Novelty Journals

ISSN 2394-966X

International Journal of Novel Research in Life Sciences
Vol. 6, Issue 4, pp: (1-9), Month: July - August 2019, Available at: www.noveltyjournals.com

A Review on Integrated Management of *Callosobruchus chinensis (Coleoptera: Bruchidae)* on Faba bean

Asela Kesho[*1]

[1]Crop protection Ethiopian Institute of Agricultural Research, Addis Abeba, Ethiopia

Email address: aselakesho@gmail.com

Mobile: +251916411269

Abstract: **Insecticide chemicals can provide effective control of bruchids on pulses. However, small-scale farmers commonly do not use insecticides. In addition, dependence on insecticide chemicals is discouraged because of health and environmental hazards associated with their use. For more effective, safe and sustainable pest control integration of different compatible options is desirable. Use of resistant crop varieties is the most important component of integrated pest management strategy. The result of this study shows that to control the bruchids most of the botanicals are relatively, inexpensive, simple to apply, safe to the environment, animals and plants. They are easily avail to the farmers, adopted readily and integrated with other pest management practices. However, further research is needed on non-target effect and effective rate and frequency determination among others.**

Keywords: **Antixenosis, Bruchids, Coleoptera, Faba bean, Integrated Manageme.**

1. INTRODUCTION

Fababean (Vicia fabae L.) is the most predominately grown food legume in Ethiopia as a whole and vertisol areas of the country in particular. This cool-season food legume constitutes an essential part in the daily diet of the Ethiopian population. However, yield of this crop is by far below the potential. The low yield of faba bean is mainly attributed to several biotic and abiotic stresses, among which diseases caused by biotic agents take a considerable share (Habtu and Dereje, 1986).

Chocolate spot (*Botrytis fabae*), rust (*Uromyces vicia-fabae*) and black root rot (*Fusarium solani*) are the most important and predominant diseases in faba bean in vertisol areas. In the former studies, 34-91% yield loss was reported from fusarium root-rot. Yield losses due to these diseases could be very high unless resistance/tolerant genotypes and appropriate management interventions are identified and developed for users. Besides their food value, they have a considerable potential as a source of foreign exchange. Research on faba bean and field pea was concentrated only on development of cultivars that have high yield potential. Hence, information on their reaction to insect pests in general and that of storage pests in particular is scanty or unavailable. On the other hand, a large genetic diversity is known to exist in both crops indicating the high probability of finding resistant materials to biotic and abiotic stresses. The assessment of resistance of any crop germplasm is an important step for its utilization in breeding programs. Bruchids, *C. chinensis* L. and *C. maculatus* (F.), are the major pests of both faba bean and field pea in storage. In faba bean, for example, *C. chinensis* was reported to cause an average of 41% damage within a storage period of 6-8 months in mid altitude areas (Habtu and Dereje, 1986).

The objective of this study is to review the different safe, effective and sustainable management options of *C. chinensis* on faba bean and to reduce the population of pest below economic threshold level both in the storage and field.

2. *CALLOSOBRUCHUS CHINENSIS (L.)*

2.1. Distribution, Biology and Behavior of *C. chinensis*

C. chinensis was first described by Linnaeus. It belongs to the Kingdom: *Animalia*, Phylum: *Arthropoda*, Class: *Insecta*, Order: *Coleoptera*, Family: *Chrysomelidae*, Genus: *Callosobruchus*, Species: *Callosobruchus chinensis*. According to Kemal (1988) who thoroughly reviewed the life history, distribution, biology and control of the beetle, the species is one of the most widely spread of the genus *Callosobruchus.* It originated in Asia and spread to the tropical and sub-tropical regions of the world. It is capable of breeding on the seeds of a number of legumes, but relatively few are considered suitable hosts. It is well recognized as a pest of chick pea (*Cicer arietinum* L.), field peas (*Pisum sativum* L.), faba beans (*Vicia faba* L.), Adzuki beans (*Phaseolus angularies*) and lentil (*Lens culinaries* or *Lens esculenta Medik*.)

