Review of Literature

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The review of literature reveals that many workers have attempted different materials and methods targeted to control this economically most important pest in pulses. In view to search viable options to the chemical insecticides for stored commodities, traditional practices of mixing plant/tree leaves, other powdered parts of plants or use of edible/non-edible oils as protectants has received the attention of researchers from quite some time. Onu and Aliyu (1995) have studied impact of powdered fruits of four-capsicum spp., on *Callosobruchus maculatus*. One practical approach for managing insect problems, especially for low resource farmers is by growing and storing cowpeas that resist insect attack (Lienard and Seck, 1994; Shade *et al.*, 1996). The identification of resistant germplasm is important because of the fact that it could either be utilized as such or can be incorporated in the breeding programme for better quality traits. Since early '70s, researchers at the International Institute of Tropical Agriculture at Ibadan, Nigeria, have screened >15,000 cowpea accessions for seed resistance to cowpea weevil. In 1977, they identified first cowpea weevil resistant accession Tvu 207 (Singh *et al.* 1982). Appleby and Credland (2004), through this study suggested development and release of resistant cowpea varieties represents an attractive alternative to conventional chemical methods for control of
*Callosobruchus maculatus* The researches conducted by various workers on these and related aspects have been reviewed in the following pages in chronological order beginning from the most recent work under the different aspects:

**Screening for Resistance:**

Appleby and Credland (2004) in a laboratory studies on geographically distinct populations have highlighted significant intra-specific variation in performance on resistant cowpeas, which could interfere with their effectiveness as a control method. In this study, the effect of different environmental conditions on population performance on susceptible and resistant cowpeas was investigated to determine whether they could also affect the degree of control achieved in different areas. These observations have been made on the basis of the study utilizing seven Nigerian populations, screened against cowpeas under two environmental regimes (condition A- 26°C, 75±5% relative humidity (RH) LD11.5: 12.5 h, and condition B- 30:15°C (11.5:12.5 h), 30±5% RH, LD11.5: 12.5 h), designed to simulate field conditions during the storage period in different regions of Nigeria. Independent of environmental conditions and seed variety, significant differences among populations were expressed in terms of embryonic mortality, post-embryonic mortality, development time and adult weight. Resistant seeds delayed development, resulted in protracted adult emergences and increased post-embryonic mortality. Environmental conditions are shown for the first time to have a significant effect on population performance on resistant seeds, principally on development time and post-embryonic mortality. Effects on these parameters were not the same; rapid development
was favored under Condition A, although mortality was higher under this regime. The effects of resistant seeds and environmental conditions on performance could not be generalized across biological traits. Furthermore, significant interactions between environment and seed variety and between environment and population were identified in certain parameters, suggesting performance on a resistant variety may vary significantly across populations, with seed variety and in response to differences in environmental conditions. It is suggested that the only reliable way of predicting the effectiveness of resistant varieties in the field would be to test them against local populations in the areas targeted for release, under local environmental conditions.

In a related but important aspect, Babu et al., (2003) studied the sources of semiochemicals mediating host finding in Callosobruchus chinensis. In this study the chemical composition of the headspace volatiles from healthy and fourth instar larvae-infested cowpea seeds were identified, characterized, and compared using gas chromatography–mass spectrometry. Y-tube olfactometer bioassays were performed to evaluate the effect of these chemicals on the orientation of conspecific adult females. Analysis of volatiles released from healthy and infested seeds revealed qualitative differences for three out of the 17 compounds identified. Dimethyl disulphide, isobutenyl methyl ketone and methyl trisulphide were found only in the blend emitted from infested but not from healthy seeds. Quantitative differences were apparent for tridecane, which was released, in larger amounts from infested seeds. While volatiles collected from healthy seeds were attractive to female bruchids, volatiles collected from infested seeds were repellent. To test the hypothesis that the qualitative
differences in the chemical composition found may be due to insect-derived components, the volatiles from first and fourth instars larvae combined were analyzed. These volatiles contained both of the sulphides emitted from infested seed but not from healthy seeds. Although a limited induction of volatiles from cowpea seeds cannot be excluded, it is postulated that behavioural differences of the female weevils are largely due to insect-derived semiochemicals. The potential use of such semiochemicals as part of an integrated pest management strategy has been visualized.

Devereau et al., (2003) used the bio-monitor technique for this investigation as a rapid and automatic method for measuring the resistance of cowpea varieties to the seed beetle Callosobruchus maculatus. This technique measures the activity of internally feeding insect larvae by counting ultrasonic emissions produced as they feed. Activity throughout the development of C. maculatus larvae in known susceptible and resistant cowpea varieties was recorded. This showed details of the development of each larval instar, and showed clear differences between the resistant and susceptible cowpeas. A rapid method for comparing cowpeas has been proposed in which the activity of larvae was recorded for 24 h starting 14 days after oviposition. Using this method, significant differences in activity were apparent between one susceptible and two resistant cowpea varieties. Further comparisons using a randomized block experimental design also showed a clear difference in activity between one susceptible and one known resistant cowpea variety.

Edde and Amatobi (2003) conducted studies to compare the oviposition preference of cowpea seed beetle Callosobruchus maculatus (F.) on 22 cowpea
varieties, with and without seed coat. The cowpeas included five resistant, four moderately resistant and 13 susceptible varieties. Ten of the varieties had smooth seed coats while 12 were wrinkled. Mean numbers of eggs laid on smooth and wrinkled varieties were not significantly different. The survival of the bruchid was also assessed on intact and decorticated seeds of five varieties, comprising two resistant varieties "Kanannado" and "IT89KD-288", a moderately resistant variety "IT93K-513-2" and two susceptible varieties "IT87K-941-1" and "IT89KD-374-57". There was no correlation of resistance level with the number of eggs oviposited on cowpea varieties. Under limited and free-choice conditions, cowpea seeds with intact seed coats were preferred to decorticate seeds for oviposition. Adult emergence, mean development periods and pre-adult mortality were similar when seed coats were removed or left intact. It is concluded that the seed coat may not be a useful aspect to consider for breeding of bruchid resistance into cowpea varieties.

Bhatnagar et al., (2001) studied varietal preference of pulse beetle in cowpea. Fifteen varieties were evaluated for their affect on orientation, oviposition, development and survival of *Callosobruchus maculatus* (Fab.). Varieties IFC 9907 and IFC 9909 were less preferred for orientation and oviposition, which resulted in less percentage of seed damage and weight loss. The survival percentage and food consumed per grub was also less in these varieties. Whereas local variety was found to be most preferred for orientation and oviposition. Percentage seed damage, weight loss, survival percentage and food consumed per grub was also higher in local variety. Varieties did not influence
the developmental period. There was no significant relationship of seed colour and seed size with orientation and oviposition of the beetle.

Barreto and Quindere (2000) have worked out the resistance of cowpea genotypes to the *Callosobruchus maculatus* utilizing germplasm of different origin.

Ignacimuthu *et al.*, (2000) indicated on the basis of this study that various wild and cultivated pulses express varied degrees of resistance to damage by *Callosobruchus maculatus*, a major pest of stored pulses. Seeds were analyzed for trypsin/ chymotrypsin inhibitors (qualitatively and quantitatively) and protein profiles (SDS-polyacrylamide gel electrophoresis) to study the chemical basis of resistance to bruchid infestation. Seeds of the wild pulses *Dunbaria ferruginea*, *Neonotonia wightii*, *Tephrosia cararensis*, *Cajanus albicans* and *Vigna bourneae* differ from other wild germplasms as well as cultivars in having characteristically higher levels of trypsin/chymotrypsin inhibitors. SDS-PAGE analyses of seed proteins of *Dolichos lablab*, *Lablab purpureus* and *Rhynchoea cana* reveal the presence of high levels of non-nutrient chemicals such as vicilins, α-amylase inhibitors, and lectins in quantities that may impart resistance to *C. maculatus*. The importance of these protease inhibitors and other non-nutrient chemicals has been discussed with reference to resistance to *C. maculatus* infestation.

Chavan *et al.*, (1997) studied ovipositional preference of *Callosobruchus chinensis* for cowpea lines. The pulse beetle showed a definite intra-varietal response for oviposition. The cowpea lines with rough seed surface were less preferred for oviposition, where the percentage of grains infested with eggs and the number of eggs laid per grain was lower as compared with the smooth
surface seeds. They tested 70 cowpea lines for this purpose. No antibiosis effect in the viability of eggs was noticed. *C. Chinensis* distributed eggs uniformly on grains of different cowpea lines and oviposited a small number of eggs/grain. Brown, black, gray and red coloured seeds were more preferred than white seeds.

Dongre *et al.*, (1996) studied for identification of resistant sources of cowpea weevil *Callosobruchus maculatus* (F.) in Vigna sp. and inheritance of their resistance in black gram (*Vigna mungo* var. *mungo*). Seventy five cultivated accessions and two wild progenitors of black gram (*Vigna mungo*) and mung bean (*V. radiata*) were evaluated for their resistance to infestation by *C. maculatus*. None of the cultivated accessions either of black gram or mung bean was found to be resistant. However, resistance was evident in a wild progenitor of black gram, *Vigna mung* var. Silvestris. The mechanism of resistance of *V. mungo* var. Silvestris was examined and it was found to be larval antibiosis expressed as reduced survival, longer developmental period and reduced body weight. *V. mungo* var. Silvestris was successfully crossed with black gram accession TAU-1 In F1 plants, pollen fertility was normal and seeds were completely resistant to *C. maculatus*. Inheritance of bruchid resistance was further studied in the F2 and F3 generation. In the F2 generation, a 15:1 ratio was observed indicating the presence of two dominant duplicate genes that are controlling resistance to *C. maculatus*. The segregation of F3 plants was as expected for a digenic ratio and segregation showed a good fit to a 7:4:4 ratio (χ² = 0.28). These resistant genes have been designated Cmr1 and Cmr2.
Shade et al., (1996) have studied cowpea weevil biotype virulence to cowpea weevil resistant accession TVu 2027. The result of the study indicate that the cowpea weevil biotypes selected for virulence to TVu 2027 may be used for identifying sources of resistance having the same or different genes for resistance. Xavier-Filho et al., (1996) have reported the resistance of cowpea germplasm/seeds to the cowpea weevil.

Ganapathy and Janarthanan (1995), in their study on phenetic resistance in black gram (Vigna mungo L. Hepper) against Callosobruchus maculatus Fab., evaluated seven entries of Vigna mungo for susceptibility and seedling vigor against infestation by C. maculatus under pot culture conditions. Among the entries, the L/B ratios were lowest in CVSYKR 415/2 (1.21), Vamban (1.27) VB 3 (1.28) and VB4 (1.28), and 1.33 each in T9, CO4 and PDU 10. Seed damage was lowest in small-seeded YKR 415/2 (90.0%) and VB3 (90.0%), germination percentage and seedling vigor index were highest in YKR 415/2, (100.0% and 2129.7) and lowest in T9 (13.3% and 58.17), respectively.

Kadoo and Sane (1995), in their study on relative susceptibility of some pigeon pea varieties to pulse beetle Callosobruchus chinensis L. used 12 commonly grown varieties of pigeon pea (ICPL-87051, BDN-2, ICPL-332, C-11, No. 148, BDN-1, M-33, ICPL-85012, TU-1, AK-8811, ICPL-85014 and ICPL-87119) for observing extent of damage and varietal resistance/ susceptibility to C. chinensis. None of the 12 varieties was found to be immune to infestation by C. chinensis. However, there were significant differences in the relative susceptibility of different varieties to bruchid attack. It was found that ICPL-332
was the most susceptible and BDN-1 was the least susceptible variety as compared to other varieties.

Macedo et al., (1995) studied purification and properties of storage proteins (Vicilins) from cowpea seeds, which are susceptible or resistant to the bruchid beetle *Callosobruchus maculatus*. Vicilins (7S storage proteins) from the seeds of cowpea cultivars, which were susceptible, or resistance to the bruchid *C. maculatus* were purified by size-exclusion and ion exchange chromatography. The vicilins were partially characterized by polyacrylamide gel electrophoresis under both denaturing and non-denaturing conditions by western blotting and by amino acid analysis. The variant vicilins from *i* - resistant seeds by these criteria except that they were more strongly bound to DEAE sepharose, suggesting differences in charge between various molecules.

Edward and Gunathilagaraj (1994 a), evaluated pigeon pea accessions for resistance to *Callosobruchus maculatus* (F). Some 208 *Cajanus cajan* accession were screened for resistance by free choice test. Of those accessions screened, 7 were resistant, 26 moderately resistant, 84 susceptible and 91 highly susceptible.

