Introduction
Cowpea, *Vigna unguiculata* (L.) Walpers. is grown throughout tropical and subtropical regions of the world where it is an important source of human dietary protein and livestock feed (Dobie1981). Among the various fodder crops, cowpea is a subsistence legume par excellence and being rich in proteins, it is important ingredient of feed for livestock. It is extensively grown in Africa, India and Brazil. In India, cowpea which is mainly cultivated for grain, fodder and also because of its nitrogen fixing capacity, is also used as green manuring crop. Among pulses, it is known to be one of the most important droughts tolerant legumes. Cowpea is exclusively used for human diet as a green vegetable and for cattle feed as a green fodder, serving as a main source of protein in their diet. It is grown in approximately 9.88 lakh hectares in India. In general the grain contain 200 – 300g proteins and about 600g carbohydrates per kg seed. The cotyledons contain 90\% of the protein and mineral available in the whole seed, where as seed coat accounts for 32 to 50\% of the calcium of the whole seed. Oyenuga, (1968), has described the importance of this crop as “Cowpea is an important leguminous crop and it is a ready source of plant protein for humans in Nigeria”.

Insects are a serious constraint to cowpea production and to their storage during the post harvest period. The cowpea weevil *Callosobruchus maculatus* (F.) is the most serious post-harvest insect pest of cowpeas throughout the tropics (Singh
et al., 1990). To protect the cowpeas under storage, the use of commercial pesticides and other chemical control methods are usually not advisable. They are too expensive and also too hazardous for low-resource farmers in almost every developing country (Rachie, 1985).

The two most damaging and widespread species, which are distributed throughout the tropics and sub-tropics, are *Callosobruchus maculatus* and *Callosobruchus chinensis*. The known facts about the biology, nature of damage etc. of this pest, are as follows:

Affected plant stages: Fruiting stage, and post-harvested seed/pulse under storage.

Affected plant parts: Maturing seeds in the pods and stored seeds.

Symptoms of infestation: In the early stages of attack the only symptom is the presence of eggs cemented to the surface of the pulses. As development occurs entirely within the seed, the immature stages are not normally seen. The adults emerge through windows in the grain, leaving round holes that are the main evidence of damage.

Morphology of *C. maculatus*:

Eggs: The eggs are smooth, domed structures with oval, flat bases and are cemented to the surface of pulses.

Larva and Pupa: The larva on hatching towards the cemented surface, penetrates the seeds and grows inside by consuming the parts of cotyledons. The fully-grown larva pupates in the cell bored within the pulses seed.
Adult: *C. maculatus* are 20.35 mm long. The antennae of both sexes are slightly serrate. Females often have strong markings on the elytra consisting of two large lateral dark patches mid-way along the elytra and smaller patches at the anterior and posterior ends, leaving a paler brown cross-shaped area covering the rest. The males are much less distinctly marked. In common with other species of *Callosobruchus*, *C. maculatus* has a pair of distinct ridges (inner and outer) on the ventral side of each hind femur, and each ridge bears a tooth near apical end. The inner tooth is triangular and equal to (or slightly longer than) the outer tooth. Several workers have described an active or flight form of adult *C. maculatus* that is apparently more active and is more strongly marked, with a white pygidium (Utida, 1953).

Cowpea seed is subject to serious infestation from this pest during storage and as high as 100% infestation could occur on unprotected cowpea following 3-5 months storage (Singh, 1977). A numbers of other important legume seeds yet to be studied for their suitability as host to different species of pulse beetle.

The most frequently encountered storage pests of cereals and legumes are *Stitophilus oryzea* Linn., *Oryzeaphilus surinamensis* Linn., *Coreyra cephalonica* Saint, *Ephestia cautella* Wlk., *Sitotroga cerealella* oliv., *Tribolium confusium* Duval, *Tribolium castaneum* Herbst, *Rhizopertha dominica* F., *Trogoderma granarium* Everts and *Callosobruchus maculatus* Fab. Damage caused by the pulse beetle is responsible for serious loss of cowpea in store. It is because of these reasons, it has been suggested by some researchers that any dry, powdery substance might serve as a good protectant for *C. maculatus* F. The non availability as well as the high cost of synthetic pesticides, coupled with the
potential hazards posed by these pesticides to the environment, humans and livestock, have necessitated the search for various local plant products for use in the control of insect pests of cowpea in storage (Pereira, 1982; Ivbijaro, 1983; Don-Pedro, 1985; Ajayi et al. 1987; Dike and Mbah; 1992). Currently in Nigeria farmers utilize local plant products to control insect pests in stored produce. Powdered fruits of pepper are one such plant product. The study conducted showed that application of different rates of powdered pepper gives good results in the control of *C. maculatus* in stored cowpea.