The females lay their egg which adheres to the seed coat of bean seeds in stores or in maturing pods in the field. This adhesion is affected by fluid secreted from the ovipositor immediately prior to oviposition (Arora and Singh, 1971 cited in Teshome, 1990). The eggs are elongate, oval in shape and translucent white in color, flattened on the side of attachment to the seed. Oviposition period ranges between 3 to 6 days. The duration of the egg stage has been given as10 to 14 days and the total number of eggs laid per female is said to range from 32 to 91 (Arora and Singh, 1971), therefore the larvae need only to bore through the shell and pod to reach the food. Most bruchid larvae leave the egg in characteristic manner; the larva bites a neat hole on the underside of the egg where it is in contact with substratum. Then, leaving the shelter of the egg shell, it proceeds to burrow into the seed pod or into the integument of the seed (Arora and Singh, 1971).

The first visible signs are the holes made in the seed by the emerging adults. This is perceived as damage (Koona and Koona, 2006). Bruchids can mate and females produce their eggs to begin secondary infestation immediately after emergence and also when infested seeds are harvested and stored the bruchids continue to feed and eventually adults emerge and cause secondary infestation.

The duration of a complete lifecycle may take only 4 weeks, or it may take several months depending largely on the environmental conditions. According to Arora and Singh (1971) the time taken from egg to adult ranged between 45 and 61 days in summer and 134 days in the winter. Various factors may influence the number of generation and the life span of the adults. Generally, the adults are short lived (less than two weeks) and don't feed. Davey (1965) reported that the minimum and maximum temperature required for the development of *C. chinensis* range between 20 to 35ºc and the relative humidity ranges between 10-90 %. The adults are capable of making short as well as long flight (Kemal, 1988).

2.2. Damage and Economic Loss Due to Bruchids

In the context of stored food legumes, loss is usually expressed as loss of commodity weight in the period between harvest and consumption, loss of nutrients in stored legumes, qualitative deteriorations caused by contaminants or biochemical changes rendering legumes unfit for human consumption, loss of seed viability and loss as a result of physical damage. While damage refers to the superficial evidence of deterioration for example, holed or broken grains or bruised fruits or physical spoilage which may later result in loss (Salunkhe *et al*., 1985).

Crop losses and deteriorations of produce during storage are likely to occur unless adequate precautions are taken. It is frequently, reported that worldwide a minimum of 10% of cereals and legumes are lost after harvest (Boxall *et al*., 2002). Likewise, in Ethiopia loss of stored produce reached up to 20-30% (Abraham, 1996, Bisrat and Laike, 2016). However, it is widely agreed that food losses after harvest can be substantial and are important in terms of quantity, quality, nutritional and economic value (Golob *et al*., 2002).

The degree of loss due to bruchid damage is quite variable and depends on the storage period, storage conditions, storage containers and varieties (Nchimbi-Msolla and Misangu, 2002; Mebeasilassie, 2004). In Ethiopia, the structural condition of the traditional granaries used for storage of pulses varies from one farm to another. The main problem associated with these storage structures are lack of repair or replacement of the old structures, poor hygiene store, and the distance at which they are located. Granaries that are not repaired permit easy access to rodents, insects and flooding.

Moreover, poor store hygiene and storage structures located near by the farm land may cause the development, carry over and cross-infestation of insect pest from previous season harvest. As a result, they attribute to different amount of stored pulse loss and damage by bruchids. Study conducted in1993 in south eastern Honduran communities indicated that post-harvest weight losses associated with bruchids infestations in dry beans stored by subsistence farmers ranges from 5.5% to 8.5% (Espinal, 1993). In a related report, weight loss of pulses ranges from 4-29% in Eritrea (Adugna, 2006) and 3.2% in Ethiopia (Abate and Ampofo, 1996). Abate and Ampofo (1996) also showed that in Ethiopia stored bean damage by *A. obtectus* and *Z. subfaciatus* reached up to 38% and bean weight loss reach 3.2%.

In Nigeria, the dry weight loss of cowpea to bruchids infestation is over 29,000 tones each year (Casuell, 1981) with an estimated value of 30 million dollars. Koona and Koona (2006) indicated that *Acanthoscelides obtectus* (Say) on common bean (*Phaseolus vulgaris*) and *Callosobruchus maculates* F. on cow pea (*Vigna unguculata*) can cause seed loss of 20-100% at farm level if left untreated.

In Tanzania, bean losses up to 40% due to bruchids have been reported (Kiula and Karel, 1985). FAO (1985) estimated losses on pulses in the range of 25-50% due to infestation from bruchids, weevils and others. Bruchids pose serious post-harvest problem to chick pea and lentil in particular with the extent of damage sometimes exceeding 90% after three months of storage (DZARC, 1984 cited in Abrham, *et al*., 2008).