Edward and Gunathilagaraj (1994 b) studied the relative susceptibility of Green gram, Black gram and Cowpea cultivars to *Callosobruchus maculatus* (F) in the field. Studies showed that green gram CV.VGG -2, black gram CV.Vamban-1 and cowpea CV.CO-4 were the most resistant to *Callosobruchus maculatus* in the field.
Edward and Gunathilagaraj (1994 c), tested resistance in Bengal gram (*Cicer arietinum* L.) to the pulse beetle, *Callosobruchus maculatus* (F.). Twenty-six accessions of chickpeas were screened for their resistance to the bruchid on the basis of 7 biological parameters: number of eggs laid, survival, development period, adult weight, adult longevity, weight loss and suitability index. The number of eggs laid by the bruchid was not associated with the suitability of the seed for further development. The accession NEC-1592 was more suitable for development with a suitability index of 0.0620 and suffered a weight loss of 62.42% due to the infestation. The accession RBH99 had a suitability index of 0.0138 with a weight loss of only 2.06% It seems that the resistance to *C. maculatus* was due to antibiosis as reflected in lower survival, prolonged development period, emergence of more males and sub sized adults with reduced longevity. A positive and significant correlation was found between the survival and other factors like suitability index, adult weight and adult longevity. Survival was negatively correlated with the development period.

Pacheco *et al.*, (1994) have studied the resistance to bruchids in relation to fatty acid composition and grain texture in genotypes of chickpea.

The relative susceptibility of 44 pigeon pea varieties to attack by *Callosobruchus chinensis* and factors involved in their susceptibility were determined in this study in India by Modi *et al.*, (1994). Both, number of eggs per 50 grains and grain damage showed that the cultivars ICPL89044, KM-9 and KPAS-120 were less susceptible than the other varieties. Susceptibility was affected by size and shape of seed but not by seed colour.
Zhu et al., (1994) in their attempt to understand the mechanism of resistance, have reported cowpea trypsin inhibitor and related resistance to cowpea weevil in cowpea variety ‘TVU 2027’.

Sarkar et al., (1991) have reported some genetic parameters of resistance to C. maculatus in mungbean, Vigna radiata. The researchers have studied sixteen mungbean genotypes in this study. The parameters considered were number of healthy seeds (resistance), number of eggs oviposited (ovipositional preference) and emergence hole (adult survival). It was concluded that resistance is the negative function of adults emerged, indicating the importance of this parameter while selecting bruchid resistant mungbean varieties.

Manohar and Yadava (1990), made a laboratory study to see the relative resistance and susceptibility of some cowpea cultivars to pulse beetle, Callosobruchus maculatus. Ten commonly grown cultivars of cowpea viz. Udaipur 1 and 2, P 1309, 1302, 1414, 454-157, IC 11352, CS 152, CO 1 and Kanpur Black (14/2-3) were studied to see the reaction of this pest. The results have indicated that Udaipur 2 was the most and CO 1 the least susceptible variety to this pest. Udaipur 2 and P 1309 were the two most preferred for ovipositional and adult development while CO 1 was least preferred. They have concluded this to the morphological features of these varieties i.e., Udaipur 2 having the large flat seeds having smooth and loose testa with reddish brown colour are favorable for all vital activities of the pest then the small and oval seeds having rough and tight testa in CO 1.

Ramazan et al., (1990) have studied the storage losses to common pulses by pulse beetle, Callosobruchus maculatus. They have reported up to 69.3% seed
damage in different cowpea varieties by this weevil. Mookherjee et al., (1970) in
the similar studies have indicated 18.5% damage.

Afzal et al., (1987) have studied the genetic parameters of resistance to
Callosobruchus maculatus in chickpea. The results indicate that the number of
adults emerged had the true negative correlation with the resistance to bruchid
attack meaning thereby that the number of oviposited eggs are not in any way
reliable indication of the resistance.

Katiyar and Khare (1987), Brewer and Horber (1986) and Seddiqui (1972) have
also worked on ovipositional preference of this weevil on different cowpea lines
and have reported that bruchus preferred lines with smooth surfaced seed over
lines with rough surfaced seed.

Brewer and Horber (1986) evaluated different seed legumes to find out the level
of resistance to Callosobruchus chinensis Linn. As regards to the ovipositional
preference based on seed coat colour, Dias (1986) has worked on this and other
related aspects. They have reported that dark brown coloured seed were
preferred over light coloured ones.

Khattak et al., (1986) have studied relative susceptibility of different mungbean
varieties to pulse beetle, Callosobruchus maculatus F. and have classified the
 genetic material in to different categories.

Rustamani et al., (1985), studied the relative resistance/susceptibility of different
pulses [gram, matar, moong and mash against pulse beetle, Callosobruchus
chinensis L]. Messina and Renwick (1985) have studied selected cowpea lines
for their response to pulse beetle and have elaborated on these and related
issues. Singh et al., (1985) worked out bruchid resistance in cowpea. Dharen et al., (1984), conducted detailed study on pigeon-pea varieties to find out the level of resistance/susceptibility to pulse beetle. Khare and Johari (1984), have reported the influence of phenotypic characters of chickpea (Cicer arietinum L.) cultivars for their susceptibility to *Callosobruchus chinensis*.

Redden (1983), has studied the inheritance of resistance to seed weevil in cowpea. The analysis of percentage emergence and emergence period in these crosses has been described. Singh et al., (1982), have described the resistance of bruchids in cowpea and other tropical legumes. Singh et al. (1980) have studied the ovipositional preference of *Callosobruchus chinensis* and *C. fabricus*, in an attempt to explore resistance to pulse beetle.

Dabi et al., (1979) have studied the relative susceptibility of some cowpea varieties to pulse beetle. The results obtained indicated that seed morphological characters like seed texture, colour, size, weight, volume and hardiness had no correlation with susceptibility/resistance. Gatehouse et al., (1979) have conductedout investigations to find out the biochemical basis of insect resistance in *Vigna unguiculata*.

Nwanze and Horber (1975), have worked out different types of laboratory techniques for screening cowpeas for assessing the levels of resistance to *Callosobruchus maculatus* F.

Girish et al., (1974) have studied oviposition and development of *Callosobruchus maculatus*, on some pulses. Results indicated that RS 9 was the least susceptible, PS118, 42 and No. 5-19-4-1 proved to be more susceptible
then the others. The weight, volume and colour of the seed had no effect on the resistance of the variety. Gokhale (1973) studied the developmental compatibility of this pest on several pulses by observing the growth and developmental parameters. Chopra and Khurab (1970) have studied the relative resistance of some pulses to the attack of *Callosobruchus analis*.

**Sand, Ash and Inert material:**

Stathers *et al.*, (2004), have worked out efficacy and persistence of two commercially available enhanced diatomaceous earth (DE) products against four common tropical storage pests (*Prostephanus truncatus*, *Sitophilus zeamais*, *Callosobruchus maculatus* and *Acanthoscelides obtectus*). Persistence of the enhanced DE treatments was considered after 3 and 6 months storage by assessment of both adult mortality and F1 progeny emergence. Both DEs usually increased parental mortality and reduced progeny emergence of all four insect species in comparison with the untreated control at both 50% and 60% RH, and at all storage periods. However, efficacy was inversely related to duration of storage and over time the host commodity also became less suitable for insect development. Each insect species differed in its susceptibility to the DE treatments, highlighting the need for field application rates to be based upon the entire spectrum of pest species likely to be present during storage.

Naito (2000), made an attempt to develop technologies acceptable to farmers in controlling soybean pests through research programs in Indonesia. Three kinds of natural substances, namely, rice husk ash, wood ash and lime, were mixed
with soybean seeds at three ratios (0.25, 0.5, and 1.0 by weight) and in five replications. Pairs of adult beetles were then released in test cages for one month, two months and three months respectively. Adult mortality was checked with five replications at 0-5 and 90-95 days after release. Evidently, rice husk ash had a marked effect on the mortality rate. Mixtures with 0.5% and 1% gave 100% mortality which continued for three months after treatment. The lethal effect of wood ash did not last as long as that of rice husk ash. Treatment with lime was less effective than with the other substances. The number of deposited eggs was the smallest in seeds treated with rice husk ash (only 10-20 eggs in 500g of soybean seed). One hundred to 160 eggs were deposited on seeds treated with wood ash, and even more eggs were laid on lime-treated seeds. The study has concluded that the rice husk ash was found to be effective against bruchid beetles that attack stored legume seeds. Mixing 1% in weight of the ash in the seeds before storage effectively protects the seeds from pest infestation. The lethal action of rice husk ash on bruchid beetles has not yet been fully analyzed. However, there are some interesting indications. The main ingredient of rice husk ash is silica (SiO₂), accounting for 96% of the total content. The ash has almost the same composition as diatomaceous earth. One type of diatomaceous earth, commercially named "Insect", is effective in controlling pests of stored grain. The high silica content must have a lethal effect on insects. Apuuli and Villet (1996), tested wood ash for the protection of stored cowpea seed (Vigna radiata (L.) Walp.) against bruchids in a laboratory test wood ash was added at rates of 5,10,15,20 and 30% by weight of seed. Damage to seeds ranged from a mean of 63% in the ash free control to a mean of 1.3% in seeds
treated with 30% ash. The number of progeny similarly ranged from 148 in the control to 2.5 in the 30% ash treatment. They suggested that any dry, powdery substance might serve as a good protective medium for stored seeds.

Mohamed (1996), tested cotton stem and cow dung ashes for the control of Callosobruchus maculatus and Callosobruchus chinensis in mungbean seeds. Result showed that average mortalities of C. maculatus reached only 6.7 and 16.7% for cotton stems and cattle dung ashes, respectively, and for C. chinensis 16.7 and 25.6% respectively. Malathion showed very high efficiency, 94.4 and 93.3% for C. maculatus and C. chinensis respectively, the corresponding mortalities of C. maculatus were 34.4 and 95.6%.

Javaid and RamatlaKapela (1995), studied the management of cowpea weevils in cowpea seeds by using ash and sand. The types of sand used were fine sand (0.05-0.25 mm) and coarse sand (0.25-2.00 mm and the dosages were 2.5, 5 and 10% wt/wt. The results showed that sand performed poorly but were better than the untreated control that provided partial control.

Onu, I. and Aliyu, M. (1995) in their study evaluated fruits of four peppers (Capsicum Spp.) for the control of Callosobruchus maculatus (F.) on stored cowpea seed. They have reported that various pepper powders at 2.5-5.0 g/250 g of seed were effective in reducing oviposition and damage to cowpea seeds. The pepper type Capsicum frutescens var yarmunchi was most effective in discouraging oviposition and minimizing damage to the seed, as indicated by the significantly lower number of emergence holes. The seed quality and viability were not affected by the powdered pepper treatment. The results of this study
are indicative of potential for use of powdered fruits of some of pepper types in protecting stored cowpea seeds.

Lienard and Seck (1994), made a review of control methods against *Callosobruchus* (F.) in tropical Africa. This is one of the most important pests of stored-cowpea in tropical Africa. The anthers view that in rural area where preservation techniques and facilities are limited, it causes post-harvest weight and quality losses. The importance of damage, which can reach 100% in a few months, justifies the development of effective and appropriate control methods in the villages. Chemical control is inappropriate at farm level, because of its cost and hazards. Many studies conducted on varietal resistance have enabled identification of varieties that are more or less resistant to this pest; however, the varieties are often of little interest from the agronomic point of view. The incorporation of that resistance in cultivated varieties is in progress. The physical control methods are inadequate, biological control is an alternative but is still not fully worked out. All these limitations support promotion of traditional control methods. Among them, the use of inert substances as well as indigenous plants or their by-products have given, in many cases, satisfactory control of *C. maculatus*.

Longstaff (1994), reviewed the range of techniques currently in use in Australia, including controlled atmospheres, the heating or cooling of grain, the use of inert dusts, and hygiene. Historically, Australia has relied heavily on the use of residual chemicals, in the form of structural treatments and admixtures, to protect grain in storage and in transit. Frequently, this method is supplemented by the use of grain cooling. Other methods, such as fumigation and controlled
atmospheres, have been used when this method of control has broken down or where the storage structure has been modified to permit their long-term use. With the development of insect and consumer resistance to insecticides, there are pest-management and economic incentives to increase the emphasis on these alternative non-residual or non-chemical measures. A number of other techniques are also discussed. These are being investigated as possible candidates for use in the future.

Chiranjeevi (1991) has studied the relative efficacy of some indigenous plant material and ashes on the egg laying capacity, adult emergence and developmental period pulse beetle in green gram. The ashes are reported to be reasonably effective.

Suyono and Naito (1991) have studied the effectiveness of natural substances, ashes and lime on the soybean stored pest, *Callosobruchus analis* (F.) and have reported different level of protection by these substances against this pest.

Wolfson et al., (1991) studied the efficacy of ash for controlling infestations of *Callosobruchus maculatus* (F.) in stored cowpea. They have also reported the traditional use of wood ash to control bruchid beetles attacking cowpea seeds in Africa, including South Africa and Cameroon.

Matsumoto (1987) has reported that some Indonesian farmers used rice husk ash in storing soybean seeds. In those cases, seeds were mixed with ash at a ratio of 10% of seed weight in plastic bags or cans. Good results were obtained, and the rice husk ash promoted the drying of grain.
Ofuya (1986) tested wood ash and other material also in an attempt to reduce the damage in cowpea seeds during storage. It is reported that use of wood ash reduces the percentage of seed damaged and the number of adults emerged after 95 days of storage compared with the unprotected control. The cowpea seed treated with wood ash were least damaged as compared to other treatments (powdered onion scale and dry chili pepper fruits). The viability of seeds was not affected by any of these treatments.

