SUCCESSION OF INSECT PESTS IN STORED GROUNDNUT AND THEIR CONTROL

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CERTIFICATE

This is to certify that the thesis entitled "**SUCCESSION OF INSECT PESTS IN STORED GROUNDNUTAND THEIR CONTROL"**submitted to the Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (MS)** in **ENTOMOLOGY**, embodies the result of a piece of bonafide research work carried out by **SUDIPTA MONDAL**, Registration No. **12-04779**under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

June, 2018

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Dedicated
to
All Freedom Fighters of Bangladesh

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ABSTRACT

The experiment was conducted in the central laboratory of Sher-e-Bangla Agricultural University (SAU), Dhaka – 1207, Bangladesh during the period from July 2017 to June 2018 to study the succession of insect pests in stored groundnut and their control. Six treatments such as T_1 = Sevin 85 SP @ 0.5 g/200g seed, T_2= Red chili powder @ 1.0 g/200 g seed, T_3 = Neem leaf powder @ 1.0 g/200 g seed, T_4 = Turmeric powder @ 1.0 g/200 g seed, T_5 = Coriander seed powder @ 1.0 g/200 g seed of groundnut and T_6 = Control (untreated) were used in this experiment. Treated and untreated containers were kept open in laboratory for natural infestation of insect pests. Two insect pests namely dried fruit beetle (*Carpophilus hemipterous*) and red flour beetle (*Tribolium castaneum*) were found to attack in stored groundnut seeds. Dried fruit beetle population was higher upto 315 days after storage. Sevin 85 SP provided the best protection against these pests in storage compared plant materials. Among the four plant materials, neem leaf powder gave better results for protection of groundnut seed in storage compared to other three plant materials.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Millilitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celsius
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
Mg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a self-pollinating, annual herbaceous plant belonging to the family of Fabaceae. The centre of origin for *Arachis spp* is thought to be in the Mato Grosso region of Brazil or northeastern Paraguay (Gregory *et al*. 1980). *Arachis hypogaea* L., is the most widely cultivated species of the genus Arachis, probably originated in the region of south Bolivia or northern Argentina (Hammons 1982) and was subsequently taken to Africa, Europe and Asia. Cultivation of this crop is mostly confined to the geographical belt between 40°N and 45°S latitude.

Being a legume crop, groundnut is rich in oil content (45-50%) having 27-33% protein and also the source of essential minerals like phosphorus, calcium, magnesium and potassium (Savage and Keenan 1994) and vitamins. Groundnut oil is composed of mixed glycerides and contains a high proportion of unsaturated fatty acids, in particular, oleic (50-65%) and linoleic (18-30%) (Young 1996).

Increasing of global demands from one side and various productions and by-products from the other side determine the economic importance of this crop (Smart 1994). They play an important role in the diet of resource poor human being in our third world countries and haulms are used as livestock feed. The oil of groundnut is one of the most important vegetable oil in regions where other oily vegetables cannot grow up (Smart 1994, Norman *et al*. 2005).

In our country fried or roasted groundnut is popular snacks. They are also important in the confectionary trade and the stable oil is preferred by the deep-frying industries, since it has a smoke point of 229.4°C compared to the 193.5°C of extra virgin olive oil. Only 20% of total oil consumption in Bangladesh is meet from local production and the rest 80% oil is imported from different countries which cost 300 million $ per year. So considering the oil and protein content with

nutritional value there is huge opportunity cultivating and storing of groundnut in our country.

In Bangladesh, groundnut is the 2nd important oil seed crop next to mustard (*Brassica spp*.) on the basis of annual production, and it stands 3rd next to sesame (*Sesamum indicum* L.) on the basis of acreage among the major oil crops. It covers 32000 ha of land with annual production 54000 t and the average yield is 1.6 t ha^{-1} (FAOSTAT, 2013).

Enormous amount of loss in the production was caused by the insect pests that attack groundnut crop under the field condition as well as under storage. Groundnut is usually stored as pods (unshelled form) and in kernels (shelled form) for different uses. Generally the harvested produce is stored by farmers, processors, seed agencies and other oil extraction units for about 6-9 months before final use (Azeemoddin, 1993). However, groundnut kernels are more susceptible to insect attack than pods in storage. The amount of damage inflicted by insect pests during post- harvest processing and storage depends on several factors such as moisture content in the product, the form in which it is stored, level of maturity at harvest, sanitation of storage space and the quality of the material itself. In addition, the storage structure also influences the rate of deterioration through its physical environment. Post-harvest processing of groundnuts (threshing, drying and cleaning) has significant influence on insect behavior and establishment in the store. Mature pods are less susceptible to insect pests than immature pods. Damage to pod shells also increases susceptibility to insect pests. Pre-storage processing of groundnut varies from country to country and region to region. In developing countries, pods are often removed from haulms by hand, when the pod-moisture content can be about 15%. However, this procedure is labor intensive. In some situations, beating the haulms against wooden poles until the nuts fall off, or stripping the haulms by using simple strippers, is a common

practice. In most cases, manual hand picking is safe and avoids damage to the shells. Excessive drying in the sun or from an artificial heat source can affect the viability of the nuts; therefore, care should be taken to ensure that seed nuts are dried either under shade or at the appropriate temperature. Undamaged unshelled groundnuts can be stored for long periods without insect pest damage provided the moisture content is below 7% (Ranga-Rao *et al*. 2010).

Post-harvest losses in groundnut range between 10 to 25% of the production in Asia, and severe damage under long-term storage situations is not uncommon (Azeemoddin, 1993). In India, Bangladesh, Pakistan, Thailand, storage losses of groundnut range between 10% - 15% (Ranga-Rao *et al*., 2010). Its quality and quantity is reduced during storage and post-harvest due to several insect pests such as groundnut bruchid, *Caryedon serratus* (Olivier); pod sucking bug, *Elasmolomus sordidus* (F.), dried fruit beetle, *Carpophilus sp.* and red flour beetle, *Tribolium castaneum* (Herbst) etc. Apart from insect pests different mycoflora belonging to storage fungi *viz*., *Aspergillus flavus* and *Aspergillus parasiticus* also reduces the quality by producing secondary metabolites known as aflatoxins. These aflatoxins can even pose serious health hazards in humans and animals upon consuming the contaminated food and feed.

Insect infestation not only causes direct loss to the produce, but also creates entry points to the fungal colonization especially storage fungi belonging to *Aspergillus* group. It is because of these post-harvest losses farmers sell their produce immediately after harvest and fetch marginal profits in spite of scope for achieving higher market price for the produce if stored for a little longer time. However, the storage of the produce has to be done following safe post-harvest management practices including use of proper storage structures, maintaining moisture content of 8-12%, temperature of 25-30°C and relative humidity of 65% (Pattee and Young, 1982) which play a major role in storing any produce for longer duration

without any damage. Above all the safe postharvest management practice at farmer level involves use of chemical insecticides or botanicals on the stored produce.

Groundnut attracts more than 100 species of insects (Redlinger and Davis, 1982 and Ofuya and Lale 2001). To face the threat posed by insects which are the main stock pests, the strategy relies on chemical pesticides. The effectiveness of these products to control the stocks is proven in optimal conditions. However several drawbacks are noted like the insect a customing and the selection of resistant strains (Benhalima *et al*. 2004), poisoning, pollution and ecological disorders (Regnault-Roger, 2002). The advent of synthetic insecticides has put the practices of local communities on hold. During many years, an excessive, unreasonable and continuous application of synthetic pesticides (insecticides, fungicides, nematicides, rodenticides) was observed in spite of the warning on pesticide adverse effects that led governments to consider environmental issues related to pesticide overuse Carson, (1962). The pesticide usage is now declining worldwide due to their high persistence.

Scientists stress the need of a concerted effort of researchers and politicians to increase the competitiveness of alternative pest control methods and give them more consideration (NRC 2000). Research programs on natural insecticides were initiated in many countries (Glitho 2002). Various insecticidal plants tested on the beetle (Bruchidae family) attacking groundnut, maize and bean showed insecticidal and ovicidal effects (Monge *et al*. 1988 and Glitho *et al*. 2008). As one of the most studied plants, the neem, mehegony, ginger, garlic, coriander, red chilli, turmeric, eucalyptus etc. are currently the main source of natural insecticide controlling more than 400 species of insects (Walter *et al*. 1999 and Greenberg, 2005). The neem regulates the growth and modifies the behavior of certain pests (Pierre 2004 and Isman 2006).

Although the information regarding insect pests damaging groundnut under field conditions is plenty but the information regarding the biology and management of storage pests of groundnut is scanty. The present investigation has been planned with the idea of conducting detailed investigations on the pest fauna, biology of major storage pests and evolving suitable management practices for the key storage pests of groundnut, with the fallowing objectives:

1. To study the insect pests of groundnut in storage and their time of incidence.
2. To know the protection efficiency of plant materials compared to chemical insecticides.

CHAPTER II

REVIEW OF LITERATURE

The literature pertaining to groundnut stored pest relating to the present investigation has been reviewed and presented below.

2.1Origin and distribution

2.1.1 Dried fruit beetle, *Carpophilus hemipterus* (Linnaeus)

Biology and damage

The adult is a brown beetle, about 4-7 mm long and 5 mm wide with prominent large hind legs. A single gravid female lays 2030 creamy white eggs (1 mm long), which are glued to the surface of groundnut shell or kernels. The incubation period varies from 4 to 6 days. The newly hatched larva burrows straight through the eggshell and pod wall, and starts eating the kernel. No damage can be seen at this stage unless one searches carefully. The first sign of attack is the appearance of ‘windows' (approximately 3 mm in diameter) made on the pod wall by the grub to allow the adult to leave the pod. Each larva feeds solely within a single kernel. Larval development is completed in 40 to 45 days, and the pupal stage lasts for about 15 days. Sometimes, the grown-up larvae leave the pod and pupate at the bottom of the sacks. By this stage, the groundnut seeds are badly damaged and are unfit for human consumption, seed use or oil expulsion. Under optimum conditions (30-33°C and 70-90% relative humidity), the life cycle of *C. hemipterus*is completed in about 60 days.

Distribution

*C. hemipterus*is widely distributed in groundnut growing areas of the world from Myanmar through Hawaii, India, Indonesia, Iran, Israel, Jordan, Mexico, New Zealand, Nigeria, Pakistan, Sri Lanka, Sudan, Thailand and Uganda

(Kingsolver1970). Further, it has also been reported from Zambia, Senegal and West Africa (Feakin 1973), Central Africa (Delobel 1989), and Australia (Cunningham and Walsh 2002). In India, *C. hemipterus* was first reported to be infesting groundnut round the year in Andhra Pradesh and Tamil Nadu in 1914 (Fletcher 1914). Subsequently, several workers reported its distribution from Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Tamil Nadu, Kerala, Andhra Pradesh and Orissa (Mittal and Khanna 1974, Arora and Singal 1978, Ranga-Rao and Wightman 1999).

Host range

Reports on damage to seeds of legumes by this insect in storage as well as in the field from different parts of the world have been well documented (Cunningham and Walsh 2002, Nandagopal and Prasad 2004). They include *Tamarindus indica*Linn.,*Arachis hypogaea* Linn., *Acacia farnesiana* Willd., *Acacia nilotica* (L.), *Acacia tortilis* Hayne., *Albizia lebbek* (Linn.) Benth.,*Bauhinia malabarica* Roxb., *Bauhinia monandra* Kurz., *Cassia fistula* Linn., *Cassia brewsteri* (F. Muell.) Benth., *Cassia tomentella* (Benth.) Domin, *Cassia renigera*Benth.,*Piliostigma reticulatum* Dc., *Piliostigma thonningii* (Schum), *Pongamia pinnata* (L.) and *Prosopis juliflora* (Sw.).

Extensive pre-season survey of groundnut post-harvest process and storage premises in Zambia suggested that primary infestation from the field was critical in establishment of bruchid in the stores, and that the groundnuts lifted early and dried for longer period than usual in the field (a common practice for confectionery varieties) received consistently higher insect infestation (Conway 1983).

Red flour beetle, *Tribolium castaneum* (Herbst)

Biology and damage

Red flour beetles attack stored groundnuts and other grain products such as flour, cereals, meal, crackers, beans, spices, pasta, cake mix, dried pet food, dried flowers, chocolate, nuts, seeds and even dried museum specimens. The adults are 3-4 mm long and brown in color. The adults live for several months and are strong fliers. The female lays eggs in cracks of the testa or on the damaged portions of the kernel to enable the young grub to feed on the kernel directly. A female lays up to 450 individual eggs, distributed among the pods or seed. Eggs hatch in 3-4 days.

The grubs are cylindrical in shape with prominent projections on the last abdominal segment. The pupal period lasts for 7-10 days, and the adults can live up to 18 months. The mean developmental period requires about a month under optimal conditions (30°C and 90% RH). Pupation takes place inside the damaged kernel without a cocoon.

The grubs are facultative predators of other storage insect eggs and larvae, and are sometimes cannibalistic. The grubs feed on the kernel making them unfit for use as seed and human consumption. The damage results in powdery appearance in the produce. The infestation can be recognized by the presence of creamy white grubs and active adults. This species has been recognized to cause direct and indirect losses affecting both viability and quality of the produce.

Distribution

The red flour beetle is of Indo-Australian origin, widely distributed in temperate areas, and can survive the winter in protected places (godowns). In the United States, it is found primarily in the southern states. Thus, it is known to be

cosmopolitan in distribution and infests all crop products, which is particularly severe in the tropics.

2.2 Brief bio-ecology and nature of damage by the pest

Besides wheat, *R. dominica* and *S. oryzae* also appear as primary pests on several other hosts viz., stored rice, maize, sorghum, pulses and dried cassava root, etc. The first instar larvae enter the kernels a short time after egg hatching (Crombie 1944) and prefer breaks or the germ area where the covering testa was loose (Birch 1945).

Birch (1945) observed 26° and 36°C temperature with 9 per cent grain moisture content as most favorable for *R. dominica* able to complete its development from egg to adult and cause damage in wheat kernels. He also reported the beetle to lay eggs outside the grain or in fine powdered grain associated with its infestations. Golebiowska (1969) reported the newly born larvae of *R. dominica* and *S. oryzae* able to feed on dusts produced by adults or deriving from food processing and drilling the kernels to complete their life cycle.

Chander (2003) studied the growth and development of *R.dominica* at different temperature and humidity ranges and thus revealed a negative correlation of temperature with its pre- and post-oviposition period, larval and pupal period, total development period and adult longevity. The temperatures 35°C and 40°C, respectively, were found as favorable for the short and no development of insect larvae, and observed maximum adult emergence at 30°C temperature and 80 per cent relative humidity whereas maximum fecundity and egg viability at 35°C temperature and 90 per cent relative humidity. He also recorded the maximum growth index of test insect (2.09) at 30°C temperature and 70 per cent relative humidity. On the basis of various biological parameters, 30-35°C temperature and 70-80 per cent relative humidity were found to be optimum for the insect development in his studies.