Survey of faba bean in Chilalo (2050-2690m) and Yerer and Kereyu awraja (1900- 2000m) indicated that more infestations were observed in warmer areas than cooler areas (Yemane and Yilma 1985 cited in Abrham, *et al*., 2008). Variability in degree of infestation depending on crop varietals of Pulses, Agro ecological area, Altitude, Storage time and damage Weight loss. Faba bean Chilalo awraja 2050-2690m 13 months 40.2% 4.8%, Faba bean Yerer and Kereyu awraja 1900-2000m 6-7 months 41% 14.4% and Chick pea Yerer and Kereyu awraja 1900-2000m lower altitude 6-7 months 27.5% 8.2%, respectively **(**Yemane and Yilma 1985 cited in Abrham *et al*., 2008).

In addition to direct weight loss, bruchids also render qualitative loss, which is more frequently based up on subjective judgment and it perhaps identified via comparison with locally accepted quality standard. It may include the presence of contaminants, such as uric acid and other nitrogenous wastes, the presence of adult bruchids inside the seed, exit holes, glued eggs to the seeds, coastal larval skin, species of insect chitin and changes in appearance, texture and taste, making it unfit for human consumption, Commercial grain buyers usually reject or refuse to accept delivery of insect contaminated grain or may pay very low price for it (Hill, 1990; Espinal, 1993; Nchimbi-Mosolla and Miswangu, 2002).

According to FAO **(**1985) importers of bean and peas in the UK, objects to accept products infested with most bruchid species. This situation will lead to economic losses to the producer and quantitative losses to the consumer (Nchimbi-Msolla and Miswangu, 2002). In addition to their probable negative impacts on the quality of products, these foreign particles have been reported to have serious abrasive effects on human alimentary canal (Southgate, 1978).

Bruchids damage can also cause nutrition loss which is represented by the reduction in the food value of the grain because of decreasing in its hydrocarbon, protein and vitamin content, (Sing, 1997) and it's also the product of both qualitative and quantitative losses. Mc Farlance *et al.* (1994) demonstrated that a reduction in a protein content of pulses due to the feeding activities of bruchids on cotyledons. In beans particular, loss of protein is very important where there is infestation, as up to 25% of dry matter may be crude protein (FAO, 1992). Besides, contamination from uric acid by bruchids is correlated with negative changes in nutritive composition of pulses, causing an increased fat acidity and decreased levels of various vitamins in particular thiamin and essential amino acids (Salunkhe *et al*., 1985).

A single larva of *Callosobruchus maculatus* infesting a seed of cowpea will remove about a quarter of the cotyledon of an average sized seed. When it infests the smaller seed of *Phaseolu radiatus*, it consumes virtually all the cotyledons, thereby removing all possible chance of germination of the seed (Southgate, 1979). Venkatrao *et al*. (1960) reported considerable loss in viability and weight of field beans (*Dollchos lablab* L.) and black gram (*Phaseolus mungo*), an increased in acidity and non-protein nitrogen and a decrease in thiamine content. Finally, the damage of pulses by insect can provoke loss in qualitative and quantitative grain production enhancing more instability and poverty.

3. SUSTAINABLE *CALLOSOBRUCHUS CHINENSIS L.* MANAGEMENT APPROACHES

There is a continuous need to protect the stored products against deteriorations, especially loss of quality and weight during storage (Mohale, 2004; Negamo *et al*., 2007). Effective management efforts always begin with a thorough inspection of storage site to determine the source, type, and importance of the infestation which is normally called prevention. In general, biotechnical, biological, cultural, and chemical methods are crucial approaches for successful control of the most dominant stored product pests in general (Gwinner *et al*., 1990).

3.1. Cultural control

Traditional methods usually provide cheap and feasible ways of post-harvest handling of the crops. During storage, some traditionally used materials are often added to the product, which contribute to the reduction of pests' activity. Inert dust for example, is added in variable amounts to the stored product. Friction of the particles with insect's cuticle leads to desiccation and hampers the development of the pest (Golob *et al*., 1997; Emana and Assefa, 1998). It is crucially important to limit the rate of insect migration into stored grain from infestation sites in bin bottoms; nearby stored grain, or other places where grain, grain dust, or grain based materials accumulate before harvesting and bringing of new crops in to a store, it is very important to clean tracks, combines and the bins. Research conducted on control of the Coleopterans in stored agricultural products by non-chemical methods indicated that sanitation as preventive control measures of stored grains (Porca *et al.,* 2003).