Khan and Borle (1985), studied various pulse protectants viz., Acorus calamus L. rhizome powder and activated clay and cowdung ash smearing with groundnut oil and reported that Cowdung ash 1.0% and smearing with groundnut oil 1 ml/kg grain were not found effective. Acorus calamus L. rhizome powder and activated clay both in the proportion of 0.1, 0.3 and 0.5% by weight proved to be quite effective in arresting the development activities of the pulse beetle attacking stored gram.

Tee, (1981) studied powdered paddy husk ash as a grain protectant against stored product beetles. The use of paddy husk ash against five beetles infesting stored grains studied was found effective at a rate of 1-2.5% (by weight).

Kranz et al., (1977) have reported storing cowpea seeds with dry sand for protecting seed from damage by this pest. Similarly, Whitney (1971) has reported that the traditional farmers' practice of mixing fine-seeded millet or sand with large seeded sorghum or maize in storage is effective against moth pests because it prevents access by filling the inter-granular spaces.
Mahanthi and Gour (2004) based on their study described Neem - as a safer grain protectant against stored grain pests in maize. The insecticidal activity of two neem products viz., Neem Leaf Powder (NLP), 2% w/w and Neem Seed Kernal Powder (NSKP), 2% w/w was evaluated for the efficacy against four storage pests of maize keeping in view the qualitative and quantitative losses caused by storage pests in maize, failures of management and importance of pesticide residues in poultry feed. NSKP was highly effective compared to NLP against *Sitophilus oryzae* and *Tribolium castaneum* causing high mortality. Grain treatment with NSKP caused 36.67 percent adult mortality of *S. oryzae* (at 20 DAT) and 41.67% mortality of *T. castaneum* (at 30 DAT), whereas NLP caused 6.67% mortality of *S. oryzae* (at 20 DAT) and 41.67% mortality of *T. castaneum* (at 30 DAT) mortality of *T. castaneum*. Hundred percent adult mortality of *S. oryzae* and *T. castaneum* was observed in NSKP treated grain at 50 days after treatment. Complete adult mortality was observed at 80 days after NLP treatment in case of *S. oryzae*. In case of *T. castaneum*, complete adult mortality was observed at 40 days after NLP treatment. NSKP also gave high larval mortality (73.33%) and pupal mortality (3.3%) of *Corcyra cephalonica* compared to NLP causing 48.33 per cent larval mortality and 1.67 per cent pupal mortality at 40 days after release. Adult emergence of *S. oryzae*, *T. castaneum*, *Sitotroga cerealella* and *C. cephalonica* was affected in NSKP and NLP treated grain. Thirty five days after infestation, adult emergence of *S. oryzae* (4.67) and *T. castaneum* (14.0) was very low in NSKP treated grain compared to the adult emergence of *S. oryzae* (27.67) and *T. castaneum* (22) in NLP treated grain. No
adult emergence was observed up to 140 days. Similarly juvenile action of neem on larvae and pupae of Ceratitis capitata and oviposition deterrent or oxicidal action of neem on S. oryzae, T. castaneum, and S. cerealella resulted in reduced adult emergence. Grain damage caused by S. oryzae, T. castaneum was highly reduced in NSKP treated grain compared to NLP due to population decrease of these species in successive generations. Neem leaf powder exhibited higher efficacy in reducing the grain damage caused by S. cerealella than that of S. oryzae and T. castaneum. Even though neem leaf powder was effective in reducing the adult emergence of S. oryzae, T. castaneum, S. cerealella and C. cephalonica but the efficacy was low compared to neem seed kernel powder.

Singh (2004), studied management of insect pests of crop and stored grain through neem. Neem has emerged as single most important source of safe pesticide. Certain key insect pests, viz., Helicoverpa armigera, Bactrocera dorsalis, B. cucurbitae, Idioscopus nitidulus, Nilaparvata lugens, Cotton bollworms, Chilo partellus and stored grain pests such as Trogoderma granarium, Callosobruchus chinensis and Lasioderma sericorne have been successfully managed by the neem based pesticides.

Neem oil volatiles evaluated for the first time exhibited high fumigant toxicity at an incredibly low concentration against adults of Callosobruchus maculatus, Ceratitis capitata, Sitotroga cerealella and Trogoderma granarium. Neem has been found highly compatible with nuclear polyhedrosis virus as lethal time log has been found to reduce considerably when used in combination with NPV against Spodoptera litura. Neem seed kernel has about 55 biologically active compounds. Azadirachtin is the most important biologically active compound
and its quantity varies greatly in neem trees so is the case with oil and other compounds. Neem is cheap, safe, effective, available and renewable source of pesticide and fits-in-well in sustainable agriculture as well as the life style of Indian farmers.

Satya Vir (2004, a) reviewed neem research in India. Neem, a native of Indian subcontinent, is one of the important multipurpose tree species, which is receiving worldwide recognition for its versatile characters and multifarious uses. Neem based pesticides have the excellent potential in view of the low capital cost, abundant availability of raw material, eco-friendly nature and government support for the Integrated Pest Management Programmes.

Satya Vir (2004, b), studied utilization of neem based formulations for the management of insect pests of arid legumes in Thar desert of India. Neem based pesticides which offer great enhanced environmental safety while retaining a high degree of bio-efficacy have been accepted as important component in Integrated Pest Management Programme in several countries. Different Neem based formulations prepared were tested against pest complex of Kharif pulses viz. Vigna aconitifolia, V. radiata and V. unguiculata under field conditions. The study highlights the need for better understanding for the use of these eco-friendly products, which are efficient antifeedant and repellent to pest attack. Products are cost effective as all the raw material is locally available and can be easily exploited by the farmers as and when required.

Doumma and Alzouma (2001), studied the Bruchidius atroleineatus Pic. and Callosobruchus maculatus Fab., in Sahelian area, where these are most important pests of cowpea beans. Cowpea infestation by these two species of
bruchids starts in the field at the beginning of the plant fruit bearing and continues during storages where damage can be high if no control action is taken. In this study, the impact of several introductions of *B. senegalensis* (Pers.) Lam. Ex Poir. (Capparaceae), an insecticidal plant which is usually used by farmers in Niger, on the population dynamics of the two bruchids species in traditional cowpea storage system has been investigated. The results obtained from this study point out that bruchid population are important in the standard jars than in the one, which have received regular inputs of *Bruchidius senegalensis*. Thus, preservation action by regular inputs of *B. senegalensis* seems to be an efficient way to control bruchids in the cowpea traditional storage system.

Bhatnagar *et al.*, (2001) studied efficacy of vegetable oils against pulse beetle, *Callosobruchus maculatus* in cowpea. Six vegetable oils namely groundnut, sesame, soybean, coconut, mustard and neem were tested for their efficacy as repellent, ovipositional deterrent and ovicidal effect against pulse beetle, *Callosobruchus maculatus* (Fab.) in cowpea, at one, seven, fifteen and thirty days after seed treatment (10 ml/kg seed). Neem oil was found most effective and showed significantly higher repellent, ovipositional deterrent and ovicidal effect against the beetles followed by coconut, soybean and mustard oil. Groundnut oil was least effective. All the vegetable oils except neem lost their efficacy at thirty days after treatment.

to 12h of fumigation using pure essential oils at a dose of 25 μl /vial, 80% mortality was recorded for *Ocimum basilicum*, 70% for *O. gratissimum* and 0% in the control. A significant difference was observed between the responses of males and females with males exhibiting greater sensitivity. When 1 g of aromatized powder was applied to adults, a 50% lethal concentration at 48h was found to be 65 μl /g for *Ocimum basilicum*, and 116 μl /g of *O. gratissimum* oils. The essential oils from the two plant species exhibited a significant effect both on the egg hatch rate and on the emergence of adults. The egg hatch rate was reduced to 3% with *O. basilicum* and 15% with *O. gratissimum* using an essential oil concentration of 30 μl, whereas the egg hatch rate for the control was 95%. When compared with the control (97%), adult emergence dropped to 0% with *O. basilicum* and to the 4% with *O. gratissimum*. Storage bioassays were run to assess the long-term effect of powders aromatized with essential oils of *Ocimum*. Complete protection was observed over 3 months starting at a dose of 400 μl in the case of both oils. From a germination test, it was concluded that aromatized powders have no significant effect on the seed germination rate. After 5 d, a rate of 88% germination was seen in seeds treated with aromatized powder and protected from insects, compared with 97% for untreated seeds that were not exposed to insects.

Singh *et al.*, (2001), tested efficacy of different indigenous plant products as grain protectant against *Callosobruchus chinensis* Linn. on pea. Attempts have been made to protect the pea grain with indigenous plant products viz., leaf powder of *lantana, sadabahar, neem, madar* and *kali tulsi* @ 10gm/kg grain and oils of *castor, neem* and *mahua* @ 2ml/kg grain to develop the safer products for
its control. The efficacy of various products was assessed on the basis of per cent grains damage and per cent loss in weight. The result revealed that neem oil and neem leaf powder appeared to be most effective to minimise the damage by the pest in grains being 2.06 and 2.66 per cent respectively, as against 69.63 per cent in untreated grains followed by the treatment of castor oil (2.86 per cent). The loss in weight was as high as 47.40 per cent in untreated grains which reduced considerably to a level of 0.63, 1.00 and 1.10 per cent by application of neem oil, neem leaf powder and castor oil, respectively.

Ban et al. (2000) have described the efficacy of volatile ingredients in neem oil against Callosobruchus chinensis. El-Lakwah et al., (2000), studied comparative toxicity and joint action of the commercial insecticide of botanical origin - neemazal-w with Malathion to the cowpea weevil, C. maculatus.

Kéïta et al., (2000), tested the efficacy of essential oils were extracted from four West African plant species [Tagetes minuta (Family: Compositae), Hyptis suaveolens (Family: Labiatae), white basil Ocimum canum (Family: Labiatae), and sweet basil O. basilicum (Family: Labiatae)] by steam distillation. The oil of the pepper Piper guineense (Family: Piperaceae) was extracted from the fruits by hydro distillation and ethanol extraction. Mixed essential oil and total ethanol extract was used. Kaolin powder (clay) was mixed (aromatized) with these different oils. Cowpea weevils were reared on chickpeas and newly emerged males and females were deposited on uninfested seeds. Bioassays, i.e. fumigation with pure essential oils and aromatized kaolin powders, were carried out on adults and eggs. Twenty-four hours after fumigation, 99 and 0% adult mortality were observed, respectively, as the result of treatments with Ocimum
basilicum and the control. The application of powders aromatized with the same oils to weevil pairs resulted in a complete lack of oviposition, whereas 31, 56 and 76 eggs were laid in the controls after 24, 48 and 72 h, respectively. Application of aromatized powders did not have a significant effect on egg hatching (50 out of 110 with O. canum, 100 out of 115 with O. basilicum and 100 out of 130 in the control sample) but did have a significant impact on adult emergence- 0% for the two treatments compared with 100% in the controls. The results suggest that plants of the genus Ocimum can be used as an alternative to synthetic insecticides.

Lale and Mustapha (2000), tested efficacy of different rates (25, 50, 75 and 100 mg/5 g seed) of application of neem seed oil (NSO) on four cowpea varieties (Kanannado, IT89KD-391, Borno brown and IT89KD-374) with differing susceptibilities to Callosobruchus maculatus. The different rates of NSO significantly interacted with cowpea varietal resistance and reduced oviposition and percentage adult emergence of C. maculatus. The interaction of the strategies also significantly reduced percentage of cowpea seeds infested by C. maculatus. Treatment of seeds with NSO at the rates of 50 mg/5 g and 75 or 100 mg/5 g reduced seed damage from over 25% in controls to less than 10% and less than 5%, respectively, in all varieties.

Tun et al., (2000), tested fumigant activity of essential oil vapours distilled from anise, Pimpinella anisum; cumin, Cuminum cyminum; eucalyptus, Eucalyptus camaldulensis; oregano, Origanum syriacum var. bevanii and rosemary; Rosmarinus officinalis against eggs of two stored-product insects, the confused flour beetle, Tribolium confusum, and the Mediterranean flour moth, Epestia
kuehniella. The exposure to vapours of essential oils from anise and cumin resulted in 100% mortality of the eggs. Oregano achieved mortalities as high as 77 and 89% in T. confusum and E. kuehniella, respectively. The highest mortalities caused by essential oils of eucalyptus and rosemary was 45 and 65%, respectively. At a concentration of 98.5 μl anise essential oil/l air, the LT_{99} values were 60.9 and 253.0 h for E. kuehniella and T. confusum, respectively. For the same concentration of the essential oil of cumin, the LT_{99} value for E. kuehniella was 127.0 h. As the essential oils from other plants investigated were less active their estimated LT_{99} values were too far beyond the tested exposure range to be reliable.

Ahmad et al., (1999) studied the effects of plant oils on oviposition preference and larval survivorship of Callosobruchus chinensis (Coleoptera: Bruchidae) on azuki bean (Vigna angularis). Babu et al., (1999) have worked on comparative efficacy of some of indigenous plant extracts against pulse beetle.

