of the seeds were damaged by C. maculatus and after storage for 56 days the damage attained 68.46 per cent.

Majumdar (1976) stated that the taxonomic distribution of storage pests follows a pattern in relation to the ecologic factors and physico-chemical composition of food stuffs. C. chinensis thrived on milled whole pulses with the husk but not on the processed products.

In a comparative study on the biology of C. chinensis, Bhattacharya et al. (1977) reported that the development was not completed on seeds of French bean and black gram, but it was more on green gram.

Jarry (1980) studied the comparative fecundities and oviposition of Acanthoscelus obtectus Say on the seeds and pods of Phaseolus vulgaris L. and found that the fecundity of fertilized females was higher on pods than seeds. Pods provided a strong stimulus to sustain egg laying activity than seeds.

Control of pulse beetles

Use of inert dusts

Use of inert dust materials in controlling storage pests have been in vogue from very early days. Inert dust materials are effective in abrading the epicuticle and causing desiccation as in aluminium oxide or may absorb moisture from the body due to hygroscopic properties as in charcoal (David and Kumaraswami, 1981).

Headlee (1924) reported that among the dusts ground burnt lime, calcium oxide, hydrated lime, calcium chloride, calcium sulphate, dolomite and various other clays afforded marked protection of edible beans from the attack of Bruchus obtectus.

Studies on the use of burnt paddy husk for the control of stored grain pests have shown that when the grains were mixed with finely powdered burnt rice husk, 100 per cent mortality of Bruchus beetles was obtained (Narasimham and Krishna Murthy, 1944). According to them the efficiency of burnt rice husk was due to the repellent effect of the powder adhering on the grains. The adhered powder can be easily freed by usual winnowing and cleaning of pulses.

Peas and beans can be protected from bruchid infestation by mixing 200 lb of seeds with 6 to 8 oz of colloidal silica, colloidal aluminium pentasilicate or finely ground diatomite or the same quantity of diatomite or kaolin impregnated with 0.05 per cent gamma BHC or 0.05 per cent technical DDT (Parkin and Bills, 1955).

Nair (1957) reported that the inert dusts killed insects by removing or abrading water proof wax layer and thus exposing them to desiccation. Studies with inert dusts like kaoline, rice husked charcoal, silica gel, insecticidal dusts like DDT, Malathion, Lindane, BHC, Pyrethrum and Acorus calamus have shown that silica gel was found to be significantly superior than all other treatments. Silica gel being an inert dust can be used with advantage in protecting stored paddy from insect infestation without any toxic hazards (Mammen et al. 1968).

The effect of drie-die (silica aerogel) as an absorptive dust was tested for the control of C. analis in stored seeds of Phaseolus (aureus) radiatus by Thontadarya and Rajagopal (1969) have shown that all adult beetles introduced to seeds mixed with dri-die at 0.03 and 0.04 per cent by weight were dried within 6 hours.

El-Rafie et al. (1970) reported that rock phosphate at 1 per cent concentration used as seed treatment on horsegram, cowpea and lentil against C. chinensis gave mortality after 24 hours.

Effect of kaolinic clay in protecting cowpea seeds from the infestation of pulse beetle C. chinensis was studied by Swamiappan et al. (1976) and found that activated clay minerals removed the fat molecules from cuticular waxy layer by absorption.

Varma et al. (1977) investigated the insecticidal activity of dusts attapulgite and other clays against the adults of stored pests like Callosobruchus chinensis, Tribolium castaneum Abst, Sitophilus oryzae (L), Lasioderma serricorne Fb. Oryzaephilus surinamenis Linn and Rhyzopertha dominica Fabr. Treatment with fullers earth cause 90 per cent mortality of C. chinensis, S. oryzae and L. serricorne within 48 hours.

Use of indigenous plant products

Complete protection of pulse seeds from bruchids was obtained by treating the seeds with dusts and sprays formulated from the dry bark of *Mundulea suberosa* (Subramaniam, 1934).

Puttarudriah and Lakshminarayana Bhatta (1955) reported 80 per cent mortality of *C. chinensis* within 4 days when the second and third instar larvae were allowed to crawl over the dusts of *Derris elliptica* for five minutes. Petroleum extracts of *Acorus calamus* were found to be effective against *S. oryzae* (Paul *et al.* 1965).

Jotwani and Sircar (1967) studied the repellent effect of neem seed against the pulse beetle *C. maculatus*. The powdered kernels were mixed with the seeds of mung, bengal gram, cowpea and peas at the rate of 1 to 2 parts neem kernel powder per 100 parts (w/w) of seeds and were protected from the attack of the pest for about 8, 11, 9 and 9 months respectively without affecting germination, taste and smell of seeds.

Relative efficacy of various plant products in controlling the infestation by Angoumois grain moth in stored paddy *Sitotroga cerealella* Oliv. was studied by Abkham et al. (1972). Chopped leaves of *Azadirachta indica* followed by leaves of

Vitex negundo, Adhatoda vasica and Clerodendron infortunatum and rhizomes bits of A. calamus when used as direct mixtures gave best results.

Agarwal et al. (1973) reported that an essential oil asarone extracted from the rhizomes of A. calamus, is effective in controlling various stored grain pests like T. castaneum, B. chinensis, R. dominica, Trogoderma granarium and Corcyra cephalonica. They found that the LD 50 value for B. chinensis was 1.35.

Studies conducted by Girish and Jain (1974) showed that wheat seed mixed with powdered kernel of neem was found to be effective in reducing the population build up and extent of damage of T. granarium and R. dominica.

Powdered neem kernel mixed with paddy at 1 and 2 per cent concentrations were found to be effective in reducing the rate of oviposition of lesser grain borer and grain moth respectively and concentrations of 0.5, 0.75 and 1 per cent significantly reduced the adult population of rice weevil, lesser grain borer and grain moth (Savithri and Subba Rao, 1976).

Saradamma et al. (1977) reported that mixing the neem seed powder with one or two per cent concentrations gave effective protection against storage pests of paddy.

Toxicity of oleoresin extracted from Chrysanthemum cinerarifolium in combination with neem seed extract A. indica and garlic clove extract was tested by Qadri et al. (1981) against C. chinensis and R. dominica. It was found that garlic and neem extracts had a synergistic effect with the oleoresin from pyrethrum against these insects.

Deshpande (1974) investigated the toxicity of the extracts of two Indian medicinal plants, Nigella sativa and Pogostemon leyneanus against S. oryzae, Stegobium paniceum (L), T. castaneum and C. chinensis found that both of them were having insecticidal properties.

Chatterjee (1980) reported that petroleum extracts of dried and powdered seeds of Jatropha gossypifolia Linn. contain some toxic principles that exerts contact action against T. castaneum.

Use of edible and vegetable oils

Su et al. (1972) gave an account of the effect of oils obtained from lemon, grapefruit, lime, Kumquat and tangerine in reducing the population build up of C. chinensis and S. oryzae.

Oils of mustard, sunflower, safflower, castor, cotton, neem and pongamia when used as surface protectants on red gram against C. chinensis, number of larvae emerged from the treated seeds were very few (Singappa, 1977).

Work done at Tamil Nadu Agricultural University, it has been found that the use of domestic edible oils like groundnut, coconut, gingelly, castor at 1 per cent had preserved the green gram seeds absolutely free from infestation of C. chinensis for a period of 13 months (Anon., 1976).

Varma and Pandey (1978) studied the effect of edible oils in protecting green gram seeds against the attack of C. maculatus in storage. Very little damage upto 5 months was seen in sample treated with coconut oil followed by mustard, groundnut and sesame oils @ 0.3 parts per 100 parts of seed (w/w) without affecting the viability of treated seeds.

Heat treatment

Reppert and Bentley (1936) tried the exposure of cowpea seeds to the open sunlight on clear day for a period of 75 minutes or more as a preventive step against bruchids and obtained complete destruction of bruchids without affecting germination.

All the stages of _C. maculatus_ can be killed by resorting to heating at a temperature of 45 to 55°C (Mookherjee _et al._ 1968).

Use of synthetic organic insecticides

Ohta (1961) reported that naphthalene, camphor and P-dichlorobenzene possess repellent properties against adults of _C. chinensis_.

Post embryonic development of _C. chinensis_ was adversely effected when the newly hatched larvae penetrated the seeds treated with camphor crystals at concentration of 0, 12, 24, 48 and 96 ppm in airtight containers (Abivardi, 1977).

Lin (1964) reported that stored red beans and green beans were found to be effectively protected from the attack of _C. chinensis_ with bromocyclen (Bromodan) or chlorbicyclen (Alodan) applied as 5% dust at a rate of 0.4 to 0.5 lb/100 lb.

Toxicological studies using gamma BHC, methyl parathion, dimethoate, malathion and carbaryl on adults of _C. analis_ conducted by

Nisa and Ahmed (1970) showed that applying the insecticides either topically or mixing the dusts with stored pulses, into which the insects were introduced gamma BHC at 1 ppm gave good protection for two months while at 5 ppm this afforded protection for four months.

El-Rafie *et al.* (1974) reported that the spray deposits of malathion, bioallethrin and seven applied on three types of pulse seeds against *C. chinensis* have shown that malathion was more toxic followed by bioallethrin and sevin.

Gouhar *et al.* (1974) evaluated the effectiveness of four chemicals against *C. maculatus* at 25°C and 75% relative humidity. The LD 50 values showed that trichlorphon (200 ppm) was found to be the most toxic compound followed by gamma BHC, malathion and carbaryl.

Experiments on the effectiveness of malathion, lindane, diazinon and fenitrothion against *T. castaneum*, *S. orysae* and *B. chinensis* were carried out by Kattera P. Kashi (1976) showed that fenitrothion was more toxic to all the three species of insects.

Abdel-Wahab et al. (1974) compared the toxicity of topical application of several insecticides and the LD values have shown that aldicarb was the most effective material against adult males of C. maculatus.

Gram seeds can be protected from the attack of C. chinensis for long periods using methoxychlor and malathion at concentration above 24 ppm (Dhari et al. 1978).

Pawar and Yadav (1980) compared the persistence of different organophosphorus insecticides, namely, phoxim (baythion), bromophos, fenitrothion, pirimiphos methyl, iodofenphos and malathion against adults of C. chinensis on different surfaces such as glass, cement, mud, jute, polythene, aluminium and plywood surfaces. Phoxim was found to be the most persistant chemical and glass was the most suitable surface for the retention of toxicity of the chemical.

Malathion at 20 ppm with pyrophyllite as a carrier against C. maculatus and C. chinensis was found to be most effective upto 48 months (Yadav et al. 1980).

Lloyd and Hewlett (1958) found that adults of *C. chinensis* were highly susceptible when treated with pyrethrins (1.3 per cent) alone and in combination 0.3% (w/w) with 3% (v/v) piperonyl butoxide in a heavily refined mineral oil.

Pyrethrin at 0.2 and 0.025 per cent concentrations afforded control of *S. oryzae* and *C. analis* in stored grains and pulses respectively (Uniyal *et al.* 1967). *C. chinensis* showed great response to the pyrethrins synergised with piperonyl butoxide when the adult beetles were exposed to the talc based powders admixed with wheat (Weaving, 1970).

Caswell and Akibu (1980) reported that pirimiphos methyl at 0.25 to 1% concentration was effective against bruchid infestation on stored cowpea, *V. unguiculata*. Hundred per cent mortality of pulse beetles was obtained when the seeds of peas and beans were treated with dust formulations of pirimiphos methyl at 2.5, 5 or 10 mg per kg and permethrin at 1.5 and 5 mg/kg of seeds.

Fumigation methods

Cornes Adeyemo (1972) reported that satisfactory control of the different stages of bruchids remained in all parts of sacks was obtained when one or two phostoxin pellets were dropped through an applicator tube.

Olivier *et al.* (1977) obtained 100% mortality of bruchids within 24 hours when lindane was applied in the form of fumite tablets at the rate of one tablet per 45m^3 and sealed.

Phosphine @ 1 to 2 tablets/ton of seed was an effective fumigant in the control of *C. maculatus* and *C. chinensis* in stored seeds of pea, cowpea and mung without affecting germination (Singh *et al.* 1980).

Jay (1980) suggested use of CO_2 introduced into the seeds along with grain streams for controlling stored product pests viz., *Tribolium castaneum* Hbst., *T. confusum* Bhst. and *C. maculatus*.

Biological control

Kairya and Kurosawa (1939) reported a Braconid *Heterospilus psocopidis* vier as a parasite of *B. chinensis* in Japan and studied the biology.

In an investigation of *C. chinensis* and its parasite *Anisopteromalus calandrae* (Howarot) Okamoto (1971) studied the development stage of the host at the time of attack, percentage of parasitism and duration of development of parasite. The preferred developmental stage was the fourth instar larvae, but few of the wasps parasitized the third instar larvae and pupae and found that percentage of parasitism changed with the development of host larvae.

New approaches in bruchid control

Nagasawa *et al.* (1965) observed that the percentage hatching of eggs laid by females of *C. chinensis* was very low when both male and female insects were treated with fentin hydroxide at 0.2 µg/adult.

Bhatnagar-Thomas (1973) reported that a Juvenile hormone analogue methyl 3, 7, 11 trimethyl 7, 11, dichloro 2 dodecenoate at concentrations of 12.5 to 20 ppm was effective against *C. chinensis* in green gram *P. mungo*.

Effects of gamma radiation on the eggs of cowpea weevil *C. maculatus* was studied by Elbadry and Ahmed (1975). No hatching was occurred when newly laid eggs exposed to 1,000 rad, but for olden eggs about 8,000 rad was needed to obtain 100% mortality.

Rizvi *et al.* (1980) reported that 1, 3, 7 trimethyl xanthine isolated from a seed extract of arabica coffee proved to be effective chemosterilant for the stored grain pest *C. chinensis* causing 100 per cent mortality at concentration of 1.5%.

Materials And Methods

MATERIALS AND METHODS

1. Materials

1.1 Insecticides

The following materials comprising botanical, inert and organic insecticides were used in the experiment.

Sl. no.	Common name	Active ingredient	Proprietary name	Formulation
1	Sweet flag (*Acorus calamus*)	--	--	Rhizome bits
2	Neem (*Azadirachta indica*)	--	--	Kernel powder
3	Activated charcoal	--	--	Dust
4	Carbaryl	1-naphthyl-N-methyl carbamate	Sevin	5% dust
5	Etrimphos	Phosphorothioic acid O, O-Dimethyl O-(6-ethoxy-2 ethyl-4-pyrimidinyl)	San 197	2% dust 16% Emulsion concentrate
6	Fenvalerate	RS-α-Cyano-3 phenoxy benzyl (RS)-2-4-Chloro phenyl-3 methyl butyrate	Sumicidin	20% Emulsion concentrate

Sl. no.	Common name	Active ingredient	Proprietary name	Formulation
7	Bendiocarb	Carbamic acid-Methyl-2,3 (Dimethyl methylene dioxy phenyl ester)	Garvox	80% wettable powder
8	Permethrin	3 phenoxy benzyl I.RS c.s, trans-3-2-dichlorovinyl 2,2-dimethyl cyclopropene carbexylate	Permasect	25% Emulsion concentrate

1.2 Stock cultures of Callosobruchus maculatus (F.)

Adults of pulse beetle Callosobruchus maculatus (F.) required for studies were obtained from the Entomology Department, College of Horticulture, Vellanikkara.

1.3 Cowpea seeds required for the experiment

The variety Kanakamani PTB_1 was used in the trial. This was obtained from Regional Agricultural Research Station, Pattambi.

1.4 Aspirator for introducing the beetle

For introducing the beetles into the containers, an aspirator consisting of a cylindrical glass vial of size 12 x 3 cm was used. The vial is closed with a rubber cork having two perforations through which two glass tubes each of 0.25 cm diameter are introduced. One of the tubes is bent at right angles with the arm lengths of 18 cm and 8 cm. The longer arm is inserted into the glass vial. This tube was used as inlet and exit while aspirating and releasing the beetles. The other glass tube is straight with a total length of 8 cm. To the outer extremity of this is attached a rubber tubing of length 14 cm.

For collecting the adult beetles from the stock culture, the bent tube is inserted close to the beetles and these are then sucked into the vial. The beetles thus collected are introduced into the containers by blowing air into the vial. A hard board of 8 cm diameter was introduced through the bent glass tube prior to releasing the beetles. The disc is allowed to rest over the container while introducing the beetles so that these do not escape.

1.5 Plastic containers of uniform size (14 x 14 cm) for storing pulse seeds.

1.6 Gunny bags of uniform size and thickness (18 x 30 cm) for storing pulse seeds.

1.7 Glassware: Measuring cylinder, beakers, glass troughs, pipettes, specimen tubes, petridishes.

1.8 Atomizer for spraying pulse seeds with the spray solution of insecticides.

1.9 Simple balance, tally counter, metal probe for drawing sample, filter paper etc.

2. Methods

2.1 Determination of the moisture content of seeds

To determine the moisture content of the cowpea seeds used in the experiment a sample size of 100 seeds were taken at random, weighed and kept in a hot air oven at 105°C till a constant weight was obtained. Difference between the initial and final weights was taken as the moisture content of seeds.

2.2 Conditioning the seeds

The seeds required for experiments were thoroughly cleaned to remove chaff, small kernels and other foreign materials and dried to maintain the moisture content at 14 per cent.

2.3 Maintenance of stock culture of *C. maculatus*

Stock culture of *C. maculatus* was maintained in the laboratory for experimental purpose. These were maintained in museum jars using cowpea seeds as the host material. Museum jars were filled to half capacity with the seeds, about 50 to 100 adult beetles were introduced and closed with muslin cloth. The jars were kept in store for multiplication.

2.4 Treatments

The following treatments were included in the experiment.

T_1. Mixing seeds with small rhizome bits of sweet flag (*Acorus calamus*) rhizomes @ 1.5% (w/w).

T_2. Mixing seeds with neem (*Azadirachta indica*) kernel powder @ 1.5% (w/w).

T_3. Mixing seeds with activated charcoal @ 1.5% (w/w).

T_4. Mixing seeds with carbaryl 5% dust @ 1.5% (w/w).

T_5. Mixing seeds with etrimphos 2% dust @ 1.5% (w/w).

T_6. Surface spraying with etrimphos 16% EC @ 0.05%.

T_7. Surface spraying with fenvalerate 20% EC @ 0.01%.

T_8. Surface spraying with bendiocarb 80% WP @ 0.06%.

T_9. Surface spraying with permethrin 25% EC @ 0.0125%.

T_{10}. Untreated control.

2.5 Treating of seeds before storage

Five hundred grams of insect free cowpea (PTB_1) seeds with uniform moisture content (14 per cent) were used for each replication of the treatments. Required quantity of sweet flag rhizome bits, neem kernel powder, dusts of activated charcoal, carbaryl and etrimphos for each replication were weighed separately and mixed throughly with the seeds in a small seed dressing drum for getting uniform coating or distribution of the material. Before mixing the materials 10 ml of water was sprayed uniformly on the seeds and dried at room temperature.

In the case of spray formulations, spray solutions of the insecticides namely etrimphos 0.05%, fenvalerate 0.01%, permethrin 0.0125% and bendiocarb 0.06% were prepared for each replication and 10 ml of the prepared solution was sprayed on the seeds spread in a plastic tray with the help of atomizer while the seeds were kept agitated intermittently for getting a uniform coverage. After the treatment the seeds were allowed to dry at room temperature and used for the experiment. Control replicates of 500 gm seeds were also maintained after spraying with 10 ml of water and dried at room temperature.

2.6 Storing: The storing was done under two sets of conditions.

2.6.1 Storage in plastic containers: Treated seeds together with untreated control were stored separately in plastic containers of one litre capacity. Ten pairs of newly emerged adult beetles were introduced, at monthly intervals, into the plastic containers with the help of an aspirator and the containers were closed with muslin cloth. The containers were then arranged randomly in the store.