Post-harvest systems regulated by moisture content, temperature, aeration, pest access and time that the product is in a susceptible state. Within biological limits, the greater the temperature, moisture content, aeration and the time products are in a susceptible condition, the higher the resultant pest population. Thus, management systems built around these biological, management factors, and their influence on population is dynamics. If planting and sowing is arranged so that harvest fall in dry season, there are no particular problem with drying the crop. Harvest time is also considered when infestation had started from the field. For instance, *Callosobruchus chinensis* (adzuki bean beetles) infest beans in the field only when the pods are almost dry. Timely harvesting can therefore ensure that the weevils not carried in to the store along with the beans (Stoll, 1988).

3.2. Biological Control

In biological control, natural enemies are used to keep pest populations at acceptable levels, usually in combination with other control methods. The natural enemies may be predators, parasitoids or pathogens (Flinn *et al.,* 2006). Predators such as spiders, ladybirds, lacewings or predatory mites, usually feed on a range of different insects. Parasitoids lay eggs on one host insect, and the larvae live and feed on the host, which dies (true parasites do not kill their hosts).The adult parasitoids are typically honey feeders. Pathogens may be bacteria, fungi, viruses, nematodes or protozoa. There are several ways that natural enemies can be used in biological control (Imamura *et al.,* 2008).

Management of the crop and its surrounding habitats can enhance the abundance of native parasitoids or predators. Parasitoids and pathogens can be mass reared in the laboratory, and inundative releases made in the field for biological control, or as bio pesticides. Classical biological control is where natural enemies are introduced from overseas usually from the country of origin of the exotic pest (Schmale *et al.*, 2001).

3.3. Botanical Control

Botanical pesticides are an alternative to chemical pesticides *i.e*. insecticidal plants or plant compound and the use of natural compounds, such as essential oils that result from secondary metabolism in plants. Essential oils and their constituents have been shown to be a potent source of botanical pesticides. The toxicity of a large number of essential oils and their constituents has been evaluated against a number of bruchids (Keita *et al.,* 2000; Tripathi *et al.,* 2002). In the context of agricultural pest management, botanical insecticides are best suited for use in organic food production in industrialized countries, but can play a much greater role in the production and post-harvest protection of food in developing countries (Isman, 2005).

The insecticidal activity of extracts derived from different plants and parts of the plant against stored product insects has been reported. Bekele *et al*. (1995) evaluated the bioactivity of plant materials from the leaves of *Ocimum kilimandscharicum* against S. zeamais; R. *dominica* and *Sitotroga cerealella* (Oliver).They reported 100% mortality after 48 hrs. exposure of adults of the three insects to dried leaves and essential oil extract of the plant. Bekele (2002) also evaluated toxicity of different plant extracts and seed powder of *Milletia ferruginea* (Hochest.) against *S. zeamais* in maize seeds. Moreover, Mebeasilassie (2004) reported the efficacy of *M.ferruginea* seed powder against *Zabrotes subfasciatus* and found that100% mortality at the dose of 15g/250g of grain within 24 hr exposure time.

3.4. Pheromones

Semiochemicals determine insect life situations such as feeding, mating and egg laying (ovipositing). Semiochemicals are thus potential agents for selective control of pest insects. Biological control with pheromones or kairomones can be used for detection and monitoring of insect populations. Monitoring is important for the efficient use of conventional insecticides. Mating disruption by use of pheromones is a promising and, in many causes, a successful strategy for control (confusion strategy). The use of semiochemicals as feeding deterrents is another strategy. The most common strategy for control by the use of semiochemicals is to attract, trap and kill the pest insects (Norin, 2007).

The olfactory system of insects is very sensitive and limited amounts of semiochemicals are needed for control. This is demonstrated by the current application of pheromones for control (mating disruption by confusion strategy) of codling moth (*Cydia pomonella*) in apple orchards (Witzgall, *et al.*, 1999 as cited in Norin, 2007).

3.5. Varietal Resistance

Insect resistance in crop varieties refers to their inherent ability to combat specific insect pests and to achieve better performance over other varieties of the same crop at the same levels of insect populations. Crop varieties differ in their susceptibility to storage insect pests. Traditional varieties are more resistant than new varieties. Resistant varieties functions in insect control based on the mechanism of non-preference antixenosis) and antibiosis, in which biophysical or biochemical factors are involved (Pedigo, 2004 cited in Teshome, 1990).