The indigenous materials of botanical origin have been found to possess toxic, deterrent and/or repellent properties against insects when mixed with grain. Such treatments were also found to have no residual effect to the produce when cooked. The powders of plant origin, vegetable oils and some ashes (Cow dung ash) are found to be useful in controlling many storage pests (Khare and Agarwal, 1972). These materials were also found to be effective in controlling the pulse beetle *Callosobruchus chinensis*. (Pandey et al., 1976) have explored the possibility of using some plant products and ashes as protectants against pulse beetle, *Callosobruchus chinensis* (L.) infesting black gram.

Since the pulse beetle, *Callosobruchus chinensis* Linnaeus causes serious damage to pulse grains during storage; various workers have studied its ovipositional preference on different stored pulses. Extremely uniform distribution of eggs on different legume seeds has been reported. The studies on the ovipositional preference of *C. chinensis* on different cowpea lines have also been worked out. Distribution pattern of fertile eggs on the grains has also been ascertained. The colour response of cowpea seeds on the ovipositional behavior
of this beetle was also studied in the past but has resulted in contradictory results. All these attempts have been made in view to understand some mechanism which can be instrumental in reducing the pest population and thereby protecting the commodity. One practical approach for managing insect problems, especially for low-resource farmers, is by growing and storing cowpeas that resistant to insect attack and use vegetable oils and plant products which are commonly used in India for the protection of various stored commodities as a house hold practice.

Ogiangbe and Onigbinde (1996), in their study on association between some physico-chemical characteristics and susceptibility of cowpea to Callosobruchus maculatus (F), have attempted to work out association between some physical characteristics and the tannin contents of cowpeas to the susceptibility to bruchid Callosobruchus maculatus. The physical characteristics considered were coat colour and texture, seed height, length and width, and the thickness of the seed coat. The study revealed that the dimensional parameters have a significant (P<0.05) correlation with the number of eggs laid with seed height accounting for about 70% of the variance. The same parameter accounted for 77% of the variance in the number of f 1 progeny. The tannic acid content however became increasingly significant with the growth of the larvae to adulthood. The tannic acid content accounted for 14.3 and 39.9% of the variance in the number of f 1 progeny and percentage adult emergence, respectively.

Chaves and Vendramim (1995) have worked out factor resulting in to non-preference for oviposition and development of Callosobruchus maculatus (Fab.) on cultivars of cowpea. Xavier-filho et al., (1996) on the basis of the findings of
their study, related the resistance of cowpea (*Vigna unguiculata*) seeds to the weevil to association of variant vicilins (7s storage proteins) to chitinous structure in the insect's mid gut. A review of studies on the biochemical nature of the resistance of certain cowpea cultivars such as CV. TVU2027 to attack by larvae of *C. maculatus* have linked it to a mutational form of the storage protein, vicilin, identified in resistant seeds. It was correlated to rates of hydrolysis by larval digestive cysteine and aspartic proteinase. These vicilins are reported to be more tightly bound to chitin and chitinous membranes, reducing availability of amino acids compared with that from the weaker association resulting from ingestion of susceptible seeds.

Pacheco *et al.*, (1994), studied the resistance to *Callosobruchus phaseoli*, *C. maculatus* and *Acanthoscelides obtectus* in six chickpea genotypes and reported that resistance to bruchids in chickpea may be related to tegument components such as pigments, in dark tegument genotypes, and to the presence of linoleic acid, affection oviposition and also larval feeding and for larval biology.

Different workers have tried different vegetable oils in their attempts to protect grain against pulse beetle on Green gram, Black gram and Cowpea. Verma *et al.*, (1975) and Sangappa (1977) reported the effectiveness of vegetable oils against *C. chinensis* on red gram. In view of the encouraging results obtained by these workers, many other workers have tested the effectiveness of vegetable oils along with other promising material against pulse beetle, *C. chinensis* (L.) infesting different pulses.

Several workers have studied growth inhibitory, toxic and hormonal effects of plant or plant-based formulations since last many years (Frankel, 1959, Maxwell
and Jennings, 1980). Use of plant material as protectants has been possible as the plants are rich source of phyto-chemicals and hormones, which hamper the overall population build up of pest insects. *Murraya koenigii* Linn an Indian medicinal plant commonly known as sweet neem is very effective against many pest species (Joseph et al. 1985). The leaves are used in curry making besides these have medicinal value as are reported to be antifungal and bactericidal properties (Das et al., 1965). The volatile oil contains 16 percent monoterpenic hydrocarbons and 80 percent sesquiterpenes. The most important constituents of the oil are, beta-gurjunene, beta-elemene, beta-phellandrene and beta-thujene (Macleod and Pieris 1982). Yadav and Pant 1978, investigated contact toxicity and the fumigant action of the essential oil against the adult, egg and larval stages with an objective to find the inhibition of population of *C. chinensis* (Linn) and found it to be an effective protectant.