2.6.2 Storage in gunny bags: Another set of the same treatments were also exposed in small gunny bags of size 18 x 30 cm to natural infestation. Gunny bags were scattered randomly inside a store containing pulse seeds which were heavily infested with C. maculatus for getting even chance of natural infestation to all treatments.

3.0 Assesement of results: Relative efficacy of the materials used as protectants in preventing the damage due to pulse beetle in storage was assessed by taking the following observations.

3.1 Percentage weight loss: Count and weight method of Adams and Schulten (1976) was used to assess the percentage weight loss caused by the infestation of pulse beetle C. maculatus. A sample size of 100 seeds were drawn from each replicate at monthly intervals with the help of a metal probe for a period of six months after treatment. Seeds in the sample were seperated into damaged (with holes) and undamaged (without holes) ones, the number and weight of the two grades was recorded seperately. From the data, percentage weight loss was calculated by using the following formula.

$$\text{percentage weight loss} = \frac{UNd - DNu}{U\ (Nd + Nu)} \times 100$$

where Nd = Number of damaged seeds

Nu = Number of undamaged seeds

D = Weight of damaged seeds

U = Weight of undamaged seeds

3.2 Fecundity: Counts of number of eggs laid by the beetles on the surface of seeds in a sample of 100 seeds drawn were taken at monthly intervals for a period of 6 months after treatment.

3.3 Viability of seeds: In order to assess the effect of the materials used, on the germination of stored seeds, viability tests were conducted at monthly intervals for a period of six months after storage. Three sub samples of 10 seeds were taken from each replication and germination tests were conducted in petridishes using moist filter paper. Counts on emergence of radicle from the soaked seeds upto a maximum of ten days were taken and the germination percentage was calculated.

4. Experimental conditions: The experiment was conducted in the Department of Entomology, College of Horticulture, Vellanikkara during the period from November 1981 to May 1982.

5. Design of experiment and statistical analysis: Completely randomised design with ten treatments replicated thrice was followed in the present investigation. The data were statistically analysed using the analysis of variance technique and interaction concept (Snedecor and Cochran, 1967).

Results

RESULTS

The relative efficiency of different materials used for the protection of cowpea seeds against the Pulse beetle Callosobruchus maculatus under two methods of storage was evaluated on the basis of three criteria, namely, weight loss in treated seeds, the number of eggs deposited and the viability of treated seeds. The above aspects were studied at monthly intervals for a period of six months from the time of treatment.

1. Assessment of efficiency of treatments based on the weight loss in treated seeds

The loss in the weight of seeds due to infestation by the beetle was recorded at monthly intervals for a period of six months. The related data are presented in Tables 1 to 6 and graphically depicted in Figures 1 to 6. The details of analysis of variance are appended (I to VI).

1.1 Percentage weight loss in treated seeds - one month after storage

The percentage weight loss at one month after treatment were significantly different under different treatments (Table 1, Fig 1), but the methods of storage

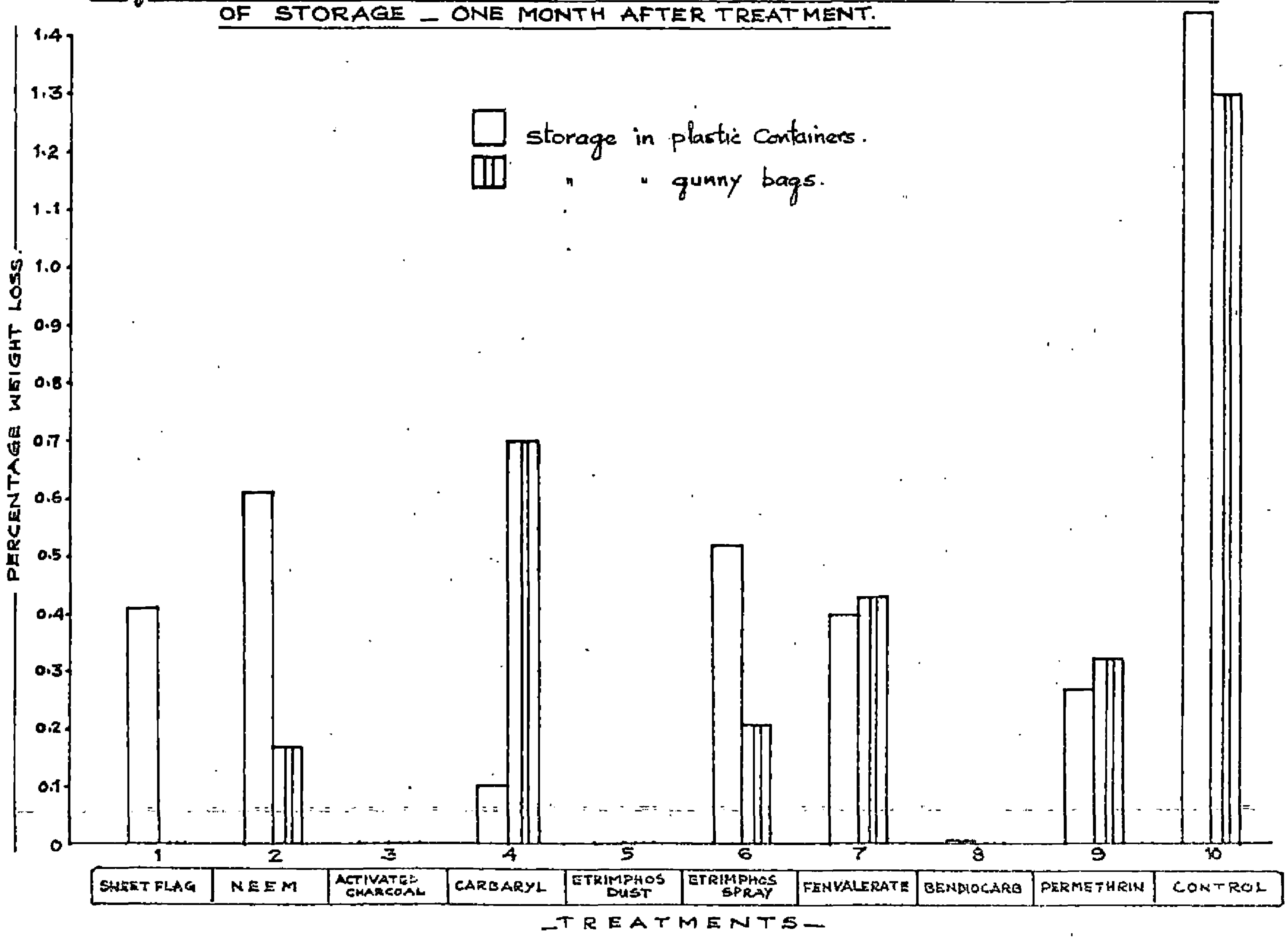
Table 1. Percentage weight loss in treated seeds observed one month after storage.

Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1 Sweet flag	0.415	0.000	0.208 a
T_2 Neem	0.617	0.173	0.395 a
T_3 Activated charcoal	0.000	0.000	0.000 a
T_4 Carbaryl dust	0.107	0.706	0.407 a
T_5 Etrimphos dust	0.000	0.000	0.000 a
T_6 Etrimphos spray	0.527	0.216	0.372 a
T_7 Fenvalerate	0.405	0.434	0.419 a
T_8 Bendiocarb	0.029	0.000	0.014 a
T_9 Permethrin	0.271	0.324	0.297 a
T_{10} Control	1.442	1.305	1.374 b
Mean	0.381	0.316	

CD (0.05) : Treatment - 0.668

** Means not following same letter are significantly different

Fig-1. PERCENTAGE WEIGHT LOSS IN TREATED SEEDS UNDER TWO METHODS OF STORAGE _ ONE MONTH AFTER TREATMENT.



did not influence the quantitative loss at this stage of the experiment. There was no weight loss in treatments with activated charcoal and with etrimphos dust and 1.374 per cent loss in untreated seeds. The weight loss in untreated control is significantly higher as compared to the rest of the treatments which were all on par.

When the treated seeds are stored in plastic containers the percentage weight loss is slightly greater then when stored in gunny bags. However these differences are not found to be significant.

Weight loss is not registered in seeds treated with activated charcoal and with etrimphos dust and kept inside plastic containers while in control the loss is 1.442 per cent under similar storage. In gunny bag storage maximum weight loss is recorded in control (1.305%) as against no loss in the treatments with sweet flag, activated charcoal, etrimphos dust and bendiocarb.

1.2 Percentage weight loss in treated seeds - two months after storage

The data on the weight loss in treated seeds as observed at two months after treatment is furnished in Table 2 and illustrated in Fig 2. At this stage

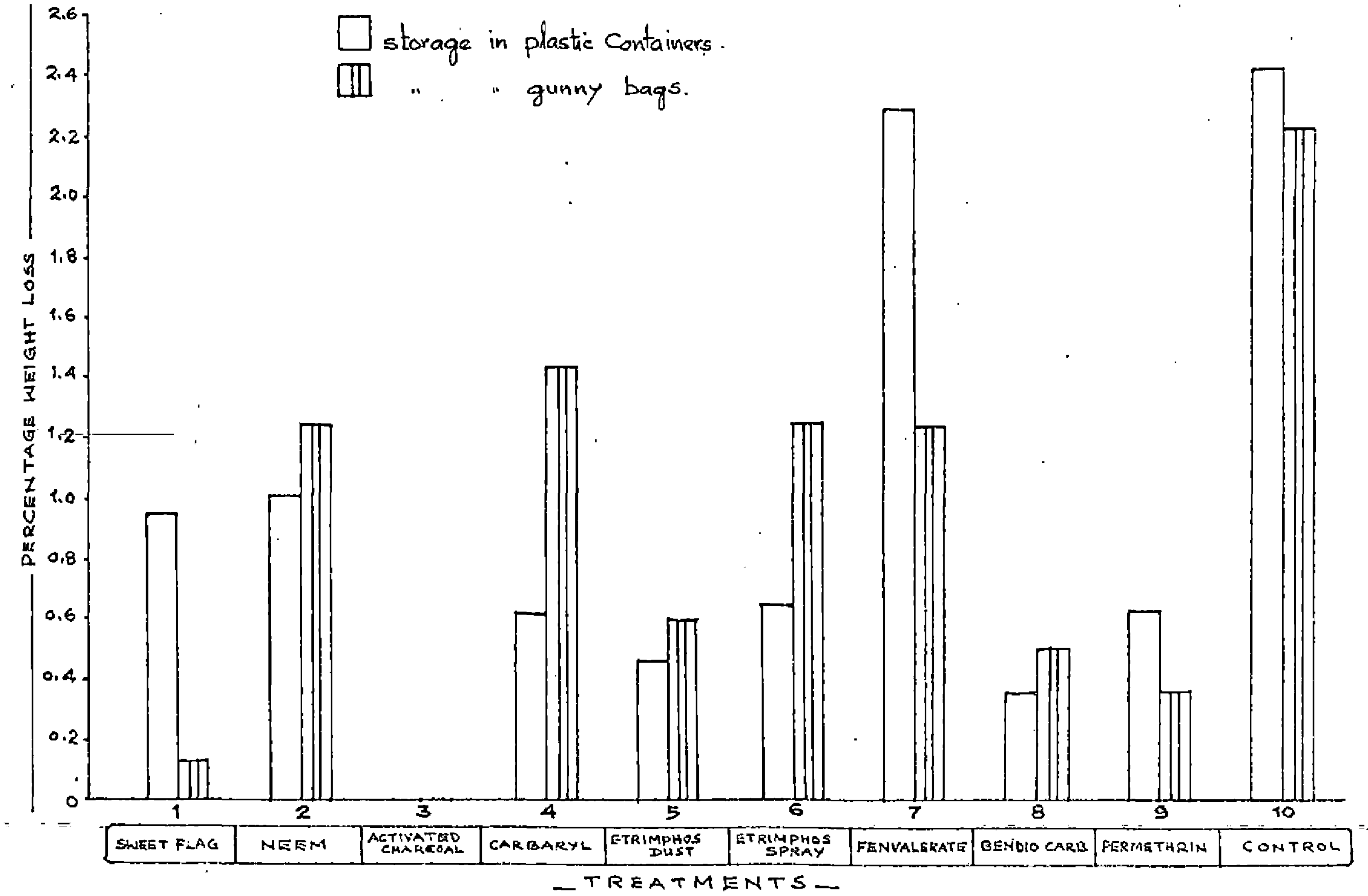
Table 2. Percentage weight loss in treated seeds observed two months after storage.

Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1 Sweet flag	0.951	0.135	0.547 ab
T_2 Neem	1.084	1.252	1.167 bc
T_3 Activated charcoal	0.000	0.000	0.000 a
T_4 Carbaryl	0.639	1.442	1.041 bc
T_5 Etrimphos dust	0.478	0.611	0.545 ab
T_6 Etrimphos spray	0.658	1.258	0.958 abc
T_7 Fenvalerate	2.299	1.244	1.772 cd
T_8 Bendiocarb	0.363	0.514	0.438 ab
T_9 Permethrin	0.632	0.372	0.502 ab
T_{10} Control	2.422	2.221	2.322 d
Mean	0.954	0.905	

CD (0.05) : Treatment - 1.029

**Means not following same letter are significantly different

Fig. 2. PERCENTAGE WEIGHT LOSS IN TREATED SEEDS UNDER TWO METHODS OF STORAGE - TWO MONTHS AFTER TREATMENT.



the treatments under two methods of storage were found to significantly influence the quantitative weight loss. Seeds treated with activated charcoal did not show any weight loss in the second month also but etrimphos dust showed 0.545% reduction in weight after second month. The treatment means with activated charcoal, bendiocarb, permethrin, etrimphos dust, sweet flag, etrimphos spray are on par and significantly better than control which showed 2.322% weight loss. Fenvalerate, neem and carbaryl were on par and inferior to activated charcoal though significantly better than control.

The difference between two methods of storage is not statistically significant, the mean percentage weight loss in gunny bag storage being 0.905% and in plastic containers 0.954%.

No weight loss is seen in activated charcoal treatment under both the methods of storage. Maximum weight loss of 2.422% and 2.2217% is recorded in untreated control under storage in plastic containers and gunny bags respectively. However, these differences are not statistically significant.

1.3 Percentage weight loss in treated seeds - three months after storage

All the treatments except activated charcoal registered an increase in the extent of damage. (Table 3, Fig 3), the untreated control showing substantial damage (21.309%) and the activated charcoal treated seeds did not show any weight loss.

Treatments with activated charcoal, bendiocarb, permethrin, etrimphos dust and carbaryl were on par and superior in reducing the weight losses. Neem and etrimphos spray are on par with etrimphos dust and carbaryl and are less effective. Fenvalerate and sweet flag are least effective, however these are significantly better than control.

There is no significant difference between two methods of storage, however the treated seeds kept in plastic containers showed mean weight loss of 4.469% compared to a loss of 3.777% in seeds kept in gunny bags.

Under both methods, the activated charcoal treated seeds did not show any weight loss. But in control the weight loss was 30.024 and 12.594% in plastic containers and gunny bags respectively.

Fenvalerate treatment is inferior to all other treatments in plastic container storage, but this is significantly better than control. Under gunny bag storage etrimphos spray, fenvalerate and neem treatments are inferior to activated charcoal but these

Table 3. Percentage weight loss in treated seeds observed three months after storage.

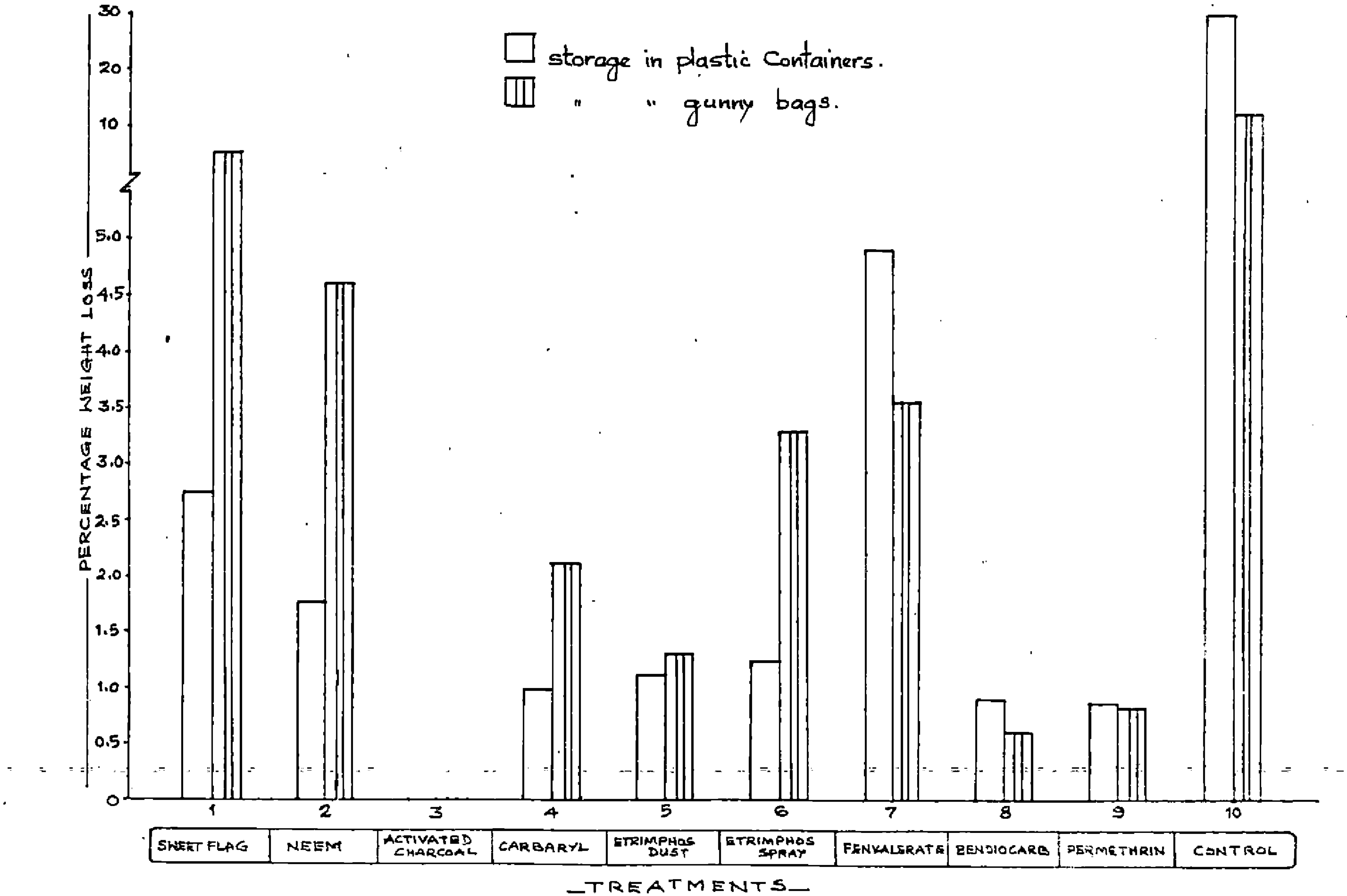
	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	2.749 ab	8.809 d	5.779 e
T_2	Neem	1.785 a	4.618 c	3.203 cd
T_3	Activated charcoal	0.000 a	0.000 a	0.000 a
T_4	Carbaryl	1.014 a	2.152 abc	1.583 abc
T_5	Etrimphos dust	1.147 a	1.311 abc	1.229 abc
T_6	Etrimphos spray	1.241 a	3.298 bc	2.269 bcd
T_7	Fenvalerate	4.923 b	3.532 bc	4.228 de
T_8	Bendiocarb	0.922 a	0.642 ab	0.782 ab
T_9	Permethrin	0.886 a	0.809 ab	0.848 ab
T_{10}	Control	30.024 c	12.594 e	21.309 f
	Mean	4.469	3.777	

CD (0.05) : Treatment - 2.124

Interaction - 3.004

** Means not following same letter are significantly different

Fig-3. PERCENTAGE WEIGHT LOSS IN TREATED SEEDS UNDER TWO METHODS OF STORAGE — THREE MONTHS AFTER TREATMENT.



treatments are significantly better than control. Even though sweet flag treatment showed considerable quantitative loss, this was superior to control.