Limonta (2011) reported 28°C temperature and 70 per cent relative humidity as the most favorable for first instar larvae of *R. dominica* to drill sound kernels in durum wheat. Koehler (2015) reported *R. dominica* and *S. oryzae* to complete total life cycle in 30 and 2632 days, respectively, during hot summer conditions. An adult male (body length of 3.25mm) is generally smaller in size than the female (body length of 3.75mm) in case of *S. oryzae* (Jadhav 2006).

2.3 Loss assessment through stored grain pest

Local storage structures which are commonly used in rural India and Bangladesh fail to provide complete grain protection from insects. In general, these structures are not moisture proof. The moisture content is high in stored grain which facilitates insect multiplication. The longer the storage period, higher is the insect infestation (Prakas, 1982).

Singh (2001) made a survey on the storage structures used by the farming community in North Bihar, India. He reported that they owned at least 13 different types of storage structures for storing of their agricultural products. Among all gunny bags were maximum (25.78%), however, the farmers use different types of structures at a time. Mandal *et al*. (1984) reported that average losses and deterioration of grains in silo/godown storage were estimated to be 1.5% and for warehouse storage to be 2.8%. Among the existing structures used by the private sector, bamboo made “dole” was suitable for short term storage.

A heavy per cent infestation of grains due to various insect pests during storage causes loss of germination capacity of seeds making them unfit for human consumption.

In a survey, Rehman (1942) recorded 2.5 per cent losses of total grain production in Punjab. Hafiz and Hussain (1961) reported 10.8 per cent losses due to insects, rats and moulds in Pakistan. Pingale (1964) determined about 83.0 per cent wheat

grain loss during 360 days of its storage period. Koura and Holfany (1974) reported 24.2-47.8 per cent stored grain losses in silos/bins.

The weight loss in wheat during storage was evaluated due to *R. dominica* (Malagon and Trochaz 1985) and *S. garanarius* (Bekon and Fleurat-Lessard 1992). Girish *et al*. (1975) reported 7.0-22.0 per cent weight loss in wheat due to various storage pests within 180 days of its storage in Uttar Pradesh (India). Adams (1976) reported up to 18.30 per cent of substantial losses in the stored grains by *S. oryzae.*

Campbell and Sinha (1976) reported up to 60 per cent weight loss to occur with exposure of a single wheat grain kernal to the *R. dominica.*Khan and Cheema (1978) determined 2.32 per cent weight loss in stored wheat in some parts of Punjab (Pakistan). Simwat and Chahal (1984) recorded an increase of 2.80 to 6.37 per cent adult population of *S. oryzae* and *Tribolium* spp. on wheat during its six months storage period.

Mohammad (2000) reported significantly high grain weight loss (10.0 to15.0%) due to various stored grain insect pests on wheat. Khan and Kulachi (2002) registered 3.40 and 6.53 per cent wheat losses, respectively, in Count and Weigh and Thousand Grain Method. They also recorded 1.93 per cent average grain infestation due to *R. dominica* and other stored grain insect pests.

The poor status of storage has resulted up to 0.2-30.0 per cent grain losses due to various insect pests (Alleoni and Ferreira 2006). Talukder *et al*. (2004) and Dubey *et al*. (2008) estimated nearly one-third of the world's food production to be destroyed by more than 2,000 field and storage pest species.

The insect-pests have been considered to cause damage to the stored grains and grain products which may range from 5.0-10.0 per cent in the temperate where as 20.0-30.0 per cent in the tropical zones (Nakakita 1998, Talukder 2006, Rajendran

and Sriranjini 2008). Rajashekar *et al*. (2010) reported about 20-25 per cent of the total food grain production (250 MT) to be damaged by various stored grain insect pests in India.

Ahmedani *et al*. (2011) reported an initial infestation of grains with only 10 pairs of *Khapra* beetle larvae to cause more than 20.0 per cent weight loss in stored wheat seeds after 6 months of its natural storage. Khatam and Khan (2012) reported significant losses in the stored wheat by various insect-pests under high moisture conditions with their ultimate quality degradation.

2.4 Classification of plant based compounds

Since 1980s, efforts have been made to sharpen the focus on the toxicant and grain protectant activity of essential oils, extracts and their constituents. Jacobson (1989) observed the plant families like *Annonaceae, Asteraceae, Canellaceae, Labiatae, Meliaceae* and *Rutaceae* as most promising natural grain protectants, in general, and conventionally classified the plant derived compounds into six different groups viz., insect repellents, antifeedants/feeding deterrents, toxicants, growth inhibitors, chemosterilants, and attractants based on the physiological effects in the insects.

The use of various plant parts like leaf, bark, seed powder, or oil extracts as admixture to the stored grains have resulted into in reduced rates of seed damage, reduced insect oviposition and suppression of adult emergence in various stored grain insect pests (Onu and Aliyu 1995, Shaaya *et al.* 1997, Keita *et al.* 2001, Tapondjou *et al.* 2002, Bakkali *et al.* 2008).

2.5 Management of stored grain pest

Numerous stored insect pests commonly infest peanuts (Redlinger and Davis, 1995). Key post-harvest pests in peanut are Indian meal moth [*Plodia interpunctella* (Hubner)], red flour beetle [*Tribolium castaneum* (Herbst)], grain

beetles *(Oryzaephilus spp*.), lesser grain borer [*Rhyzopertha dominica* (F.)], and almond moth [*Cadra cautella* (Walker)]. These insects invade peanut hulls or feed on damaged or loose shelled kernels. Economic losses occur from both physical destruction and contamination from frass and castings. Insect populations in stored products tend to be more prevalent in areas with higher ambient temperatures and humidity (Noyes *et al*., 1995). Integrated pest management (IPM) in stored food products depends heavily on sanitation, population monitoring, and chemical control (Hagstrum and Flinn, 1995). Several non-chemical control methods have been explored to reduce losses to insects. Sanitation is an important strategy. Cleaning of farmer stock peanut at harvest to remove loose shelled kernels, foreign material, and other feeding sources may reduce insect damage during storage (Arthur, 1989). Historically, insecticides, insect growth hormones (IGR), desiccants, and fumigants have been used to reduce insect damage. More recently biological control agents, have been partially effective against some pests. Diatomaceous earth (silicon dioxide as an inert dust) has been evaluated in laboratory-scale trials (Arthur and Brown, 1994). Finely ground diatoms ingested by larva of Indianmeal moth and almond moth result in insect dehydration from destruction of the epicuticle exoskeleton. Indianmeal moth and almond moth have exhibited highly variable responses to *Bacillus thuringiensis* (Bt) (Arthur and Brown, 1994 and Kinsinger *et al*., 1980). *Trichogramma* (T. pretiosum Riley) has shown potential as a biocontrol agent in stored crops (Brower, 1983). Redlinger and Davis (1995) summarized the use of natural parasites, predators, and pathogens in post-harvest peanut but noted that commercial augmentation and introductions of viruses, bacteria, protozoans, and other natural enemies had not been adopted. Surveillance and control methods included the use of traps, pheromones, and other tactics. IPM practices and pesticide use in field production of peanuts have been summarized (Smith *et al*., 1998).

2.6 Indigenous plant materials as alternative to the synthetic compounds

Nakatia and Kuroda (1986) tested leaf powers of *Azadirachta indica* and *Adathoda vasica* by mixing seeds with walnut (1.0%) and they found to repel the larvae of *E.caetella, E.elutella* and *Plodia interpunctella* with a mean mortality of 15.00, 12.00 and 14.80 per cent, respectively.

Adult mortality of *T. casteneum* was 66 and 61 per cent when treated with powdered flowers at 1 and 2 per cent respectively, as compared with 22 per cent in untreated rice. Adult mortality of 63, 64, 60 and 53.3 when treated with 2, 4, 6 and 8 per cent of neem fruit powder in the beginning of storage, respectively (Mostafa,1988).

Neem seed kernel powder (4%) and neem leaf powder (NLP) treated at 5 per cent protected the stored maize for 5 months against *S. oryzae, S. cereallella,Rhizopertha dominica* and *Trigoderma granarium* (Sharma,1999).

El-lakwah *et al*. (1999) recorded mean mortality values of *T. casteneum* adults to be 22.2, 97.8 and 100 per cent at 50, 500 and 1000 ppm of neemzal(10% powder) after 14 days after treatment, respectively.

Leaf extract of *Azadirachta indica* was found to be the most effective repellent against *T. casteneum* on ground nut seed, followed by Vitex negundo onion and Calotrophis gigantea (Sahayaraj and Paulraj, 2000).

Zahoor *et al*., (2002) observed that extracts (0.25, 0.50 and 1.00% w/w) powders (seed kernel powders) at 1.25, 2.50, 5.00 and 10% w/w and leaf powders at 30% and parts (kernel pieces and whole kernels) of neem (*Azadirachta indica)* seed kernels and leaves. The greatest repellancy was observed with fresh seed kernels extracted in ethyl alcohol at 150mg/cm. Dried kernel powder at 10 per cent protected wheat against *Rhizopertha dominica* for up to one year.

Islam and Talukder (2005) reported the direct and residual effects of seed extracts and leaf powders of the neem tree (*Azadirachta indica*), marigold (*Tagetus erecta*) and durba (*Cyandon doctylon*) towards the red flour beetle among the tested plant derivatives, neem seed extract (100 mg/ insect) showed higher direct toxicity (53.13% mortality) towards red flour beetles than marigold (46.88%) and durba (37%) seed extracts on the other hand. Marigold leaf powder (5%) showed a higher residual toxicity (57.09% inhibition ratio) than neem (50.06%) and durba (43.28%) leaf powder.

Gupta and Singh (2007) noticed that the egg laying of *T. casteneum* were significantly lower (38.00 and 13.2% respectively), when treated with 1 and 2 per cent neem leaf powder compared with egg laying in untreated adults of *T.casteneum.* The mean number of eggs laid per female in 20 days was 26.6%.The development of insecticidal resistance in various insects and their residual effects are some of the serious threats. The biosphere contamination is associated with the large- scale use of broad-spectrum chemicals especially the synthetic pyrethroids that has led to the necessity for the most effective and selective biodegradable chemicals.

Chachoria *et al*. (1971) revealed *neem* kernel powder at 1.0-2.0 per cent to be the most effective protectant against *C. maculatus* and *C. chinensis* than ethylene dibromide- carbon tetrachloride (ED-CT) in stored maize. They also reported neem kernel powder at 2.0 per cent as the highly effective grain protectant based on no grain damage by these insects on gram and pigeon pea.

No progeny emergence of *C. maculatus* and *C. chinensis* even after 360 DAT on treated lentil seeds (*Lens culinaris*) was attributed to the oviposition inhibition (Yadav (1973). Rajendaran (1976) reported that *neem* seed kernel powder at 2.0 per cent when admixed to the pigeon pea and mung bean gave protection against *C. maculatus.*

Schmutterer (1981) reported neemseed kernel powder at 1.0-2.0 per cent as the best based on reduced pest infestation on cereals for considerable storage period. Mohan *et al*.(1990) reported that maize treated with deoiled neem seed kernel powder at 0.1 per cent had no grain damage by *S. oryzae.*Singh *et al*. (1996b) reported *neem* seed kernel powder at 0.5 per cent to be the most effective to provide cent percent protection against *C. maculatus* in green gram.

The awareness about pesticidal resistance, environmental pollution and health hazardous effects of the broad-spectrum pesticides has created a worldwide human interest to develop some alternative strategies, including the discovery of newer chemical approaches (Heyde *et al*. 1984, Dayan *et al*. 2009).

The new chemical approaches required some entirely different standards like their pest specificity, nonphytotoxic nature, safety to the mammals, less prone to pesticide resistance, relatively cost effective and their easy availability (Hermawan *et al*. 1997).

The re-examination of century old traditional practices was required for protecting stored products using plant materials known to resist the insect pest incidence (Lale 1992, Ewete *et al*. 1996, Sahayaraj 2008).

Among the various indigenous plants, Indian neemis a well-known example and its different components *viz*., leaves, crushed seeds, powdered fruits, oil, and so forth have been found very effective against various stored grain insect pests (Devi and Mohandas 1982, Talukder *et al*. 2004). Jamil *et al*. (1984) reported crude extract from *neem* as effective on the basis of reduced insect development, larval and adult mortality with its cuticle melanisation.

Yadava and Bhatnagar (1987) reported dried leaves of neemas effective protectant against insects when mixed with stored grains. Azadirachtin is an active principle from the *neem* plant and is an effective grain protectant to control the insect pest

infestation (Schmutterer 1990). The *neem* has been considered to possess the broad activity as a repellent, feeding deterrent, insect-growth regulator, and sterilant and oviposition inhibitor in the insects (Rembold 1989). Azadirachtin is derived from the *neem* tree grown in India and Africa (Isman 2006).

Liu *et al*. (2002) have reported various products from *Dictamnus dasycarpus* to inhibit the development of eggs and immature stages of stored grain pests inside the grain kernel. Among various plant species, about 43 have been listed as insect repellents, 21 antifeedants/insect feeding deterrents, 47 insect toxicants, 37 grain protectants, 27 insect reproduction inhibitors, and 7 insect growth and development inhibitors (Talukder 2006).

The research workers are also in an effort to seek more new classes of naturally available insecticides which might be compatible to the newer pest management strategies (Dubey *et al*. 2008, Yingjuan *et al*. 2008). Koul *et al* (2008) in their studies reported some essential oils responsible for reduction of larval and pupal survival rates and the adult emergence in insects.

The several natural occurring plant products possess broad spectrum activity against a large number of insects including stored grain insect pests, aphids, caterpillars and mealybugs (Morgan, 2009). Rajashekar *et al*. (2010) reported that root powder extracts of *Decalepis hamiltonii* when admixed to the stored grains gave protection against various stored grain insect pests.

Devi and Devi (2011) tested insecticidal potential and antiovipositional properties of eighteen commercial botanical insecticides against *S. oryzae* and reported azadirachtin extremely less toxic to the mammals with least toxic effect (LD50 of 13,000 mg/kg) and was an contact poison besides having some systemic activity in the plant foliage with its general safety to the beneficial insects and mites.

2.7 Plant materials as powder formulation against stored grain pests

Several workers have reported the insecticidal efficacy of various indigenous plant materials against number of stored grain insect pests.