3.5.1 Antixenosis

Oviposition may be affected by small differences in seed coat smoothness and convexity, by plumpness or wrinkling and perhaps by size and hardness of the seed as well as its odor. The cowpea beetle (*Callosobruchus maculates*) prefers smooth seeded to rough seeded cowpeas. Moreover, it doesn't oviposit on seed hilum, which is spongy in texture deep pit like and rich fibrils. Scanning electron microscopy revealed deep pit in rough coated but not in smooth coated seeds; seeds infested with eggs where less attractive for further oviposition (Nwanze *et al.*, 1975). Research conducted in USA with 14 common chick pea varieties by using selective preference and no choice tests indicated that the variety G109-1 was least preferred for egg laying by *Callosobruchus analis*, *Callosobruchus maculates*, *C. chinensis.* G109-1 has a rough, almost spiny seed coat, a character deterrent to oviposition and absent in susceptible varieties (Raina, 1971 cited in Teshome, 1990).

3.5.2. Antibiosis

The mechanism where the pests feed but factors in the plant have an adverse effect on them usually expressed as reduced growth and thus rate of multiplication, or on survival. Level of resistance to pests varies among plant varieties (Hill, 1990). The failure of *Callosobruchus chinensis* to develop in soy beans is attributed partly to the presence of saponins. Larvae of *Callosobruchus spp*. don't hydrolyze saponins in vitro. Saponins may therefore be regarded as specific metabolic defense mechanism of the Soybean against insects **(**Horber, 1978 cited in Teshome, 1990). Host plant resistance is a very good method of combating pest in storage. It is perhaps the easiest, most economical and effective means of controlling insect pests on stored grains as there is no special technology which has to be adopted by farmers. Screening of many seed varieties had led to the successful isolation of strains that are resistant to insect pests in some African countries. Four varieties of groundnut (*Arachis hypogea* (L.) were found resistant to both Indian meal moth *(Plodia interpunctella* (Hubner) and rust red flour beetle (*Tribolium castaneum* (Herbest) (Ahmed and Yusuf, 2007).

3.6. Chemical control

Insect pest control in stored food products relies heavily on the use of synthetic insecticides and fumigants. The components of chemical insecticides can be classified in to four chemical types: Organochlorines, Organophosphates, Carbamates and Pyrethroids (Dent, 1991).

These groups of insecticides have been used for over five decades to control insect pests both at the field and in storage conditions. Many researchers have reported that the effective utilization of synthetic insecticides including fumigants, dusts, and sprays for the control of bruchids (Harberd, 2004).

Insecticidal application is one means of preventing some losses during storage. However, the choice of insecticides for storage pest control is very limited because of the strict requirements imposed for the safe use of synthetic insecticides on or near food and also the continuous use of chemical insecticides for control of storage insect pests has led to problems such as disturbance of the environment, pest resurgence, pest resistance and lethal effect on none target organisms in addition to toxicity to the users (Khan and Selman, 1987).

3.7. Integrated Pest Management

Integrated Pest Management (IPM) is the best option in pest control. This means, Pest control measures, in general, have to be integrated into an operational system, be it large or small scale, if they are to be effectively applied. This is a basic principle, not a novel concept, but it connects with the modern idea of integrated pest management (IPM). The use in that term of the word 'management 'is appropriate, especially with regard to the need for the integration of pest control measures into management systems, but it should be remembered that the two words, 'management' and' control are almost synonymous. The fundamentally important emphasis should be placed up on the word 'integrated' (Shaaya and Kostyukovysky, 2006).

Integrated pest management can be defined as the acceptable use of practicable measures to minimize the pest density/effect in cost effective manner and ecological safe situation the loss caused by pests in a particular management system. For the measures to be cost effective, they must be appropriate and acceptable in that system. They may be simple or complex but they must suit to systems' objectives and its technical capabilities. Furthermore, in this context, cost effectiveness requires that all costs and benefits, including sociological and environmental effects, should have been taken into account (Golob *et al.*, 2002; Mohale, 2004).

4. SUMMARY AND CONCLUSION

Against high or low thermal thresh hold or fluctuating humidity and varied wavelength of light stimulate the inset to respond in a plenty of way, 30˚C and 70 percent RH was the optimum for proper growth and development of *C. chinensis*. It can affect their ovulation, rate of fecundity, development, survival, multiplication and various immune and genetic responses. *C.chinensis* affected by different biotic and abioic stresses, among these the most important factors are temperature, humidity, moisture, natural enemies, chemicals *etc*.