1.4 Percentage weight loss in treated seeds - four months after storage

The quantitative damage in seeds caused by beetle infestation four months after treatment are furnished in Table 4 and these are depicted in Fig 4. All the treatments in both methods showed an increasing trend in the weight loss except in case of activated charcoal treated seeds in which the damage was very slight.

There is no significant difference between the treatments of activated charcoal, permethrin, bendiocarb, carbaryl and etrimphos dust in terms of weight losses and these are found superior to etrimphos spray, fenvalerate, sweet flag, neem and control. The neem treated seeds showed relatively heavy weight loss of 25.039% but even this is far superior to control.

As in the previous month, the storage methods were not significantly different in respect of quantitative losses due to infestation by C. maculatus.

Under storage inside the plastic containers, infestation range from 0.055% in activated charcoal to 43.951% in untreated control. Activated charcoal,

Table 4. Percentage weight loss in treated seeds observed four months after storage.

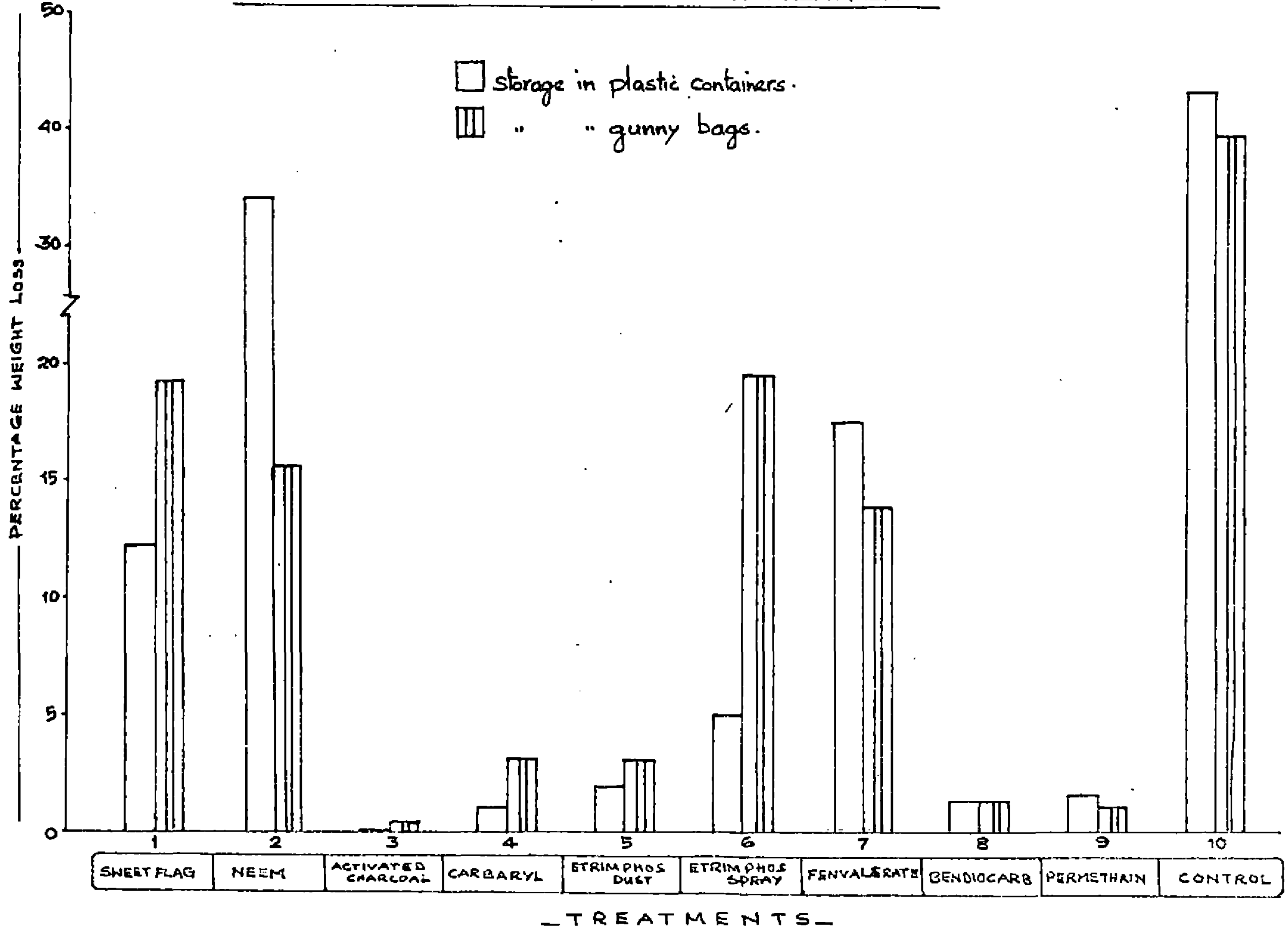
	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	12.243 b	19.208 bc	15.726 b
T_2	Neem	34.417 c	15.662 bc	25.039 c
T_3	Activated charcoal	0.055 a	0.399 a	0.227 a
T_4	Carbaryl	1.086 a	3.075 a	2.081 a
T_5	Etrimphos dust	1.907 a	3.027 a	2.467 a
T_6	Etrimphos spray	5.081 a	19.614 c	12.348 b
T_7	Fenvalerate	17.593 b	13.868 b	15.731 b
T_8	Bendiocarb	1.386 a	1.343 a	1.364 a
T_9	Permethrin	1.555 a	1.049 a	1.302 a
T_{10}	Control	43.951 d	39.316 d	41.634 d
	Mean	11.928	11.656	

CD (0.05) : Treatment - 4.038

Interaction - 5.710

**Means not following same letter are significantly different

Fig-4. PERCENTAGE WEIGHT LOSS IN TREATED SEEDS UNDER TWO METHODS OF STORAGE – FOUR MONTHS AFTER TREATMENT.



carbaryl, etrimphos dust, etrimphos spray, bendiocarb and permethrin are found to be equally effective in reducing losses and distinctly superior to sweet flag, fenvalerate, neem and control. Sweet flag and fenvalerate were par and comparatively better than neem which is least effective with a heavy weight loss of 34.417%. However, this was better than control.

When stored in gunny bags activated charcoal treated seeds recorded slight damage of 0.399% as against the maximum weight loss of 39.316% in untreated control. Fenvalerate, neem, sweet flag, etrimphos spray treatments are found to be inferior to all other treatments except control.

1.5 Percentage weight loss in treated seeds - five months after storage

It can be seen from Table 5, Fig 5 that the upward trend in the percentage weight loss is manifested in all the treatments during the fifth month, the range of infestation was 0.539% in activated charcoal and 48.043% in untreated control. At this stage permethrin and bendiocarb are found to be as effective as activated charcoal in reducing quantitative losses to seeds. Treatments etrimphos dust and carbaryl are inferior to activated charcoal. However, these are

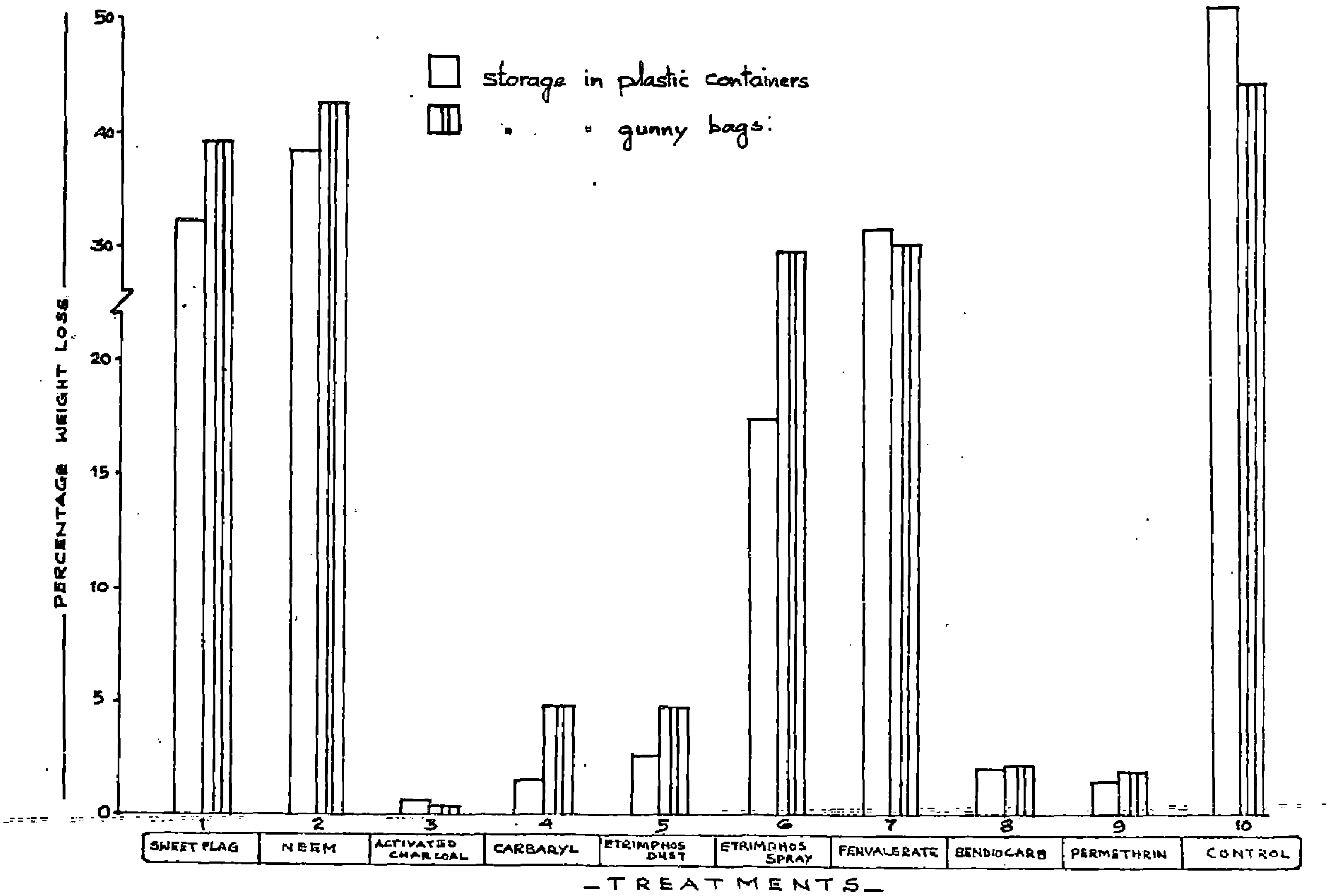
Table 5. Percentage weight loss in treated seeds observed five months after storage.

	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	32.402 c	39.479 d	35.741 e
T_2	Neem	38.540 d	42.717 d	40.629 f
T_3	Activated charcoal	0.592 a	0.487 a	0.539 a
T_4	Carbaryl	1.609 a	4.851 b	3.231 b
T_5	Etrimphos dust	2.753 a	4.866 b	3.809 b
T_6	Etrimphos spray	17.638 b	29.864 c	23.751 c
T_7	Fenvalerate	31.888 c	30.457 c	31.172 d
T_8	Bendiocarb	2.023 a	2.162 ab	2.093 ab
T_9	Permethrin	1.687 a	1.959 ab	1.823 ab
T_{10}	Control	51.496 e	44.589 e	48.043 g
	Mean	18.063	20.143	

CD (0.05) : Method - 1.203
Treatment - 2.689
Interaction- 3.803

** Means not following same letter are significantly different

Fig. 5. PERCENTAGE WEIGHT LOSS IN TREATED SEEDS UNDER TWO METHODS OF STORAGE - FIVE MONTHS AFTER TREATMENT



significantly superior to etrimphos spray, fenvalerate, sweet flag, neem and control.

There is significant difference between two methods of storage and the method involving storage in gunny bags recorded higher percentage weight loss (20.143%) as compared to storage in plastic containers (18.063%).

Cowpea seeds stored in plastic containers under control are found to suffer substantially with weight loss of 51.496%. The treatments namely activated charcoal, carbaryl, permethrin, bendiocarb and etrimphos dust are on par and superior to the rest of the treatments in reducing the infestation.

In gunny bag storage, the extent of infestation in terms of quantitative loss range from 0.487% in activated charcoal treated seeds to 44.589% in control. Neem, sweet flag, fenvalerate and etrimphos spray treatments are inferior to all other treatments except control. Even though carbaryl and etrimphos dust are inferior to activated charcoal, these are effective in reducing the damage.

1.6 Percentage weight loss in treated seeds - six months after storage

The percentage weight losses recorded six months after treatment are furnished in Table 6 and these are depicted in Fig 6. Highest damage in untreated

Table 6. Percentage weight loss in treated seeds observed six months after storage.

	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	36.322 d	47.189 c	41.755 d
T_2	Neem	50.761 f	46.386 c	48.574 e
T_3	Activated charcoal	1.253 a	5.186 a	3.219 a
T_4	Carbaryl	2.372 ab	5.486 a	3.929 a
T_5	Etrimphos dust	3.454 b	5.656 a	4.555 a
T_6	Etrimphos spray	31.342 c	35.896 b	33.619 b
T_7	Fenvalerate	40.540 e	37.829 b	39.185 c
T_8	Bendiocarb	2.471 ab	3.214 a	2.843 a
T_9	Permethrin	2.081 ab	3.154 a	2.618 a
T_{10}	Control	55.999 g	48.393 c	52.196 f
	Mean	22.659	23.839	

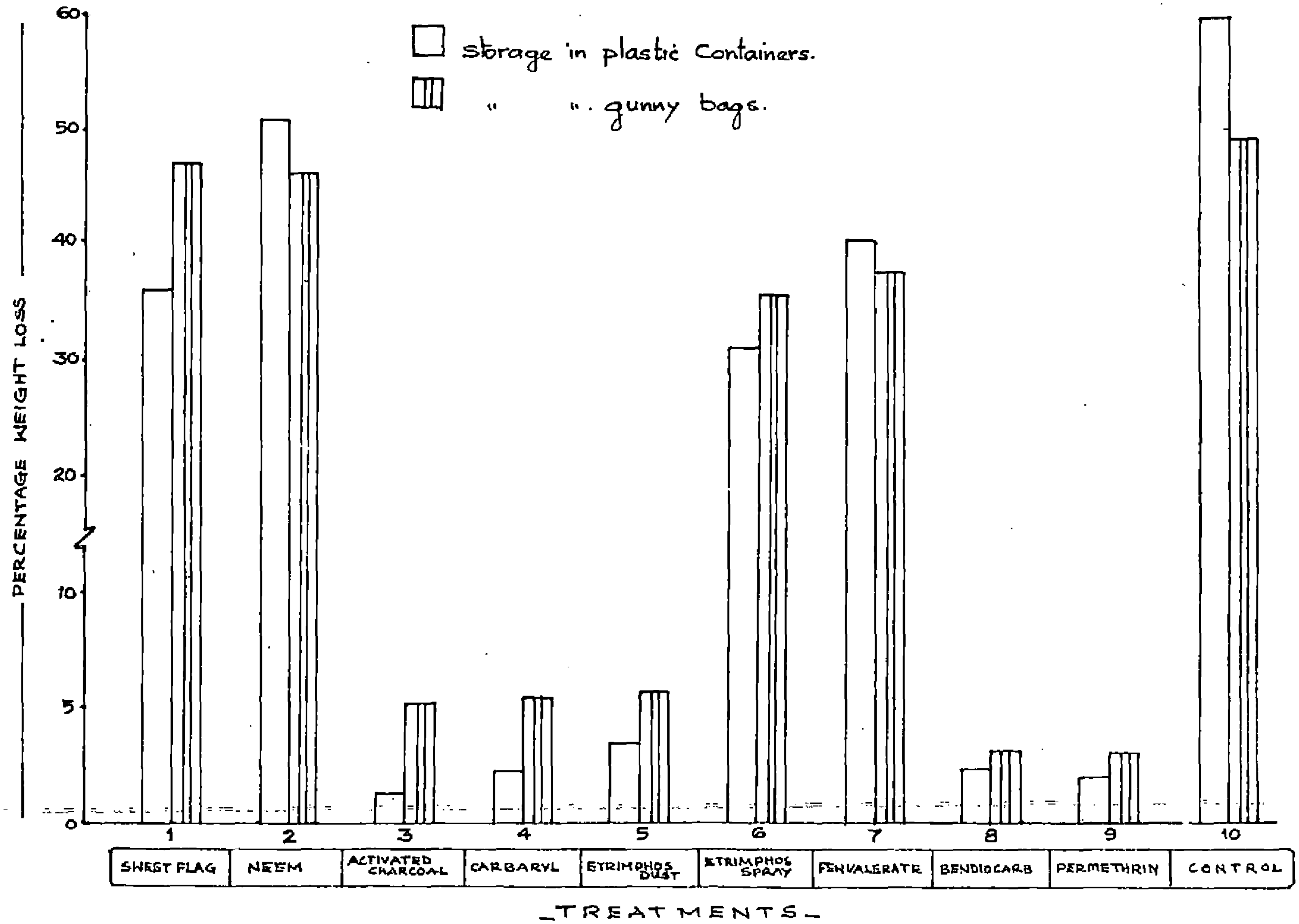
CD (0.05) : Method - 0.906

Treatment - 2.027

Interaction- 2.866

** Means not following same letter are significantly different

Fig. 6. PERCENTAGE WEIGHT LOSS IN TREATED SEEDS UNDER TWO METHODS OF STORAGE - SIX MONTHS AFTER TREATMENT.



control with a weight loss of 52.196%. The lowest loss in weight of 2.618% is registered in permothrin treated seeds.

Permethrin, bendiocarb, activated charcoal, carbaryl and etrimphos dust treatments are on par with reference to control of pest damage. The treatments etrimphos spray, fenvalerate, sweet flag and neem are the least effective in reducing the infestation, but these were superior to control.

The method involving storage in gunny bags recorded a mean weight loss of 23.839% as compared to the loss registered in plastic containers (22.659%), the difference being significant.

Storage inside plastic containers, activated charcoal treated seeds recorded lowest weight loss of 1.253% against highest percentage weight loss of 55.999 in control. Activated charcoal, permethrin, carbaryl and bendiocarb are on par in significantly reducing the infestation. Etrimphos dust is inferior to activated charcoal, but this is significantly better than etrimphos spray, sweet flag, fenvalerate, neem and the control in reducing damage.

In gunny bag storage, the infestation range from 3.154% in permethrin treated seeds to 48.393% in untreated control. However, there is no significant difference among the treatments with permethrin, bendiocarb, activated charcoal, carbaryl and etrimphos dust. Even though the treatments etrimphos spray and fenvalerate are inferior these are significantly better than control. Neem and sweet flag are on par with control and less effective than all other treatments.

2. Assessment of the efficacy of the treatments based on the number of eggs deposited

Number of eggs deposited by the pulse beetle on cowpea were counted from a sample comprising of 100 seeds at monthly intervals during the period of six months after treating the seeds and storing under two methods of storage. The data were analysed after applying square root transformation. The results are furnished in Tables 7 to 12 and depicted graphically in Figures 7 to 12. Analysis of Variance Tables are furnished in appendices VII to XII.