Jotwani and Sircar (1965) were the first in India to test that neem kernel powder mixed with grains at 1.0 or 2.0 per cent protected treated wheat grains against *R. dominica* and *S.oryzae* up to 370 and 320 days, respectively. Deshpande (1967) reported seed kernel powder at 2 per cent as highly effective to give protection of sorghum grains from feeding damage by *S. oryzae.*

Pradhan and Jotwani (1968) reported that *neem* kernel powder when admixed to the wheat gave effective protection from infestation by *R. dominica, S. oryzae* and *Khapra* beetle at 300, 270 and 360 DAT, respectively. Atwal and Sandhu (1970) revealed the drupes of *M. azadirach* as very effective against *T. castaneum* when admixed to the wheat over the BHC (0.25%).

Saramma and Verma (1971) evaluated three plant powders viz., *dharek* kernel powder, *neem* kernel powder and costus root powder at 0.5, 1.0 and 2.0 per cent (w/w) against *T. granarium* on stored wheat and revealed neem kernel powder as the most effective to give promising results followed by costus root powder and *dharek* kernel powder.

Jilani and Malik (1973) reported dharekpowder to be less effective against *R. dominica* as compared to the neempowder on wheat. Girish and Jain (1974) reported *neem* seed powder at 1.0 and 2.0 per cent as most effective to reduce oviposition of adult *S. oryzae.* Zanno *et al*. (1975) attributed insect repellent and anti-feedant actions of neem due to presence of triterpenoid azadirachtin and other related compounds. Subramaniam (1976) reportedneemkernel powder at 2.0 per cent as more effective against *S. oryzae* on stored hybrid sorghum.

Siddig (1981) in their studies on efficacy and persistence of *neem* seed powder at 1.0, 2.0 and 4.0 per cent (w/w) in stored wheat against *Trogoderma granarium* (Everts) reported it as the highly effective to reduce the wheat grain damage by *T. granarium* for a period of 7 to 16 months. Pereira and Wohlgemuth (1982) reported *neem* kernel powder at 2.0 per cent (v/w) as the most effective grain protectant against *S. oryzae, T. castaneum, R. dominica* and pulse beetle, *Callosobruchus chinensis* (Linnaeus).

The *neem* leaf powder at 5.0 per cent was reported to be very effective against *S. oryzae* in the stored wheat at 90 DAT (Chander and Ahmed 1983). Jilani and Helen (1983) reported *neem* leaves as most effective repellant against *R. dominica, S. granarius* and *T. casteneum* among the several plant materials used as insect repellants for protection of cereal grains reported. Jilani and Su (1983) revealed *neem* leaf powder at 1.0 and 2.0 per cent (w/w) as effective with low mean adult emergence in *R. dominica,* i.e. 5.16 and 3.08 adults, respectively, over the untreated control (20.16 adults) in wheat seeds.

Akou-Edi (1984) reported neemkernel powder at 3.0 per cent to be effective for repellency of *S. oryzae* in stored paddy. Jilani and Haq (1984) in their investigations on some indigenous plant materials as grain protectants against various stored grain insect pests, reported neemseed kernel powder at 0.25-1.00 per cent (w/w) as the highly effective based on reduced population of *R. dominica* on wheat during storage.

Banarjee and Nigam (1985) also reported the repellent activity of *neem* leaf powder in various stored grain pests. Ketkar (1986) in their studies on use of tree derived non-edible oils as surface protectants revealed neem kernel powder at 0.5 and 1.0-2.0 per cent (w/w) effective to reduce population and oviposition rate of *S. oryzae* and *R. dominica,* respectively, in stored wheat and paddy.

Seck *et al*. (1991) studied the protection of stored cowpeas by using powders from dry neem leaves and neemkernel against *C. maculatus* and revealed powder from dry *neem* leaves effective to give better results as compared to the fresh neemleaves. They also reported the dipping of cowpeas in aqueous solution of dry seeds effective to reduce fecundity and oviposition of the pest.

Dakshinamurthy and Goel (1992) revealed *neem* leaf powder at 0.5 per cent (w/w) as most effective to prevent the grain infestation by *S. oryzae* and *R. dominica* on stored wheat for up to 360 DAT. They also reported higher seed germination (89.5-91.5%) in the treated over the untreated control (80.75%).

Mishra *et al*. (1992) reported *neem* kernel powder at 0.5 per cent (w/w) effective to cause 100.00, 96.70, 83.30 per cent mortality in *S. oryzae* adults, respectively, at 30, 60 and 75 DAT in maize seed. They also revealed it to give cent percent insect mortality at 0.5, 1.0 and 2.5 per cent at 5 DAT and to give seed protection for up to 180 DAT without adverse effects on seed germination.

Jacob and Sheila (1993) in their laboratory evaluation of powders from *Datura alba, Calotropis procera, Chromolaena odorata* and *neem* at 2.5 and 5.0 per cent against *R. dominica* on rice grains at 28^0C temperature found all the treatments effective with significant reduction of number of adults emerging from the grains.

Patel *et al*. (1993) reported neem kernel powder at 5.0 per cent (w/w) DAT to be the most effective to reduce grain damage (2.55, 3.15 and 7.13%) due to *R. dominica* in the stored wheat over the untreated control (6.57, 13.60 and 24.71%), respectively, at 32, 64 and 96.

Fatope *et al*. (1995) evaluated various plant powders at 2.5, 5.0, 10.0 and 20.0 per cent (w/w) against maize weevil on wheat grains and found these as most effective to give better protection. Sharma (1995) reported neem kernel powder at 2 per cent (w/w) as the most effective against *S. oryzae* on maize seeds at 15 DAT.

Suss *et al*. (1997) tested the efficacy of neem at 0.5, 1.0 and 1.5 per cent as spray formulations against adults of *R.dominica, S. oryzae, T. castaneum* and *Lasioderma serricorne* on corrugated fiberboard in a 4-way olfactometer and found *neem* at 1.0 per cent as the most effective formulation with higher repellency of *S. oryzae* (76.1%) and *R. dominica* (66.3%). Nazli (1997) reported *neem* oil at 0.025, 0.05 or 0.10 per cent mixed with 2.5 ml acetone (v/w) effective to cause hindrance effect to the development of *R. dominica* and *S. oryzae* on wheat grains.

Singh and Kumar (1997) tested the efficacy of six various plant powders viz., *dharek* kernel powder, *dharek* leaf powder, neem kernel powder,neem leaf powder, *Datura* leaf powder *(Datura alba)* and *Ak* leaf powder *(Calotropisprocera)* at 2.5 and 5.0 per cent (w/w) against *R. dominica* on stored wheat and found *dharek* kernel powder at 5.0 per cent as the most effective as it registered lower adult emergence and grain damage, and higher insect mortality.

Imti and Zudir (1997) studied the efficacy of neem leaf powder and neem kernel powder at 1.0 per cent (w/w) and revealed both the powder formulations as highly effective against *S. oryzae* due to lees grain damage (12.34%) over the untreated grain samples (38.00%).

Kalasagond (1998) reported neem kernel powder at 0.8, 1.0, 1.2 and 1.4 per cent as effective to produce higher adult mortality in *S. oryzae* (25.00, 8.33, 8.33 and 6.66%), (43.33, 26.66, 25.00 and 8.33%), (51.66, 41.66, 35.00 and 10.00%) and (61.66, 53.33, 43.33 and 26.66%), respectively, over the untreated control (0.00, 0.00, 6.66 and 5.00%) at 60, 120, 180 and 240 DAT.

Longiswaran and Rahim (1998) revealed the ethanolic neem kernel extract as effective grain protectant against *R. dominica.* Rama Rao and Sarangi (1998) reported neemkernel powder at 5.0 per cent as most effective to cause 87.70 and 82.50 per cent adult mortality in *S. oryzae,* respectively, at 30 and 90 DAT.

Sharma (1999) reported neem kernel powder at 4.0 per cent (w/w) as highly effective based on good protection of maize grains from *S. oryzae* infestation for up to 150 DAT.

EL-Lakwah and EL-Kashlan (1999) reported neem'azal-wp powder (containing 10 % azadirachtin) at 50-1000 ppm as most effective to produce average mortality (32.2-100.0%) in *R. dominica* at 14 DAT. Yadu *et al*. (2000) in their studies on evaluation of *neem* kernel powder, *neem* leaf powder, eucalyptus leaf powder, sarifa leaf powder and lantana leaf powder at 1.0 and 2.0 per cent (w/w) for recording their adverse effects on the development of *S. cereaella* in stored maize and paddy, *neem* kernel powder was found to be the most effective as it registered less grain damage and adult emergence whereas lantana leaf powder was the least effective. They also observed no seed germination impaired in any of the powder treatment.

Sivasrinivasu (2001) reportedneem kernel powder at 5.0 per cent as effective to register cent percent adult mortality and no grain weight loss by *S. oryzae* in stored rice, respectively, at 7 and 90 DAT. Mahanti (2002) reported neemkernel powder at 0.2 per cent (w/w) as the highly effective to inflict cent percent mortality in *S. oryzae* on maize seed at 10 DAT.

Sunilkumar (2003) reported neem kernel powder at 1.0 per cent as the most effective to inflict low grain damage over the untreated control, respectively, at 30 and 60 DAT. Khan and Marwat (2003) tested the deterrent effects of leaf, seed and bark powder of neemand oleander *(Nerium oleander)* against *R. dominica* where neem leaves and seeds was found as best to register a highest per cent mortality in the insect.

Kumawat (2009) recorded no adult emergence, grain damage and weight loss due to *R. dominica* in the neem powder treated wheat grains for up to 90-270 DAT. He also recorded no adverse effect of neem powder on wheat seed germination for up

to 270 days. Ileke and Bulus (2012) reported the powders and extracts of neem and black pepper (*Piper guineense*) at 5.0, 10.0 and 20.0 per cent (w/w) as the most effective to cause cent percent mortality of *R. dominica* on wheat grains during storage within 4 DAT.

Kemabonta and Falodu (2013) revealed no significant difference in wheat seed germination in neem leaf powder and neem oil over the untreated control at 90 DAT. Arya and Tiwari (2013) revealed neem leaf powder, jatropha seed powder, mustard oil, cow dung powder, cow dung ash powder and cow urine at 2.0 per cent as the effective to produce highest mortality, low adult emergence, grain damage and weight loss in *S.oryzae* on stored wheat. They registered higher seed germination and vigour index in both the treatments.

Kakde *et al*. (2014) reported minimum adult emergence of *R. dominica* in wheat grains treated with neem leaf powder at 2.0 per cent (1.33 adults) followed by *dharek* leaf powder (2.33 adults). The grain damage and weight loss they reported was, respectively, as lowest in neem leaf powder at 2.0 per cent (1.00 and 1.33%) which was followed by *dharek* leaf powder (6.67 and 1.66%).

Mishra and Pandey (2014) reported neem leaf powder at 1.0 per cent (w/w) as the most effective against *S. oryzae* based on low grain damage (5.36, 8.43 and 16.02%) and weight loss (5.36, 7.87 and 13.13%) over the untreated control with high grain damage (9.20, 18.55 and 29.60%) and weight loss (8.72, 14.40 and 20.99%) in stored wheat, respectively, at 30, 60 and 90 DAT. They also recorded higher seed germination (87.50, 85.00 and 81.00%) in neem treated samples over the untreated control (92.00, 71.25 and 54.37%), respectively, at 30, 60 and 90 DAT.

2.8 Use of various plant oils against stored grain pests

The literature available on efficacy of various indigenous plant oils against various stored grain insect pests including *R. dominica* and *S. oryzae* has been discussed below:

Ambika Devi and Mohandas (1982) in their studies on assessment of relative efficacy of eleven antifeedants and deterrents against R. *dominica* and *S. cerealella* infestation in stored paddy found *neem* extract at 1.0 and 0.5 per cent, *neem* and coconut oils at 1.0 per cent as the highly effective to provide more protection against *R. dominica* for up to 180 DAT.

Pereira and Wohlgemuth (1982) reported *neem* oil at 1.0 per cent (v/w) as the highly effective grain protectant against stored grain insect pests like *R.dominica, S. oryzae, T. castaneum* and *C. chinensis.*Verma *et al*. (1983) found oils and cakes of *neem,* castor and mustard to be effective to reduce the fecundity, hatching and adult emergence in *Sitotroga cerealella* (Olivier). Their studies recorded no adverse of all the oil treatments on seed viability.

Ali *et al*. (1983) reported neem oil at 0.5 per cent on gram seed as most effective on the basis of reduced fecundity and adult emergence with 55.0 per cent adult mortality in *C. chinensis* within 3 DAT. The *neem* oil at 0.1 per cent caused effective repellent effect against *T. confusum* on stored corn (Akou-Edi 1984). The admixing of *neem* oil at 0.2 per cent admixed to the gram was reported to reduce adult emergence of *C. maculatus* when adults were introduced 33 DAT (Jadhav and Jadhav 1984).

Pandey *et al*. (1985) reported various oils viz., neem oil, neem kernel powder, *neem* cake, *neem* leaves, *neem* flowers and babul gum at 0.1, 1.0, 5.0, 1.0, 0.5 and 1.0 per cent (w/w or w/v) as effective against *C. cephalonica* in stored wheat based on reduced developmental period, survival period, fecundity and fertility of

the adults in the treated over the untreated control. They also reported no seed germination to be impaired in any of the plant products.

Mohiuddin *et al*. (1987) tested twelve vegetable oils for their toxic and repellent effects against *T. castaneum* and revealedneem oil at 0.25 per cent (v/w) as the highly effective to show highest repellent activity (80.1-100 %) for up to 60 DAT. Devakumar (1988) reported a neem oil fraction as the potent fumigant and sterilant against pulse beetle.

Babu *et al*. (1989) reported neem and karanj oils at 0.25, 0.5 and 1.0 per cent as the most effective ones to reduce the fecundity in *C. chinensis* on green gram seed during storage. Kumari *et al*. (1990) reported neemoil at 1.0 percent as the highly effective against *C. chinensis* based on reduced adult emergence and grain damage in pea seeds during storage for up to 90 DAT.

Agrawal (1990) tested the ovicidal activity of extracts neem and *Calophyllum inophyllum* by dipping eggs of *Myllocerus undecimpustulatus* in 1.0 per cent solution of each extracts for 10 seconds and recorded mortality (94.6%) in the *neem* extract as compared to the *C. inophyllum.*Ivbijaro (1990) reported that the *neem* oil applied to cowpea seeds at the rate of 0.2 and 0.3 per cent (v/w) was very effective to give 65-100 per cent mortality of *C. maculatus* at 3-5 DAT. They also recorded reduced oviposition from 60.75 to 49.50 eggs in the insect with neem oil treatment.

Singh and Mall (1991) found a significant reduction of adult emergence in *S. oryzae* with castor, neem, mustard and linseed oils at 0.1 per cent (v/w) on stored wheat. Choudhary (1992) evaluated different vegetable oils viz., groundnut *(Arachis hypogea),* sesamum (*Sesamum indicum*), linseed (*Linum usitatissimum*), soybean (*Glycine max*), neem*,* castor, safflower *(Carthmus tinctorius)* and coconut at 0.25, 0.50 and 1.0 per cent (v/w) for their efficacy against *C. chinensis* on stored chickpea and revealed neem*,* groundnut, castor and sesamum oils at 1.0 per

cent as most effective which registered a significant reduction in adult emergence of *C. chinensis*.