Insecticide chemicals can provide effective control of bruchids on pulses. However, small-scale farmers commonly do not use insecticides. In addition, dependence on insecticide chemicals is discouraged because of health and environmental hazards associated with their use. For more effective, safe and sustainable pest control integration of different compatible options is desirable. Use of resistant crop varieties is the most important component of integrated pest management strategy. The result of this study shows that to control the bruchids most of the botanicals are relatively, inexpensive, simple to apply, safe to the environment, animals and plants. They are easily avail to the farmers, adopted readily and integrated with other pest management practices. However, further research is needed on non-target effect and effective rate and frequency determination among others.

5. FUTURE PERSPECTIVES

Recent studies show that to control the bruchids most of the botanicals are relatively, inexpensive, simple to apply, safe to the environment, animals and plants. They are easily avail to the farmers, adopted readily and integrated with other pest management practices. However, further research is needed on non-target effect and effective rate and frequency determination among others.

REFERENCES

[1] Abate Tsedeke. and Ampofo, J.K.O. 1996. Insect pests of common bean in Africa: Their ecology and management. *Annu.Rev.Entomol.* 41:45-75.

[2] Abraham Tadese. 1996. Insects and other arthropods recorded from stored maize in western Ethiopia. *J. Afri. Crop Sci.* 4(3)**:**339-343.

[3] Abraham Tadesse, Amare Ayalew, Emana Getu. and Tadele Tefera 2008. Review of Research on Post-Harvest Pests. In: Abraham Tadesse (ed.) 2008. *Increasing Crop Production through Improved plant protection-Volume1*. Proceedings of 14th Annual conference of plant protection society of Ethiopia (PPSE), 19-22 December 2006. Addis Ababa, Ethiopia. PPSE and EIAR, Addis Ababa, Ethiopia. Pp. 475-580.

[4] Adugna Haile. 2006. On-farm storage studies on sorghum and chickpea in Eritrea. *African Journal of Biotechnology*. 5(17).

[5] Ahmed, B.I. and Yusuf, A.U. 2007. Host plant resistant: A variable non chemical and environmentally friendly strategy of controlling stored products pests a review. *J. Food Agric*. 19(1):1-12.

[6] Arora, G.L. and Singh, T. 1971. The biology of *Callosobruchus chinenesis* (L.). *Res. Bull. Punjab Univ*. 21: 55-556.

[7] Bekele Jembere., Ofori, D.O. and Hassanali, A. 1995. Products derived from the leaves of *Ocimum kilimandscharicum* (Labitate) as post-harvest grain protectants against the infestation of three major stored product insect pests. *Bull. Entomol. Res. 85:*361-367

[8] Bekele Jembere 2002. Evaluation of the toxicity potential of *Milletia ferruginea* (Hochest) Baker against *Sitophylus zeamais* (motsch.). *Int.J.Pest Mgmt*., 48(1):29-32.

[9] Bisrat Getnet, and Laike Kebede. 2016. Role of Mechanization in Post-harvest losses: Challenges and the way forward. *Plant Protection Society of Ethiopia (PPSE) 22nd Annual Conference. Book of Abstracts*. March, 10-11, 2016.

[10] Boxall, R.A., Brice, J.R., Taylor, S.J., and Bancroft, R.D. 2002. Technology and management of storage. In: Golob, P., Farell, G. and Orchard, J.E. (eds). *Crop* 40 *post-harvest: Science and technology: volume 1. Principles and practice. NRI, University of Greenwich.* Pp: 141-232.

[11] Casuell, G.H. 1981. Damage to stored cowpea in the northern part of Nigeria. *Samaru J. Agric. Res*. 1(1):11-19.

[12] Davey, P.M. 1965. Insect pests of stored products in the tropics and the commodities and conditions in which they occur. *Trop. Stored Prod. Inf.* 10: 377-386.

[13] Dent. 1991. *Insect pest Management.*C.A.B.International.UK Pp. 32-135.Emana Getu and Assefa Gebreamlak. 1998. Arthropod pests of stored maize in sidama zone: Economic importance and management practice. *Pest Mgmt. J. Eth*. 2(1-2)**:**26-35.