Lale and Abdulrahman (1999) evaluated neem seed oil obtained by different methods and neem powder for the management of Callosobruchus maculatus (F.) in stored cowpea. Golob and Gudrups (1999) have used spices and plant materials of medicinal importance as bioactive protectants for insect pests in stored grains and other commodities.

Oliveria et al., (1999) studied the toxicity of jack bean (Canavalia ensiformis) cotyledon and seed coat proteins to the cowpea weevil. Pérez Alvarez Castellanos (1999) have reported the pesticidal activity of essential oils extracted from the plant material of Chrysanthemum coronarium L. a wild relative of ornamental chrysanthemums.
Srivastava and Mann (1999), have dealt with evaluating insecticidal efficacy of *Peganum harmala* (Family: Zygophyllaceae), a desert plant, and have tested different plant parts, which were formulated using different extracts and at various concentrations, against *Callosobruchus chinensis*. The results showed that ether extracts at highest dose concentration of 10% were the most effective in increasing adult mortality, retarding rate of development, reducing egg laying, adult emergence and weight loss in host grains of pulse, *Vigna radiata*. Among the plant parts, leaf was found to be the most effective followed by fruit, root and stem.

Ahn *et al.*, (1998), studied insecticidal and acaricidal components from sawdust of *Thujopsis dolabrata* var. hondai against eight species of anthropod pests (*Reticulitermes speratus*, *Lasioderma serricorne*, *Callosobruchus chinensis*, *Sitophilus oryzae*, *Plutella xylostella*, *Myzus persicae*, *Blatella germanica*, and *Tetranychus urticae*). These components were isolated by chromatographic techniques and characterized by spectroscopic analyses as the terpenoids carvacrol and beta-thujaplicine. In tests using the filter paper diffusion method, carvacrol had broad insecticidal and acaricidal activity against agricultural, stored-product, and medical arthropod pests. However, beta-thujaplicine showed only weak termiticidal activity. Insecticidal activity of carvacrol was attributable to fumigant action. As a naturally occurring insecticide, carvacrol could be useful as a new preventive agent against damage caused by these arthropod pests.

Babaran, V.B. (1997), tested the effectiveness of neem in the control of *Callosobruchus* sp. insects on stored legume seeds was evaluated. The application of dried neem leaves to cowpea and mungbean seeds can cause
mortality to *Callosobruchus* sp. Based on the obtained results in the study, crushed neem leaves applied on top of the legume seeds are an effective control measures against *Callosobruchus* sp. insects compared to control (without neem leaf treatment). Neem leaves possesses controlling properties as an antifeedant and repellent and causes mortality in the insects.

Javid and Mpotokwane (1997), studied evaluation of plant material for the control of *C. maculatus* (Fab.) in cowpea seeds. On the basis of number of eggs and adult emergence of *C. maculatus* and weight loss of cowpea seeds, powers obtained from *Eucalyptus, Melia azedarach* and *Croton gratissimus* were shown to have some insecticidal activity against the pest. Powders from 8 other plants were ineffective.

Mohamed (1997), tested effectiveness of *datura* leaf extracts and their mixture with Malathion against the cowpea beetle *Callosobruchus maculatus* (F.). The toxic effects were investigated of acetone, petroleum, ether and ethyl alcohol [ethanol] extracts of *Datura stramonium* leaves, separate and in mixtures with the LC$_{25}$ of Malathion, on mortality and reduction in F1 progeny of *Callosobruchus maculatus*. Results concerning the toxicity of the various plant extracts revealed low mortality values even after 7 days from treatment at the highest concentration used (10%). Results also indicated that the petroleum ether extract was more toxic than the other plant extracts. There was a greater effect on the reduction in F1 progeny of *C. maculatus* than on mortality. There was a slight repellent effect at all concentrations. At 7 days from treatment, all mixtures of the plant extracts with the LC$_{25}$ of Malathion gave considerably higher mortality values than the plant extract alone. A pronounced synergistic
effect for the combination of plant petroleum ether extract plus insecticide and an
additive effect for the mixture of plant ethanol extract plus insecticide was
demonstrated at all concentration used. Mixtures of the plant acetone extract
plus Malathion exhibited a synergistic effect at higher concentrations and an
additive effect. At low concentrations (1.25 and 2.5%). It is suggested that
application of mixture of the LC$_{25}$ of Malathion plus petroleum ether extract (5
and 10%) may be useful as grain protectants against C. maculatus. The results
indicate that the datura leaf and mixture was quite effective.

Maheshwari and Dwivedi (1997), in their study on screening of some plant
extracts for their oviposition deterrent properties against the pulse beetle,
*Callosobruchus chinensis* (L). tested ten plants extracts in two solvents (acetone
and pet-ether) for the oviposition deterrent properties against *C. chinensis* on
cowpea seeds in the laboratory at 27 ± 2°C and 60-70% RH. The extracts tested,
acetone extracts of *Cassia occidentalis* and *Croton bonplandianus* and pet-ether
extracts of *Verbesina encelioides* and *Cassia occidentalis* were effective in
deterring oviposition.

Mansoor (1997), tested effectiveness of plant oils as protectant of mung bean
*Vigna radiata* against *C. chinensis* infestation. In practice-oriented results on use
and production of neem ingredients and pheromones, Neem Azal-S, Soybeen
and Sunflower oils were evaluated in the laboratory. Among the oils used, neem
Azal-S at 0.5% gave 100% mortality of the different stages of the insect for up to
three months and could protect the seeds from serious damage up to one year.
Neem Azal-S at 0.5% could be used most effectively when the stored mung
beans are to be used for seeding.
Namrata et al., (1997), studied contact and fumigant action of volatile essential oil of *Murraya koenigi* against *Callosobruchus chinensis* in the laboratory for contact and fumigant toxicity. The oil was toxic at concentrations of ≥ 340 p.p.m.

Negi et al., (1997) studied egg-laying and adult emergence of *Callosobruchus chinensis* on green gram (*Vigna radiata*) treated with Pongam oil. Study was conducted to observe the effect of different concentration of pongam oil on egg-laying and adult emergence of pulse beetle on green gram. Marked effect of different dose concentration of oil on egg laying was observed. It decreased with increase in dose of oil. A similar trend of decrease in emergence percentage was observed with increase in dose concentration.

Onu and Sulyman (1997), tested efficacy of powdered citrus peel (from orange, lemon, grapefruit and lime) for control of *C. maculatus* in stored cowpea seeds. Dried, powdered peel from four citrus fruits was tested, using two application rates. Powdered grape fruit peel at 10 and 20 g/200g cowpea, and lime peel at 20g/200g cowpea discouraged oviposition, suppressed emergence of the F1 generation, and substantially reduced damage to cowpea seeds by *C. maculatus*. Seed quality and viability were not effected by any of the citrus peel treatments.

Modgil and Mehta (1997), studied the effects of oil treatment against the infection of *Callosobruchus chinensis* (L.) on the levels of B vitamins in stored legumes. Groundnut, coconut and mustard oil treated whole chickpea, mung bean and pigeon pea were infested with *Callosobruchus chinensis* (L.) and stored for six months. Groundnut, mustard and coconut oils were able to protect legumes for six months against insect infestation when applied in small amount.
(0.5%), whereas coconut oil was effective against insect infestation only for four months.

Prijono and Manuwoto (1997), in their study on evaluation of insecticidal activity of seed extracts of 30 species of Annonaceae, Fabaceae and Meliaceae were exposed to C. maculatus females (1-2 days old) in petridishes. Extracts that yielded at least 90% mortality were considered active. Amongst the Annonaceae species, Annona squamosa and A. glabra at 0.5% showed good contact effect against C. maculatus (>90% mortality after 3 days and 100% after 5 days); that of A. muricata had a fairly good contact effect (71.2%) mortality after 5 days); and that of Stelchocarpus cauliflorus was moderately active (58.6% mortality after 5 days). Among the meliaceae species, Dysoxylum cauliforum was the only one whose seed extract (at 0.5%) possessed a good contact effect against C. maculatus (88.3%) mortality after 3 days and 100% after 5 days). The seed extract of another meliaceae species, Aglaia elliptica, showed a fairly good contact affect (76.3% mortality after 5 days). None of the Fabaceae seed extracts were effective against C. maculatus. Further tests revealed that the LC_{50} of A. Squamosa and A. glabra seed extracts against C. maculatus were 0.206 and 0.254% at 3 days after treatment (DAT) and 0.163 and 0.158% at 5 DAT, respectively, the respective figures for the LC_{95} were 0.351 and 0.639% at 3 DAT, and 0.299 and 0.357% at 5 DAT.

Pandey and Singh (1997), tested effect of neem bark powder on infestation of pulse beetle Callosobruchus chinensis in stored chickpea. It was observed that neem bark powder contains insect growth regulating and insecticidal properties.
and effectively control the increase of population of *C. chinensis* on chickpea in storage.

The importance of pulses and legumes as the world’s major source of plant protein of high biological value is rapidly increasing especially in the tropics due to the population explosion coupled with food shortages. Losses to pulses due to infestations of bruchids have been reported by Mookherjee et al. (1970) and Krishnamurthy (1975). attempted to study the effects of *neem* bark powder on the population growth of *Callosobruchus chinensis* (L.) infesting seeds of chickpea.

Rajapakse et al. (1997), studies potential of four vegetable oils and ten botanical powders for reducing infestation of cowpeas by *Callosobruchus maculatus, C. chinensis* and *C. rhodesianus*. The possible use of ten botanicals and four vegetable oils in managing the bruchid legume pests *C. chinensis, C. maculatus* and *C. rhodesianus* was investigated: All four oils tested (Maize, Groundnut, Sunflower and Sesame) significantly reduced the oviposition of all 3 bruchid species at 10 ml/kg and also significantly reduced the longevity of adult of *C. maculatus* and *C. chinensis* at this dose. Only maize and sunflower oil caused a significant reduction of longevity of *C. rhodesianus* at 10 ml/kg. The number of eggs laid by all three bruchid species was significantly reduced in treatments to which powders of *Cymbopogon citratus, Cinnamomum camphora, Derris inudata, Monodora myristica, Zingiber spectabile* or *Z. zerumber* had been added.

Rajapakse and Senayake (1997), have studied effectiveness of seven vegetable oils against *C. chinensis* (L.) in pigeon pea *Cajanus cajan* L. Entomon. The
effects of seven plants oils at 0.4, 0.6 and 0.8% w/w concentrations/100 grams of pigeonpea seed on oviposition of *C. chinensis* were studied at 30±3⁰ and 75 ± 6% RH. Observations were taken at 1, 15, 30 and 45 days after treatment. The seven plants oil tested were *Cymbopogon citratus*, *Bassia longifolia* (*Madhuca longifolia*), *Ricinus communis*, *Cocos nucifera*, *Arachis hypogaea*, *Glycine max* and *Azadirachta indica*. All the oils significantly affected oviposition at all 3 concentrations tested at one day after treatment. *C. citratus*, *R. communis* and *B. longifolia* at 0.8% concentration were found to reduce oviposition significantly compared to the control. All the oils tested did not appear to affect seed germination significantly.

Schmidt *et al.* (1997) made a study on evaporation, sorption and penetration of insecticidal ingredients of *Acorus calamus* oil. The most active ingredient of the oil against *Sitophilus oryzae*, *S. granarius* and *C. chinensis* was identified as cis-asarone. The volatilization of the oil was very slow and the vapours are highly absorbed by the treated commodities and their penetration through the food materials is negligible. The oil was active against *S. oryzae* and *S. granarius* adults at 30⁰C but not at cooler temperatures.

Shaaya *et al.*, (1997) reported plant oils as fumigants and contact insecticides for the control of stored product insects. In an attempt to find ecologically safe alternatives for the control of stored product insects. The fumigant toxicity of a large number of essential oils extracted from various spices and herbs were assessed against several major stored product pests. *Tribolium castaneum* was found to be the most resistant, compared with *Sitophilus oryzae*, *Rhizopertha dominica* and *Oryzoephilus surinamensis*, to most essential oils tested. With the
highly active labiatae sp. oil ZP51, a concentration of 1.4-4.5 μ 1/liter air and
exposure time of 24h was enough to obtain 90% mortality of all the insects. In
columns 70% filled with wheat, a concentration of 50 μ 1/liter and 7 days
exposure were needed to obtain 94-100% mortality of the insects. The biological
activity of a number of edible oils, when applied as contact insecticides, was
assessed in field studies. Edible oils are potential control agents against C.
maculatus and to a lesser extent, against S. zeamais, S. oryzae and Sitotroga
cerealella. These materials could be very useful at farm level in developing
countries. It is concluded that plant oils can play an important role in stored-grain
protection and reduce the need for, and risks associated with the use of
insecticides.