Gupta *et al*. (1992) evaluated various non-edible oils viz., *neem,* karanj *(Pongamia glabra*), mahua (*Bassia latifolia*), pilu (*Salvadora persica*), undi (*Calophyllum inophyllum*), palas *(Butea frondosa)* and dhupa *(Vateria indica)* at 0.25 and 0.50 per cent (v/w) against storage pests of wheat and found neem and palas at 0.50 per cent as the best to offer a better protection against pest infestation over the untreated control with no adverse effect on seed germination during storage.

Khaire *et al*. (1992) tested different vegetable oils viz., sunflower *(Helianthus annus),* castor *(Cocos nucifera),* mustard, safflower, palm, groundnut, sesame, *neem,* karanj oil (*Raphanus sativus*) on maize as effective grain protectants against *C. chinensis* on pigeon pea seeds and found karanj and *neem* oil as most effective with complete insect inhibition up to 100 DAT and castor oil with no adult emergence for up to 66 days. They also reported castor, mustard and groundnut oils at 1.0 per cent as the most effective based on lowest grain weight loss by the pests with no adverse effect of these treatments on the seed viability for up to 100 DAT.

Khatre *et al*. (1993) in their investigations showed that the treatments with *neem,* castor and karanj were highly effective as they registered significant repellent action on the adult fecundity of pulse beetle. Dey and Sarup (1993) reported mustard, soybean, coconut, *neem*, groundnut, sesame and castor oils as highly effective based on significant reduction in the average population of *S. oryzae* in stored maize grains. Ahmed (1994) reported that when the *neem* oil was admixed to the grains it created a uniform coating around the grains thereby giving protection against storage pests for 180-330 DAT.

Singh *et al.* (1994) evaluated sesame oil, sunflower oil, soybean oil, linseed oil, karanj oil, castor oil, coconut oil, groundnut oil, rice bran oil (*Oryza sativa*) and

taramira oil *(Eurca sativa)* at 0.1 and 0.3 per cent against *C. chinensis* in stored chick pea and found oils of taramira, coconut, sunflower and castor as most effective based on reduced oviposition. They also reported castor, mustard, soybean, groundnut, coconut, taramira and rice bran oils at 0.1 and 0.3 per cent, respectively, as effective to have reduced and no adult emergence.

Venugopal (1994) evaluated the effect of *neem* oil either in combination with carbaryl, monocrotophos or phosphamidon against *S. cerealella* on stored rice and recorded similar level of pre-harvest infestation as obtained either in carbaryl, monocrotophos and phosphamidon alone at economic cost. Saxena and Singh (1994) found significantly reduced adult longevity of *R. dominica* on stored wheat when treated with castor cake and mustard oil.

Pacheco *et al*. (1995) evaluated the oils of soybean and castor at 0.0, 0.5 and 1.0 per cent against *C. maculatus* and *C. phaseoli* in stored chick pea and found to low adult emergence, high inhibition rate and low overall development of these insects in castor oil as most effective due of the insects for up to 150 DAT over the untreated control. Their investigations revealed no harmful effect of any of the oil treatments on the seed germination.

Bhargava (1997) evaluated five plant extracts viz.,neem seed extract, neem oil, *undi extract* (C. inophyllum), *karanj extract* (P. glabra) *and lemongrass oil(Cymbopogan flexuosus)* at 0.1, 0.5 and 1.0 per cent (v/w) against *C. cephalonica* and revealed all of plant extract dosages effective against this insect based on its reduced fecundity and adult longevity and there was cent percent adult mortality in lemongrass oil. They also recorded varied levels of reduced egg viability (24.63 to 59.63%) in various plant extracts.

Reddy *et al*. (1999) applied four different plant oils viz.,neem, karanj, mohua and palmolein *(Elaeis guineensis)* at 0.5 and 1.0 per cent (v/w) against *C. chinensis* on green gram and found neem oil at 1.0 per cent as the most effective based on its

reduced oviposition rate and adult emergence followed by palmolein, karanj and mohua oils. These oils were also reported to cause a significant reduction in oviposition and adult emergence.

Sharma and Bhargava (2001) evaluated various plant extract concentrations viz., *neem,* karanj, undi and lemongrass at 0.25, 0.50, 1.0, 2.0, 3.0 and 5.0 per cent against the eggs of *C. cephalonica* and found a positive correlation of egg hatch inhibition with the extract concentrations and recorded LC50 values as 0.7079 ± 0.0581, 0.08954 ± 0.0566, 1.1041 ± 0.0597 and 1.4125 ± 0.0547, respectively, for the egg mortality in extracts of lemongrass oil, *neem* extract, karanj extract and undi.

Sundria *et al*. (2001) tested powders of six different plant products viz., ratanjot *(Euphorbia* spp.), garlic *(Allium sativa* Linnaeus), neem seed kernel suspension, *neem* kernel powder, neem leaf powder and black pepper (*Piper nigrum* Linnaeus) against *C. chinensis* on stored green gram and revealed black pepper seed powder as the best protectant based on no insect damage. It was followed by ratanjot and neem kernel powder and suspension at 2.0 per cent (w/w and v/w) over the untreated control with no adverse effect on the seed viability for up to 120 DAT.

Hassan (2001) in studies on the effect of three plant oils viz., sesame, sunflower and castor oils at 0.5, 1.0 and 1.5 per cent (v/w) on the oviposition, hatchability, eclosion and population of *T. granarium* and *S. granarius* on stored wheat and sorghum recorded reduced oviposition, egg hatchability and adult eclosion of *T.granarium* in all the oil concentrations with no significant effect on seed germination.

Abdallah *et al.* (2001) evaluated ten different vegetable oils viz., cotton seed, sesame, castor, sunflower, lettuce, olive, soybean, fenugreek, maize and black cumin at various concentrations as grain protectants in stored wheat and reported adverse effect of all these treatments on the larval and pupal stages of *R.*

*dominica*with its reduced progeny emergence. However, they observed no adverse effect of any oil treatment on the wheat seed germination for up to 120 DAT.

Bhargava and Meena (2002) tested oils of castor, mustard, groundnut, sesamum, coconut and sunflower at 1.0 per cent (v/w) against *C. chinensis* in stored cowpea and revealed castor oil at 1.0 per cent as the most effective based on reduced oviposition (26.6 eggs/female), egg viability (61.7%) and adult emergence (85.0%) followed by mustard and groundnut oils. They recorded no adverse effect of plant oils on the seed germination for up to 150 DAT.

Rahman *et al*. (2003) evaluated leaf powders and extracts of Nishinda *(Vitex negunda),* eucalyptus, Bankalmi *(Ipomoea* sp.), ash of *babla* wood *(Acacia arabica),* neemoil, sesame and safflower against *S. granarius* on stored wheat and revealed neem oil at 0.25per cent as most effective on the basis of reduced insect infestation, adult emergence, grain damage, weight loss and increased inhibition rate.

Wong *et al*. (2005) compared various plant products viz., citronella, garlic oil, *neem* extract, pine oil and pyrethrum for their repellent effects against stored insect pests and found all the products to give positive results. Yadav *et al*. (2008) evaluated different plant oils viz., neem, castor, karanj, lemongrass and eucalyptus oils at 0.1, 0.5 and 1.0 per cent (v/w) against *S. oryzae* in stored wheat and they reported neem, karanj, clove and lemongrass oils at 1.0 per cent as the most effective due to reduced fecundity, adult emergence, longevity, grain damage, weight loss and prolonged developmental period.

Lal and Raj (2012) in their studies revealed neem, eucalyptus, sunflower and castor oil at 0.1 and 0.3 per cent (v/w) as safest and most effective to minimize the incidence of *C. maculatus* on pigeon pea based on its reduced fecundity, adult emergence and delayed development. However, their investigations registered no adverse effect on seed germination for up to 120 DAT.

Kumawat and Naga (2013) reported low adult emergence of *R. dominica* in neem oil (4.7, 0.0 and 0.0 adults) followed by castor oil (7.3, 6.7 and 0.0 adults) and eucalyptus oil (13.3, 9.3 and 5.0 adults), respectively, at 0.1, 0.5 and 1.0 per cent over the untreated control (34.0%), low grain damage inneem oil (15.7, 9.3 and 0.0%) was followed by castor oil (23.3, 20.7 and 0.0 %) and eucalyptus oil (38.3, 18.0 and 9.7%) over the untreated control (86.0%), and weight loss in neem oil (4.9, 7.3 ,0.0%) followed by castor oil (7.3, 7.3, 0.0%) and eucalyptus oil (9.5, 5.0, 2.7%), respectively over untreated control (32.0%) at 90 DAT. They also observed no adverse effect of these plant oils on the seed viability for up to 270 DAT.

2.9 Chemical control

Kumar *et al*. (1982) found that application of malathion @ 0.15g./m2 gave satisfactory results in controlling *E. cautella* infestation. The effectiveness of malathion gradually decreased after 95-110 days after application.

Treatment of groundnut with malathion 36.4ppm gave effective control of Ephestia cautella and *T. castaneum* for over an year. Primphos methyl @ 22 ppm also gave good results in checking *E. cautella* infestation. However the residual effect of primphos methyl decreased at 33 per cent lesser than malathion(Redlinger, 1976).

Larvae of *P. inte tella, E. cautella, S. cereallella* rpunc were initially susceptible to all the insecticides, but mortality declined with time (120 days) exposure of adults of *T. castaneum* to malathion cause significantly lower mortality (Chakanyuka *et al*., 1990) observed the relative toxicants of nine insecticides to *Sitophius zeamais* and *T. castaneum* in maize. Among the nine insecticides primphos methyl, chloropyriphos, methyl fenitrothion and bendilarb were most effective, being persistant and active for 120days. Malathion, deltamethrin and alpha deltamethrin were effective upto 90 days only.

The organophosphorus insecticides malathion, fenitrothion, chlorpyriphos, primphos methyl and methacrifos, the synthetic pyrethroid insecticides (viz., bioresmethrin, deltamethrin, d- phenothrin, fenvalerate and permethrin) and the insect growth regulators (*viz*., methoprene, deflubenzuran and fenoxycarb) were assessed in the laboratory separately against adults and progeny of *T. castaneum*. Among them malathion had a low potency against both adults and progeny owing to its resistance to test insects. Primphos methyl prevented the development of progeny when applied at 25-50mg/kg, but had a low potency to adults (Daglish *et al*., 1992).

Vinuela *et al*. (1990) studied the effects of malathion and the insect growth regulator fenoxycarb at 2.5, 5.0, 10 ppm applied to the food on larvae of *T.castaneum.* They observed very low mortality in the field population at lowest dosages and cent per cent mortality at higher dosages in the laboratory.

Reddy and Chaitra (2004) reported there was no mortality in the susceptible strain at 30 days after the application 100, 150, and 250 mg ai malathion/m^2 Dichlorvas at all rates resulted in absolute mortality in the susceptible strain upto 60 days and in the resistant strain for upto 30 days.

The efficacy of malathion against adults as well as 1^{st}, 2^{nd} and 3^{rd} instar larvae of *T. castaneum* on wheat flour was studied under laboratory conditions. The LD50<sub>LD50 for the instars was 228.22, 78.13 and 183.01 ppm, respectively.The rate of mortality increased with increasing concentrations (Husain and Hasan 2006).

CHAPTER III

MATERIALS AND METHODS

The materials required for this experiment are given bellow:

3.1 Location

The different sets of experiments on stored grain groundnut were conducted in the laboratory of the Department of Entomology of Sher-e-Bangla Agricultural University, Dhaka - 1207, Bangladesh.

3.2 Duration

The experiment was conducted during the period from July 2017 to June, 2018.

3.3 Experimental material

Groundnut seeds were purchased from the Mohammadpur Krishi Market. Then kept in refrigerator at 0°C temperature for disinfection of the seeds.

3.4 Experimental treatment

The experiment consists of the following different treatments with different chemical and botanicals:

1. T_1 = Sevin powder 85 SP@0.5 g/200 g of groundnut
2. T_2= Red chili powder @1.0 g/200 g of groundnut
3. T_3= Neem powder @1.0 g/200 g of groundnut
4. T_4= Turmeric powder @1.0 g/200 g of groundnut
5. T_5= Coriander powder @1.0 g/200 g of groundnut
6. T_6= Control

3.5 Preparation of different treatments and application

3.5.1 Sevin powder 85 SP

Sevin powder 85 SP was collected from registered pesticide shop and mixed with the stored groundnut at the rate of 0.5 g/200 g of groundnut.

3.5.2 Red chili powder

Fresh dried red chilli was collected from the market. After bringing to the laboratory, it was cleaned and dried. Powder was prepared by a grinder machine. A25-mesh diameter sieve was used to obtain fine powder. It was applied at the rate of 1 g/200 g of groundnut.

3.5.3 Neem leaf powder

Fresh leaves of neemwere collected from the field area of SAU, Dhaka.After bringing to the laboratory, they were washed in running water and dried in shade. Dust was prepared by pulverizing the dried leaves in a magnetic stirrer. A25-mesh diameter sieve was used to obtain fine dust.It was applied at the rate of 1 g/200 g of groundnut.

3.5.4 Turmeric powder

Fresh dried turmeric was collected from the market.After bringing it to the laboratory, it was cleaned and dried. Powder was prepared by grinder and dried again. A25-mesh diameter sieve was used to obtain fine powder.It was applied at the rate of 1 g/200 g of groundnut.

3.5.5 Coriander powder

Dried coriander was collected from the market.After bringing it to the laboratory, it was cleaned and dried. Powder was prepared by grinder and dried again. A25-

mesh diameter sieve was used to obtain fine powder.It was applied at the rate of 1 g/200 g of groundnut.

3.6 Experimental design and layout

The experiment was laid out in the ambient condition of the laboratory following Complete Randomized Design (CRD) and the treatments was replicated four times for each.

3.7 Identification of insect

Two insect *viz*. Dried fruit beetle and Red flour beetle was identified as stored grain insect of groundnut during the study period.

3.8 Assessment of different treatments against insect

The effects of different treatments as grain protectant against Dried fruit beetle and Red flour beetle evaluated considering adult mortality, adult emergence, number ofdamaged seeds, grain weight loss etc. from treated and untreated grains of groundnut. Data were collected on the following parameters:

3.8.1 Incidence of insect

At different days after storage, incidence of different stored insect by number was counted.