It can be seen from the Table 7 (Fig 7) that the beetles did not deposit eggs on activated charcoal treated seeds under both methods of storage against a maximum number of 294.362 and 64.423 eggs were deposited in untreated seeds stored in plastic containers and gunny bags respectively. The number of eggs laid by the beetle in permethrin, bendiocarb, etrimphos dust, sweet flag, etrimphos spray and carbaryl treated

Table 7. Number of eggs deposited by the beetle on treated seeds - one month after storage.

	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	42.414 (6.589)	3.246 (2.061)	17.703 (4.325)*ab
T_2	Neem	192.277 (13.902)	22.765 (4.875)	87.147 (9.389) cd
T_3	Activated charcoal	0.000 (1.000)	0.000 (1.000)	0.000 (1.000) a
T_4	Carbaryl	26.232 (5.218)	24.462 (5.046)	25.339 (5.132) abc
T_5	Etrimphos dust	9.338 (3.215)	14.111 (3.887)	11.611 (3.551) ab
T_6	Etrimphos spray	23.234 (5.499)	21.041 (4.695)	24.976 (5.097) abc
T_7	Fenvalerate	29.643 (5.536)	57.778 (7.667)	43.711 (6.601) bc
T_8	Bendiocarb	17.320 (4.280)	5.409 (2.532)	10.600 (3.406) ab
T_9	Permethrin	6.933 (2.817)	10.938 (3.455)	8.833 (3.136) ab
T_{10}	Control	294.362 (17.186)	64.423 (8.089)	179.393 (12.637) d
	Mean	41.565 (6.524)	18.199 (4.331)	

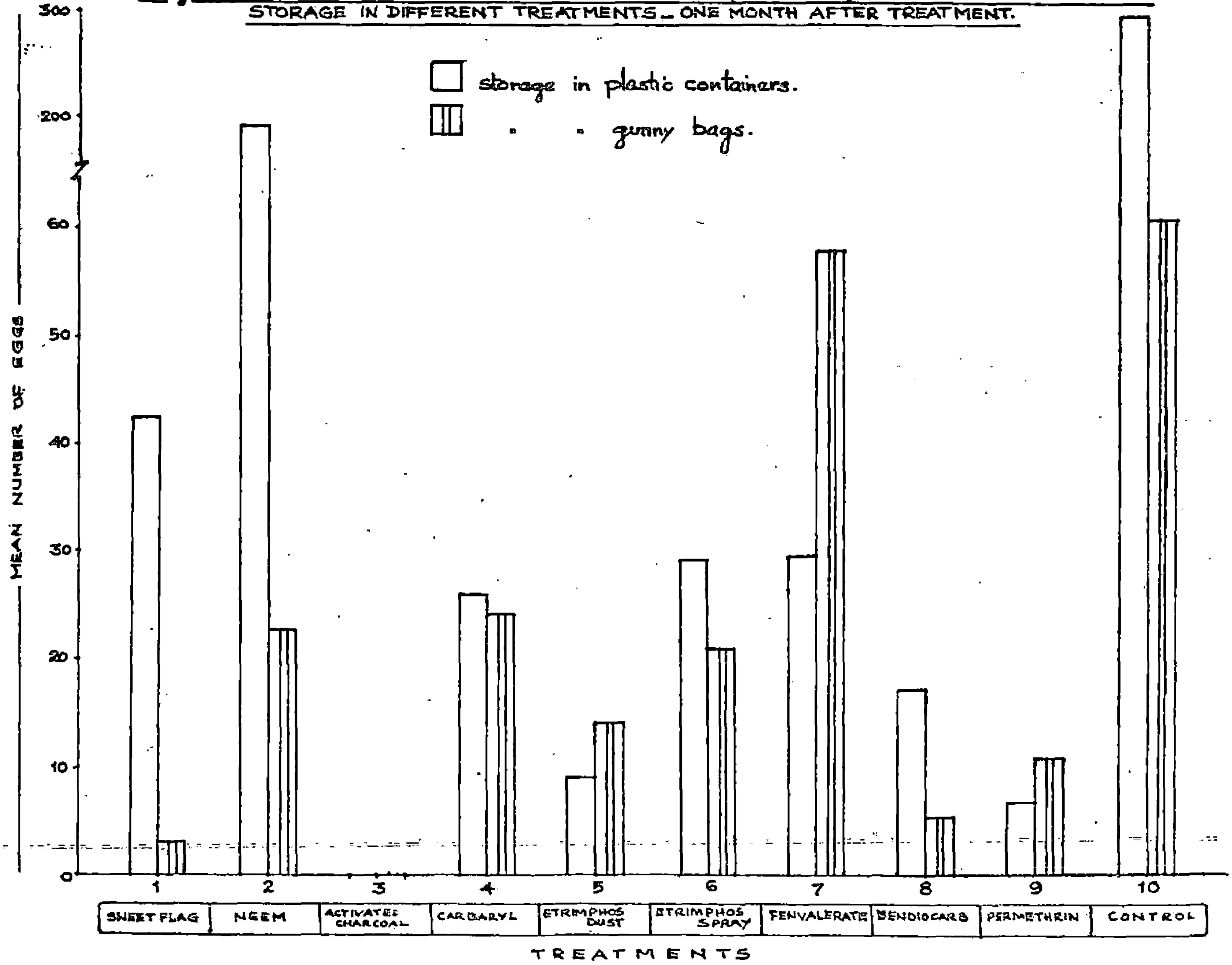
CD (0.05) : Method - 2.078

Treatment - 4.646

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

Fig-V. MEAN NUMBER OF EGGS PER SAMPLE (100 SEEDS) UNDER TWO METHODS OF STORAGE IN DIFFERENT TREATMENTS – ONE MONTH AFTER TREATMENT.



seeds are comparatively less when compared to the eggs deposited in neem and fenvalerate treated seeds.

There is significant difference between two methods of storage and higher number of eggs are recorded (41.565) in plastic containers storage as compared to gunny bag storage (18.199).

2.2 Number of eggs deposited by pulse beetle on cowpea seeds - two months after storage

Number of eggs laid by pulse beetle during second month after storage are furnished in Table 8, Fig 8. The mean number of eggs deposited ranges from 0.000 in activated charcoal treated seeds to 382.735% in untreated control, the differences being significant. There is no significant difference between neem and untreated control in respect of the number of eggs deposited. Treatments with fenvalerate and sweet flag are comparatively less effective than the other treatments namely carbaryl, etrimphos spray, etrimphos dust, bendiocarb, permethrin and activated charcoal.

Between the two methods of storage, seeds stored in plastic containers recorded significantly higher number of eggs (106.192) than in gunny bag storage (56.087).

Egg laying is suppressed in seeds treated with activated charcoal and kept in the two methods of storage

Table 8. Number of eggs deposited by the beetle on treated seeds - two months after storage.

Treatment	Plastic containers storage			Gunny bag storage			Mean**		
T_1 Sweet flag	115.811	(10.808)	c	22.439	(4.841)	abc	60.225	(7.825)*	c
T_2 Neem	482.886	(21.997)	d	222.337	(14.945)	e	340.175	(18.471)	e
T_3 Activated charcoal	0.000	(1.000)	a	0.000	(1.000)	a	0.000	(1.000)	a
T_4 Carbaryl	50.139	(7.151)	bc	49.505	(7.107)	cd	49.821	(7.129)	bc
T_5 Etrimphos dust	47.843	(6.989)	bc	18.829	(4.453)	abc	31.728	(5.721)	bc
T_6 Etrimphos spray	41.943	(6.553)	bc	56.976	(7.614)	cd	49.178	(7.084)	bc
T_7 Fenvalerate	333.469	(18.289)	d	108.173	(10.449)	de	220.821	(14.369)	d
T_8 Bendiocarb	17.487	(4.299)	ab	32.873	(5.820)	bcd	24.602	(5.059)	bc
T_9 Permethrin	9.543	(3.247)	ab	17.321	(4.188)	ab	12.819	(3.717)	ab
T_{10} Control	513.251	(23.200)	d	228.219	(15.139)	e	382.735	(19.170)	e
Mean	106.192	(10.353)		56.087	(7.556)				

CD (0.05) : Method - 1.737

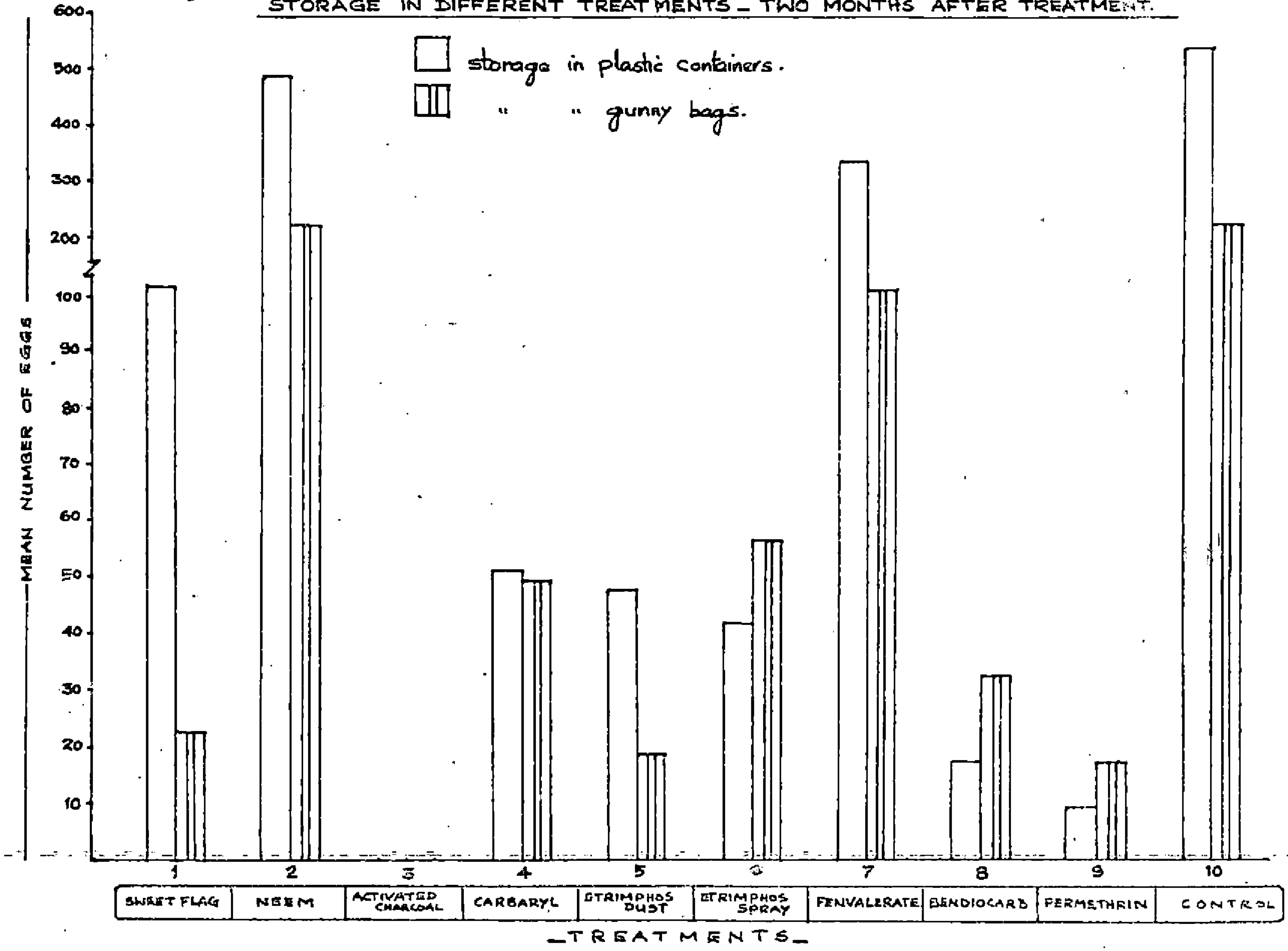
Treatment - 3.884

Interaction - 5.493

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

Fig. 8. MEAN NUMBER OF EGGS PER SAMPLE (100 SEEDS) UNDER TWO METHODS OF STORAGE IN DIFFERENT TREATMENTS – TWO MONTHS AFTER TREATMENT.



but the number of eggs deposited in untreated control seeds were 513.251 and 228.219 under plastic containers and gunny bag storage respectively.

In plastic containers, seeds treated with activated charcoal, permethrin, bendiocarb were superior to carbaryl, etrimphos spray, etrimphos dust treatments in suppressing egg deposition. The treatments with neem, fenvalerate, sweet flag and control were quite inferior to the rest of the treatments.

In gunny bag storage also activated charcoal treatment recorded the minimum damage but this was on par with etrimphos dust, sweet flag and permethrin treatments. Neem and control are on par and are distinctly inferior to the rest of the treatments.

2.3 Number of eggs deposited by the pulse beetle on cowpea seeds - three months after storage

Data in Table 9 (Fig 9) show that there is an increase in number of eggs laid in all the treatments. The oviposition in activated charcoal treated seeds was 0.527 as against 1232.238 eggs recorded in the untreated control. Neem, fenvalerate, etrimphos spray and sweet flag treated seeds registered very high egg deposition, the numbers being 608.810, 518.032, 366.553 and 323.676 respectively. These were however superior to control in reducing egg production whereas activated charcoal, permethrin, etrimphos dust, bendiocarb

Table 9. Number of eggs deposited by the beetle on treated seeds - three months after storage

	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	397.900(19.973) e	249.451(15.826) d	323.676(17.899)* d
T_2	Neem	510.303(22.612) ef	715.991(26.771) e	608.810(24.694) e
T_3	Activated charcoal	1.165(1.471) a	0.000(1.000) a	0.527(2.236) a
T_4	Carbaryl	74.783(8.705) c	72.956(8.599) c	73.867(8.653) c
T_5	Etrimphos dust	70.494(8.455) c	24.828(5.082) bc	44.816(6.769) bc
T_6	Etrimphos spray	199.522(14.161) d	583.806(24.183) e	366.553(19.172) d
T_7	Fenvalerate	748.309(27.374) f	329.913(18.191) d	518.032(22.782) e
T_8	Bendiocarb	40.585(6.449) bc	49.771(7.125) c	45.064(6.787) bc
T_9	Permethrin	17.864(4.343) ab	24.457(5.046) b	21.037(4.694) ab
T_{10}	Control	1 655.782(40.704) g	808.674(28.455) e	1 232.228(34.579) f
	Mean	239.919(15.425)	195.795(14.028)	

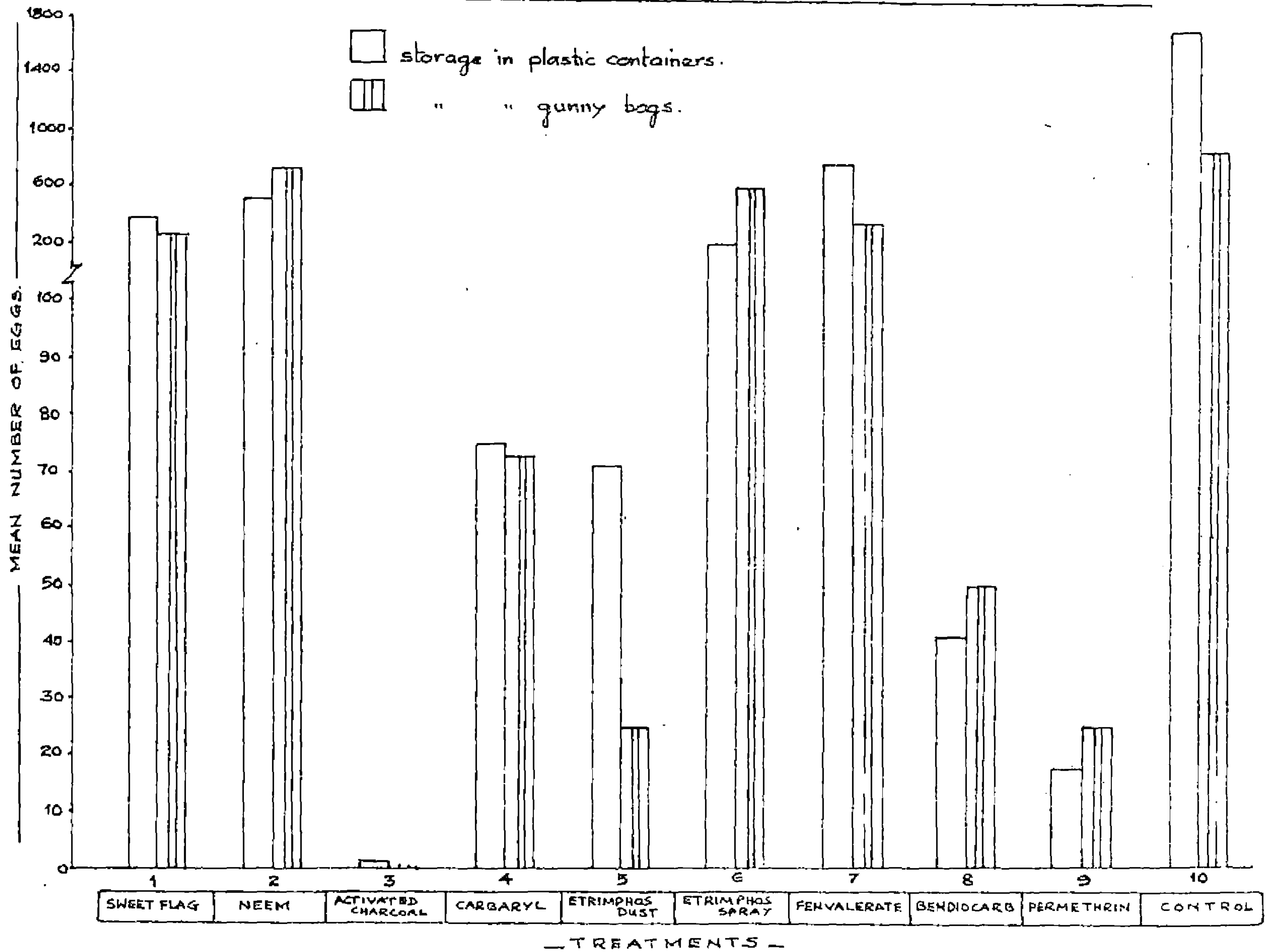
CD (0.05) : Treatment - 3.522

Interaction - 4.980

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

Fig. 9. MEAN NUMBER OF EGGS PER SAMPLE (100 SEEDS) UNDER TWO METHODS OF STORAGE IN DIFFERENT TREATMENTS – THREE MONTHS AFTER TREATMENT.



and carbaryl treatments recorded less number of eggs.

There is no significant difference between the two methods of storage.

In plastic containers the mean number of eggs ranges with in wide limits from 1.165 in activated charcoal treated seeds to 1655.782 in untreated control. Fenvalerate, neem, sweet flag and etrimphos spray are comparatively less effective than carbaryl, etrimphos dust, bendiocarb, permethrin and activated charcoal.

Egg laying is not recorded in charcoal treated seeds when stored in gunny bags while the maximum number of 808.674 eggs deposited in untreated control. As in case of storage in plastic containers, activated charcoal, permethrin, etrimphos dust, bendiocarb and carbaryl treatments registered the least number of eggs deposited while neem and etrimphos spray show relatively heavy oviposition, the difference being significant.