Alebeek (1996), tested natural suppression of bruchid pests of stored cowpea in
West Africa. Stored cowpea (Vigna unguiculata) was collected from village
storage units and from market in Niger, to study the occurrence of bruchid pests
and their parasitoids. High variability in storage methods and structures and in
the levels of bruchid and parasitoid attack was observed. The village of origin,
the cowpea variety and the type of storage structure all had significant effects on
the percentage of beans attacked by bruchids. Some samples with high levels of
egg or larval parasitism showed the potential for natural control, given the right
conditions. The use of insecticides seems to decrease the impact of parasitoids,
leading to higher bruchid populations and losses. Comparing the results from
this survey with the out come of interviews with farmers in Nigeria and Niger, it
appears that traditional storage methods and protection techniques are gradually
disappearing.
Aheer et al., (1996), studied some plant derived oils viz; Coconut, Mustard, Castor, Sesame, Palm, Olive oil and a grain protectant Reldan 25 EC as check. The results revealed that Coconut oil @ 1 ml/kg gave 100% control and proved statistically equal to Castor oil and Reldan 25 EC (@ 1:50) with 97.5% and 100% mortality of the test insect, respectively.

Chiranjeevi and Sudhakar (1996), in their study on effect of indigenous plant materials on the fecundity, adult emergence and development of pulse beetle, Callosobruchus chinensis (L.) in black gram tested powders from neem (Azadirachta indica), sweet flag (Acorus calamus), apamarga (Achyranthus aspera), kesara chettu(Crinum defixum), and lantana (Lantana camara); and cowdung; Acacia arabica, (A.nilotica) wood; neem wood and Casuarina indica. Wood ashes were tested for their effect on egg laying developmental period and adult emergence of C. chinensis infesting Vigna mungo. The application of 0.5-2.0 (w/w) neem seed powder completely prevented the development of the pest. Cowdung ash and A. calamus powder prevented egg laying at 1.0 part per 100 parts of seed (w/w) and reduced the development at higher concentrations in other treatments (1.5 and 2.0 parts per 100 parts (w/w). The egg laying capacity of the pest and total number of adults emerging decreased with increase in concentrations of the powders and ashes. The developmental period of C. chinensis was prolonged in the treated samples over the untreated control.

Donato and Pables (1996) studied the effects of neem leaves in different preparations as protectant of corn and mungbean seeds against storage pests.

Gakuru and Foua (1996), in their study on effects of plant extracts on the cowpea weevil (C. maculatus Fab.) and the rice weevil (Sitophilus oryzae L.)
tested ester extracts (at 0.2, 0.5 and 1% w/w) of nine plants in the laboratory against two stored products insects. Against the bruchid *C. maculatus*, the LD₅₀ was exceeded after 24 h with 1% *Ocimum basilicum* and 0.2% *Piper guineense*, and after 48h with 1% *Eucalyptus citriodora*, 1% *Capsicum frutescens* and 1% *Tetrapleura tetraptera*. Against *Sitophilus oryzae*, the LD₅₀ was exceeded after 24h with 1% *O. basilicum*, 1% *C. frutescens*, 0.2% *P. guineense* and 1% *T. tetraptera*, and after 48h with 1% *Eichornia crassipes*.

Lognay *et al.* (1996) have reported the composition of the essential oil of *Piper acutifolium* ruiz and pav. From Peru. The major constituents identified were: (E)-β – ocimene (8.1%), α – copaene (6.1%), allo- aromadendrene (6.0%), α – cadinene (6.7%), δ- cadinene (6.8%), myristicin (4.2%) and dillapiole (5.9%). The oil was evaluated for biological activity against *Callosobruchus maculatus*. There was no effect on mortality; however, a significant decrease in oviposition was observed.

Miah *et al.* (1996), studied application of leaf powders and oils as a protectant of lentil seeds against *Callosobruchus chinensis* Linn. Powdered leaves of *Amoora ruhituba* (A. rohituba), *Azadirachta indica* and *Vitex negundo* and oils of *A. indica*, linseed (*Linum usitatissimum*) and sesame (*Sesamum indicum*) under laboratory conditions. Uninfested healthy lentil seeds were placed in petri dishes on top of perforated paper discs covering powdered leaves or oil mixed with powdered soil and exposed to three pairs of newly-emerged adults of the bruchids *V. negundo*. Leaf powder significantly (P<0.05) reduced oviposition, adult bruchid emergence and the weight loss of lentil seeds. The powdered leaves of *A. rohituba* and *A. indica* had no significant effect on these aspects.
Linseed oil (at 0.5, 1.0 or 2.0g/2g soil) was found to be a less effective than powdered V. negundo leaves. The other oils were marginally effective at some doses and A. indica oil at 2.0 ml/2g soil reduced oviposition more than the smaller doses and the sesame oil treatments.

Naqvi et al., (1996), studied toxic effect of neem compounds NfC and NC and an insect growth regulator dimilin against adults of pulse beetle Callosobruchus analis. The experiments were conducted by two laboratory methods i.e. filter paper impregnation and glass film method. The LC_{50} values of NfC, NC and dimilin were found as 39.28 μg/cm², 7/1 μg/cm² and 13.5 μg/cm², respectively, by filter paper impregnation method while 10.0 μg/cm² and 3.2 μg/cm² for NC and dimilin by glass film method. No sufficient toxicity of NfC was observed by glass film method at the highest dose. On the basis of the efficiency, the tested compounds may be arranged descendingly as NC > dimilin > NfC by filter paper method and by glass film method as-dimilin > NC > NfC.

Ogunwolu and Odunlami (1996), in their study on suppression of seed bruchid development and damage on cowpea with Zanthoxylum zanthoxyloides (Lam.) waterm. (Rutaceae) root bark powder when compared to neem seed powder and primiphosmethyl. The reproductive suppresser properties of root bark powder of Zanthoxylum zanthoxyloides against the bruchid Callosobruchus maculatus were evaluated in comparison with neem seed powder (NSP) and pirimiphosmethyl (PM) (Actelic 2% dust, ICI). At application rates ranging from 0.125 to 3g per 20g cowpea seed, ZRBP was as effective an oviposition suppressant as PM, due to high contact toxicity to the bruchid adults, but significantly more effective than NSP. At the rate of 0.25g per 20g seed, ZRBP,
NSP and PM had nearly five months residual effectiveness. Preserved seed germinated fairly well (up to 70% germination in ZRBP treated seeds) and had no objectionable taste when cooked.

Okonkwo and Okoye (1996) in their study on the efficacy of four seed powders and the essential oils as protectants of cowpea and maize grains against infestation by *C. maculatus* (F.) and *Sitophilus zeamais* (Motschulsky) tested seed powder and the essentials oils of *Dennettia tripetala*, *Piper guineense*, *Mondora myristica* and *Xylopia aethiopica* for their effectiveness in protecting cowpea and maize grains during storage. *D. tripetala* powder mixed with maize grains at 1.5g per 25g was significantly more effective (P<0.05) than *P. guineense*, *M. myristica* and *X. aethiopica* in achieving 100% mortality of adults of *Sitophilus zeamais* in 24h and was also as effective as pirimiphos-methyl (10ppm) in achieving 100% mortality of adult weevil in 24 h, three months after treatment at a dose of 3g per 25 g. There was no F1 emergence except in grains treated with *M. myristica*, *X. aethiopica* and the untreated controls. Essential oils of *D. tripetala* and *P. guineense* achieved 100% mortality of adults of *C. maculatus* and *Sitophilus zeamais* in 24 h. Except in cowpea treated with *X. aethiopica*, cowpea and maize grains treated with seed oils suppressed the emergence of F1 offspring and gave protection for up to four months of storage. However, cowpea and maize grains treated with oils and maize grains treated with seed powders of *M. myristica* changed colour from white to orange.

Rajapakse (1996) tested the effect of four botanicals on the oviposition and adult emergence of *Callosobruchus maculatus* F. A Laboratory trial was designed to find the potential of four plants (*Piper Nigrum*, *Annona reticulata*, *Dillenia retusa*)
and Ocimum Sanctum) transformed in to a powder using local technology as protectants against the cowpea bruchid C. maculatus on mung bean seeds. At low concentration, the powder obtained from fruits of P. nigrum significantly reduced oviposition and adult emergence while 100% adult mortality was obtained at a higher concentration of 4.2%. The powder however did not show any fumigant effect. Volatile oils obtained from the same fruits of P. nigrum at 0.2 and 0.4% concentrations caused significant adult mortality while oviposition was completely suppressed at 0.8% and above. The plants tested did not significantly affected oviposition and adult emergence of Callosobruchus maculatus.

Seck et al., (1996), have worked out protection of cowpea seeds against Callosobruchus maculatus (F.) using hermetic storage alone or in combination with Bosca senegalensis as botanical protection.

Mbata et al.: (1995), studied insecticidal action of preparations from the brown pepper, piper quinense schum, seed beetle Callosobruchus maculatus (Fab). The dust and ether extract of the seeds were effective in enhancing the mortality of C. maculatus adults infesting cowpea seeds. Adults of C. maculatus exposed to the ether extract died faster than those exposed to the pepper dust. The optimum quantity of the dust required for 100% mortality of bruchids (5 adult males and 5 adult females) in 20g. of cowpea seeds was 0.5%. The ether extract prepared from 0.5g. of dust also resulted in 100% mortality. The optimum exposure durations required at 0.5g. concentration of both dust and ether extract for 100% mortality were 42 and 30h, respectively. Treatment with the two seed product was able to prevent deposition of eggs by the bruchids on the seeds.
Alzouma (1995), presented a review of investigations in the Sahel (Africa) and elsewhere on the biology, injuriousness and control of bruchid pests of grain légumes, mainly as stored products. The review is followed by an account of investigations in Niger on Bruchidius atrolineatus and Callosobruchus maculatus on cowpea. Traditional methods of storage and control using parts of plants with insecticidal or repellent properties are discussed, with special reference to the use of leaves of Boscia senegalensis against several bruchids and other stored products insects.

Fatope et al. (1995), have reported that peasant farmers in northern Nigeria use various indigenous plants to protect cereals and legumes against pest damage during storage. A simple bioassay technique was developed and employed to assess plants for their ability to protect cowpea from damage by C. maculatus during storage of the 10 plants screened, Hyptis suaveolens and Sphenoclea zeylanica showed the best protectant effects after four months.

Gakuru and Foua (1995) have compared efficacy of four plant essential oils against cowpea weevil Callosobruchus maculatus Fab. and rice weevil Sitophilus oryzae L. namely essential oils from Eucalyptus tereticornis, E. citriodora, Citrus sinensis and Ocimum basilicum. Essential oils had no effect on S. oryzae, however, the essential oil of E. citriodora and Basilicum were potent against C. maculatus, with LD₅₀ of 1.26 and 1.49ml in acetone (2% dilution).

Khanna (1995), tested efficacy of black pepper in combination with mustard oil in protecting green gram against infestation by C. chinensis Linn. and C. analis Fab. Laboratory studies showed that black pepper [Piper nigrum] powder at 500 ppm used in conjunction with mustard oil gave significantly greater protection of
stored green gram (*Vigna radiata*) against *Callosobruchus chinensis* and *C. analis* compared with black pepper powder on its own.

Onu and Aliyu (1995), in their study on evaluation of powdered fruits of four peppers (*Capsicum* spp.) for the control of *C. maculatus* (F.) on stored cowpea seed. The efficacy of 2 application rates of powdered fruits of *Capsicum frutescens* var. Yarmunchi, *C. annum* var. Tattasai, *C. annum* var. Kimba and *C. chinensis* var. Attarugu were evaluated for the control of *C. maculatus* on stored cowpea seed in jars in the laboratory. The various pepper powders at 2.5-5.0g/250g of seed were effective in reducing oviposition and damage to the seed, as indicated by the significantly lower number of emergence holes. The seed quality and viability were not affected by the powder treatment.

Pacheco *et al.* (1995), studied efficacy of soybean and castor oils in the control of *Callosobruchus maculatus* (F.) and *Callosobruchus phaseoli* (Gyllenhall) in stored chickpeas (*Cicer arietinum* L.). Refined soybean and crude castor oils were evaluated against *C. maculatus* and *C. phaseoli* in stored chickpea. Both oils were used at 0.5 and 10ml/kg of seeds. Oviposition, adult emergence and development from egg to adult emergence were evaluated after storing the treated seeds for up to five months. At the end of the storage period the effect of the treatments on flavor, consumer acceptability and seed germination were evaluated. Both oils inhibited population growth of these insect species as compared to untreated seeds. Castor oil was more effective than soybean oil. Castor oil at 5 and 10 ml/kg protected stored chickpeas from infestation by *C. maculatus* for 60 and 150 days, and from infestation by *C. phaseoli* for 60 and 90
respectively. Soybean oil was not an effective protectant, but did reduce the \textit{C. maculatus} and \textit{C. phaseophi} population development for approx. 60 days at 5 ml/kg and for 90 days at 10 ml/kg. No harmful effect was observed on the germination of oil treated seeds.

Serm \textit{et al.}, (1995), studied efficacy of neem oil against cowpea weevil (\textit{Callosobruchus maculatus} F.). The results revealed that the mortality of cowpea weevil in mung bean seed treated with 5 and 10 ml of neem oil were 97.50 and 96.25 percent at O day and 8.75 and 5 percent at 30 days as compared to 7.5 and 5 percent for control, respectively. Percent damage of neem oil admixing mung bean seed at 5 and 10 ml/kg were 9.76 and 0.74 at 30 days, 10.95 and 0.62 at 90 days, respectively as compared to 9.5 and 99.01 for control. The germination of neem oil admixing mung bean seed was found non-effective at 90 days observation.