3.8.2Observation on damage

Different observation was done at different days after storage. At each observation, the numbers of damaged and healthy seeds were counted. Grains with hole were considered as damaged or infested seeds. To determine the percentage of damaged groundnut seeds, number of seeds having hole and normal seeds were

counted per Petri dish or replicate andpercentage of healthy, infested or damaged seeds were calculated by using the following formula-

$$\% \text{ Infested/damaged seeds (No.)} = \frac{\text{No. of infested or damaged seeds}}{\text{Total number of seeds}} \times 100$$

$$\% \text{ Healthy seeds (No.)} = \frac{\text{Number of infested seeds}}{\text{Total number of seeds}} \times 100$$

3.9 Statistically analysis

The data obtained from the experiments were statistically analyzed on one factor CRD with help of computer-based program MSTAT-C software. The meanswas separated to determine the level of significance following Duncan's MultipleRange Test (DMRT) and Least Significance Difference (LSD) wherever necessary at 5% level of probability.

Fig. 1. Collection of Processed Stored Groundnut Samples

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the succession of stored ground nut pests and their management. Regarding this situation, different chemicals and botanical were used to control stored ground nut insect pest.The results have been presented and discussed, and possible interpretations were given below under the following headings:

4.1 Incidence of insect pest

Two species of insect pests were found to infest the stored groundnut at storage condition in the Laboratory of Sher-e-Bangla Agricultural University, Dhaka.

Two insect pests namely red flour beetle (*Tribolium castaneum*) and dried fruit beetle (*Carpophilus hemipterus*) were found to attack groundnut seed in storage.Of which dried fruit started infestation first.

The succession of both dried fruit beetle and red flour beetle started at 1th week of Augustand it continued about the whole year. (Fig.2).

Duration	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
	Days After Storage											
Insects	30	60	90	120	150	180	210	240	270	300	330	360
Dried Fruit Beetle												
Red Flour Beetle												

Fig.2. Succession of insect pests in stored groundnut seed.

4.2 Incidence and management of insect pest at 30 days after storage with different treatments

4.2.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 30 DAS in stored ground nut (Table 1). At 30 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (0.50) where the treatment T_5 showed 0.25 dried fruit beetle (by number). The rest of the treatments, T_1, T_2, T_3 and T_4 showed best performance against insect pest and no incidence of insect pest was found at 30 DAS. Similarly in terms of red flour beetle, there was no incidence was found among the treatments except control (T_6) and this treatment showed 0.25 red flour beetle in number at 30 DAS and rest of the treatments, T_1, T_2, T_3, T_4 and T_5 was 100% effective against red flour beetle at 30 DAS.

4.2.2 Healthy and infested seeds

At 30 DAS, 100% healthy seeds were found from the treatment T_1, T_2, T_3 and T_4 where treatment T_5 showed 98.75% healthy seeds. The lowest % healthy seeds (97.50%) were found from control treatment (T_6). Similarly, the lowest infested seed was observed from the treatments, T_1, T_2, T_3 and T_4 where the highest seed infestation was found from control (T_6) and the treatment T_5 showed 2.50% infested seeds.

4.2.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 30 DAS, treatment T_1, T_2, T_3 and T_4 showed 100% reduction of dried fruit beetle over control where treatment T_5 showed 50% reduction of dried fruit beetle over control. Similarly, all the treatments (except control), showed 100% reduction of red flour beetle over control.

4.2.4 Percent reduction of infestation over control

At 30 DAS, treatment T_1, T_2, T_3 and T_4 showed 100% reduction of infestation over control where treatment T_5 showed 50% reduction of infestation over control.

Table 1. Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 30 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 c	0.00 b	100.00 a	0.00 c	100.00	100.00	100.00
T_2	0.00 c	0.00 b	100.00 a	0.00 c	100.00	100.00	100.00
T_3	0.00 c	0.00 b	100.00 a	0.00 c	100.00	100.00	100.00
T_4	0.00 c	0.00 b	100.00 a	0.00 c	100.00	100.00	100.00
T_5	0.25 b	0.00 b	98.75 b	1.25 b	50.00	100.00	50.00
T_6	0.50 a	0.25 a	97.50 b	2.50 a	--	--	--
$LSD_{0.05}$	0.14	0.12	0.48	0.23	--	--	--
CV(%)	3.36	2.53	3.68	3.11	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5g/200g of ground nut

T_2= Red chili powder @1.0 g/200g of ground nut

T_3= Neem powder @1.0 g/200g of ground nut

T_4= Turmeric powder @1.0 g/200g of ground nut

T_5= Coriander powder @1.0 g/200g of ground nut

T_6= Untreated Control

4.3 Incidence and management of insect pest at 45 days after storage with different treatments

4.3.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 45 DAS in stored ground nut (Table 2). At 45 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (0.50) where the treatment T_5 showed 0.25 dried fruit beetle (by number). The rest of the treatments, T_1, T_2, T_3 and T_4 showed best performance against insect pest and no incidence of insect pest was found at 45 DAS. Similarly in terms of red flour beetle, there was no incidence was found among the treatments except control (T_6) and this treatment showed 0.75 red flour beetle where T_5 showed 0.25 red flour beetle in number at 45 DAS and rest of the treatments, T_1, T_2 and T_3, T_4 was 100% effective against red flour beetle at 45 DAS.

4.3.2 Healthy and infested seeds

At 45 DAS, 100% healthy seeds were found from the treatment T_1, T_2, T_3 and T_4 where treatment T_5 showed 98.75% healthy seeds. The lowest % healthy seeds (95%) were found from control treatment (T_6). Similarly, the lowest infested seed was observed from the treatments, T_1, T_2, T_3 and T_4 where the highest seed infestation was found from control (T_6) and the treatment T_5 showed 2.50% infested seeds.

4.3.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 45 DAS, treatment T_1, T_2, T_3 and T_4 showed 100% reduction of dried fruit beetle over control where treatment T_5 showed 50% reduction of dried fruit beetle over control. Similarly, treatments, T_1, T_3 and T_4 showed 100% reduction of red flour beetle over control where the treatment T_2 and T_5 showed 66.67 and 66.67% reduction of flour beetle over control, respectively.

Table 2.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 45 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 c	0.00 c	100.00 a	0.00 c	100.00	100.00	100.00
T_2	0.00 c	0.25 c	100.00 a	0.00 c	100.00	66.67	100.00
T_3	0.00 c	0.00 c	100.00 a	0.00 c	100.00	100.00	100.00
T_4	0.00 c	0.00 c	100.00 a	0.00 c	100.00	100.00	100.00
T_5	0.25 b	0.25 b	98.75 b	1.25 b	50.00	66.67	75.00
T_6	0.50 a	0.75 a	95.00 c	5.00 a	--	--	--
$LSD_{0.05}$	0.13	0.14	0.43	0.52	--	--	--
CV(%)	2.54	2.87	3.11	1.61	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.3.4 Percent reduction of infestation over control

At 45 DAS, treatment T_1, T_2, T_3 and T_4 showed 100% reduction of infestation over control where treatment T_5 showed 75% reduction of infestation over control.

4.4 Incidence and management of insect pest at 60 days after storage with different treatments

4.4.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 60 DAS in stored ground nut (Table 3). At 60 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (7.50) where the treatment T_2, T_3, T_4 and T_5 showed 0.1.75, 0.75, 1.25 and 2.50 dried fruit beetle (by number), respectively. The rest of the treatments, T_1 best performance against insect pest and no incidence of insect pest was found at 60 DAS. Similarly in terms of red flour beetle, there was no incidence was found in T_3 and T_4 where T_2, T_5 and T_6 gave 0.25, 0.25 and 0.75 red flour beetle in number, respectively at 60 DAS and the treatments, T_1 was 100% effective against red flour beetle at 60 DAS.

4.4.2 Healthy and infested seeds

At 60 DAS, 100% healthy seeds were found from the treatment T_1, T_2, T_3 and T_4 where treatment T_5 showed 95% healthy seeds. The lowest % healthy seeds (93.75%) were found from control treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, T_2, T_3 and T_4 where T_5 showed 5% infested seeds and the highest seed infestation (6.25%) was found from control treatment (T_6).

Table 3.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 60 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 c	100.00 a	0.00 c	100.00	100.00	100.00
T_2	1.75 c	0.25 b	100.00 a	0.00 c	76.67	66.67	100.00
T_3	0.75 e	0.00 c	100.00 a	0.00 c	90.00	100.00	100.00
T_4	1.25 d	0.00 c	100.00 a	0.00 c	83.33	100.00	100.00
T_5	2.50 b	0.25 b	95.00 b	5.00 b	66.67	66.67	20.00
T_6	7.50 a	0.75 a	93.75 c	6.25 a	--	--	--
$LSD_{0.05}$	0.21	0.14	0.75	0.48	--	--	--
CV(%)	3.17	2.52	3.87	2.87	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.4.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 60 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 76.67, 90, 83.33 and 66.67% reduction of dried fruit beetle over control, respectively. Similarly, T_1, T_3 and T_4 showed 100% reduction of red flour beetle over control and $T_2$and T_5 showed 66.67 and 66.67% reduction of red flour beetle over control, respectively.

4.4.4 Percent reduction of infestation over control

At 60 DAS, treatment T_1, T_2, T_3 and T_4 showed 100% reduction of infestation over control where treatment T_5 showed 20% reduction of infestation over control.

4.5 Incidence and management of insect pest at 75 days after storage with different treatments

4.5.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 75 DAS in stored ground nut (Table 4). At 75 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (10.00) where the treatment T_2, T_3, T_4 and T_5 showed 3.50, 1.75, 3.00 and 6.50 dried fruit beetle (by number), respectively. The rest of the treatments, T_1 best performance against insect pest and no incidence of insect pest was found at 75 DAS. Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 and T_6 gave 0.75, 0.25, 0.25, 0.50 and 1.75 red flour beetle in number, respectively at 75 DAS where T_6 gave the highest incidence of red flour beetle.

4.5.2 Healthy and infested seeds

At 75 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 98.75, 98.75, 95.00 and d95.00% healthy seeds, respectively. The lowest % healthy seeds (90%) were found from control

treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 1.5, 1.25, 5.00 and 5.00% infested seeds, respectively and the highest seed infestation (10.00%) was found from control treatment (T_6).

4.5.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 75 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 65.00, 82.50, 70 and 35.00% reduction of dried fruit beetle over control, respectively. Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 57.14, 85.71, 85.71 and 71.43% reduction of red flour beetle over control, respectively.

4.5.4 Percent reduction of infestation over control

At 75 DAS, treatment T_1 showed 100% reduction of infestation over control where treatment T_2, T_3,$T_4$and T_5 showed 87.50, 87.50, 50.00 and 50.00% reduction of infestation over control.

Table 4.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 75 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 d	100.00 a	0.00 d	100.00	100.00	100.00
T_2	3.50 c	0.75 c	98.75 b	1.25 c	65.00	57.14	87.50
T_3	1.75 e	0.25 c	98.75 b	1.25 c	82.50	85.71	87.50
T_4	3.00 d	0.25 c	95.00 c	5.00 b	70.00	85.71	50.00
T_5	6.50 b	0.50 b	95.00 c	5.00 b	35.00	71.43	50.00
T_6	10.00 a	1.75 a	90.00 d	10.00 a	--	--	--
$LSD_{0.05}$	0.25	0.20	1.04	0.82	--	--	--
CV(%)	2.71	3.19	4.70	3.79	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.6 Incidence and management of insect pest at 90 days after storage with different treatments

4.6.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 90 DAS in stored ground nut (Table 5). At 90 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (14.00) where the treatment T_2, T_3, T_4 and T_5 showed 4.75, 3.75, 4.25 and 6.75 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 90 DAS. Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 and T_6 gave 0.50, 0.25, 0.75, 1.25 and 1.75 red flour beetle in number, respectively at 90 DAS where T_6 gave the highest incidence of red flour beetle.

4.6.2 Healthy and infested seeds

At 90 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 98.75, 98.75, 95.00 and 95.00% healthy seeds, respectively. The lowest % healthy seeds (90%) were found from control treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 2.50, 1.25, 5.00 and 6.25% infested seeds, respectively and the highest seed infestation (10.00%) was found from control treatment (T_6).

4.6.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 90 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 66.07, 73.21, 69.640 and 51.79% reduction of dried fruit beetle over control, respectively. Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 71.43, 85.71, 57.14 and 28.57% reduction of red flour beetle over control, respectively.

Table 5.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 90 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	0.00 f	100.00 a	0.00 f	100.00	100.00	100.00
T_2	4.75 c	0.50 d	97.50 c	2.50 d	66.07	71.43	75.00
T_3	3.75 d	0.25 e	98.75 b	1.25 e	73.21	85.71	87.50
T_4	4.25 c	0.75 c	95.00 d	5.00 c	69.64	57.14	50.00
T_5	6.75 b	1.25 b	93.75 e	6.25 b	51.79	28.57	37.50
T_6	14.00 a	1.75 a	90.00 f	10.00 a	--	--	--
$LSD_{0.05}$	0.52	0.17	1.07	0.75	--	--	--
CV(%)	3.75	2.84	4.71	3.62	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.6.4 Percent reduction of infestation over control

At 90 DAS, treatment T_1 showed 100% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (37.50%).

4.7 Incidence and management of insect pest at 105 days after storage with different treatments

4.7.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 105 DAS in stored ground nut (Table 6). At 105 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (14.00) where the treatment T_2, T_3, T_4 and T_5 showed 6.00, 5.75, 6.00 and 10.25 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 105 DAS. Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5, gave 00.75, 0.25, 1.75, and 1.25 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (2.50) at 105 DAS.

4.7.2 Healthy and infested seeds

At 105 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 95, 97.50, 95.00 and 93.75% healthy seeds, respectively. The lowest % healthy seeds (85%) were found from control treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 5.00, 2.50, 5.00 and 6.25% infested seeds, respectively and the highest seed infestation (15%) was found from control treatment (T_6).

Table 6.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 105 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	0.00 e	100.00 a	0.00 e	100.00	100.00	100.00
T_2	6.00 c	0.75 c	95.00 c	5.00 c	66.20	70.00	66.67
T_3	5.75 d	0.25 d	97.50 b	2.50 d	67.61	90.00	83.33
T_4	6.00 c	0.75 c	95.00 c	5.00 c	66.20	70.00	66.67
T_5	10.25 b	1.25 b	93.75 d	6.25 b	42.25	50.00	58.33
T_6	17.75 a	2.50 a	85.00 e	15.00 a	--	--	--
$LSD_{0.05}$	0.74	0.24	1.10	0.26	--	--	--
CV(%)	3.85	3.41	4.03	3.71	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.7.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 105 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 66.20, 67.61, 66.20 and 42.25% reduction of dried fruit beetle over control, respectively. Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 70, 90, 70 and 50% reduction of red flour beetle over control, respectively.

4.7.4 Percent reduction of infestation over control

At 90 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3 which showed 83.33% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (37.50%).