2.4 Number of eggs deposited by pulse beetle on cowpea seeds - four months after storage

It is seen from Table 10 (Fig 10) that the mean number of eggs are 1298.936 in untreated control and 18.363 only in activated charcoal treatments. The treatment differences are significant. The treatment

Table 10. Number of eggs deposited by the beetle on treated seeds - four months after storage

	Treatment	Plastic containers storage		Gunny bag storage		Mean**	
T_1	Sweet flag	873.561(29.556)	e	895.534(29.926)	de	884.548(29.741)*	e
T_2	Neem	1 258.115(35.469)	f	1 126.362(33.561)	e	1 192.239(34.516)	f
T_3	Activated charcoal	18.055(4.249)	a	18.673(4.321)	a	18.363(4.285)	a
T_4	Carbaryl	125.745(11.214)	c	72.061(8.489)	bc	97.049(9.851)	bc
T_5	Etrimphos dust	130.394(11.419)	c	111.523(10.561)	c	120.775(10.988)	c
T_6	Etrimphos spray	380.072(19.495)	d	931.098(30.514)	de	625.233(25.005)	d
T_7	Fenvalerate	778.229(28.075)	e	692.471(26.315)	d	739.576(27.195)	de
T_8	Bendiocarb	42.950(6.554)	bc	47.401(6.885)	bc	45.149(6.719)	ab
T_9	Permethrin	29.686(5.449)	b	29.276(5.411)	b	29.481(5.429)	a
T_{10}	Control	1 379.905(37.147)	f	1 217.968(34.899)	e	1 298.936(36.023)	f
	Mean	355.805(18.863)		364.356(19.088)			

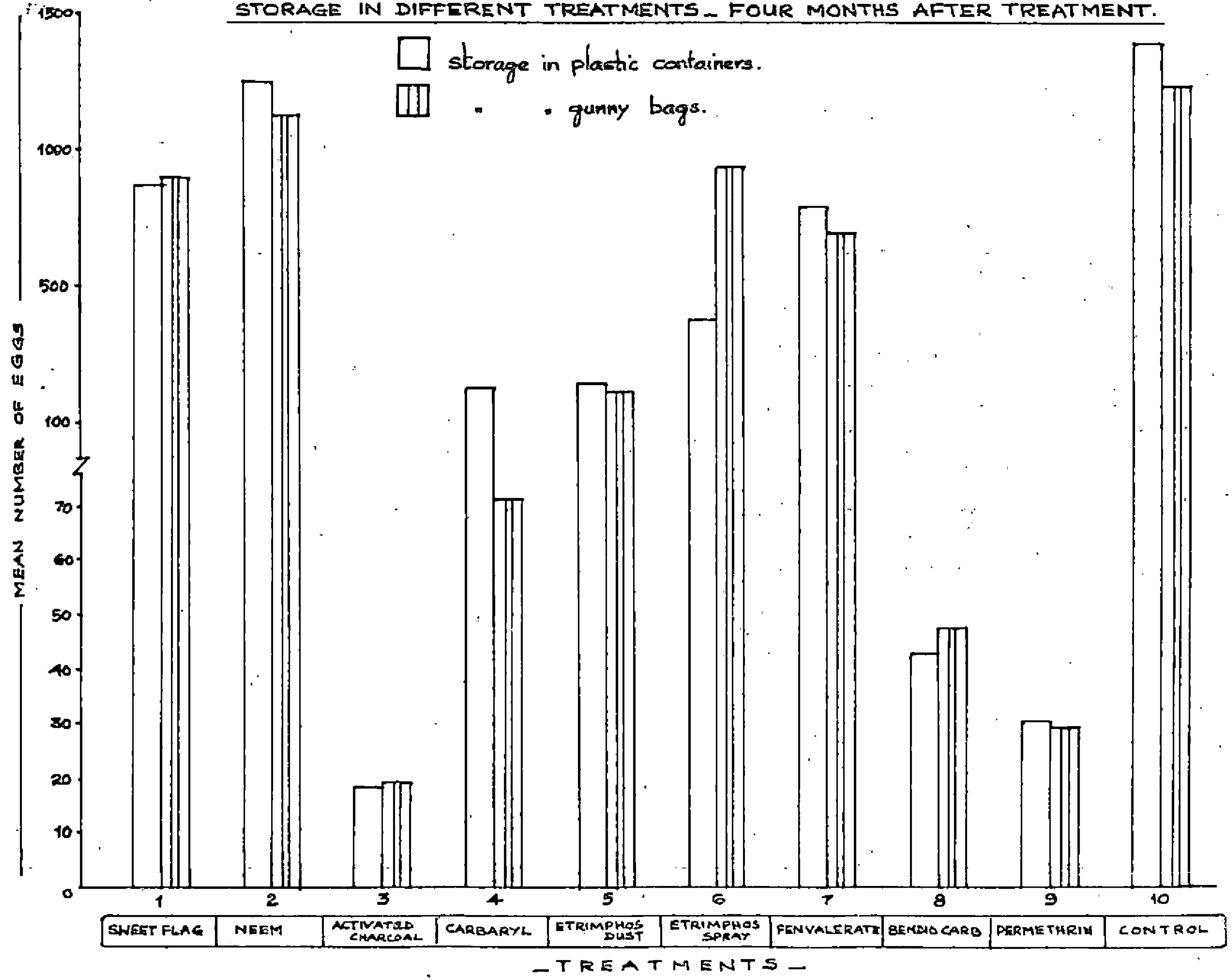
CD (0.05) : Treatment - 3.729

Interaction - 5.725

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

Fig-10. MEAN NUMBER OF EGGS PER SAMPLE (100 SEEDS) UNDER TWO METHODS OF STORAGE IN DIFFERENT TREATMENTS - FOUR MONTHS AFTER TREATMENT.



with activated charcoal continued to maintain its efficiency against oviposition by the beetle and this was superior to etrimphos spray fenvalerate, sweet flag, neem and control. Contrary to the previous observations, gunny bag storage registered marginally higher number of eggs (364.356) than plastic container storage (355.805). However the difference is not statistically significant.

Less number of eggs recorded in activated charcoal, permethrin, bendiocarb, carbaryl and etrimphos dust treated seeds when stored in plastic containers and thus these treatments are found to be effective than all other treatments.

In gunny bag storage also, seeds treated with neem, etrimphos spray, sweet flag recorded higher number of eggs and these are on par with control. Fenvalerate treatment also recorded high number of eggs but this is statistically better than control. Lesser number of eggs are laid in activated charcoal, permethrin, bendiocarb, carbaryl and etrimphos dust treated seeds and are superior, even though there is significant differences among the treatments. Activated charcoal followed by permethrin are found to be effective in preventing the egg production of the beetle under both methods of storage.

2.5 Number of eggs deposited by the pulse beetle on cowpea seeds - five months after storage

Counts on number of eggs deposited by the pulse beetle on cowpea seeds after five months are presented in Table 11, Fig 11. The treatments, methods and interaction are all found to be significant. Mean number of eggs from two methods of storage are highest in untreated control (1431.316) and the lowest of 23.496 only in activated charcoal treated seeds. Sweet flag, neem, fenvalerate and etrimphos spray treatments recorded higher number of eggs and are, therefore, inferior. However these are found superior to control.

Carbaryl and etrimphos dust treatments are comparatively less effective than permethrin, bendiocarb and activated charcoal treatments and these appeared to be on par.

Treated seeds stored in plastic containers recorded increase in the number of eggs (441.407) than in gunny bag storage (422.439), but these differences are however not statistically significant.

In plastic containers storage activated charcoal, bendiocarb and permethrin treatments are better than carbaryl and etrimphos dust treatments. However neem,

Table 11. Number of eggs deposited by the beetle on treated seeds - five months after storage

	Treatment	Plastic containers storage		Gunny bag storage		Mean**	
T_1	Sweet flag	1 116.794(33.419)	e	1 144.532(33.831)	c	1 130.663(33.625)*	d
T_2	Neem	1 189.988(34.496)	ef	1 071.488(32.734)	c	1 130.739(33.615)	d
T_3	Activated charcoal	30.711(5.542)	a	17.245(4.153)	a	23.496(4.847)	a
T_4	Carbaryl	172.641(13.139)	c	73.165(8.554)	b	117.646(10.847)	c
T_5	Etrimphos dust	134.612(11.602)	bc	51.458(7.173)	b	88.113(9.388)	bc
T_6	Etrimphos spray	776.527(27.866)	d	1 284.915(35.846)	c	1 014.803(31.856)	d
T_7	Fenvalerate	989.508(31.456)	de	1 093.922(33.075)	c	1 041.715(32.266)	d
T_8	Bendiocarb	41.572(6.476)	a	43.819(6.619)	b	42.873(6.548)	ab
T_9	Permethrin	54.534(7.385)	ab	43.829(6.620)	b	49.036(7.003)	ab
T_{10}	Control	1 498.895(38.716)	f	1 363.737(36.929)	c	1 431.316(37.822)	e
	Mean	541.407(21.009)		422.439(20.553)			

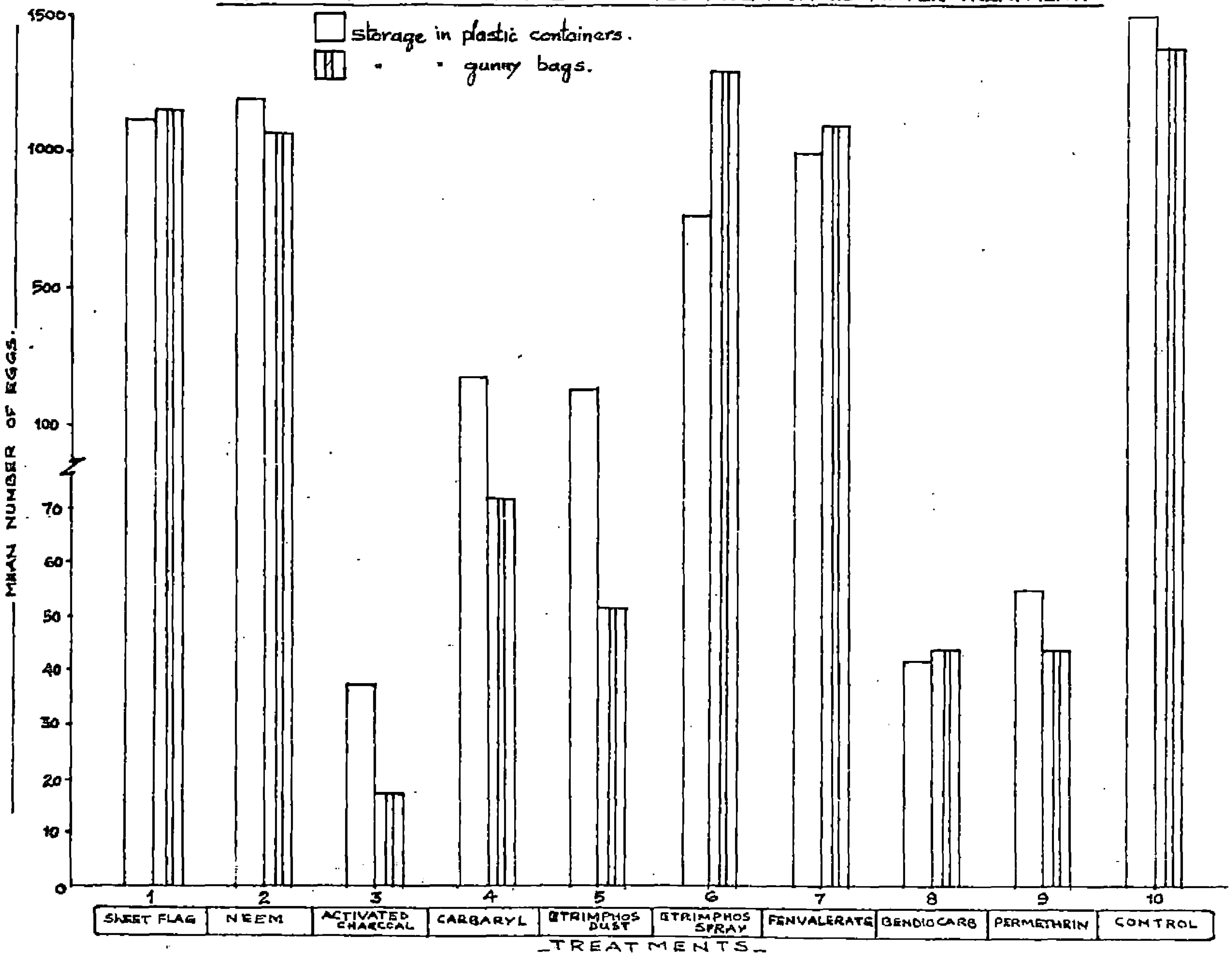
CD (0.05) : Treatment - 3.398

Interaction- 4.806

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

Fig. 11. : MEAN NUMBER OF EGGS PER SAMPLE (100 SEEDS) UNDER TWO METHODS OF STORAGE IN DIFFERENT TREATMENTS. FIVE MONTHS AFTER TREATMENT.



sweet flag, fenvalerate and etrimphos spray treatments are ineffective with larger number of eggs deposition.

In gunny bag storage also neem, fenvalerate, sweet flag and etrimphos spray recorded marginally less number of eggs than control, but the difference is not statistically significant. Treated seeds with bendiocarb, permethrin, etrimphos dust and carbaryl recorded lesser number of eggs and are effective in reducing egg production but these are statistically inferior to the charcoal treatment.

2.6 Number of eggs deposited by the pulse beetle on cowpea seeds - six months after storage

Data furnished in Table 12 and depicted by Fig 12 represents the counts of the number of eggs laid by the pulse beetle on treated seeds after six months of storage.

It is seen that the mean number of eggs ranges from 48.920 in activated charcoal treated seeds to 1527.748 eggs deposited in untreated control. Activated charcoal is found to be the most effective material in reducing the population build up. Bendiocarb, etrimphos dust, permethrin and carbaryl treatments also recorded less number of eggs, but significantly different from activated charcoal treatment.

Table 12. Number of eggs deposited by the beetle on treated seeds - six months after storage

	Treatment	Plastic containers storage		Gunny bag storage		Mean**	
T_1	Sweet flag	1 261.137(35.512)	e	1 367.149(36.975)	d	1 314.144(36.244)*	de
T_2	Neem	1 399.057(37.404)	ef	1 421.649(37.705)	d	1 410.353(37.554)	ef
T_3	Activated charcoal	29.691(5.449)	a	72.926(8.539)	ab	48.920(6.994)	a
T_4	Carbaryl	100.664(10.033)	b	107.451(10.366)	b	104.029(10.199)	b
T_5	Etrimphos dust	166.160(12.890)	c	45.975(6.781)	a	96.735(9.835)	b
T_6	Etrimphos spray	1 037.633(33.212)	d	1 150.169(33.914)	c	1 093.901(33.063)	c
T_7	Fenvalerate	1 223.878(34.984)	e	1 327.032(36.428)	cd	1 275.455(35.706)	d
T_8	Bendiocarb	106.750(10.332)	bc	81.593(9.033)	ab	93.749(9.682)	b
T_9	Permethrin2	91.039(9.541)	b	117.351(10.833)	b	103.778(10.187)	b
T_{10}	Control	1 566.943(39.585)	f	1 488.552(38.582)	d	1 527.748(39.083)	f
	Mean	519.581(22.794)		525.124(22.916)			

CD (0.05) : Treatment - 1.823

Interaction- 2.578

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

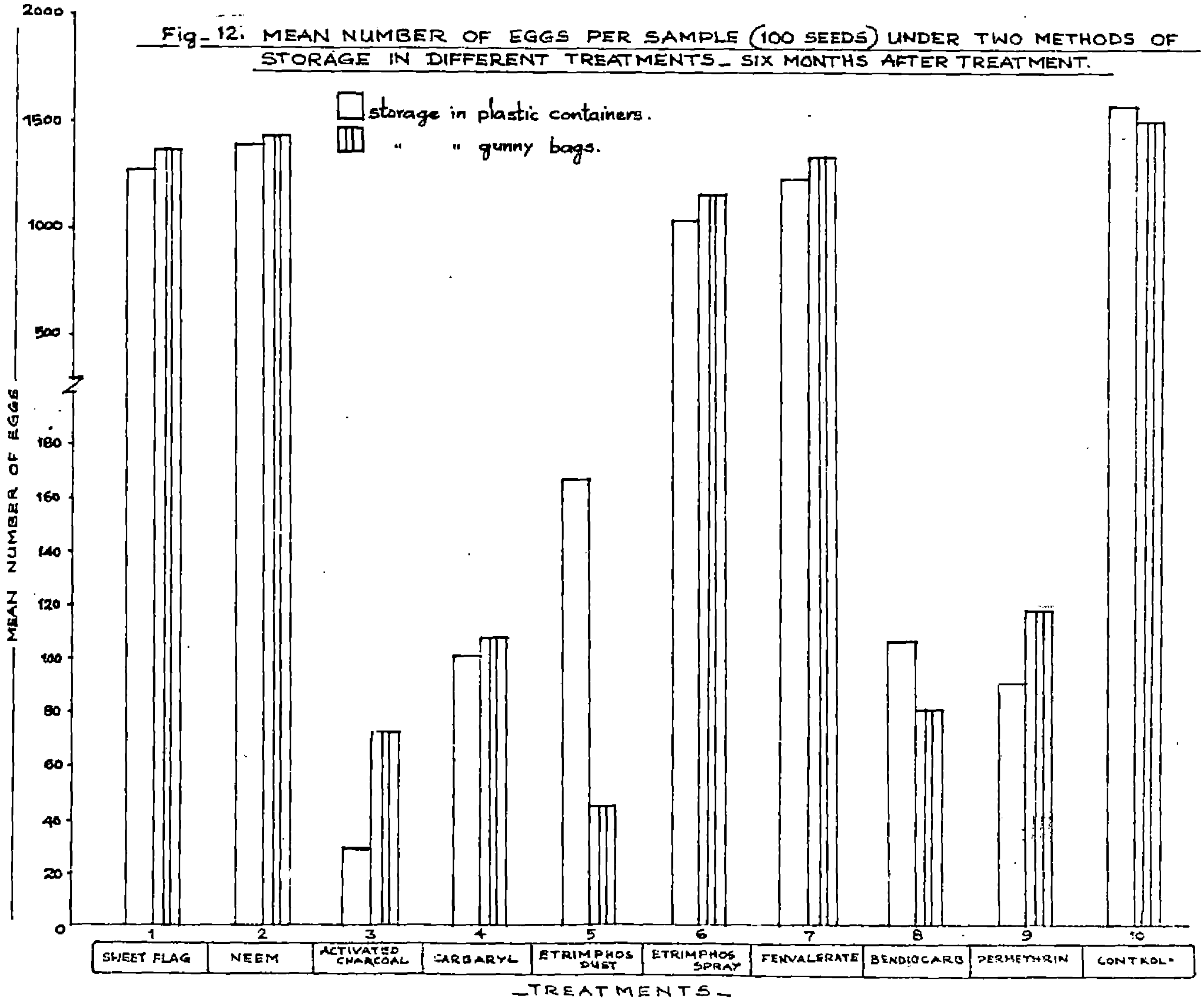


Fig_12: MEAN NUMBER OF EGGS PER SAMPLE (100 SEEDS) UNDER TWO METHODS OF STORAGE IN DIFFERENT TREATMENTS_ SIX MONTHS AFTER TREATMENT.
storage in plastic containers.
" " gunny bags.
MEAN NUMBER OF EGGS
2000
1500
1000
500
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
SWEET FLAG
NEEM
ACTIVATED CHARCOAL
CARBARYL
ETRIMPHOS DUST
ETRIMPHOS SPRAY
FENVALERATE
BENDIOCARB
PERMETHRIN
CONTROL
TREATMENTS

Neem, sweet flag, fenvalerate and etrimphos spray treatments are found to be ineffective in protecting cowpea seeds. However, these are statistically better than control.

There is no significant difference between two methods of storage. The total number of eggs laid on seed stored in gunny bags is slightly higher (525.124) than in case of plastic containers storage (519.581).

Storage in plastic containers, neem, sweet flag, fenvalerate and etrimphos spray are ineffective with the maximum number of eggs. However, these are superior to untreated control. Etrimphos dust and bendiocarb treatments are also less effective when compared with activated charcoal, permethrin and carbaryl treatments.