Sohati \textit{et al.}, (1995) on the basis of their work have highlighted the role of natural plant products in protecting cowpea seeds from the bruchid, \textit{Callosobruchus rhodesianus} (Pic) in a study conducted in Zambia.

Solsoloy (1995) has reported that studied the crude \textit{Jatropha curcas} seed oil formulated as an emulsifiable concentrate had contact toxicity to stored grain insects (\textit{Sitophilus zeamays} and \textit{Callosobruchus chinensis}), molluscicidal effect to golden snail, \textit{Pomacea} sp., moderate fungicidal effect to damping-off and wilt pathogens, \textit{Rhizoctonia solani}, \textit{Sclerotium rolfsii} and \textit{Fusarium oxysporum} and chronic toxicity to \textit{Musca domestica}. The product, therefore, effectively controlled various pests and safe to some beneficial insects.
Yang et al. (1995) in a study on the control of *C. chinensis* with rice bran oil, 10gm mung beans were mixed with rice bran oil at 0.1-0.3 ml and inoculated with 25 pairs of the bruchid, or 50 gm mung beans were mixed with 1-8 ml rice bran oil and inoculated with three pairs of the bruchid. Result showed that the rice bran oil at 1-8 ml/kg mung bean had a 52.6-82.5% repellent effect on the adults and a 96.3-100% inhibitory effect on egg hatching. After 38 days the mung beans were 0.6-1.3% infested in the 3ml/kg. Treatment compared with 78.7% infestation in untreated controls. The results suggest that rice bean oil is effective for control of *C. chinensis*.

Adebayo and Gbolade (1994) in their study on protection of stored cowpea from *Callosobruchus maculatus* using plant products they evaluated at a range of 0.5-4gm powder and 0.5-30 µl for oils. Oils from *Lantana camara*, *Cymbopogon citratus*, *Eugenia uniflora* and *Lippia adoensis* were more potent then their respective powders in reducing or inhibiting oviposition and adult emergence. The effectiveness of the oils as protectants for stored cowpea in decreasing order of afficacy was *L. adoensis>*C. citrotus*> *L. camara* and *E. uniflora*. Only the powdered leaves of *E. uniflora & L. adoensis* were effective in providing a high level of bruchid control. However, dressing with all the oils and powder of *E. uniflora* left the seeds fresh at 54 days after treatment.

Agrawal (1994) reported the effect of essential oils as protectants against pulse beetle (*Callosobruchus chinensis* Linn.) infesting green gram seeds during storage and their impact on nutritive valve and acceptability of the seeds.

Belko (1994) on the basis of his study on efficacy of traditional methods of storage of cowpea in the rural environment of Niger has reported small farmers
in Niger traditionally use plant extracts or parts of plant to control insect pest of cowpeas stored in straw-covered beehive shaped granaries. The leaves of seven species of common plants in Niger were tested in traditional granaries as repellents or insecticides against the bruchids *C. maculatus* and *Bruchidium atrolineatus* in cowpea. Neem gave the best results, based on the average numbers of holes produced.

Jacob (1994), tested efficacy of coconut oil in protecting different pulses from the pulse beetle, *Callosobruchus chinensis* Linn. The persistence of toxicity of coconut oil treatments against *Callosobruchus chinensis* was investigated in the grain of four pulses in the laboratory. Coconut oil was applied at 1 ml/100 gm to groups of 20 seeds in plastic jars, and 5 pairs of bruchids were added to each jar. Toxicity was determined at weekly intervals for 10 weeks. At the end of this time, toxicity averaged 51.2% in green peas, 43.69% in Bengal gram, 34.8% in green gram and 34.14% in cowpeas. No adverse effects of seed germination were detected when treated grains were kept exposed in the laboratory for natural infestation, none of the grains were found to be infested by the bruchid before 90 days.

Juneja and Patel (1994), in their study on botanical materials as protectant of Green gram against pulse beetle, *Callosobruchus analis*, experiment was carried out to determine the relative bio-efficacy of various botanical materials. Among the various plant materials studied, the seed powder of custard apple *Annona squamosa* and black papper, *Piper nigrum*, leaves of mint, *Mentha piperita* and peel of orange, *Citrus reliculata*, all at 5 parts per 100 parts of green gram(w/w) resulted in 100% adult mortality after three days of treatment and completely
prevented the femals from laying egg until 60 days after treatment. Furthermore, no population build-up and grain damage were observed up until four months of storage, where as neem seed kernel powder gave protection for only three months.

Kachre et al. (1994), studied efficacy of ten vegetable oils as seed treatment in increasing storability of pigeon pea seed against pulse beetle. Oils of Sunflower, Castor beans, Mustard, Safflower, Groundnut, Palm, Sesame, Neem, Karanj and Corn each at concentration of 0.5, 0.75 and 1% as seed protectants of pigeon peas against C. chinensis were carried out with the objective of testing their effect on oviposition and egg hatching at 33, 66 and 100 days after treatment. The treatments with neem, castor bean and karanj oils at 1% showed significant repellent action for egg lying by adult bruchids up to 100 days after treatment. No hatching of eggs at 33 days of storage was noticed in castor bean, neem, karanj and groundnut oils. At 56 and 100 days neem, karanj and castor bean oils were quite effective in suppressing the egg hatching.

Koumaglo et al., (1994), studied the leaf oil of Diplolophium africanum Turcz. and analyzed using both Kovats indices and GC/MS. They identified 24 compounds including alpha-pinene (38%) and beta-pinene (20%) as the major components followed by p-mentha-1, 3,8-triene (11%). Except for a substantial decrease in the amount of the latter compound in one sample, the composition of the oil varied only slightly with the collection period. The oil exhibits insecticidal activity against the bruchids Callosobruchus maculatus Fab. and Callosobruchus subinnotatus Pic.
Mayura, (1994), studied four species of botanical insecticides (garlic bulbs (*Allium sativum* Linn.) sugar apple seeds (*Annona squamosa* Linn.), castor bean seeds (*Ricinus communis* L.) and neem tree seeds (*Azadirachta indica* Juss)) were tested for controlling cowpea weevil (*Callosobruchus maculatus* F.). The experiment was conducted in laboratory at temperature 33 deg C and 77 percent relative humidity, by using of 0.4 g ground plants per 10 g mung bean seeds were treated at two days old ten pairs of cowpea weevil adults. The best results were obtained using castor bean seeds these were followed by sugar apple seeds, neem tree sees and garlic bulbs.

Mishra *et al.*, (1994) tested three essential oils for insect repellency against *Callosobruchus chinensis*, oil of *Seseli indicum* was found to be the most effective.

Ogunwolu and Idowu (1994), tested powdered *Zanthoxylum zanthoxyloides* root bark and *Azadirachta indica* seed for control of the cowpea seed bruchid, *Callosobruchus maculatus* in Nigeria. The efficacy of powdered root bark of *zanthoxylum zanthoxyloidies* was compared with that of seeds of *Azandirachta indica*, pirimiphosmethyl and permethrin. At a rate of 2.5% of the treated seed weight both plant products were toxic to *C. maculatus*. Consequently, loss in seed weight after 3 months of storage was reduced by 55-93% with powdered seed of *A. indica* and by 83-85% with powdered *Z. zanthoxyloides* root bark. Both materials performed well enough to serve as alternatives to pirimiphosmethyl (78% reduction in weight loss) and permethrin (86% reduction). Both natural products were more effective when applied as finely ground
particles (300 μm) than when applied as coarse particlals (2mm). The insecticidal activity of both materials was not increased in mixtures.

Parsai et al. (1994) conducted laboratory experiments to investigate the efficacy of Mustard, Sesemum and Soya bean oils at 0.25, 0.50, 0.75 and 1.0% in the control of C. chinensis on pigeon peas and to establish their effects on cooking quality of the crop. All the three oils were all equally effective in the control of this pest in terms of reduced oviposition and adult emergence and increased developmental period. This was dose dependent, with maximum effects achieved at the 1% oil concentration.

Shivanna et al. (1994), studied efficacy of a number of plant products seed powder of neem (Azadirachta indica) honge (Pongamia glabra P. pinnata), soapnut (Acacia sinuata) custard apple (Amona squamosa) and black pepper (Piper nigrum); rhizome powder of turmeric (Curcuma longa) and sweet flag (Acorus calamus); and leaf powder of tulsi (Ocimum basilicum) and Eucalyptus was evaluated each at 0.5, 1.5 and 2.5g/50g of seeds as pre-storage treatments against C. chinensis on red gram. Parameters measured were fecundity, adult emergence and percentage grain weight loss. Among the plant products, the sweet flag powder applied at all three rates gave maximum protection against all three generations of the pest, closely followed by custard apple, black pepper, turmeric and neem powders at the highest rate, but these gave only moderate protection at the lower rates. In contrast, tulsi at all rates gave minimum protection against all generations of the beetle pest, which was on per with the untreated control.
Singh et al., (1994) have studied effectiveness of vegetable oils on the development of Callosobruchus chinensis Linn. Infesting stored gram. Oils of sesame (Sesamum indicum), sunflower (Helianthus annuus), soybean (Glycine max), linseed (Linum sitatissimum), mustard (Brassica juncea), safflower (Carthamus tinctorius), karad (Raphanus sativus), castor (Ricinus communis), coconut (Cocos nucifera), groundnut (Arachis hypogea), rice bran (Oryza sativa) and taramira (Eruca sativa [E. vesicaria]) were evaluated as a grain protectants at 1 and 3 ml/kg seed of gram against Callosobruchus chinensis. In general, the oil of taramira, coconut, sunflower, safflower and castor were found to be the most effective in inhibiting oviposition by the pest on gram seeds at both dosages as compared with the other oils. All the oils were found to be superior to the control. Adult emergence was lowest from the seeds treated with castor, mustard, soybean, groundnut, coconut, safflower, taramira and rice bean oils at 1 ml/kg seed, while at 3 ml there was no adult emergence from the seeds treated with oils of castor, mustard, soybean or taramira. Seed treatment with oils usually delayed the development period of the insect by 6-14 days at both dosages.

Subramaya et al., (1994) studied use of locally available plant products against Callosobruchus chinensis in red gram. Laboratory trials conducted with 6 plant species against the bruchid C. chinensis infesting red gram showed that extracts of Eucalyptus citriodora were most promising for control applying dry leaf powder either as a layer above the grain mass or mixed with the grain gave a better reduction in the number of eggs oviposited and emerging adults. Concentration
of dry leaf powder above 4% (w/w) were effective. Large scale trials using *E.
citriodora* further confirmed the effectiveness of a dry leaf powder application.

Talukdar and Howse (1994), have studied and reported repellent, toxic, and food
protectant effects of pithraj, *Aphanamixis polystachya* extracts against pulse
beetle, *Callosobruchus chinensis* in storage. Zibokere (1994) had described the
insecticidal potency of red pepper (*Capsicum annuum*) on pulse beetle
(*Callosobruchus maculatus*) infesting cowpea (*Vigna unguiculata*) seeds during
storage.

Ahmed et al., (1993) conducted laboratory experiments to ascertain the efficacy
of oils of Neem, *Azadirachta indica* A. Juss; *Linseed, Linum usitatissimum* L.,
Safflower, *Carthamus tinctorius* L.; Sunflower, *Helianthus annus* L.; and
Sesame, *Sesamum indicum* L. against the pulse beetle, *Callosobruchus
chinensis* (L.) on mungbean seeds. Four concentrations viz., 0.5, 1.0, 2.0 and
4% (v/v) of each oil were tested. All the concentrations of each oil significantly
reduced the oviposition and adult emergence of the pulse and 0.44 adults were
recorded on mungbean seeds treated with 4% concentration completely
protected the pulse seeds from the attack of the pulse beetle while only 2.00,
11.27, 2.08 and 1.96% of seed loss were recorded at the same concentration of
linseed, safflower, sunflower and sesame oil, respectively compared to 56.27 in
control. The effectiveness of oils increased with the increase of the
concentrations in all cases. Among the oils tested neem oil was found to be the
best protectant of pulse seeds against *C. chinensis*.

Bandara and Seneviratna (1993) have reported the effect of wild ginger, *Zingiber
purpureum* roscoe. on cowpea seed bruchid, *Callosobruchus maculatus* (F.).
Naqvi and Perveen (1993), have studied and described the toxicity of three plant extracts (Calotropis procera, Carissa carandass and Nerium indicum) in comparison to coopex (Bioallethrin: Permethrin) against stored grain pest, Callosobruchus analis. Donato and Padles (1993) have attempted to see the effects of neem leaves (Azadirachta indica) in different preparations as protectant of corn and mungbean seeds against storage pests.

Khaire et al., (1993) studied to find out the effect of different vegetable oils on ovipositional preference and egg hatching of Callosobruchus chinensis Linn. on pigeon pea seeds. The effect of 10 vegetable oils (Sunflower, Castor, Mustard, Safflower, Groundnut, Palm, Sesame, Neem, Karanj and corn on ovipositional preference and egg hatching of C. chinensis was tested on pigeon peas. All the treatments had an adverse effect on ovipositional preference compared with the control. Neem oil at concentration of 1% was superior to all the other treatments.