[14] Espinal, J.R. 1993. Economic losses associated with *Zabrotus subfaciates* (Boheman) *(Coleopteran: Bruchidae) and Acanthoscelides obtecus (Say) (Coleopteran: Bruchidae) infestations of stored dry red beans (phaseolus vulgaris L.) in southeastern Honduras.* Ph.D. Dissertation, *Kansas State University, Kansas*. Pp. 210.

[15] FAO. 1985. *Prevention of post-harvest food losses.* Training series no.10.Food and Agriculture Organization of the United Nations. Rome, Italy.

[16] FAO. 1985. *Handling and Storage of Food Grains.* FAO, Rome, Italy.

[17] FAO. 1992. Towards integrated commodity and pest management in grain storage. In: Semple, R.L., Hicks, P.A., Lozare, J.V., and Castermans, A. (eds). *Proceeding and selected papers from the Regional Training Course on Integrated Pest Management Strategies in grain Storage Systems. Conducted by the National Post Harvest Institute for Research and Extension (NAPHIRE). Department of Agriculture. June* 6-18, 1988, Philippines. Pp. 556.

[18] Flinn, P.W., Kramer, K.J., Throne, J.E and Morgan, T.D. 2006. Protection of stored maize from insect pests using a two-component biological control method 42 consisting of a hymenopteran parasitoid, *Theocolax elegans*, and transgenic avid in maize powder. *J. stored Prod. Res*. 43:218 225.

[19] Golob, P. 1997. Current status and future perspectives for inert dusts for control of stored product insect. *J. Stored Prod. Res.* 33:69-79

[20] Golob, P., Birkinshaw, L.A., Stathers, T.E., Meyer, A.N., Belmain, S.R., Farell, G. and Hodges, R. 2002. In: Golob, P., Farell, G. and Orchard, J.E. (eds). Crop postharvest: Science and technology. Volume1. Principles and practice. NRI, University of Greenwich. Pp: 223-320.

[21] Gwinner, J., Hamisch, R. and Muck, O. 1990. *Manual on the Prevention of Post-Harvest Grain Losses.* Post-harvest project, pickvben 4, D-200.Hamburg. 11. F.R.G. Pp. 294.

[22] Habtu Assefa and Dereje Gorfu. 1986. A review of food legume diseases in Ethiopia. Ethiopian institute of Agricultural research.

[23] Harberd, A.J. 2004. *Reference Manual on the Major Insect Pests of Stored Ccereal and Pulse Grains in Somalia and their control*. UNA, IPM Project Training Module No. 3, Somalia. Pp. 135. 43.

[24] Hill, D.S. 1990. Pests of Stored Products and Their Control. Belhaven, London. Pp. 274.

[25] Imamura T., Murata M. and Miyanoshita A. 2008. A Review on Biological Aspects and Predatory Abilities of Hemipterans Attacking Stored-Product Insects. *JARQ*. 42 (1):1- 6.

[26] Isman, M.B. 2005. Botanical Insecticides, Deterrents, and Repellents in Modern Agriculculture and an Increasingly Regulated World. *Annu.Rev.Entomol.* 51**:**45-66.

[27] Keita, S.M., Vincent, C., Belanger, A. and Schimit, J. 2000. Effect of Various Essential oils on *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *J. stored prod. res.* 36**:**355- 364.

[28] Kemal Ali. 1988. *Biology of Callusobruchus chinensis (Coleoptera:Bruchidae) and varietals resistance in vicia faba*. M.Sc.Thesis. presented to School of Graduate Studies, University of Reading, Department of Pure and Applied Zoology, 12p.

[29] Khan, A.R. and Selman, B.J. 1987. Effects of pirimiphos, *Nosema whitei, pimiphos* methyl- *Nosema whitei* doses on the growth of *Tribolium Castaneum* adults. *J. Invert.pathol*. 49:6-338.

[30] Kiula, B.A. and Karel, A.K. 1985. Effectiveness of vegetable oils in protecting beans against bean weevil (*Zabrotes subfaciatus*) (Boh). Bean improvement cooperative *Annual Report*, No. 28. 3-5. 44 p.

[31] Koona, P. and Koona, O.E.S. 2006. Testing Fractionated Extracts Grained from the Ethno botanical Pachypodanthinum Staudtii (Annocaceae) for Bruchid Insssect Control (Coleopteran:Bruchidae). *Res. J. Agri. Biol. Sci*. 2(6): 410-414.