4.8 Incidence and management of insect pest at 120 days after storage with different treatments

4.8.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 120 DAS in stored ground nut (Table 7). At 120 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (19.50) where the treatment T_2, T_3, T_4 and T_5 showed 7.00, 6.75, 8.50 and 12.75 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 120 DAS. Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 0.75, 0.25, 0.75 and 1.25 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (2.50) at 120 DAS.

4.8.2 Healthy and infested seeds

At 120 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 94.25, 96.25, 93.75 and 92.50% healthy seeds, respectively. The lowest % healthy seeds (80%) were found from control treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 5.75, 3.75, 6.25 and 7.50% infested seeds, respectively. The highest seed infestation (20%) was found from control treatment (T_6).

4.8.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 120 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 64.10, 65.38, 56.41 and 34.62% reduction of dried fruit beetle over control, respectively. Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 70, 90, 70 and 50% reduction of red flour beetle over control, respectively.

4.8.4 Percent reduction of infestation over control

At 120 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3 which showed 81.25% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (62.50%).

Table 7.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 120 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00	0.00 d	100.00 a	0.00 d	100.00	100.00	100.00
T_2	7.00 c	0.75 b	94.25 c	5.75 b	64.10	70.00	71.25
T_3	6.75 c	0.25 c	96.25 b	3.75 c	65.38	90.00	81.25
T_4	8.50 c	0.75 b	93.75 c	6.25 b	56.41	70.00	68.75
T_5	12.75 b	1.25 a	92.50 c	7.50 b	34.62	50.00	62.50
T_6	19.50 a	2.50 a	80.00	20.00 a	--	--	--
$LSD_{0.05}$	3.01	0.26	1.83	1.80	--	--	--
CV(%)	6.12	3.11	5.79	4.79	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.9 Incidence and management of insect pest at 135 days after storage with different treatments

4.9.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 135 DAS in stored ground nut (Table 8). At 135 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (44.50) where the treatment T_2, T_3, T_4 and T_5 showed 31.00, 7.50, 18.50 and 36.25 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 135 DAS. Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 0.75, 0.25, 1.25 and 1.50 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (3.00) at 135 DAS.

4.9.2 Healthy and infested seeds

At 135 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 90, 93.75, 91.25 and 88.75% healthy seeds, respectively. The lowest % healthy seeds (78.75%) were found from control treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 10., 6.258.75 and 11.25% infested seeds, respectively. The highest seed infestation (21.25%) was found from control treatment (T_6).

4.9.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 135 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 30.34, 83.15, 58.43 and 18.54% reduction of dried fruit beetle over control, respectively. Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 75, 91.67, 58.33 and 50% reduction of red flour beetle over control, respectively.

Table 8.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 135 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 e	100.00 a	0.00 e	100.00	100.00	100.00
T_2	31.00 c	0.75 c	90.00 b	10.00 b	30.34	75.00	52.94
T_3	7.50 e	0.25 d	93.75 c	6.25 d	83.15	91.67	70.59
T_4	18.50 d	1.25 b	91.25 c	8.75 c	58.43	58.33	58.82
T_5	36.25 b	1.50 b	88.75 d	11.25 b	18.54	50.00	47.06
T_6	44.50 a	3.00 a	78.75 e	21.25 a	--	--	--
$LSD_{0.05}$	1.36	0.28	1.85	1.31	--	--	--
CV(%)	6.28	2.75	5.38	5.37	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.9.4 Percent reduction of infestation over control

At 135 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3, which showed 81.25% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (47.06%).

4.10 Incidence and management of insect pest at 150 days after storage with different treatments

4.10.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 150 DAS in stored ground nut (Table 9). At 150 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (47.00) where the treatment T_2, T_3, T_4 and T_5 showed 33.25, 8.25, 20.00 and 39.75 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 150 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 0.75, 0.25, 1.75 and 1.50 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (3.25) at 135 DAS.

4.10.2 Healthy and infested seeds

At 150 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 89, 93, 90.25 and 87% healthy seeds, respectively. The lowest % healthy seeds (78.25%) were found from control treatment (T_6). Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 11.00, 7.00, 9.75 and 13.00% infested seeds, respectively. The highest seed infestation (21.75%) was found from control treatment (T_6).

Table 9.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 150 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 e	100.00 a	0.00 f	100.00	100.00	100.00
T_2	33.25 c	0.75 c	89.00 c	11.00 c	29.26	76.92	49.43
T_3	8.25 e	0.25 d	93.00 b	7.00 d	82.45	92.31	67.82
T_4	20.00 d	1.75 b	90.25 c	9.75 e	57.45	46.15	55.17
T_5	39.75 b	1.50 b	87.00 d	13.00 b	15.43	53.85	40.23
T_6	47.00 a	3.25 a	78.25 e	21.75 a	--	--	--
$LSD_{0.05}$	2.07	0.26	1.38	1.05	--	--	--
CV(%)	4.84	2.79	5.38	4.78	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.10.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 150 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 29.26, 82.45, 57.45 and 15.43% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 76.92, 92.31, 46.15 and 53.85% reduction of red flour beetle over control, respectively.

4.10.4 Percent reduction of infestation over control

At 150 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 67.82% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (40.23%).

4.11 Incidence and management of insect pest at 165 days after storage with different treatments

4.11.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 165 DAS in stored ground nut (Table 10).

At 165 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (48.75) where the treatment T_2, T_3, T_4 and T_5 showed 34.00, 8.50, 22.00 and 42.25 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 165 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 1.00, 0.50, 2.50 and 2.00 red flour beetle in number,

respectively where T_6 gave the highest incidence of red flour beetle (3.50) at 165 DAS.

4.11.2 Healthy and infested seeds

At 165 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 86.25, 88.75, 87.75 and 85.75% healthy seeds, respectively. The lowest % healthy seeds (75.00%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 13.75, 11.25, 12.25 and 14.25% infested seeds, respectively. The highest seed infestation (25.00%) was found from control treatment (T_6).

4.11.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 165 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 30.26, 82.56, 54.87 and 13.33% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 71.43, 85.71, 28.57 and 42.86% reduction of red flour beetle over control, respectively.

4.11.4 Percent reduction of infestation over control

At 165 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 55.00% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (43.00%).

Table 10.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 165 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 f	100.00 a	0.00 d	100.00	100.00	100.00
T_2	34.00 c	1.00 d	86.25 b	13.75 b	30.26	71.43	45.00
T_3	8.50 e	0.50 e	88.75 b	11.25 c	82.56	85.71	55.00
T_4	22.00 d	2.50 b	87.75 b	12.25 c	54.87	28.57	51.00
T_5	42.25 b	2.00 c	85.75 b	14.25 b	13.33	42.86	43.00
T_6	48.75 a	3.50 a	75.00 c	25.00 a	--	--	--
$LSD_{0.05}$	1.85	0.25	3.07	1.02	--	--	--
CV(%)	4.87	2.07	6.89	4.07	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.12 Incidence and management of insect pest at 180 days after storage with different treatments

4.12.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 180 DAS in stored ground nut (Table 11).

At 180 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (57.00) where the treatment T_2, T_3, T_4 and T_5 showed 39, 28.25, 30.50 and 54.75 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 180 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 1.25, 0.50, 2.75 and 2.25 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (3.75) at 180 DAS.

4.12.2 Healthy and infested seeds

At 180 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 82.75, 86.25, 85.00 and 83.75% healthy seeds, respectively. The lowest % healthy seeds (72.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 17.25, 13.75, 15.00 and 16.25% infested seeds, respectively. The highest seed infestation (27.50%) was found from control treatment (T_6).

Table 11.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 180 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 d	0.00	100.00 a	0.00 d	100.00	100.00	100.00
T_2	39.00 c	1.25 c	82.75 c	17.25 b	32.17	66.67	37.27
T_3	28.25 b	0.50 d	86.25 b	13.75 c	50.87	86.67	50.00
T_4	30.50 b	2.75 b	85.00 b	15.00 b	46.96	26.67	45.45
T_5	54.75 a	2.25 b	83.75 c	16.25 b	4.78	40.00	40.91
T_6	57.50 a	3.75 a	72.50 d	27.50 a	--	--	--
$LSD_{0.05}$	3.52	0.28	1.52	2.26	--	--	--
CV(%)	6.14	2.89	5.38	4.28	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.12.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 180 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 32.17, 50.87, 46.96 and 4.78% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 66.67, 86.67, 26.67 and 40% reduction of red flour beetle over control, respectively.

4.12.4 Percent reduction of infestation over control

At 180 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 50% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (40.91%).

4.13 Incidence and management of insect pest at 195 days after storage with different treatments

4.13.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 195 DAS in stored ground nut (Table 12).

At 195 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (61.50) where the treatment T_2, T_3, T_4 and T_5 showed 46, 42, 47 and 59.75 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 195 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 1.50, 0.75, 2.75 and 2.50 red flour beetle in number,

respectively where T_6 gave the highest incidence of red flour beetle (3.75) at 195 DAS.

4.13.2 Healthy and infested seeds

At 195 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 77.50, 82.50, 77.50 and 75% healthy seeds, respectively. The lowest % healthy seeds (72.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 22.50, 17.50, 22.50 and 25% infested seeds, respectively. The highest seed infestation (27.50%) was found from control treatment (T_6).

4.13.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 195 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 25.20, 31.71, 23.58 and 2.85% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 60, 80, 26.67 and 33.33% reduction of red flour beetle over control, respectively.

4.13.4 Percent reduction of infestation over control

At 195 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 36.36% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (9.09%).

Table 12.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 195 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 d	0.00 e	100.00 a	0.00 d	100.00	100.00	100.00
T_2	46.00 b	1.50 c	77.50 c	22.50 b	25.20	60.00	18.18
T_3	42.00 c	0.75 d	82.50 b	17.50 c	31.71	80.00	36.36
T_4	47.00 b	2.75 b	77.50 c	22.50 b	23.58	26.67	18.18
T_5	59.75 a	2.50 b	75.00 d	25.00 a	2.85	33.33	9.09
T_6	61.50 a	3.75 a	72.50 e	27.50 a	--	--	--
$LSD_{0.05}$	2.53	0.36	2.55	2.53	--	--	--
CV(%)	5.75	3.57	5.87	4.93	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.14 Incidence and management of insect pest at 210 days after storage with different treatments

4.14.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 210 DAS in stored ground nut (Table 13).

At 210 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (83.50) where the treatment T_2, T_3, T_4 and T_5 showed 69.50, 48.50, 72.50 and 82.00 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 210 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 1.75, 0.75, 3.00 and 2.75 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (4.00) at 210 DAS.

4.14.2 Healthy and infested seeds

At 210 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 75, 80, 70 and 63.75% healthy seeds, respectively. The lowest % healthy seeds (57.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, but T_2, T_3,$T_4$and T_5 showed 25, 20, 30 and 36.25% infested seeds, respectively. The highest seed infestation (42.50%) was found from control treatment (T_6).

Table 13.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 210 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 d	0.00 e	100.00 a	0.00 f	100.00	100.00	100.00
T_2	69.50 b	1.75 c	75.00 c	25.00 d	16.77	56.25	41.18
T_3	48.50 c	0.75 d	80.00 b	20.00 e	41.92	81.25	52.94
T_4	72.50 b	3.00 b	70.00 d	30.00 c	13.17	25.00	29.41
T_5	82.00 a	2.75 b	63.75 e	36.25 b	1.80	31.25	14.71
T_6	83.50 a	4.00 a	57.50 f	42.50 a	--	--	--
$LSD_{0.05}$	3.21	0.33	3.52	2.83	--	--	--
CV(%)	6.35	3.21	6.37	4.63	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

TT_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.14.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 210 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 16.77, 41.92, 13.17 and 1.80% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 56.25, 81.25, 25 and 31.25% reduction of red flour beetle over control, respectively.

4.14.4 Percent reduction of infestation over control

At 210 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 52.94% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (14.71%).

4.15 Incidence and management of insect pest at 225 days after storage with different treatments

4.15.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 225 DAS in stored ground nut (Table 14).

At 225 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (92.25) where the treatment T_2, T_3, T_4 and T_5 showed 75.75, 51.25, 78.25 and 87.25 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 225 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 3.25, 1.25, 2.00 and 3.25 red flour beetle in number,

respectively where T_6 gave the highest incidence of red flour beetle (4.25) at 225 DAS.

4.15.2 Healthy and infested seeds

At 225 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 66.25, 72.50, 66.00 and 60.75% healthy seeds, respectively. The lowest % healthy seeds (52.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 33.75, 27.50, 34.00 and 39.25% infested seeds, respectively. The highest seed infestation (47.50%) was found from control treatment (T_6).

4.15.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 225 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 17.89, 44.44, 15.18 and 5.42% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 23.53, 70.59, 52.94 and 23.53% reduction of red flour beetle over control, respectively.

4.15.4 Percent reduction of infestation over control

At 225 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 42.11% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (17.37%).

Table 14.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 225 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	0.00 e	100.00 a	0.00 e	100.00	100.00	100.00
T_2	75.75 c	3.25 b	66.25 c	33.75 c	17.89	23.53	28.95
T_3	51.25 d	1.25 d	72.50 b	27.50 d	44.44	70.59	42.11
T_4	78.25 c	2.00 c	66.00 c	34.00 c	15.18	52.94	28.42
T_5	87.25 b	3.25 b	60.75 d	39.25 b	5.42	23.53	17.37
T_6	92.25 a	4.25 a	52.50 e	47.50 a	--	--	--
$LSD_{0.05}$	3.41	0.53	3.01	2.17	--	--	--
CV(%)	5.93	4.04	5.31	2.70	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.16 Incidence and management of insect pest at 240 days after storage with different treatments

4.16.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 240 DAS in stored ground nut (Table 15).

At 240 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (103.50) where the treatment T_2, T_3, T_4 and T_5 showed 91.25, 62.75, 95.25 and 101 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 240 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 3.50, 1.75, 3.75 and 2.75 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (4.50) at 240 DAS.

4.16.2 Healthy and infested seeds

At 240 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 61.25, 65.00, 58.75 and 52.50% healthy seeds, respectively. The lowest % healthy seeds (46.25%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 11.84, 39.37, 7.97 and 2.42% infested seeds, respectively. The highest seed infestation (53.75%) was found from control treatment (T_6).

Table 15.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 240 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	0.00 e	100.00 a	0.00 f	100.00	100.00	100.00
T_2	91.25 c	3.50 b	61.25 c	38.75 d	11.84	22.22	27.91
T_3	62.75 d	1.75 d	65.00 b	35.00 e	39.37	61.11	34.88
T_4	95.25 b	3.75 b	58.75 d	41.25 c	7.97	16.67	23.26
T_5	101.00 a	2.75 c	52.50 e	47.50 b	2.42	38.89	11.63
T_6	103.50 a	4.50 a	46.25 f	53.75 a	--	--	--
$LSD_{0.05}$	3.04	0.53	2.03	1.36	--	--	--
CV(%)	5.21	2.31	4.36	4.41	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.16.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 240 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 11.84, 39.37, 7.97 and 2.42% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 22.22, 61.11, 16.67 and 38.89% reduction of red flour beetle over control, respectively.