Lale, (1993), studied four storage systems, were assessed in the laboratory for their effectiveness in reducing infestation of stored cowpeas by Callosobruchus maculatus. Experiments consisted in introducing 10 g of infested cowpeas with or without chilli pepper, Capsicum frutescens, admixture into each type of storage device. The result suggests that the level of ventilation played a significant role in the effectiveness of the storage systems in checking infestation of cowpeas by the bruchid. The unventilated plastic device was the most effective both in enhancing the efficacy of C. frutescens as a grain protectant, and in the reduction of fecundity and adult emergence of C. maculatus. It was suggested consequently that the adoption by peasant farmers of a storage system with minimal ventilation in conjunction with C. frutescens as a grain
protectant could be a cheaper option in the protection of stored cowpeas against C. maculatus infestation.

Seck et al., (1993), studied biological activity of leaves, fruits and extract of the African shrub Boscia senegalensis (PERS.) against five stored-grain insects. When added to cowpeas at 2-4% (w/w), fresh ground fruits and leaves caused 80-100% mortality in Callosobruchus maculatus (F.) adults and significantly reduced both emergence and damage of the F1 progeny. Acetone fruit extract exhibited a potent fumigant effect on Prostephanus truncatus, C. maculatus, and Sitotroga cerealella with LC₅₀ values of 3.8, 2.3, and below 1.5 hr, respectively. LC₅₀ determination for B. senegalensis fruits and leaves as well as pure methylisothiocyanate (MITC) on Tribolium castaneum, Sitophilus zeamais, and C. maculatus showed a differential response of the insects to plant parts or MITC. Quantitative dosage of Boscia active components and LC₅₀ values obtained for the plant tissues, compared to those of pure molecules, indicate that the biological activity of B. senegalensis is due to the liberation of MITC from a glucosinolate precursor glucocapparin contained in Boscia fruits and leaves.

Ahmed and Ahamad (1992) worked out the efficacy of some indigenous plants as pulse protectants against Callosobruchus chinensis. Cobbinah and Appiah (1992) studied the pesticidal properties of the extracts of five local plants and compared with extracts of neem, Azadirachta indica, using pest insects Sitophilus zeamais, Callosobruchus maculatus, Zonocerus variegatus and Pseudocanthotermes militaris as test organisms. Extracts of Jatropha curcas provide similar level of protection to cowpea, maize, cassava foliage, and Pycnanthus angolensis wood blocks, as that of neem.
Cockfield (1992) has studied the effect of groundnut oil application and the varietal resistance for control of *Callosobruchus maculatus* (F.) in cowpea grain. George and Patel (1992) worked on mint, *Mentha spicata* and have reported it as a promising botanical protectant for green gram against pulse beetle, *Callosobruchus analis* F. Dike and Mbah (1992) evaluated lemon grass (*Cymbopogon citrus staph*) products for the control of *C. maculatus* F. on stored cowpea.

Gharib *et al.* (1992) have studied the comparative efficacy of four oils of plant origin viz., neem, maize, olive and cottonseed against *C. chinensis* infestation to pea seeds. Khaire *et al.* (1992) have tested the efficacy of different vegetable oils as grain protectants against pulse beetle, *Callosobruchus chinensis* L. with the aim of increasing storability of pigeon pea. Okonkow and Okoye (1992) have reported their findings of the researches on the control of *Callosobruchus maculatus* (F.) in stored cowpea with dried and grounded *Ricinus communis* (L.) leaves. Lale (1992) has tested products from dry chilli pepper fruits, *Capsicum* sp. for oviposition deterrent and repellent effects of on *Callosobruchus maculatus*. Mahgoub (1992), studied the Neem seed extracts and powders as grain protectants to cowpea seeds against the cowpea weevil, *Callosobruchus maculatus* Fab. under storage. The study indicated the effectiveness of neem in protecting this commodity from pest losses.

Mbata and Ekpendu (1992), studied products of four botanicals, which are either, medicinal or used as spices in some parts of West Africa for insecticidal activity against three storage insect pests: *Callosobruchus maculatus* (F.), *Callosobruchus subinnotatus* (Pic.) and *Sitophilus zeamais* (Motsch.). Powder
from low temperature dried shoots and leaves of *Mitracarpus scaber*, *Napoleona imperialis* and *Diodia sarmentosa* were not effective in causing mortalities to the adult beetles at concentrations up to 0.75g powder per 20g of seeds. However, at the concentration of 0.75g powder per 20g of seeds, *C. maculatus* and *S. zeamais* females were prevented from ovipositing on the seeds. Powder from the seeds of *Piper guineense* was effective in causing high mortality of the adults of the three beetles. Solvent extracts of *M. scaber*, *N. imperialis* and *D. sarmentosa* did not show any insecticidal activity against the beetles. Extract from *P. guineense* caused high mortality of the adult beetles even at low concentrations. Both the powder and solvent extract of *P. guineense* prevented oviposition and caused egg mortality.

Ofuya et al., (1992), studied crude ether extract of seeds of *Monodora myristica* was tested in the laboratory for effectiveness as surface protectant against damage by the seed beetle, *Callosobruchus maculatus* on infested legume seeds. Seed damage in different legume seeds treated with full strength of the crude extract was zero as compared to 100% in the control after four months of storage. The extract significantly inhibited oviposition by the beetle. It exhibited ovicidal and larvicidal action. At 20% and 50% concentrations, the extract did not significantly reduce the germinability of treated cowpea seeds.

Okonkwo and Okoye (1992) have used dried grounded *Ricinus communis* (L.) leaves for control of *Callosobruchus maculatus* (F.) by mixing it in stored cowpea in their study conducted in Nigeria.

Adgeh and Rejesus (1991), studied the residual toxicity by admixture treatment of the oils and the powders from neem (*Azadirachta indica* A. Juss), lagundi
(Vitex negundo L.) and Oregano (Coleus amboinicus Lour.) against three storage insects (Sitophilus zeamais Motsch., Rhyzopertha dominica Fab. and Callosobruchus chinensis L.) which was determined on grains at different storage intervals for 180 days. Their effects on adult emergence, damage and viability of the seeds were also noted. The oils were more toxic than the powders but not as toxic as the standard synthetic pirimiphos ethyl against S. zeamais, C. chinensis and R. dominica except the latter insect was tolerant to pirimiphos methyl. The order of decreasing toxicity of the oils at 24 hours after treatment is:

S. zeamais- oregano> lagundi >neem; R. dominica- lagundi> oregano=neem; C. chinensis- oregano> lagundi= neem.

The study further reported that the plant derivatives markedly reduced adult emergence of R. dominica and C. chinensis. All plant materials did not affect the viability of treated seeds except oregano and neem powders. Based on residual effectiveness, oregano oil can be utilized for the protection of mungbean for 90 DAT from C. chinensis and corn for 60 days from S. zeamais and neem and lagundi can protect sorghum from R. dominica damage for 30 days.

Begum and Quinones (1991), Result of the effectiveness of coconut, soybean, mustard and peanut oils at low and high dosages (0.5 ml and 3 ml per kg of seed) in protecting pre-infested stored mungbean seeds from mungbean weevil Callosobruchus chinensis. Oils at higher dosages were found to reduce the rate of population increase gradually while population in the seeds treated with lower dosage of oil increased in the subsequent months.

Ahmad and Ahmed (1991), assessed the potential of some rhizomes of the plants belonging to Zingiberaceae family as grain protectant against storage
insect pests. Chiranjeevi (1991) has studied the relative efficacy of some indigenous plant material and ashes on the egg laying capacity, adult emergence and developmental period pulse beetle in green gram. The results have been reported in order of effectiveness. Schmidt et al., (1991) through their research using vapours of Acorus calamus oil have reported the reduction of progeny of some stored-product pest, including pulse beetle.

Daniel and Smith (1991) have reported the repellent effect of neem oil and its residual efficacy against Callosobruchus maculatus on cowpea. Echendu (1991) reported on the basis of their study that ginger, cashew and neem act as effective surface protectants of cowpeas against infestation and damage by Callosobruchus maculatus (Fab). Gupta et al., (1991) reported the bio-efficacy of edible and non-edible oils against pulse beetle (Callosobruchus chinensis L.) on stored pulses. They have also reported their effect on germination.

Lale (1991) have reported the biological effects of three essential oils on Callosobruchus maculatus. Ofuya et al., (1991) worked onto find out the efficacy of crude extract from seeds of Monodora myristica (Gaertn.) as surface protectant against Callosobruchus maculatus (F.) attacking legume seeds in storage.

Seck et al., (1991) has suggested the use of different formulations of Neem (Azadirachta indica) for farm level protection of stored cowpea (Vigna unguiculata (L.) Walp) on the basis of study conducted in Senegal. Tanzubi (1991) has recommended use of neem for the control of some insect pests of cowpea (Vigna unguiculata) in northern Ghana. Shikaan and Ovah (1991) have reported the effect of some plant materials on progeny development in
Callosobruchus maculatus in established infestations on cowpea grain in Nigeria. Su (1991a, b, 1986, 1985, 1977) has performed laboratory evaluation of toxicity of black pepper, Calamus oil and Chenopodium oil, coriander seed and Cinnamomum cassia against four species of stored-product insects. Result indicated that both these oil vapours to be quite effective against pulse beetle.

Weaver et al., (1991), have worked out the efficacy of linalool, a major component of freshly milled Ocimum canum Sims. for protection against post-harvest damage by certain stored product Coleoptera.

Bloszyk (1990), studied the effectiveness of anti-feedants of plant origin in protection of packaging materials against storage insects. Choudhary (1990), reported the residual effect of eight vegetable oils in chickpea against pulse beetle, Callosobruchus chinensis (Linnaeus). Daniel and Smith (1990), have reported the repellent effect of neem (Azadirachta indica) oil and its residual efficacy against Callosobruchus maculatus infesting cowpea.

Garcia (1990), studied the toxicity, repellency, growth inhibitory, antiovipositional and ovicidal actions of several extracts (petroleum ether, ethanol, water and oil) from five plant species against the bean weevil Callosobruchus chinensis (L.). The plants tested were acacia (Samanea saman (Jacq.), ampalaya (Momordica charantia L.), atis (Annona squamosa L.), cinnamon (Cinnamomum mercadei Vid.) and butalaw (Calophyllum inophyllum L.). Only the petroleum ether extracts of ampalaya and cinnamon and the oil of cinnamon were toxic to the bean weevil, having LC50 of less than 200 mg/ml. Cinnamon oil also showed fumigating action which caused 100% mortality at 50 mg (about 45 µl) of 100% oil per 40 cubic centimeters of space. All extracts, except the water-based,
showed repelling action. The cinnamon and ampalaya petroleum ether extracts were found equal in effect and most repelling among the materials tested. Among the ethanol extracts, the one from cinnamon exhibited the strongest action. Cinnamon was found to be a stronger repellent than butalaw oil. Repellency was affected by extract concentration and exposure period. In general, there was increased repellency as concentration and exposure time increased. All the other extracts exhibited egg deposition inhibitory action except Water extracts. The active extracts showed increased effect with increase in concentration. Only the petroleum ether extracts and oils showed growth inhibitory action. This was evidenced by the low adult emergence (%) from seeds treated with the extracts. The same extracts showed growth inhibitory action at 10-40 mg/ml. Only the petroleum ether, ethanol and oil extracts of cinnamon and the butalaw oil exhibited ovidical toxicity. Further increase in concentration beyond 10 mg/ml did not affect egg mortality.

Giga and Munetsi (1990), studied five vegetable oils and found castor oil was the most effective in reducing oviposition. Vegetable oils reduced oviposition and egg hatch more than the citrus oil. The results showed that vegetable oils at a minimum of 5ml per kg seed would give adequate control of the insect for village-level storage.

Ivbijaro (1990) has worked out and reported the efficacy of seed oils of *Azadirachta indica*, and *Piper guineense* on the control of *Callosobruchus maculatus*. Kumari *et al.*, (1990) reported the effect of some vegetable oils as protectants against pulse beetles *Callosobruchus chinensis*.
Ofuya (1990), reported oviposition deterrence and ovicidal properties in some plant powders against *Callosobrachus maculatus* in stored cowpea seeds. Sube *et al.*, (1990) reported the evaluation results of some edible oils as protectants of chickpea seeds, *C. arietinum* L. against pulse beetle, *Callosobrachus chinensis* (L.). The study was based on the preferential feeding method.

Afifi *et al.*, (1989) studied the insecticidal properties of the extracts of lupin seed and caraway fruits against some stored product insects. El-Nahal *et al.*, (1989) studied the effect of vapours of *Acorus calamus* oil on different stored product insects and have reported it to be quite effective as space treatment. Makaljuola (1989) evaluated extracts of neem *Azadirachta indica* for the control of some stored product pests. It is reported to be effective at different doses. Don-Pedro (1989a, b) reported the mode of action of fixed oils against eggs and effects of fixed vegetable oils on oviposition and adult mortality of *Callosobrachus* (F.) on cowpea respectively.