Under gunny bag storage, neem and sweet flag treatments are highly ineffective and are on par with control. Fenvalerate and etrimphos spray treatments are also inferior with very large number of eggs, however these are better than control. Lowest number of eggs is recorded in etrimphos dust treatment followed by activated charcoal bendiocarb, carbaryl and permethrin treatments and are found to be effective in reducing the deposition of eggs by the beetles even though there is significant difference among the treatments.

3. Assessment of efficacy of various seed protectants on the viability of seeds

The viability of treated seeds was estimated at monthly intervals for a period of six months by estimating the percentage germination. For this purpose three sub samples of each 10 seeds were drawn and tested for germination as already described in the Materials and Methods.

The data on percentage germination was subjected to Analysis of Variance after Arc sine transformation and the mean values are presented in Tables 12 to 18. The Analysis of Variance Tables are appended (XIII to XVIII).

3.1 Effect of different treatments on the viability of cowpea seeds - one month after storage

The data on the effect of treating the cowpea seeds with various protectants and kept under two methods of storage are presented in Table 13. Mean percentage germination of seeds one month after storage ranged from 97.499%, in untreated control, etrimphos spray,

Table 13. Percentage germination of treated seeds - one month after storage.

	Treatment	Plastic containers storage	Gunny bag storage	Mean**
T_1	Sweet flag	97.499(80.903) a	95.527(77.790) ab	96.582(79.346)*ab
T_2	Neem	97.499(80.903) a	97.499(80.903) a	97.499(80.903) a
T_3	Activated charcoal	97.499(80.903) a	97.499(80.903) a	97.499(80.903) a
T_4	Carbaryl	93.017(74.678) b	97.499(80.903) a	95.527(77.790) abc
T_5	Etrimphos dust	97.499(80.903) a	97.499(80.903) a	97.499(80.903) a
T_6	Etrimphos spray	97.499(80.903) a	97.499(80.903) a	97.499(80.903) a
T_7	Fenvalerate	95.527(77.790) ab	93.017(74.678) b	94.338(76.234) bc
T_8	Bendiocarb	93.371(75.080) b	97.499(80.903) a	95.671(77.991) abc
T_9	Permethrin	86.987(68.855) c	97.499(80.903) a	93.195(74.879) c
T_{10}	Control	97.499(80.903) a	97.499(80.903) a	97.499(80.903) a
	Mean	95.805(78.182)	96.966(79.969)	

CD (0.05) : Treatment - 4.042

Interaction- 5.716

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

etrimphos dust, activated charcoal and neem treatments to 93.195% in permethrin treated seeds, the differences being significant.

Carbaryl, bendiocarb and sweet flag treatments recorded comparatively lower seed viability, but the differences are not significant. Fenvalerate treated seeds recorded less percentage germination than in untreated control and the effect is statistically significant.

Treated seeds stored in gunny bags recorded marginally high percentage germination (96.966%) than in plastic containers storage (95.805%), though the difference is not statistically significant.

In plastic containers storage, sweet flag, neem, activated charcoal, etrimphos spray, etrimphos dust and untreated control recorded 97.499% germination and fenvalerate recorded 95.527% germination and these were on par. Permethrin treated seeds recorded lowest percentage of germination (86.987%) and the reduction in germination ability was significantly lower than all the other treatments. Carbaryl and bendiocarb showed germination percentages of 93.017% and 93.371% respectively and these were better than permethrin in terms of germinability.

Seeds treated with neem, activated charcoal, carbaryl, etrimphos dust, etrimphos spray, bendiocarb, permethrin and untreated control stored in gunny bags recorded maximum percentage germination of 97.499% against 93.017% in fenvalerate treated seeds, the difference being significant.

3.2 Effect of different treatments on the viability of cowpea seeds - two months after storage

Percentage germination of treated seeds recorded two months after storage is furnished in Table 14. The mean percentage germination of seeds varies from 97.499 in untreated control to 93.739% in fenvalerate treated seeds. However significant difference is not detected between the different treatments.

The mean percentage germination of two methods of storage revealed that there is no significant difference between them. The treatment differences in respect of germinability of grains stored in plastic containers were not significant.

There is no significant difference among the treatments in gunny bag storage also. However, sweet flag, activated charcoal and untreated control showed 97.499% germination and fenvalerate treatment recorded the lowest percentage germination (89.999).

Table 14. Percentage germination of treated seeds - two months after storage.

	Treatment	Plastic containers storage	Gunny bag storage	Mean
T_1	Sweet flag	95.527 (77.790)	97.499 (80.903)	95.582 (79.346)*
T_2	Neem	95.527 (77.790)	95.527 (77.790)	95.527 (77.790)
T_3	Activated charcoal	90.418 (71.968)	97.499 (80.903)	94.499 (76.435)
T_4	Carbaryl	95.527 (77.790)	95.527 (77.790)	95.527 (77.790)
T_5	Etrimphos dust	95.527 (77.790)	93.017 (74.678)	94.338 (76.234)
T_6	Etrimphos spray	95.527 (77.790)	95.527 (77.790)	95.527 (77.790)
T_7	Fenvalerate	97.499 (80.903)	89.999 (71.565)	93.739 (76.234)
T_8	Bendiocarb	95.527 (77.790)	93.017 (74.678)	94.338 (76.234)
T_9	Permethrin	95.527 (77.790)	95.527 (77.790)	95.527 (77.790)
T_{10}	Control	97.499 (80.903)	97.499 (80.903)	97.499 (80.903)
	Mean	95.556 (77.830)	95.098 (77.208)	

* Figures in parenthesis are transformed values

3.3 Effect of different treatments on the viability of cowpea seeds - three months after storage

Data presented in Table 15 showed that there is no significant difference between the treatment means. The germination percentage ranges from 96.582 in untreated control to 91.764 in neem and carbaryl treatments.

The method of storage in plastic containers recorded low percentage of germination then in gunny bag storage, the difference being significant.

Germination percentage of treated seeds in plastic containers ranges from 95.527% in fenvalerate, permethrin and untreated control to 86.987% in neem treatment but the difference is not significant.

In gunny bag storage also no significant difference is noticed among the treatments. However, highest percentage germination was recorded in seeds treated with activated charcoal, etrimphos dust and untreated control against 93.017% germination in carbaryl treatment.

3.4 Effect of different treatments on the viability of cowpea seeds - four months after storage

Percentage germination of treated cowpea seeds recorded after four months of storage is presented in

Table 15. Percentage germination of treated seeds - three months after storage.

Treatment	Plastic containers storage	Gunny bag storage	Mean
T_1 Sweet flag	93.371 (75.081)	95.527 (77.790)	94.499 (76.435)*
T_2 Neem	86.987 (68.855)	95.527 (77.790)	91.764 (73.323)
T_3 Activated charcoal	90.418 (71.968)	97.499 (80.903)	94.499 (76.435)
T_4 Carbaryl	90.418 (71.968)	93.017 (74.678)	91.764 (73.323)
T_5 Etrimphos dust	93.371 (75.081)	97.499 (80.903)	95.671 (77.991)
T_6 Etrimphos spray	93.017 (74.678)	95.527 (77.790)	94.338 (76.234)
T_7 Fenvalerate	95.527 (77.790)	93.371 (75.081)	94.499 (76.435)
T_8 Bendiocarb	90.418 (71.968)	95.527 (77.790)	93.195 (74.878)
T_9 Permethrin	95.527 (77.790)	93.371 (75.081)	94.499 (76.435)
T_{10} Control	95.527 (77.790)	97.499 (80.903)	96.582 (79.346)
Mean	92.674 (74.297)	95.585 (77.871)	

CD (0.05) : Method - 3.538

* Figures in parenthesis are transformed values

Table 16. Mean percentage germination ranged from 96.582 in untreated control to 90.418 in carbaryl treated seeds. The treatment differences are not statistically significant. Permethrin, etrimphos spray, etrimphos dust, fenvalerate, sweet flag recorded comparatively high percentage of germination than neem, activated charcoal, bendiocarb and untreated control.

Significant difference between the two methods of storage was observed and the method involving storage in gunny bags recorded high percentage germination than plastic containers storage.

In plastic containers germination was higher in etrimphos spray, permethrin treated seeds and untreated control (95.527%) followed by fenvalerate (93.371%) and bendiocarb (83.644%). All other treatments recorded a medium percentage of 90.418. However, the differences are not statistically significant.

In gunny bag storage, highest germination of 97.499% is recorded in untreated control, bendiocarb, etrimphos dust and sweet flag treated seeds and the lowest of 90.418% is found in carbaryl treated seeds but the differences are not statistically significant.

Table 16. Percentage germination of treated seeds - four months after storage.

Treatment	Plastic containers storage	Gunny bag storage	Mean
T_1 Sweet flag	90.418 (71.968)	97.499 (80.903)	94.499 (76.435)*
T_2 Neem	90.418 (71.968)	95.527 (77.790)	93.195 (74.879)
T_3 Activated charcoal	90.418 (71.968)	95.527 (77.790)	93.195 (74.879)
T_4 Carbaryl	90.418 (71.968)	90.418 (71.968)	90.418 (71.968)
T_5 Etrimphos dust	90.418 (71.968)	97.499 (80.903)	94.499 (76.435)
T_6 Etrimphos spray	95.527 (77.790)	93.017 (74.678)	94.338 (76.234)
T_7 Fenvalerate	93.371 (75.081)	95.527 (77.790)	94.490 (76.435)
T_8 Bendiocarb	83.644 (66.145)	97.499 (80.903)	91.956 (73.524)
T_9 Permethrin	95.527 (77.790)	95.527 (77.790)	95.527 (77.790)
T_{10} Control	95.527 (77.790)	97.499 (80.903)	96.582 (79.346)
Mean	91.879 (73.443)	95.777 (78.142)	

CD (0.05) : Method - 3.330

* Figures in parenthesis are transformed values

3.5 Effect of different treatments on the viability of cowpea seeds - five months after storage

Data presented in Table 17 reveals that the mean percentage of germination ranges from 97.499% in untreated control to 87.741% in sweet flag treated seeds. However, the differences between different treatments are not significant.

The method involving storage in plastic containers recorded comparatively lower percentage of (91.628%) germination than in gunny bag storage (95.649%) and the difference is found to be significant.

The germination ranges from 97.499% in untreated control and etrimphos dust treatments to 76.820% in sweet flag when seeds are stored in plastic containers. Fenvalerate, bendiocarb, etrimphos spray and permethrin treated seeds recorded marginally low percentage germination when compared to untreated control and these differences are not statistically significant. Activated charcoal, carbaryl and neem treatments are inferior with low percentage germination compared to untreated control.

In gunny bag storage maximum percentage germination of 97.499 recorded in untreated control, carbaryl, activated charcoal and neem treatments and minimum of 91.319% in etrimphos dust. All other treatments

Table 17. Percentage germination of treated seeds - five months after storage.

	Treatment	Plastic containers storage		Gunny bag storage		Mean**
T_1	Sweet flag	76.820(61.219)	d	95.527(77.790)	b	87.741(65.505)*
T_2	Neem	89.999(71.565)	bc	97.499(80.903)	a	94.338(76.234)
T_3	Activated charcoal	79.999(63.435)	cd	97.499(80.903)	a	90.623(72.169)
T_4	Carbaryl	86.987(68.855)	cd	97.499(80.903)	a	93.195(74.879)
T_5	Etrimphos dust	97.499(80.903)	ab	91.319(72.865)	b	94.850(76.884)
T_6	Etrimphos spray	95.527(77.790)	ab	95.527(77.790)	b	95.527(77.790)
T_7	Fenvalerate	93.017(74.678)	abc	95.527(77.790)	b	94.338(76.234)
T_8	Bendiocarb	93.017(74.678)	abc	93.017(74.678)	b	93.017(74.678)
T_9	Permethrin	95.527(77.790)	ab	93.371(75.081)	b	94.449(76.436)
T_{10}	Control	97.499(80.903)	a	97.499(80.903)	a	97.499(80.903)
	Mean	91.628(73.182)		95.649(77.960)		

CD (0.05) : Method - 2.773

Interaction- 8.769

** Means not following same letter are significantly different

* Figures in parenthesis are transformed values

are significantly inferior to untreated control with low percentage of germination.

3.6 Effect of different treatments on the viability of cowpea seeds - six months after storage

Data on the germination percentage of treated seeds recorded after six months of storage and presented in Table 18. It is seen that the germination percentage ranges from 97.499 in untreated control to 93.764% in permethrin treated seeds and there is no significant difference among the treatment means.

The mean germination percentage under the two methods of storage are of the same.

In plastic containers storage maximum percentage germination of 97.499 is recorded in untreated control, bendiocarb, fenvalerate and etrimphos dust treatments and minimum of 89.987% in permethrin treated seeds and the difference between treatments are not significant.

In gunny bag storage also high percentage germination (97.499%) is recorded in untreated control and carbaryl treatments and a minimum germination (93.017%) is recorded in fenvalerate, etrimphos dust and sweet flag treated seeds and these differences are also statistically non-significant.

Table 18. Percentage germination of treated seeds - six months after storage.

	Treatment	Plastic containers storage	Gunny bag storage	Mean
T_1	Sweet flag	95.527 (77.790)	93.017 (74.678)	94.338 (76.234)*
T_2	Neem	93.017 (74.678)	95.527 (77.790)	94.338 (76.234)
T_3	Activated charcoal	95.527 (77.790)	97.371 (75.081)	94.499 (76.435)
T_4	Carbaryl	93.017 (74.678)	97.499 (80.903)	95.527 (77.790)
T_5	Etrimphos dust	97.499 (80.903)	93.017 (74.678)	95.527 (77.790)
T_6	Etrimphos spray	93.017 (74.678)	95.527 (77.790)	94.338 (76.234)
T_7	Fenvalerate	97.499 (80.903)	93.017 (74.678)	95.527 (77.790)
T_8	Bendiocarb	97.499 (80.903)	95.527 (77.790)	96.582 (79.346)
T_9	Permethrin	89.987 (68.855)	95.527 (77.790)	93.764 (73.323)
T_{10}	Control	97.499 (80.903)	97.499 (80.903)	97.499 (80.903)
	Mean	95.098 (77.208)	95.098 (77.208)	

* Figures in parenthesis are transformed values

Discussion

DISCUSSION

Protection of cowpea seeds in storage against pulse beetle was attempted by using different materials such as rhizome bits of sweet flag @ 1.5% (w/w), neem kernel powder @ 1.5% (w/w), activated charcoal powder @ 1.5% (w/w), carbaryl 5% dust @ 1.5% (w/w), etrimphos 2% dust @ 1.5% (w/w), etrimphos 16% EC @ 0.05%, fenvalerate 20% EC @ 0.01%, bendiocarb 80% WP @ 0.06% and permethrin 25% EC @ 0.0125%. The efficacy of the treatments were evaluated under two methods of storage namely storage in plastic containers and in gunny bags for a period of six months in terms of percentage weight loss and the number of eggs laid by the beetle. Viability of seeds was also assessed to study the effect of different materials on germination of treated seeds.

1. Efficiency of different treatments based on weight loss

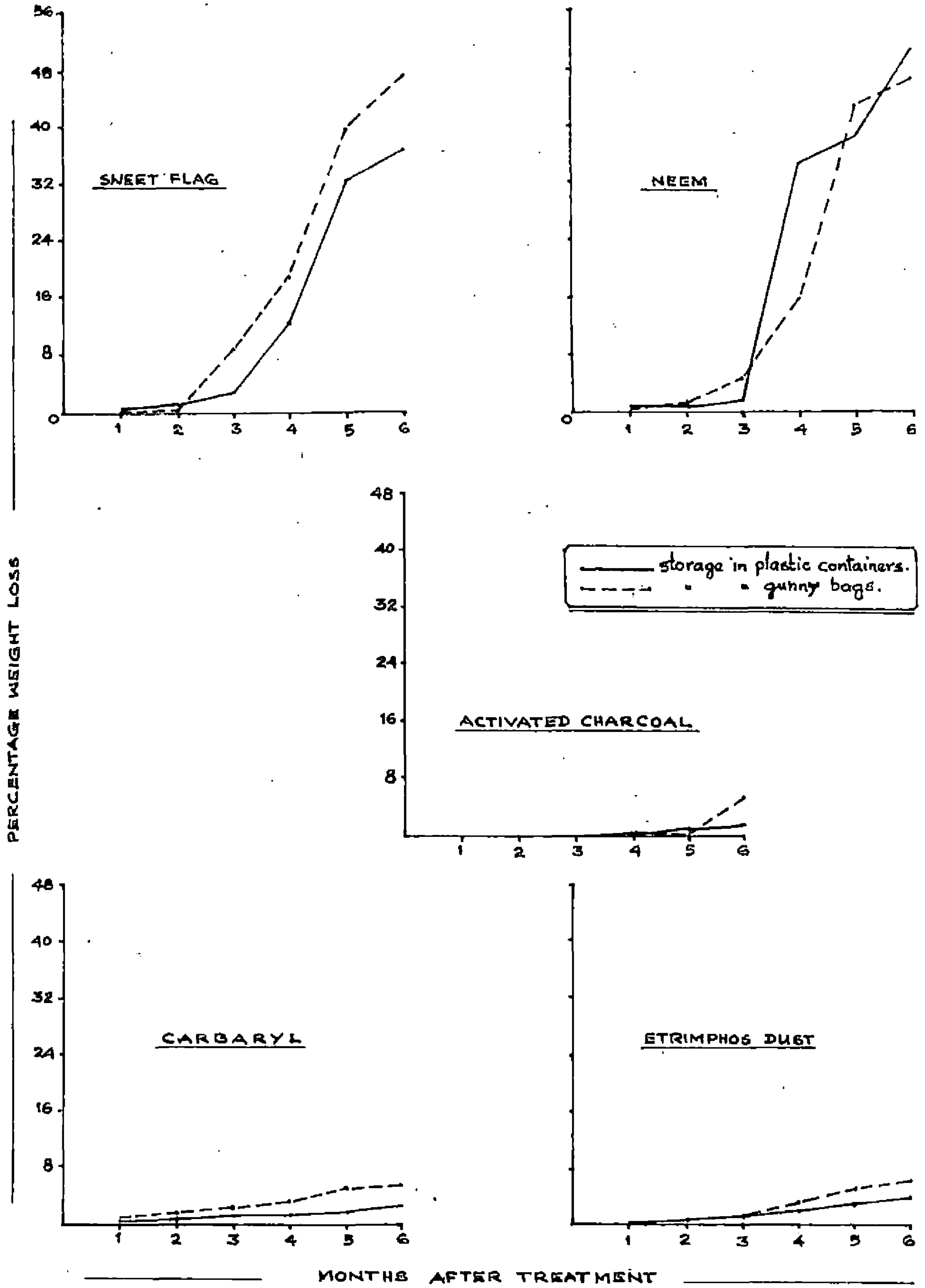
The percentage weight loss at one month after treatment showed significant treatment differences, but the methods of storage did not influence the quantitative loss at this stage. Treated seeds stored in plastic containers showed comparatively higher weight loss in all treatments except carbaryl, fenvalerate and permethrin than in gunny bag storage (Fig 13).

From the second month onwards percentage weight loss in different treatments was not showing a uniform trend in successive months under the two methods of storage and variations in weight loss were noticed in different months.

Data on the observation of weight loss after six months of storage have revealed that all treatments except neem kernel powder, fenvalerate and untreated control recorded more damage in gunny bag storage. The differences between the two methods are statistically significant. This may be due to the fact that since the developing populations are confined in the plastic containers for a longer period there might be progressive decline in oxygen tension in the ambient air reducing the microclimate unsuitable for the continuous development of the insect.

An increasing trend in the percentage weight loss was observed (Fig14) in all the treatments in successive months. However all the treatments showed some degree of protection against the infestation of pulse beetle as compared to untreated control.