4.16.4 Percent reduction of infestation over control

At 240 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3, which showed 34.88% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (11.63%).

4.17 Incidence and management of insect pest at 255 days after storage with different treatments

4.17.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 255 DAS in stored ground nut (Table 16).

At 255 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (119.25) where the treatment T_2, T_3, T_4 and T_5 showed 101, 74.50, 107.25 and 114 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 255 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 4.25, 2.00, 4.25 and 2.75 red flour beetle in number,

respectively where T_6 gave the highest incidence of red flour beetle (4.75) at 255 DAS.

4.17.2 Healthy and infested seeds

At 255 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 57.50, 60, 55 and 47% healthy seeds, respectively. The lowest % healthy seeds (42.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 42.50, 40, 45 and 52.50% infested seeds, respectively. The highest seed infestation (57.50%) was found from control treatment (T_6).

4.17.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 255 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 15.30, 37.53, 10.06 and 4.40% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 10.53, 57.89, 10.53 and 42.11% reduction of red flour beetle over control, respectively.

4.17.4 Percent reduction of infestation over control

At 255 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 30.43% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (8.70%).

Table 16.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 255 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 e	100.00 a	0.00 f	100.00	100.00	100.00
T_2	101.00 d	4.25 b	57.50 c	42.50 d	15.30	10.53	26.09
T_3	74.50 e	2.00 d	60.00 b	40.00 e	37.53	57.89	30.43
T_4	107.25 c	4.25 b	55.00 d	45.00 c	10.06	10.53	21.74
T_5	114.00 b	2.75 c	47.50 e	52.50 b	4.40	42.11	8.70
T_6	119.25 a	4.75 a	42.50 f	57.50 a	--	--	--
$LSD_{0.05}$	3.74	0.36	2.04	1.75	--	--	--
CV(%)	5.85	3.24	5.03	4.27	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.18 Incidence and management of insect pest at 270 days after storage with different treatments

4.18.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 255 DAS in stored ground nut (Table 17).

At 255 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (161) where the treatment T_2, T_3, T_4 and T_5 showed 124.25, 122.25, 140.50 and 142.25 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 255 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 5.00, 3.25, 3.52 and 4.50 red flour beetle in number, respectively where T_6 gave the highest incidence of red flour beetle (5.25) at 255 DAS.

4.18.2 Healthy and infested seeds

At 255 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 50, 50, 48.75 and 40% healthy seeds, respectively. The lowest % healthy seeds (26.25%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 50, 50, 51.25 and 60% infested seeds, respectively. The highest seed infestation (73.75%) was found from control treatment (T_6).

Table 17.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 270 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 d	0.00 d	100.00 a	0.00 d	100.00	100.00	100.00
T_2	124.25 c	5.00 a	50.00 b	50.00 c	22.83	4.76	32.20
T_3	122.25 c	3.25 c	50.00 b	50.00 c	24.07	38.10	32.20
T_4	140.50 b	3.50 c	48.75 b	51.25 c	12.73	33.33	30.51
T_5	142.25 b	4.50 b	40.00 c	60.00 b	11.65	14.29	18.64
T_6	161.00 a	5.25 a	26.25 d	73.75 a	--	--	--
$LSD_{0.05}$	3.11	0.33	2.61	2.31	--	--	--
CV(%)	6.03	3.85	4.97	4.81	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

TT_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.18.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 255 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 22.83, 24.07, 12.73 and 11.65% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 4.76, 38.10, 33.33 and 14.29% reduction of red flour beetle over control, respectively.

4.18.4 Percent reduction of infestation over control

At 255 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3, which showed 32.20% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (18.64%).

4.19 Incidence and management of insect pest at 285 days after storage with different treatments

4.19.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 285 DAS in stored ground nut (Table 18).

At 285 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (228.50) where the treatment T_2, T_3, T_4 and T_5 showed 185.75, 172.25, 191.00 and 212.50 dried fruit beetle (by number), respectively. The treatments, T_1 showed best performance against insect pest and no incidence of insect pest was found at 285 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but T_2, T_3, T_4 and T_5 gave 5.00, 4.00, 4.00 and 5.50 red flour beetle in number,

respectively where T_6 gave the highest incidence of red flour beetle (5.75) at 285 DAS.

4.19.2 Healthy and infested seeds

At 285 DAS, 100% healthy seeds were found from the treatment $T_1$where treatment T_2, T_3,$T_4$and T_5 showed 43.75, 45, 42.50 and 38.50% healthy seeds, respectively. The lowest % healthy seeds (25%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_2, T_3,$T_4$and T_5 showed 56.25, 55, 57.50 and 61.50% infested seeds, respectively. The highest seed infestation (75.00%) was found from control treatment (T_6).

4.19.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 285 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control where treatment T_2, T_3,$T_4$and T_5 showed 18.71, 24.62, 16.41 and 7.00% reduction of dried fruit beetle over control, respectively.

Similarly, T_1 showed 100% reduction of red flour beetle over control and T_2,T_3,$T_4$and T_5 showed 13.04, 30.43, 30.43 and 4.35% reduction of red flour beetle over control, respectively.

4.19.4 Percent reduction of infestation over control

At 285 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 26.67% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (18.00%).

Table 18.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 285 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 d	100.00 a	0.00 d	100.00	100.00	100.00
T_2	185.75 d	5.00 b	43.75 b	56.25 c	18.71	13.04	25.00
T_3	172.25 e	4.00 c	45.00 b	55.00 c	24.62	30.43	26.67
T_4	191.00 c	4.00 c	42.50 b	57.50 c	16.41	30.43	23.33
T_5	212.50 b	5.50 a	38.50 c	61.50 b	7.00	4.35	18.00
T_6	228.50 a	5.75 a	25.00 d	75.00 a	--	--	--
$LSD_{0.05}$	3.58	0.31	2.52	2.53	--	--	--
CV(%)	6.05	3.80	5.07	5.09	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.20 Incidence and management of insect pest at 270 days after storage with different treatments

4.20.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 270 DAS in stored ground nut (Table 19).

At 270 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (161) where no infestation was found in T_1 but among the botanical treatment, T_3 showed lowest incidence (175.25) at 270 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but among the botanical treatment the lowest incidence (4.00) was found in T_3 at 270 DAS.

4.20.2 Healthy and infested seeds

At 270 DAS, 100% healthy seeds were found from the treatment $T_1$where but among the botanical treatment, the highest % healthy seeds (37.50%) were found in T_3 treatment. The lowest % healthy seeds (22.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_3 showed the lowest infested seeds (62.50%) among the botanical treatments,. The highest seed infestation (77.50%) was found from control treatment (T_6).

Table 19.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 300 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	0.00 c	100.00 a	0.00 d	100.00	100.00	100.00
T_2	195.50 c	6.00 a	36.25 b	63.75 c	20.61	0.00	17.74
T_3	175.25 d	4.00 b	37.50 b	62.50 c	28.83	33.33	19.35
T_4	194.75 c	4.75 b	35.00 b	65.00 b	20.91	20.83	16.13
T_5	227.00 b	5.75 a	33.00 c	67.00 b	7.82	4.17	13.55
T_6	246.25 a	6.00 a	22.50 d	77.50 a	--	--	--
$LSD_{0.05}$	3.87	0.76	2.52	2.10	--	--	--
CV(%)	6.52	3.76	5.36	5.37	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.20.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 270 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control but among the botanical treatments T_3, showed the highest % reduction of dried fruit beetle over control (28.83%).

Similarly, T_1 showed 100% reduction of red flour beetle over control but among the botanical treatments, T_3,gave the highest % reduction of red flour beetle over control (33.33).

4.20.4 Percent reduction of infestation over control

At 270 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3, which showed 19.35% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (13.55%).

4.21 Incidence and management of insect pest at 315 days after storage with different treatments

4.21.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 315 DAS in stored ground nut (Table 20).

At 315 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (258.50) where no infestation was found in T_1 but among the botanical treatment, T_3 showed lowest incidence (195.25) at 315 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but among the botanical treatment the lowest incidence (4.50) was found in T_3 at 315 DAS.

4.21.2 Healthy and infested seeds

At 315 DAS, 100% healthy seeds were found from the treatment $T_1$where but among the botanical treatment, the highest % healthy seeds (30%) were found in T_3 treatment. The lowest % healthy seeds (17.50%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_3 showed the lowest infested seeds (70%) among the botanical treatments,. The highest seed infestation (82.50%) was found from control treatment (T_6).

4.21.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 315 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control but among the botanical treatments T_3,showed the highest % reduction of dried fruit beetle over control (24.47%).

Similarly, T_1 showed 100% reduction of red flour beetle over control but among the botanical treatments, T_3,gave the highest % reduction of red flour beetle over control (30.77).

4.21.4 Percent reduction of infestation over control

At 315 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3,which showed 15.15% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (9.70%).

Table 20.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 315 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	0.00 d	100.00 a	0.00 e	100.00	100.00	100.00
T_2	218.50 c	6.50 a	27.00 c	73.00 b	15.47	0.00	11.52
T_3	195.25 e	4.50 c	30.00 b	70.00 d	24.47	30.77	15.15
T_4	199.50 d	5.25 b	28.00 c	72.00 bc	22.82	19.23	12.73
T_5	243.25 b	6.00 a	25.50 d	74.50 b	5.90	7.69	9.70
T_6	258.50 a	6.50 a	17.50 e	82.50 a	--	--	--
$LSD_{0.05}$	3.12	0.58	1.11	1.10	--	--	--
CV(%)	7.86	3.84	6.37	5.21	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.22 Incidence and management of insect pest at 315 days after storage with different treatments

4.22.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 330 DAS in stored ground nut (Table 21).

At 330 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (131.25) where no infestation was found in T_1 but among the botanical treatment, T_3 showed lowest incidence (158.50) at 330 DAS.

Similarly in terms of red flour beetle, there was no incidence was found in T_1 but among the botanical treatment the lowest incidence (53.75) was found in T_3 at 330 DAS.

4.22.2 Healthy and infested seeds

At 330 DAS, 100% healthy seeds were found from the treatment T_1but among the botanical treatment, the highest % healthy seeds (6.25%) were found in T_3 treatment. The lowest % healthy seeds (1.25%) were found from control treatment (T_6).

Similarly, no infested seed was observed from the treatments, T_1, butT_3 showed the lowest infested seeds (93.75%) among the botanical treatments,. The highest seed infestation (98.75%) was found from control treatment (T_6).

4.22.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

At 330 DAS, treatment T_1 showed 100% reduction of dried fruit beetle over control but among the botanical treatments T_3,showed the highest % reduction of dried fruit beetle over control (17.79%).

Similarly, T_1 showed 100% reduction of red flour beetle over control but among the botanical treatments, T_3,gave the highest % reduction of red flour beetle over control (20.96).

Table 21.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 330 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 d	0.00 e	100.00 a	0.00 e	100.00	100.00	100.00
T_2	152.00 b	62.75 c	3.75 bc	96.25 ab	4.10	7.72	2.53
T_3	131.25 c	53.75 d	6.25 b	93.75 d	17.19	20.96	5.06
T_4	151.50 b	65.25 b	5.00 b	95.00 bc	4.42	4.04	3.80
T_5	156.00 a	67.75 a	2.50 d	97.50 a	1.58	0.37	1.27
T_6	158.50 a	68.00 a	1.25 d	98.75 a	--	--	--
$LSD_{0.05}$	2.56	1.10	1.60	1.25	--	--	--
CV(%)	7.38	7.32	5.87	6.31	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.22.4 Percent reduction of infestation over control

At 330 DAS, treatment T_1 showed 100% reduction of infestation over control followed by T_3, which showed 5.06% reduction of infestation over control where treatment T_5 showed lowest % reduction of infestation over control (1.27%).

4.23 Incidence and management of insect pest at 345 days after storage with different treatments

4.23.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 345 DAS in stored ground nut (Table 22).

At 345 DAS, the control treatment, T_3showed the highest insect incidence of dried fruit beetle by number (74.75) where no dried fruit beetle was found in T_1 but among the botanical treatment, T_6showed lowest incidence (108.50) at 345DAS.

Similarly in terms of red flour beetle, 125.25 red flour beetle in number was found in T_4but among the control treatment the lowest incidence (153.75) was found in T_6 at 345DAS.

4.23.2 Healthy and infested seeds

At 360 DAS, 100.00% healthy seeds were found from the treatment T_1but among the botanical treatment, no healthy seeds were remain including control.

Similarly, 98.75% infested seed was observed from the treatments, T_2, where T_5 and T_6 showed 100% infested seeds including control at 345 DAS.

Table 22.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 345 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	0.00 d	100.00 a	0.00 c	100.00	100.00	100.00
T_2	102.00 b	128.50 c	1.25 b	98.75 b	5.99	16.42	1.25
T_3	74.75 d	141.25 b	2.50 b	97.50 b	31.11	8.13	2.50
T_4	94.50 c	125.25 c	1.25 b	98.75 b	12.90	18.54	1.25
T_5	106.00 a	144.50 b	0.00 c	100.00 a	2.30	6.02	0.00
T_6	108.50 a	153.75 a	0.00 c	100.00 a	--	--	--
$LSD_{0.05}$	3.05	3.67	1.73	1.67	--	--	--
CV(%)	6.63	6.28	5.83	7.31	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated control

4.23.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

Only treatment T_1 showed 100% reduction of dried fruit beetle over control and 16.42% reduction of red flour beetle over control at 345 DAS.

4.23.4 Percent reduction of infestation over control

Only treatment T_1 showed 87.50% reduction of infestation over control at 360 DAS

4.24 Incidence and management of insect pest at 360 days after storage with different treatments

4.24.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 360 DAS in stored ground nut (Table 23).

At 360 DAS, the control treatment, T_6 showed the highest insect incidence of dried fruit beetle by number (35.00) where no dried fruit beetle was found in T_1 but among the botanical treatment, T_3 showed lowest incidence (149.50) at 360 DAS.

Similarly in terms of red flour beetle, 9.75 red flour beetle in number was found in T_1but among the botanical treatment the lowest incidence (149.50) was found in T_3 at 360 DAS.

4.24.2 Healthy and infested seeds

At 360 DAS, 87.50% healthy seeds were found from the treatment T_1but among the botanical treatment, no healthy seeds were remain including control.

Similarly, 12.50% infested seed was observed from the treatments, $T_{1,}$ where rest of all the treatments showed 100% infested seeds including control at 360 DAS.