Makanjuola (1989), based on results he obtained in his study using extracts of neem (*Azadirachta indica*) for the control of some stored product pests has recommended the effectiveness of neem for protecting stored grain by using neem. Babu *et al.*, (1989) studied effect of edible and non-edible oils on the development of the pulse beetle (*Callosobrachus chinensis* L.) on viability of stored mungbean (*Vigna radiata* L).

aspects of protection of stored chickpea, *Cicer arietinum* L., from attack of *Callosobruchus chinensis* L. by using derivatives of plant origin. Jilani *et al.* (1988) have studies insecticidal activity of some indigenous plant materials against the pulse weevil *Callosobruchus analis* (F.).

Results of the study by Suksamrit (1988), showed that pole beans and cowpea bean seeds were more suitable host than kidney bean for *Callosobruchus maculatus* Fab. All the bean and seed species are smooth coated whereby oviposition of *C. maculatus* Fab was not suppressed. However, in spite of the high mean of eggs in kidney bean, all first instar larvae failed to survive. This was also attributed to the thick testa of this bean species. Neem seed powder when mixed with bean seed species at the rate of 5%, 10% and 15% reduced percent egg hatching, adult emergence, adult longevity, and prolonged larval pupa development. Treatment of neem seed powder did not affect the germination rate and moisture content of three bean seed species at different dosages of application at the prevailing conditions during the study. Prolonged larval and pupal development as an effect of neem seed powder treatment caused high mortality especially in the fourth larval instars treated at the rate of 15%. The effect of longer larval period as related to the degree of percent infestation on the seed varieties was not determined in this study. Results also revealed that the number of eggs had a strong positive bearing on percent adult emergence, which in turn showed the same correlation with adult longevity. However, a negative relationship was found between total developmental period and percent adult emergence.

Khalique *et al.*, (1987), used vegetable oil for protection of stored green gram (*Vigna radiata* (L.) Wilczek) from attack of *Callosobruchus maculatus* (Fabr.). Naik and Dumbare (1987), tested and recommended surface coating of cowpea seed with certain vegetable oils for protection against pulse beetle and recommended this practice based upon the efficacy of these oils.

Naik and Dumbare (1987), studied the efficacy of nine commonly available oils and five crude non-edible oils on cowpea against the pulse beetle (*Callosobruchus maculatus* F). Non-edible oils exhibited a definite potential of protection. Reduction in oviposition was noticed with all except soybean oil. Neem seed oil extract and sesamum oil caused least oviposition. All non-edible oils except Karanj were clearly ovicidal. Mustard, Niger and Sesamum oil showed moderate ovicidal action. No adults emerged from seed treated with non-edible oils, suggesting larvicidal action. Sesamum oil was highly toxic among the edible oils.

Thawatsin (1987), studied the effects of bean seed varieties, namely; mungbean, bush bean and cowpea bean seeds and different dosages of neem
leaf and seed kernel powder at laboratory conditions of 22-37 deg C, R.H. 98 percent with 14 percent moisture content on the development and growth index of *C. maculatus*. Treatment of bean seeds at the rate of 0.5, 1.0, and 2.0 parts per 100 parts of the seed reduced oviposition capacity, lengthened larval and pupal period, reduced percent adult emergence, longevity and growth index. Relationship of the different parameters related to the development of *C. maculatus* revealed that number of eggs had strong positive bearing on percent adult emergence and growth index. But the total developmental period and percent adult emergence was observed to have an inversed relationship.

Das (1986), reported pesticidal efficacy of some indigenous plant oils in a study conducted in Bangladesh against the pulse beetle, *Callosobruchus chinensis* Linn. Kolcsei (1986), tested non-chemical methods for protection of foodgrais against eleven important stored grain (*Ephhestia cautella, E. elutella, Plodia interpunctella, Tribolium castaneum, Sitophilus zeamais, S. oryzae, Rhyzopertha dominica, Dermestes frischii, Trogoderma granarium, Acanthoscelides obtectus* and *Callosobruchus maculatus*).

Khan (1986), reported the efficacy of *Acorus calamus* L. rhizome powder against pulse beetle (*Callosobruchus chinensis*). Nasiruddin (1986), studied efficacy of three different edible oils namely tishi (*Linum usitatissimum*), til (*Sesamum indicum*) and soybean (*Glycine max*) mixed at the rate of 10 ml per kg seeds for the control of pulse beetle, *Callosobruchus chinensis* Lin. The percent infestations were 4.48, 12.44, 20.08 and 78.54 for tishi, til, soybean oil and control respectively after nine months of observation in storage. There was a
significant difference in infestation of seeds treated with oil as compared to untreated ones.

Das (1986), studied the effects on adult *Callosobruchus chinensis* Linn. when introduced in neem, *Azadirachta indica*; soybean, *Glycine max* (L.); sesame, *Sesamum indicum* Linn; coconut, *Cocos nucifera* Linn. and mustard, *Brassica* sp. oil-treated seeds of chickpea (*Cicer arietinum* L.). Results have indicated that pest population died within four days of release in 10 ml/kg treated seeds, while none died in the control. Oviposition was completely inhibited when stored seed was treated with neem, sesame and coconut oils, and very few eggs were found on the seeds treated with soybean and mustard oils. After one and three months of storage, the rate of seed infestations in the above oil-treated seeds was nil, while it was 25.91% and 98.55% respectively in the control. The viability of the treated seeds remained unaffected. Ibijaro and Agbaje (1986), have reported insecticidal activities of *Piper guineense* and capsicum species on the cowpea bruchid, *Callosobruchus maculatus*.

Kolcsei (1986), worked out the protection methods against storage pests without pesticides. He worked on eleven stored grain pests viz., *Ephesia cautella*, *E. elutella*, *Plodia interpunctella*, *Tribolium castaneum*, *Sitophilus zeamais*, *S. oryzae*, *Rhyzopertha dominica*, *Dermetes frischii*, *Trogoderma garanarium*, *Acanthoscelides obtectus*, including *Callosobruchus maculatus*. Pandey et al.,(1986) have reported the effects of some plant extracts against pulse beetle, *Callosobruchus chinensis* Linnaeus.

Bhaduri et al., (1985) evaluated some plant extracts as protectants against the pulse beetle, *Callosobruchus maculatus* (Fab.) infesting cowpea seed. Five
indigenous plant products, viz, Ipomea cormea, Adhatoda vasica, Parthenium hysterophorus, Tridax procumbens and Embelia ribes, were extracted in three different solvents, viz., Petroleum ether, benzene and alcohol. The extracts were used @ 4 parts/100 parts of cowpea seeds (w/w) for testing their repellent antifeedant and insecticidal properties against the pulse beetle, Callosobruchus maculatus (Fab.). Tridax procumbens plant material extracted in petroleum ether was most effective in checking the fecundity as well as the population of pulse beetle. All the plant materials extracted in three different solvents protected cowpea seed from the damage by pulse beetle up to 60 days after treatment however, the extract of Tridax procumbens in petroleum ether was the most effective.

Das (1985) studied infestation of Bruchid beetle on different pulse seed treated with neem (Azadirachta Indica A. juss) and til (Sesamum indicum L.) oils. After five months of storage, the infestation by Callosobruchus chinensis L. under free choice test in neem and til oil treated seeds of khesari (Lathyrus sativus L.), lentil (Lens culinaris Medik) and chickpea (Cicer arietinum L.).

Dohary et al., (1985), conducted an eco-toxicological study on pulse beetle infesting green gram and have reported effect of edible oils on the reduction of seed damage caused by pulse beetles on green gram Vigna radiata (L.) during storage. Don-Pedro (1985), has reported toxicity of some citrus peels to Dermestes maculatus.

Khan and Borle (1985), studied various pulse protectants and reported that Acorus calamus L. rhizome powder and activated clay both in the proportion of 0.1, 0.3 and 0.5% by weight proved to be quite effective in arresting the
development activities of the pulse beetle attacking stored gram. Other protectants viz. Cowdung ash 1.0% and smearing with groundnut oil 1 ml/kg grain were not found effective. Quasem and Barua (1985), have reported non-chemical control of pulse beetle (*Callosobruchus chinensis*) in green gram (*Vigna radiata*).

Sujatha and Punnaiah (1985) have studied the effect of coating stored seed of green gram with vegetable oils on the development of pulse beetle. Stored seed of green gram *Vigna radiata* (Linn.) could be effectively protected from the pulse beetle, *Callosobruchus chinensis* (Linn.), when the seed was treated with 0.25% concentration of the oils of sesamum (*Sesamum indicum* Linn.), capol (cotton-seed oil), oilpalm (*Elaeis guineensis* Jacq.) and neem (*Azadirachta indica*). All the oils recorded lesser infestation at 0.125% than the control. The groundnut oil or coconut oil at 0.5% and sesamum oil or capol or oil palm or neem oil at 0.25% were found to be effective in protecting the green gram against the pulse beetle.

Yadav and Tanwar (1985), performed assays and have reported olfactory response of *Lasioderma serricorne* (Fab.) to different spices and dry fruits. The results of this study can help in formulating strategy to protect stored grains.

Khan and Borle (1984), tested activated clay a 0.5% and 1.0% and *Acorus calamus* L. rhizome powder at 0.1%, 0.5% and 1.0% by weight. The treatment proved to be quite effective in controlling the activities of the pulse beetle. Other protectant viz., cow dung ash a 1.0% and 2.0% though gave better results over control was not very promising. Sharma and Srivastava (1984), reported effect of groundnut oil on embryonic development of *C. chinensis* L.
Sujatha and Punnaiah (1984), studied the effect of different vegetable oils (groundnut oil, gingelly oil, capol, coconut oil, palm oil, and neem oil) on the development of *Callosobruchus chinensis* was studied at four concentrations (0.125, 0.25, 0.50 and 0.75%). All the oils tested completely inhibited the development of pulse beetles at 0.50 and 0.75% concentrations.

Ali *et al.*, (1983), have reported effectiveness of plant oils against pulse beetle, *Callosobruchus chinensis* Linn. Ivbijaro. (1983), has recommended preservation of cowpea, *Vigna unguiculata* with the *neem* seed during storage. Nizan (1983), has recommended use of local materials (pepper, ash and oil) to control storage pests on sorghum, millet, cowpea, groundnut and maize. Pereira (1983), has reported the effectiveness of six vegetable oils as protectant of cowpea and bambara groundnuts against infestation by *C. maculatus* Fab. Effect of two botanicals on the fecundity and mortality of cowpea weevils reared in the laboratory has been reported by Ranasinghe and Ramanathan (1983). Messina and Renwick (1983), have worked out the effectiveness of oils in protecting stored cowpeas from the cowpea weevil.

Pesticidal efficacy of some indigenous plant products against pulse beetles, *C. chinensis* has been worked out and reported by Ghosh *et al.*, (1981). Jotwani and Srivastava (1981) reported Neem as insecticide of the future based upon its value as a protectant against stored grain pests.

Golob and Webley (1980) based on the findings of their study have recommended the use of plants and minerals as traditional protectant of stored products.
Varma and Panday (1978), treated stored green gram (Vigna radiata L.) seed with edible oils for protection from Callosobruchus maculatus. The results indicated that the fecundity of Callosobruchus maculatus was inhibited when stored seed of green gram was treated with the oil of coconut (Cocos nucifera L.) mustard (Brassica juncea L.) groundnut (Arachis hypogaea L.) sesame (Sesamum indicum L.) and sunflower (Helianthus annuus L.) @ 0.3 parts/100 parts (w/w). Oviposition was completely inhibited when coconut and mustard oils were used, and very few eggs were found in green gram seeds treated with groundnut, sesame and sunflower oils. The development of adult population of the pulse beetle was prevented at least for 5 months, and the germination or viability of the treated seed was not affected. Coconut oil was the best protective, followed by mustard, groundnut and sesame oils.

Pandey et al., (1977) studied the antifeedant, repellent and insecticidal properties of some indigenous plant materials against mustard sawfly, Athalia Proxima Klug. Sangappa (1977), reported the effectiveness of oils as surface protectants against the bruchid, C. chinensis L. infestation on red gram.

Pandey et al., (1976), use some plant powders, oils and extracts as protectants against pulse beetle, C. chinensis. Chellappak. and Chellaiah (1976), studied the efficacy of certain plant products in the control of S. cerealella and R. dominica infesting rice grain.

Varma et al., (1976.1975,1974, 1973), have reported findings of their study to see the effects of vegetable oils on red, green and black gram against the infestation of pulse beetles. Goyal et al., (1971), reported biological activity of various alcohol extractives and isolates of neem seed cake against
Rhopalosiphum nymphae (Linn) and Schistocerca gregaria. Mookherjee et al., (1970), worked on the incidence and extent of damage due to insect pests of stored seeds with reference to leguminous and vegetable seeds. Jotwani and Sircar (1965), in their study on Neem recommended different products from neem seed as a protectant against grain pests infesting wheat seed. Pradhan et al., have reported the repellent property of some neem products on the basis of study conducted as early as in the year 1963.