[32] Mc Farlance, J.A., Taylor, R.W.D. and NRI. 1994. Insect Control. In: Proctor, D.L. (ed.). Grain Storage Techniques. Evolution and trends in developing countries. *FAO Agri. Serv.Bull.* 109: 189-227.

[33] Mebeasilassie Andargie 2004. *Studies on the pest status of Bean Bruchid and Managements of major bruchid species in central rift valleys of Ethiopia.* M.Sc. Thesis.

[34] Mohale, S. 2004. Environmentally friendly way of controlling stored product insect pests. *Afri .J. Food. Agric. Nutr. Devel.* 4**:**75-78.

[35] Nchimbi-Mosolla, S. and Misangu, R.N. 2002. Seasonsal distribution of common bean bruchid species in selected areas in Tanzania, *Proceedings of the Bean Seed Workshop, Arusha, Tanzania, 12-14 January, 2001. Bean/Cowpea Collaborative Research Support Program-East Africa*, Pp 5.

[36] Negamo, T.S.L., Ngatanko, I., Ngassoum, M.B., Mapongmestsem, P.M., Hance, T. 2007. Persistence of insecticidal activities of crude essential oils of three aromatic plants towards four major stored product insect pests. *Afr.J.Agri.Res*.2 (4): 73-177.

[37] Norin, T. 2007. Semiochemicals for insect pest management. *Pure Appl. Chem.*, 79(12): 2129-2136.

[38] Nwanze, K.F. and Horber, E. 1975. Laboratory techniques for screening cowpeas for resistance to *Callosobruchus maculates* F. *Environ. Ent*. 4(3): 415-419.

[39] Porca, M., Oltean, I. and Dobrin, I. 2003. Chemical Control of Bean Weevil, *Acanthoscelides obtectus* Say in Stored Condition. *J. Cent. Eu. Agri.* 4(3):209-210.

[40] Porca, M., Ghizdavu I., Oltean, I. and Bunescu, H. 2003. Control of the Coleopteres in stored Agricultural Products Not-Chemical Methods. *J. Cent. Eu.* 4(3):218-219.

[41] Salunkhe, D.K., Kadam, S.S. and Chavan, J.K. 1985. *Post-harvest biotechnology of food legumes.* CRC Press, Boca Raton, FL. Pp 160.

[42] Schmale, I., Wackers, F.L., Cardona, C. and Dorn, S. 2001. Control potential of three hymenopteran parasitoid species against the bean weevil in stored beans: the effect of adult Parasitoid nutrition on longitivity and progeny production. *Bio. Contr.*21: 134-139.

[43] Sing, S. E. 1997. Suppression of Bruchids infesting stored Grain legumes with the predatory Bug Xylocoris flavipes (Reuter) (Hemiptera: Anthocoridae). M.Sc.thesis, McGill University, Montereal, Canada. Pp. 132.

[44] Shaaya, E. and Kostyukovysky, M. 2006. Essential oils: potency against stored product insects and mode of action. *Stew. Post harv. Rev.* 4: 1-6.

[45] Southgate, B.J. 1978. The importance of bruchidae as pests of grain legumes, their distribution and control. Pp. 219-229. In**:** Singh, S.R., Van Emden, H.F., and Taylor, T.A., (eds.). *Pests of grain legumes ecology and control*. Academic press.

[46] Southgate, B.J. 1979. Biology of Bruchidae. *Ann. Rev. Entomol*.24: 449-73.

[47] Stoll, G. 1988. Natural Crop Protection in the Tropics. Magraf Publishers, FR Germany. pp. 88-165.

[48] Teshome Lemma. 1990. *The Biology and control of the Adzuki Bean Beetle (Callosobruchus chinensis*L.) *Coleoptera on chickpea* (*Cicer arietinum* L.). M.Sc. Thesis. Presented to School of Graduate Studies, Alemaya University of Agriculture.

[49] Tripathi, A. K., Prajapati, V., Verma, N., Bhal, J.R., Bansal, R. P., Khanuja, S.P.S. and Kumar, S. 2002. Bioactivities of the leaf essential oil of *Curcuma longa* (Var.Ch-66) on three species of stored-product beetles (Coleoptera). *J. Econ. Entomol.* 95 (1): 183-189.

[50] Venkatrao, S., Nuggehall, P.N., Pingale, S.V., Swamlnthan, M. and Subrahamanyan, V. 1960. Effect of insect infestation on stored field bean and black gram *(Phaseolus mungo*). *Food sci.* 9:79-82.