Fig. 13. PERFORMANCE OF DIFFERENT TREATMENTS UNDER TWO METHODS OF STORAGE AS ASSESSED AT MONTHLY INTERVALS
(MEAN PERCENTAGE OF WEIGHT LOSS)



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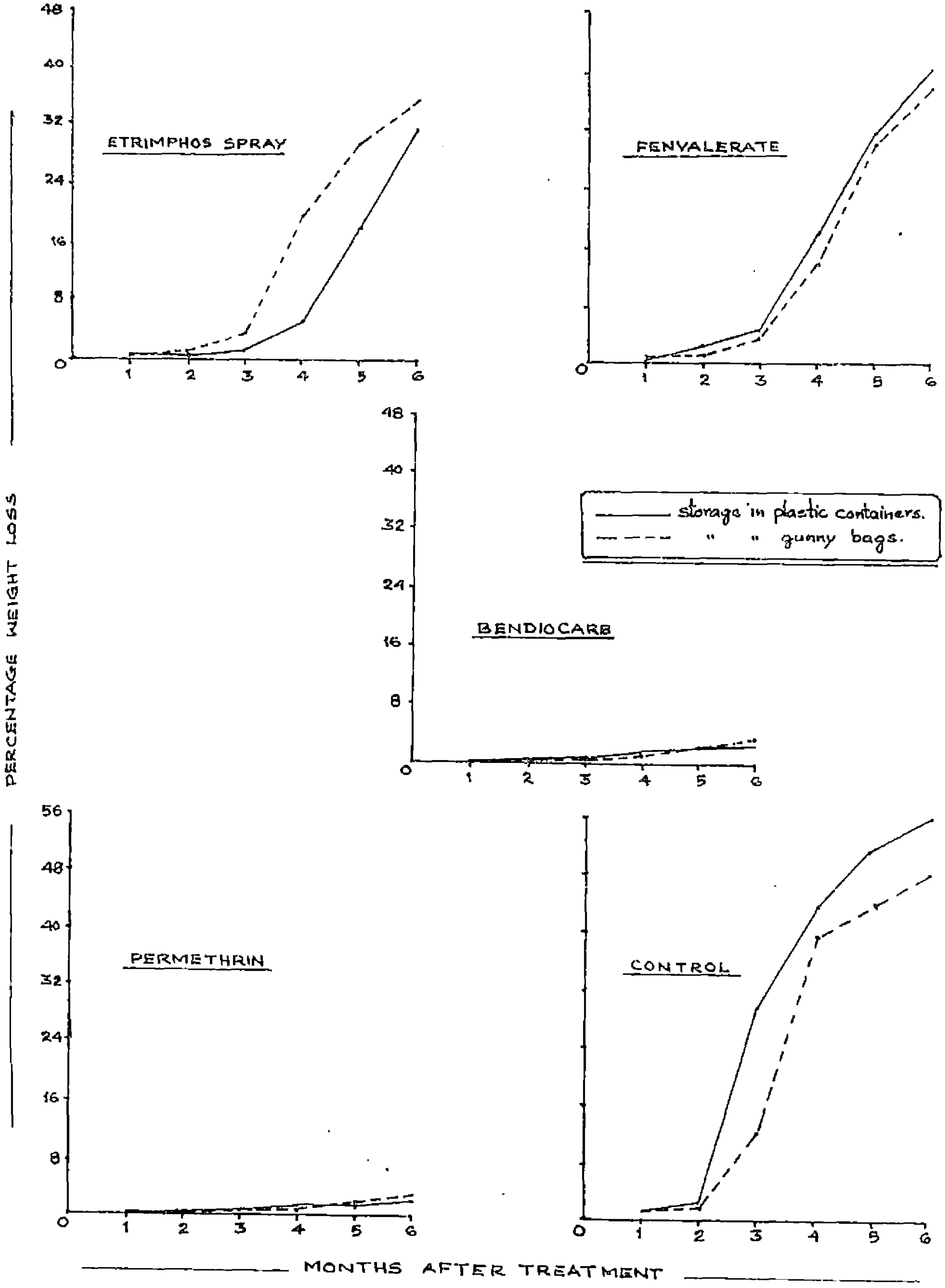
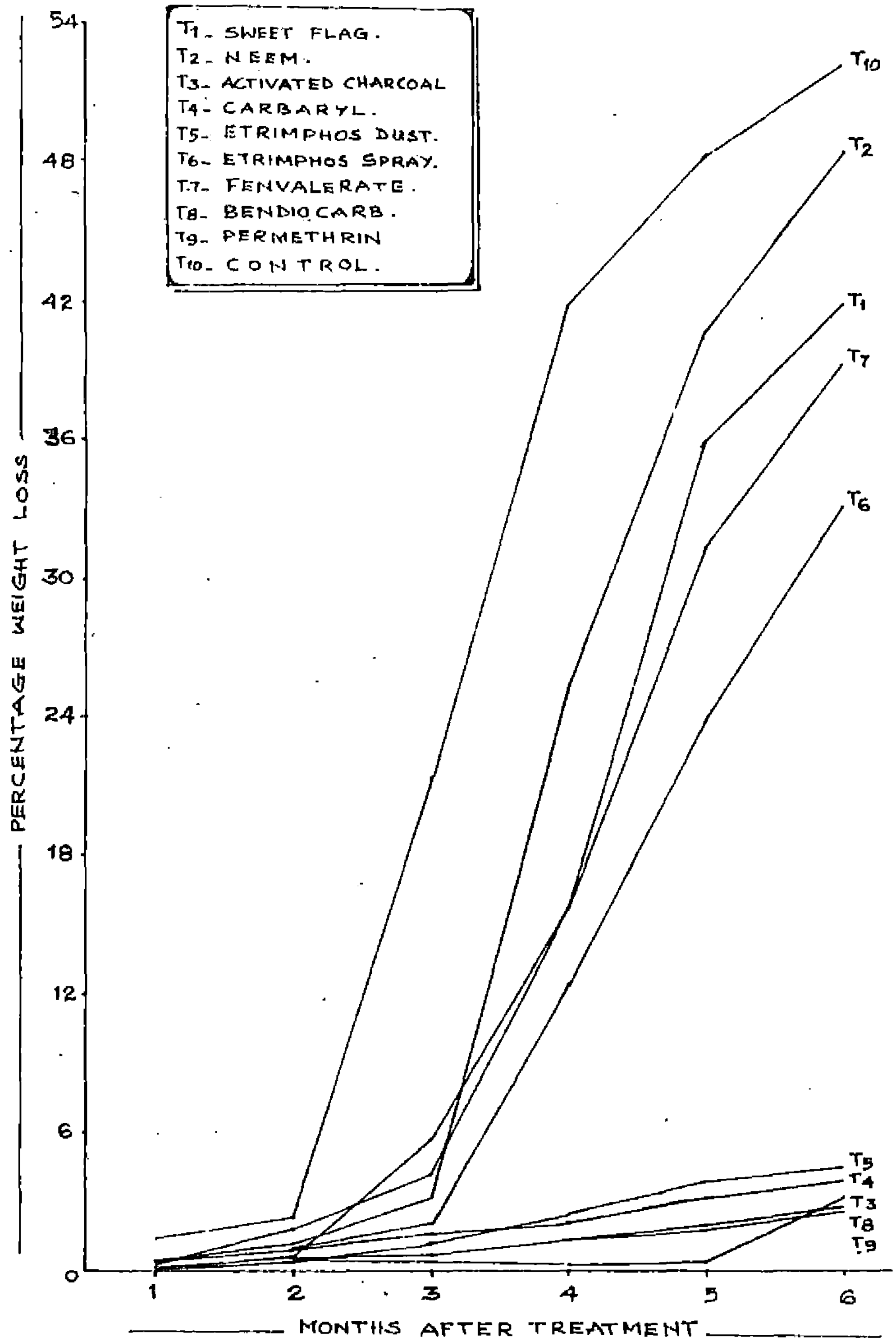


PERCENTAGE WEIGHT LOSS
ETRIMPHOS SPRAY
FENVALERATE
BENDIOCARB
PERMETHRIN
CONTROL
storage in plastic containers.
" " gunny bags.
MONTHS AFTER TREATMENT

Fig - 14. PERCENTAGE WEIGHT LOSS OF SEEDS IN DIFFERENT TREATMENTS AS OBSERVED AT MONTHLY INTERVALS.
(MEAN OF TWO METHODS OF STORAGE)



The overall effect of different seed protectants after six months of storage have shown that permethrin gave best results with a minimum percentage weight loss of less than 5 per cent.

Permethrin 25% EC @ 0.0125% proved to be the most effective material in protecting cowpea seeds with a weight loss of only 2.618% even after six months of storage. Similar results were obtained by Lloyd and Hewlett (1958) for controlling C. chinensis with pyrethrin 1.3%. Uniyal et al. (1967) also obtained control of C. chinensis using pyrethrin at 0.025%. Being a contact insecticide with knock down effect and least residual toxicity pyrethrin preparations can be safely recommended for controlling pulse beetles in storage.

Bendiocarb 80% WP @ 0.06%, a carbamic acid insecticide was also found to be an effective seed protectant with only 2.8425% weight loss after six months of storage ranked next to permethrin.

Activated charcoal powder @ 1.5% (w/w) appeared to be superior than all other treatments during the first two months of storage and infestation starts only after third month. Due to the abrasive and hygroscopic nature of activated charcoal, loss of moisture from insect body resulted in desiccation and death of insects. Similar results were also obtained by Narasimham and Krishna Murthy (1944), Nair (1957) and Mammen *et al.* (1968). Infestation of pulse beetles in seeds treated with activated charcoal, three months after storage may be due to the physical changes in the charcoal particles leading to the loss of tenacity in adhesion and the consequential irregular coverage on the seeds. However the percentage weight loss is only 3.219% after six months of storage.

Carbaryl 5% dust @ 1.5% (w/w) and etrimphos 2% dust @ 1.5% (w/w) are also found to be superior over untreated control in protecting cowpea seeds in storages with a percentage weight loss of only 3.924 and 4.555% respectively. Studies of El-rafie *et al.* (1974) was also revealed that carbaryl was superior to malathion and bioallethrin in controlling *C. chinensis*.

Percentage weight loss of seeds treated with etrimphos spray, fenvalerate, rhizome bits of sweet flag, and neem kernel powder were 33.619%, 39.185%, 41.755% and 48.574% respectively after six months of storage. Fenvalerate and etrimphos spray gave protection only upto fourth month and after that the percentage weight loss was increased. However the weight loss was comparatively lower than untreated control, even after six months.

Seeds mixed with rhizome bits of sweet flag @ 1.5% (w/w) also gave satisfactory protection only upto the end of fourth month. Even the weight loss after sixth month was 41.755%, it is significantly better than control. David and Kumarswami (1971) stated that powdered rhizomes of sweet flag mixed at 1 kg with 50 kg of wheat seed afforded protection against storage pests for a period of one year. But in the present investigation, cowpea seeds were protected from pulse beetles only for four months.

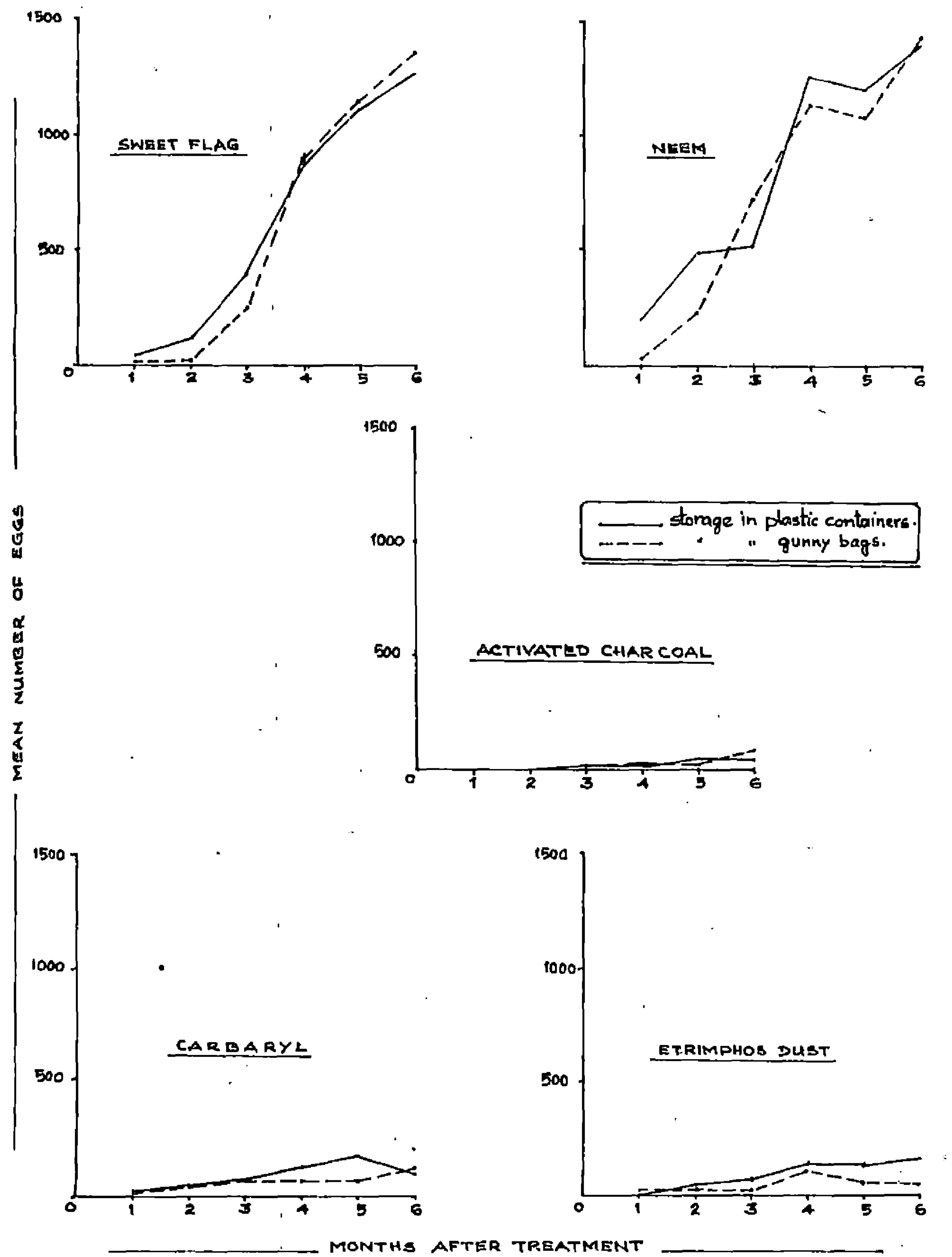
Neem seed kernel powder @ 1.5% (w/w) is found to be the least effective in protecting cowpea seeds in storage resulting in higher percentage of weight loss. As in the case of sweet flag, neem seed kernel powder also gave satisfactory protection only upto the end of fourth month. This may be due to the loss of gustatory repellent properties of neem seed kernel powder after the fourth month. Percentage weight loss after the sixth month was 48.574, however it is statistically significant than control. This result is not fully agreeing with the observation made by Jotwani and Sircar (1976) where powdered neem kernels mixed with pulse seeds afforded protection from pulse beetles for 8 to 11 months.

2. Efficiency of different treatments based on the number of eggs deposited on cowpea seeds

As in the case of percentage weight loss, more number of eggs were laid in plastic containers except etrimphos dust, fenvalerate and permethrin treated seeds after the first month (Fig 15). Even though there is an increase in the total number of eggs deposited during successive months, wide variation between all the treatments under the two methods of storage was noticed during the second, third, fourth and fifty month. Observations on the number of eggs laid after the sixth month have recorded more number of eggs in gunny bags except in etrimphos dust, bendiocarb and untreated control. But the difference between the two methods is not statistically significant.

It is seen from Fig 16 that the total number of eggs laid were maximum in untreated control and seeds treated with neem kernel powder, rhizome bits of sweet flag, fenvalerate and etrimphos spray. Neem is found to be the least effective in reducing the fecundity of pulse beetles. Abraham and Ambika (1979) reported that the sixth instar nymphs of Dysdercus cingulatus Fabr. females showed degenerate ovarioles and suffered vitellogenesis as a result of topical application of neem leaves and kernels. However in the present studies direct admixture of neem kernel is not

Fig-15. PERFORMANCE OF DIFFERENT TREATMENTS IN TWO METHODS OF STORAGE AS ASSESSED AT MONTHLY INTERVALS.
(MEAN No. OF EGGS PER 100 SEEDS)