The coating of stored pulses with a thin film of edible oils is an age-old traditional practice in the villages of India for protecting pulses against infestation by storage insects. Generally the oil used for cooking in the area serves for treating the grain, irrespective of the extent of protection it provides. These results have been obtained under different studies conducted with the aim to find out an effective, cheap and readily available material to protect the pulses from the attack of the pulse beetle, which is a serious pest all over India. Coconut, Mustard, Groundnut, Sesame and Sunflower oils were subjected to test. Pulses were separately coated with these oils, and the ovipositional behavior of *C. maculatus*, the percentage of seeds damaged, the population of the adult of
pulse beetle, and the viability of treated seeds were observed to establish the comparative efficacy of the oil in the protection of stored green gram.

Since the cowpea pulse beetle is one of the most destructive pests of seed during the period of storage the stable age distribution on either sex of _C. maculatus_ has been also worked out. The stable age distribution is also worked out in respect of other important storage and field crop pests, viz., _Calandra oryzae_ L. (Birch, 1948); _Trogoderma granarium_ Everts and _Callosobruchus analis_ Fabricius (Atwal _et al._, 1968); _Dichocrocis punctiferalis_ Guen. (Bilapate, 1977); _Heliotris armigera_ Hbn. (Bilapate _et al._, 1977), _Heliotris armigera_ Hbn. (Bilapate and Pawar, 1978); and green clover worm (Wellik and Pedigo, 1978).

Being the rich source of potent nutritional elements the tender, soft and green pods of cowpea, are used as vegetable and the other plant parts are utilized as green fodder for domesticated cattle. Dried seeds are consumed as pulse. Not only in field the recoverable biological yield is enormously decreased due to attack of insect-pests but in stores and god owns too, the dry seeds are considerably damaged by obnoxious storage pests (Casewell, 1956; Howe and Currie, 1964; Pandey _et al._, 1966; Booker, 1967; Mookherjee _et al._ 1970; Chopra and Khurab, 1970; Gokhale, 1973; Girish _et al._, 1974; Yadav and Pant, 1978; Dabi _et al._, 1979; Satyavir, 1983). Among all the stored grain pests, particularly _Callosobruchus maculatus_ Fab. exhibits a high degree of specificity towards the important leguminous vegetable seeds (Srivastava and Bhatia, 1958) thus renders them unfit for human consumption as well as the viability of the seed is tremendously lost. Mookherjee, _et al._, 1970; Raheja, 1976; Yadav and Pant, 1978; have reported that legume seeds are badly damaged by pulse beetles.
during storage. Its infestation either originates in the field or in storage, causes serious loss to the seeds. Authentic information on the insect species involved with different host/seeds complex is reported. Singh et al., (1986) and Van Reehen et al., (1983), used ethanol extracts of Datura stramonium leaves, separate and in mixtures with Malathion, to see the mortality and reduction in progeny of Callosobruchus maculatus. Results concerning the toxicity of the various plants extracts revealed low mortality values even after 7 days from treatment at the highest concentration used. There many more such reports available in the global literature, which indicate that plant extracts, are not always effective against pests.

The importance of cowpeas as indicated by various workers, the economic importance of the pests and the quantum of damage has, in the past, tempted many workers to find out economically feasible ways to protect the pulse and the seed under storage from this disastrous pest. It would not be wrong that many of them have made very practical suggestions. There are still many options available to explore. The most practical would have been to utilize the resistant cultivars but these are not available for commercial use at most of the places. In the absence of this, the other option could be to identify such materials that are easily available in the rural settings and are effective, environmentally safe and economical. The present research was undertaken with the earlier referred aim, which justifies the development of effective and appropriate non-chemical control method(s), including uses of plant components, particularly for rural settings having resource constraints. Such methods should also be suited to urban households for storage of the commodities for domestic consumption. The
commercial/ large scale use of indigenous/ locally available plant material would also generate employment opportunities and livelihoods to rural poor. Some indigenous practices under common use would also be tested for validation.

In the light of the above, the present investigation entitled, "**Non-Chemical Management of Seed Beetle, Callosobruchus maculatus (Bruchidae: Coleoptera) in Cowpea under Storage**" was undertaken with the following objectives:

- **Laboratory evaluation of relative susceptibility/ resistance of cowpea germplasm to the seed beetle.**
- **Test the efficacy of botanicals and some inert materials against the seed beetle.**
- **Suggest non-chemical safe storage methods for cowpea seed beetle.**

This study has its own importance currently and it mostly relates to environmental context of the issues involved but looking to the present trends of global demand for organics for all sphere of life including food, medical and other health related items, the out come of the studies of this nature will have ever increasing demand in not far off years.