Table 23.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 360 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 f	9.75 e	87.50 a	12.50 b	100.00	94.40	87.50
T_2	50.50 c	152.50 b	0.00 b	100.00 a	--	--	--
T_3	65.75 a	149.50 c	0.00 b	100.00 a	--	--	--
T_4	54.50 b	151.75 b	0.00 b	100.00 a	--	--	--
T_5	44.25 d	147.50 d	0.00 b	100.00 a	--	--	--
T_6	35.00 e	174.25 a	0.00 b	100.00 a	--	--	--
$LSD_{0.05}$	2.71	2.01	4.87	4.87	--	--	--
CV(%)	6.53	5.84	1.35	1.87	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

4.24.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

Only treatment T_1 showed 100% reduction of dried fruit beetle over control and 94.40% reduction of red flour beetle over control at 360 DAS.

4.24.4 Percent reduction of infestation over control

Only treatment T_1 showed 87.50% reduction of infestation over control at 360 DAS

4.25 Incidence and management of insect pest at 375 days after storage with different treatments

4.25.1 Incidence of insect pest

Significant influence was found for incidence of insect pest at 375 DAS in stored ground nut (Table 24).

All seeds were damaged at 375 DAS except in T1 treatment. However, no incidence of dried fruit beetle was found.but in this treatment 10.25 in number red flour beetle was found.

4.25.2 Healthy and infested seeds

At 375 DAS, 86.25% healthy seeds were found from the treatment T_1but among the botanical treatment, no healthy seeds were remain including control.

Similarly, 13.75% infested seed was observed from the treatments, T_1, where rest of all the treatments showed 100% infested seeds including control.

4.25.3 Percent (%) reduction of dried fruit beetle and red flour beetle over control

Only treatment T_1 showed 100% reduction of dried fruit beetle over control at 375 DAS and 94.10% reduction of red flour beetle over control at 375 DAS.

4.25.4 Percent reduction of infestation over control

Only treatment T_1 showed 87.50% reduction of infestation over control at 375 DAS.

Table 24.Incidence of dried fruit beetle and red flour beetle on stored groundnut seed in different treatments at 375 Days after storage

Treatment	Number of dried fruit beetle	Number of red flour beetle	% Healthy seed	% Infested seed	% Reduction of dried fruit beetle over control	% Reduction of red flour beetle over control	% Reduction of infestation over control
T_1	0.00 e	10.25 c	86.25 a	13.75 b	100.00	94.10	86.25
T_2	23.00 c	157.50 b	0.00 b	100.00 a	--	--	--
T_3	48.00 a	156.50 b	0.00 b	100.00 a	--	--	--
T_4	27.75 b	155.50 b	0.00 b	100.00 a	--	--	--
T_5	21.00 c	154.50 b	0.00 b	100.00 a	--	--	--
T_6	5.75 d	173.75 a	0.00 b	100.00 a	--	--	--
$LSD_{0.05}$	2.61	3.71	2.53	3.11	--	--	--
CV(%)	4.85	5.05	3.87	4.08	--	--	--

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Sevin powder 85 SP@0.5 g/200 g of ground nut

T_2= Red chili powder @1.0 g/200 g of ground nut

T_3= Neem powder @1.0 g/200 g of ground nut

T_4= Turmeric powder @1.0 g/200 g of ground nut

T_5= Coriander powder @1.0 g/200 g of ground nut

T_6= Untreated Control

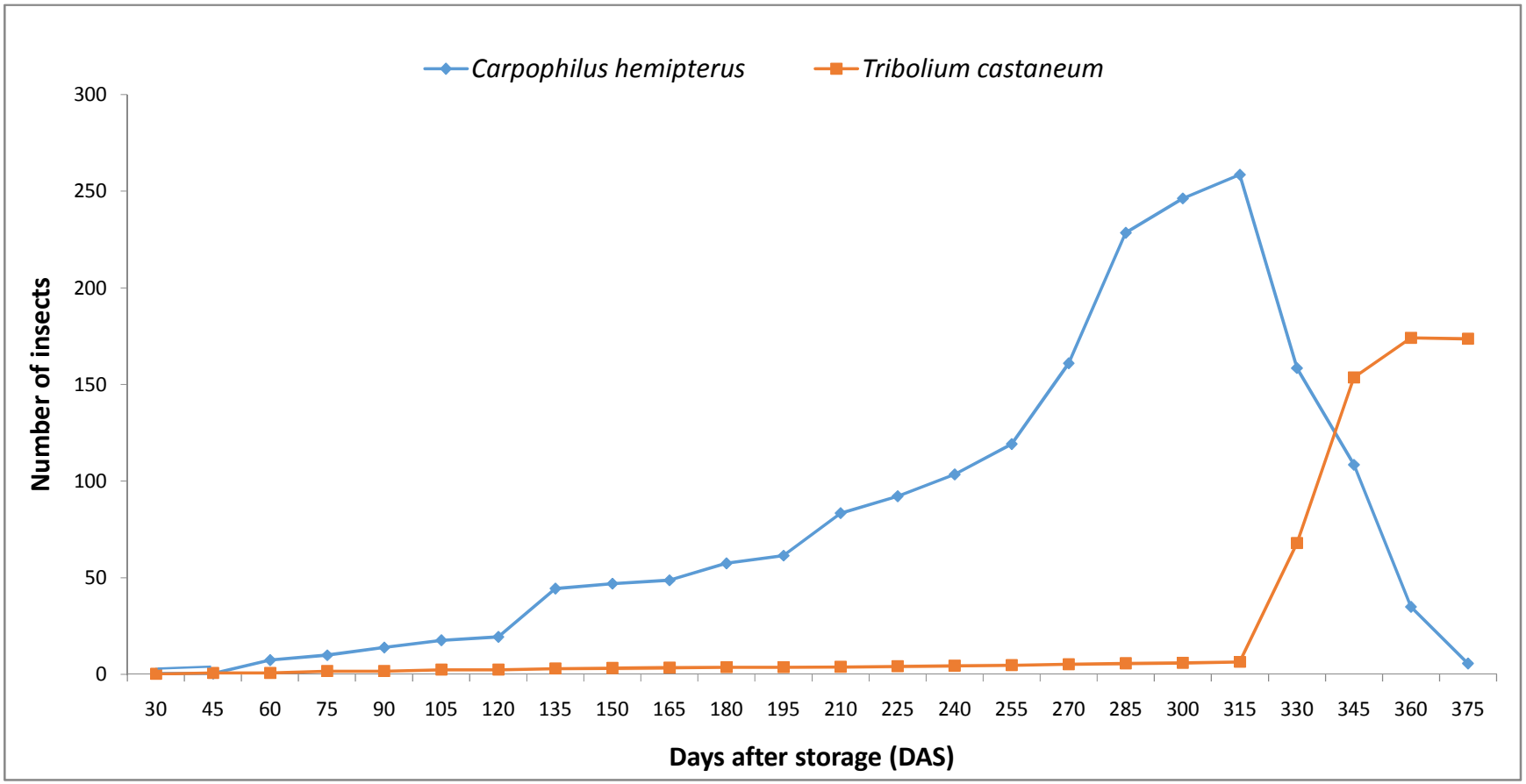

Fig. 3.Succession of *C. hemipterus* and *T. castaneum* on groundnut in storage from July 2017 to June 2018. (In untreated control)

Population trends of *C. hemipterus* and *T. castaneum* on groundnut seeds in storage from July 2017 to June 2018 are shown in Fig.3.Groundnut seeds were infested by *C. hemipterus* and *T. castaneum* 30 days after storage.Population of C. hemipterus was gradually increased with storage time and reached at the peak at 315 days after storage and then declined.Population of *T. castaneum* was almost similar upto 315 days after storage and then sharply increased and reached at the peak at 360 days after storage.Population of *C. hemipterus* was higher than that of *T. castaneum* upto 315 days after storage.After that T. castanum was higher than *C. hemipterus*.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was carried out at storage condition in the Laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2017 to June 2018 in order to succession of stored ground nut pests and their management with chemicals and botanical. The experimented consisted of six treatments viz. T_1 = Sevin powder 85 SP@0.5g/200g of ground nut, T_2= Red chili powder @1.0 g/200g of ground nut, T_3= Neem powder @1.0 g/200g of ground nut, T_4= Turmeric powder @1.0 g/200g of ground nut, T_5 = Coriander powder @1.0 g/200g of ground nut and T_6= Untreated Control. The experiment was laid out in a Complete Randomized Design (CRD) with three replications. Data on different parameters like incidence of insect pest, % healthy and infested seeds were taken during the period of the study. The collected data were analyzed statistically and the means were separated by DMRT at 5% level of probability.

Results revealed that insect incidence and seed infestation among the treatments showed significant variation. Different days after storage, two species of insect pests were identified as stored groundnut pest during the period of the study. The two insect pest namely dried fruit beetle (*C.hemipterus*) and red flour beetle (*T.castaneum*) are found about 30 days after storage and they continued the whole year.

The only chemical treatment Sevin powder 85 SP showed the best result for the management of the insect pests. The isfestation of red flour beetle were noticed about 360 days after storage in the Sevin treatment and at that time healthy seeds percentage was about 87.50. After that 375 days after storage the infestation of dried fruit beetle in Sevin powder the healthy seeds percentage was about 86.25. But there was no infestation of dried fruit beetle in Sevin powder treatment.

Among the four botanical treatments, neem leaf powder showed the best result for the management of the insect pests.The isfestation ofboth dried fruit beetle and red flour beetle were noticed 30 days after storage in the neem leaf powder treatment and continued to the whole year. But the number of insects are less then the other botanicals treatments.

So it is concluded that the treatment of T_1= Sevin 85 SP showed the best result for the management of dried fruit beetle and red flour beetle about 375 days after storage. And among the botanicals T_3= neem leaf powder showed the finest result for the management of insects.

CHAPTER VI

RECOMMENDATIONS

Based on the result of the present study the following recommendations may be suggested-

1. Such study is needed in different areas of Bangladesh for regional adaptability.

2. In terms of storage insect pests of groundnut, Sevin powder 85 SP,a chemical compound will show the best result for the management of insect pests and neem leaf powder, a botanical will also show the finest result.

CHAPTER VII

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CHAPTER VIII

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

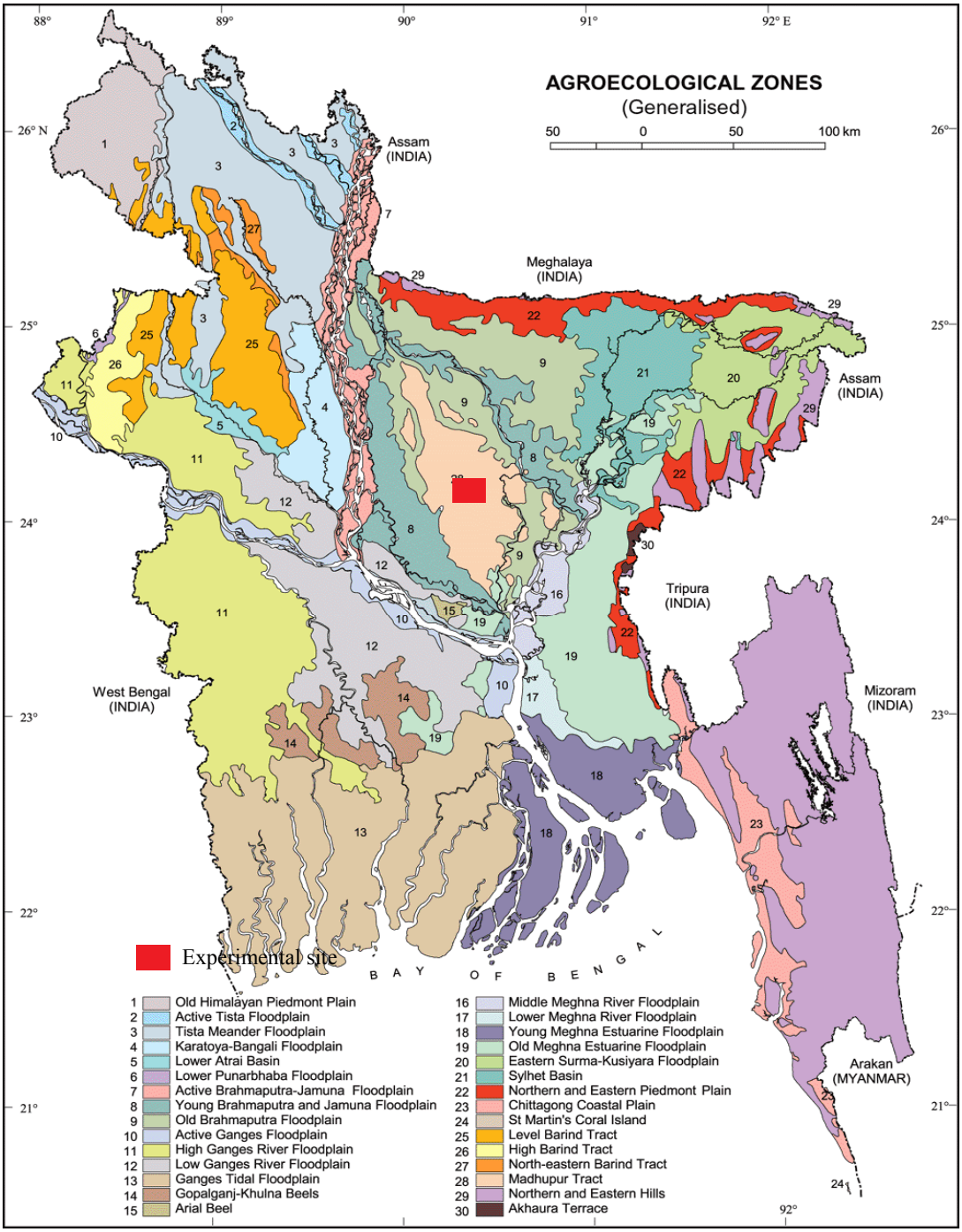

Fig.4. Experimental site

Appendix II.Monthly records of air temperature, relative humidity and rainfall during the period from July 2017 to June 2018.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2017	July	30.52	24.80	27.66	78.00	536
2017	August	31.00	25.60	28.30	80.00	348
2017	September	30.8	21.80	26.30	71.50	78.52
2017	October	30.42	16.24	23.33	68.48	52.60
2017	November	28.60	8.52	18.56	56.75	14.40
2017	December	25.50	6.70	16.10	54.80	0.0
2018	January	23.80	11.70	17.75	46.20	0.0
2018	February	22.75	14.26	18.51	37.90	0.0
2018	March	35.20	21.00	28.10	52.44	20.4
2018	April	34.70	24.60	29.65	65.40	165.0
2018	May	32.64	23.85	28.25	68.30	182.2
2018	June	27.40	23.44	25.42	71.28	190

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.