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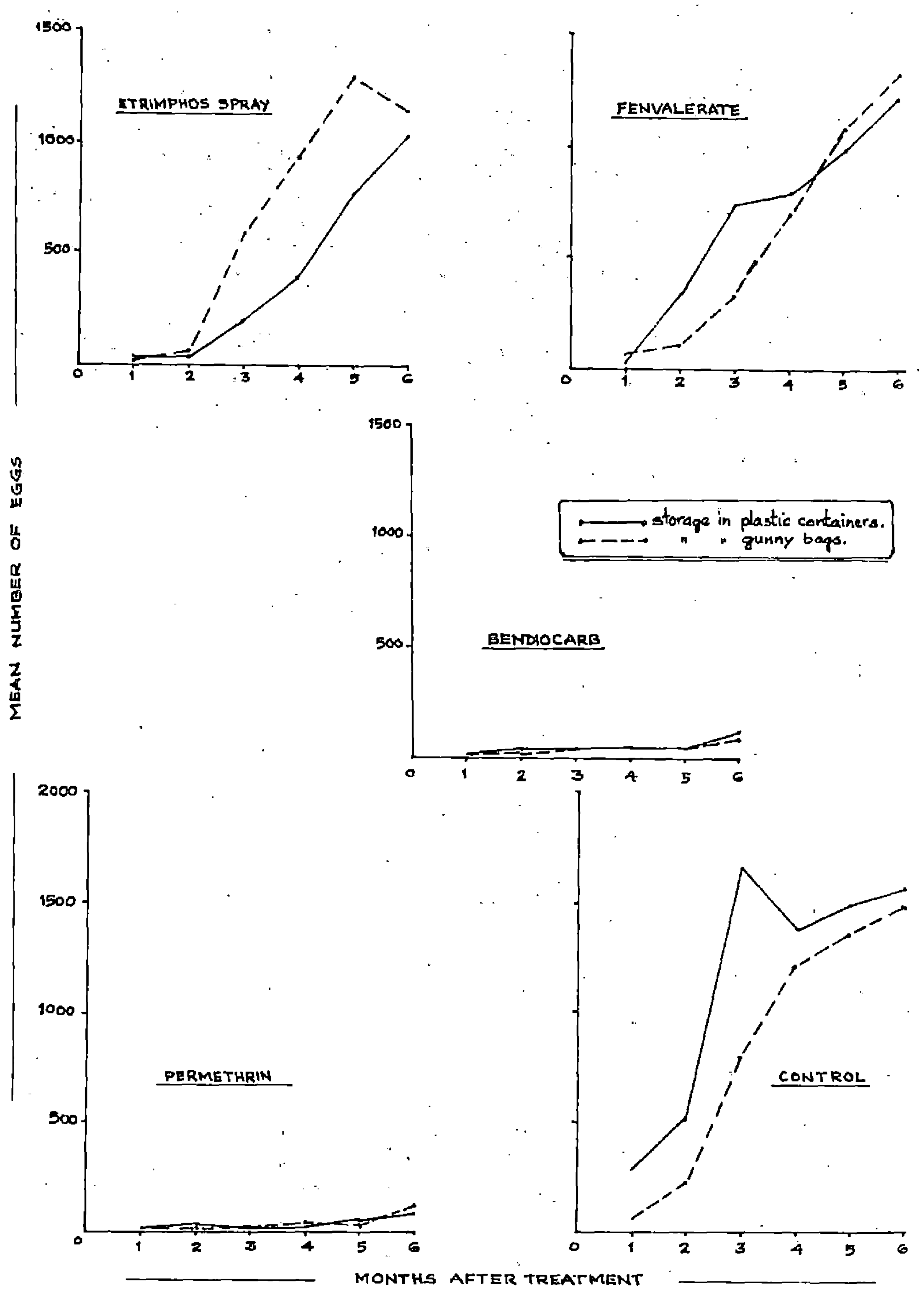
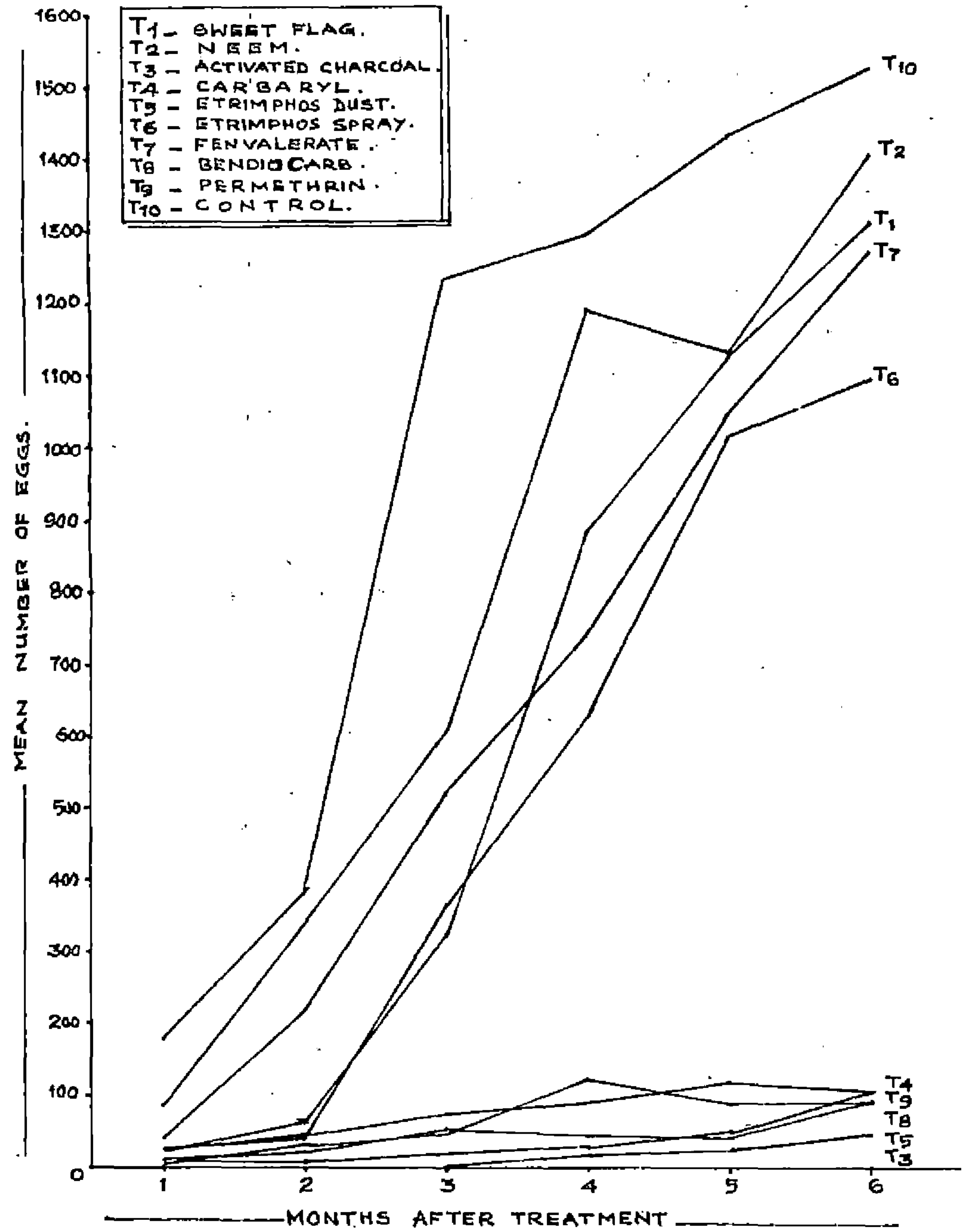


ETRIMPHOS SPRAY
FENVALERATE
BENDIOCARB
PERMETHRIN
CONTROL
storage in plastic containers.
" " gunny bags.
MEAN NUMBER OF EGGS
MONTHS AFTER TREATMENT
1500
1000
500
2000
0
1
2
3
4
5
6

Fig-16. NUMBER OF EGGS IN DIFFERENT TREATMENTS AS OBSERVED AT MONTHLY INTERVALS.

(MEAN OF TWO METHODS OF STORAGE)



found to suppress fecundity in C. maculatus. This is explicable on the basis of variation in the susceptibility of these two species. Sweet flag, fenvalerate and etrimphos spray were found to be effective in preventing the oviposition upto the end of fourth month and even after six months they are significantly better than control.

There was no egg production in seeds treated with activated charcoal during the first two months. This is either due to the mortality of the insects by the physical action or non-preference for oviposition in treated seeds. From the third month onwards there was gradual increase in the egg production with a maximum of 48.92 eggs at the end of the sixth month. Increase in the number of eggs from the third month may be due to the physical changes in charcoal powder adhering to seed coat leading to loss of its attributes conferring non-preference for oviposition.

In bendiocarb treated seeds also less number of eggs were laid after the end of six month, followed by etrimphos dust, permethrin and carbaryl dust and these materials are superior in preventing the egg production than etrimphos spray, fenvalerate, sweet flag and neem.

Relation between total number of eggs deposited and percentage weight loss is seen from Fig 14 and 16. It is observed that there is a close relationship between the number of eggs deposited and the extent of damage due to pulse beetle attack except in seed treated with permethrin and bendiocarb. Even though more number of eggs were laid in seeds treated with permethrin (103.778) and bendiocarb (93.749) the percentage weight losses recorded were 2.618% and 2.843% respectively which were comparatively less than the weight loss in activated charcoal (3.219%) which harboured lesser number of eggs of only (48.920). This may be due to the ovicidal action of the materials on the hatchability of the eggs or their toxic effect on the first instar larvae emerged from the eggs.

It has been found that the weight loss is directly proportional to the number of eggs laid by pulse beetles in all treatments except permethrin and bendiocarb.

3. Efficiency of different treatments on the viability of treated seeds.

Treated seeds were subjected to germination tests to study the effect of materials on the viability of seeds. Germination percentage of seeds stored for six months ranged from 89-97 per cent in all treatments under the two methods of storage. From the results it has been found that there was no adverse effect of the treatments on germination of cowpea seeds stored upto six months.

Storage in plastic containers recorded comparatively low germination percentage than in gunny bag storage. Due to the continuous breeding and development of insect population in the plastic containers may enhance the internal temperature of seeds affecting the quality of stored seeds. Lack of oxygen availability in the enclosed containers may also affect the germination of stored seeds. These may be the reason for low germination percentages of seeds in plastic containers than in gunny bag storage.

From the experimental studies it can be concluded that for long term storage upto six months, cowpea seeds meant for seed purposes can be protected by applying permethrin 25% EC @ 0.0125% surface spraying on the seeds before storage. Bendiocarb 80% WP @ 0.06% surface spraying and activated charcoal @ 1.5% (w/w), carbaryl 5% dust @ 1.5% (w/w), etrimphos 2% dust @ 1.5% (w/w) as direct mixing of dusts with seeds before storage can also be recommended for the protection of cowpea seeds against the attack of pulse beetles without any adverse effects on germination.

For short term storage upto four months mixing with rhizome bits of sweet flag @ 1.5% (w/w) and neem kernel powder @ 1.5% (w/w), surface spraying of fenvalerate 20% EC @ 0.01%, etrimphos 16% EC @ 0.05% can be used for protecting cowpea seeds in storage against the attack of pulse beetle.

Among the different materials used for the protection of cowpea seeds in storage against the attack of pulse beetle activated charcoal which is comparatively cheaper and non-poisonous to human beings and domestic animals can be safely used with advantage even for pulse seeds meant for consumption purpose.

Summary

SUMMARY

Studies were undertaken to evaluate the effectiveness of different seed protectant materials in protecting cowpea seeds *Vigna unguiculata* in storage against the attack of pulse beetle, *Callosobruchus maculatus*. Rhizome bits of sweet flag, neem kernel powder, activated charcoal powder, carbaryl 5% dust and etrimphos 2% dust were mixed with seeds @ 1.5% (w/w), etrimphos 16% EC @ 0.05%, fenvalerate 20% EC @ 0.01%, bendiocarb 80% WP @ 0.06% and permethrin 25% EC @ 0.0125% were applied as a surface spray on the seeds before storage. The efficiency of the treatments were assessed under two methods of storage namely storage in plastic containers and also in gunny bags and the pulse seeds were kept in the storage for six months.

Quantitative weight losses recorded during the entire period revealed wide variations in percentage weight loss with different treatments between the two methods of storage in successive months.

Among the treatments permethrin 0.0125% proved to be the most effective material in protecting cowpea seeds in storage against the attack of pulse beetle followed by bendiocarb 0.06%, activated charcoal powder 1.5% (w/w), carbaryl 5% dust 1.5% (w/w)

and etrimphos 2% dust 1.5% (w/w) for a period of six months. In seeds treated with activated charcoal powder no damage was recorded for two months under both methods of storage. Even though the other treatments etrimphos spray, fenvalerate, sweet flag and neem are inferior in protecting the pulse seeds, they are better than the untreated control and gave satisfactory protection for four months.

Variations in the number of eggs laid in different treatments between the two methods of storage during successive months have been noticed.

Activated charcoal powder appeared to be the most effective material in reducing the fecundity of beetles in storage and for the first two months, egg laying was practically nil in charcoal treated seeds. Bendiocarb followed by etrimphos dust, permethrin and carbaryl are found to be good seed protectants against pulse beetles. Etrimphos spray, fenvalerate rhizome bits of sweet flag and neem kernel powder are ineffective in reducing the egg laying of pulse beetles.

It has been found that the number of eggs laid in different treatments are directly proportional to the percentage weight loss in all treatments except in permethrin and bendiocarb. This may be due to the ovicidal action of these chemicals in reducing the hatchability of eggs or their toxic effect on young larvae.

Data on the germination percentage of seeds treated with different materials have revealed that there was no adverse effect of any treatments on the viability of pulse seeds stored for six months.

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* Originals not seen

Appendices

APPENDIX I

Analysis of Variance Table for the percentage weight loss in treated seeds observed one month after storage.

Source	df	SS	M.S.	F
Method	1	0.064	0.064	0.195
Treatment	9	8.632	0.959	2.929**
Interaction	9	1.209	0.134	0.410
Error	40	13.095	0.327	

** Significant at 1% level

APPENDIX II

Analysis of Variance Table for the percentage weight loss in treated seeds observed two months after storage.

Source	df	SS	M.S.	F
Method	1	0.036	0.036	0.046
Treatment	9	25.431	2.826	3.629**
Interaction	9	4.788	0.532	0.683
Error	40	31.149	0.779	

** Significant at 1% level

APPENDIX III

Analysis of Variance Table for the percentage weight loss in treated seeds observed three months after storage.

Source	df	SS	M.S.	F
Method	1	7.193	7.193	2.171
Treatment	9	1 460.919	162.324	48.986**
Interaction	9	1 202.698	133.633	40.328**
Error	40	132.547	3.314	

** Significant at 1% level

APPENDIX IV

Analysis of Variance Table for the percentage weight loss in treated seeds observed four months after storage.

Source	df	SS	M.S.	F
Method	1	1.102	1.102	0.092
Treatment	9	9 109.919	1 012.213	84.530**
Interaction	9	1 654.126	183.792	15.349**
Error	40	478.983	11.975	

** Significant at 1% level

APPENDIX V

Analysis of Variance Table for the percentage weight loss in treated seeds observed five months after storage.

Source	df	SS	M.S.	F
Method	1	64.907	64.907	12.223**
Treatment	9	19 019.959	2 113.329	397.972**
Interaction	9	357.825	39.758	7.487**
Error	40	212.409	5.310	

** Significant at 1% level

APPENDIX VI

Analysis of Variance Table for the percentage weight loss in treated seeds observed six months after storage.

Source	df	SS	M.S.	F
Method	1	20.860	20.860	6.914*
Treatment	9	24 895.391	2 766.155	916.878**
Interaction	9	361.479	40.164	13.313**
Error	40	120.677	3.017	

* Significant at 5% level

** Significant at 1% level

APPENDIX VII

Analysis of Variance Table for the number of eggs deposited by the beetle on treated seeds - one month after storage.

Source	df	SS	M.S.	F
Method	1	72.182	72.182	4.553*
Treatment	9	602.800	66.978	4.224**
Interaction	9	233.414	25.935	1.636
Error	40	634.224	15.856	

* Significant at 5% level

** Significant at 1% level

Note: Data analysed after $\sqrt{x + 1}$ transformation

APPENDIX VIII

Analysis of Variance Table for the number of eggs deposited by the beetle on treated seeds - two months after storage.

Source	df	SS	M.S.	F
Method	1	117.412	117.412	10.596**
Treatment	9	2 022.880	224.765	20.284**
Interaction	9	285.512	31.724	2.863*
Error	40	443.226	11.081	

* Significant at 5% level

** Significant at 1% level

Note: Data analysed after $\sqrt{x + 1}$ transformation

APPENDIX IX

Analysis of Variance Table for the number of eggs deposited by the beetle on treated seeds - three months after storage.

Source	df	SS	M.S.	F
Method	1	29.344	29.244	3.211
Treatment	9	5 419.186	602.132	66.107**
Interaction	9	1 329.053	147.673	16.213**
Error	40	364.339	9.109	

** Significant at 1% level

Note: Data analysed after $\sqrt{x + 1}$ transformation

APPENDIX X

Analysis of Variance Table for the number of eggs deposited by the beetle on treated seeds - four months after storage.

Source	df	SS	M.S.	F
Method	1	0.762	0.762	0.075
Treatment	9	8 595.783	955.087	93.466**
Interaction	9	306.639	34.071	3.334**
Error	40	408.744	10.219	

** Significant at 1% level

Note: Data analysed after $\sqrt{x}$ transformation

APPENDIX XI

Analysis of Variance Table for the number of eggs deposited by the beetle on treated seeds - five months after storage.

Source	df	SS	M.S.	F
Method	1	3.124	3.124	0.368
Treatment	9	10 410.799	1 156.756	136.399**
Interaction	9	256.587	28.509	3.362**
Error	40	339.225	8.481	

** Significant at 1% level

Note: Data analysed after $\sqrt{x}$ transformation

APPENDIX XII

Analysis of Variance Table for the number of eggs deposited by the beetle on treated seeds - six months after storage.

Source	df	SS	M.S.	F
Method	1	0.221	0.221	0.091
Treatment	9	10 977.539	1 219.727	499.879**
Interaction	9	169.711	18.859	7.728**
Error	40	97.601	2.441	

** Significant at 1% level

Note: Data analysed after $\sqrt{x}$ transformation

APPENDIX XIII

Analysis of Variance Table for the percentage germination of treated seeds - one month after storage.

Source	df	SS	M.S.	F
Method	1	47.901	47.901	3.992
Treatment	9	271.678	30.186	2.516*
Interaction	9	307.856	34.206	2.851*
Error	40	479.982	11.999	

* Significant at 5% level

Note: Data analysed after Arc sine transformation

APPENDIX XIV

Analysis of Variance Table for the percentage germination of treated seeds - two months after storage.

Source	df	SS	M.S.	F
Method	1	5.813	5.813	0.244
Treatment	9	130.120	14.458	0.607 NS
Interaction	9	404.313	44.924	1.887
Error	40	952.507	23.813	

NS : Non significant

Note: Data analysed after Arc sine transformation

APPENDIX XV

Analysis of Variance Table for the percentage germination of treated seeds - three months after storage.

Source	df	SS	M.S.	F
Method	1	191.604	191.604	4.167*
Treatment	9	183.998	20.999	0.457
Interaction	9	222.736	24.748	0.538
Error	40	1 839.253	45.981	

* Significant at 5% level

Note: Data analysed after Arc sine transformation

APPENDIX XVI

Analysis of Variance Table for the percentage germination of treated seeds-four months after storage.

Source	df	SS	M.S.	F
Method	1	331.107	331.107	8.129**
Treatment	9	237.003	26.334	0.647
Interaction	9	376.862	41.874	1.028
Error	40	1 629.297	40.732	

** Significant at 1% level

Note: Data analysed after Arc sine transformation

APPENDIX XVII

Analysis of Variance Table for the percentage germination of treated seeds - five months after storage.

Source	df	SS	M.S.	F
Method	1	342.549	342.549	12.131**
Treatment	9	434.661	48.296	1.710
Interaction	9	1 081.381	120.154	4.255**
Error	40	1 129.571	28.239	

** Significant at 1% level

Note: Data analysed after Arc sine transformation

APPENDIX XVIII

Analysis of Variance Table for the percentage germination of treated seeds - six months after storage.

Source	df	SS	M.S.	F
Method	1	0.000	0.000	0.000
Treatment	9	226.679	25.187	1.066
Interaction	9	363.273	40.364	1.709
Error	40	944.991	23.625	

Note: Data analysed after Arc sine transformation

PROTECTION OF STORED COWPEA SEEDS *Vigna unguiculata* (L) (Walp) FROM INFESTATION BY THE PULSE BEETLE *Callosobruchus maculatus* F. (BRUCHIDAE : COLEOPTERA)

BY

B. PURNAMMA

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the Degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Entomology

COLLEGE OF HORTICULTURE

Vellanikkara - Trichur

KERALA INDIA

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ABSTRACT

Studies were undertaken to assess the effect of different materials in protecting cowpea seeds against the attack of pulse beetle, Callosobruchus maculatus in storage for a period of six months. Rhizome bits of sweet flag, neem kernel powder, activated charcoal powder, carbaryl 5% dust, etrimphos 2% dust were directly mixed with seeds @ 1.5% (w/w) and etrimphos 16% EC @ 0.05%, fenvalerate 20% EC @ 0.01%, bendiocarb 80% WP @ 0.06% and permethrin 25% EC @ 0.0125% were sprayed on the surface of the seeds before storage. Treated seeds were stored in plastic containers and in gunny bags for six months along with an untreated control.

All treatments recorded low percentage of weight loss during the first four months of storage under both methods. But in the fifth and sixth month seeds treated with neem kernel powder, sweet flag rhizome bits, etrimphos 16% EC and fenvalerate 20% EC suffered higher damage and they did not gave significant protection against the pulse beetles. Extent of damage in permethrin 25% EC treated seeds was negligible even after six months followed by bendiocarb 80% WP, activated charcoal, carbaryl 5% dust and etrimphos 2% dust in which percentage weight loss

was less than 5%. Permethrin 25% EC was found to be an effective seed protectant in preventing damage of cowpea seeds due to the attack of pulse beetle in storage.

Number of eggs laid in different treatments indicated that activated charcoal proved to be effective in checking the multiplication of the pest in storage followed by bendiocarb 80% WP, permethrin 25% EC, etrimphos 2% dust and carbaryl 5% dust. No egg laying was recorded in seeds treated with activated charcoal during the first two months under the two methods of storage. Neem kernel powder, sweet flag rhizome bits, fenvalerate 20% EC and etrimphos 16% EC did not show much deterrent effect on the egg laying capacity of pulse beetle.

Close relation between number of eggs laid in different treatments and the percentage of weight loss was observed in all treatments except in permethrin and bendiocarb treated seeds. In both these treatments even though the number of eggs laid were more than in activated charcoal, percentage weight loss recorded were comparatively less than charcoal. This indicates that permethrin and bendiocarb may be showing some ovicidal action along with contact toxic effect.

Investigations on the viability of treated seeds in storage indicated that there is no adverse effect on the germination of pulse seeds stored for six months after treating with different seed protectants.