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Efficacy of some cultural management methods on *Callosobruchus chinensis* (L) infestation during storage of pigeonpea seed

M. Silim Nahdy, S.N. Silim[1]*, R.H. Ellis*[2]
Kawanda Agricultural Research Institute, P.O. Box 7065, Kampala, Uganda.
[1] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), P.O. Box 39063, Nairobi Kenya.
[2] University of Reading, Department of Agriculture, Earley Gate, Reading, England RG6 2AT.

Abstract

Studies were conducted at Kawanda Agricultural Research Institute to determine the efficacies of three storage practices *viz*: traditional mud-straw-cowdung silo "tua" storage, pod storage and storage of split seeds, on the management of *Callosobruchus chinensis* infestations in dried pigeonpea seeds. Lowest pigeonpea seed infestation was observed in sealed "tua", followed by loosely covered "tua" (2,512 insects and 3.81% seed damage), and the highest in sack stored pigeonpea. Higher temperatures were observed in the "tua" (sealed "tua" 36.2°C, loosely covered "tua" 31.8°C) than in sack storage (25.5°C). Seed viability was also higher in "tua" (sealed 72.7%, loosely covered 76.3%) than in sack stored seeds (35.0%). Pod stored pigeonpea was effective in controlling *C. chinensis* populations, with infestation and seed damage of only 3.9 insects (all dead) and 0.04% respectively, compared to 45,000 insects and 19.8% respectively, in seed stored trials. Pod stored pigeonpea also maintained higher seed viability (85.8%) than sack stored pigeonpea (45.1 %). Pigieonpea splitting depressed infestation by *C. chinensis,* reducing pest numbers, from 320 insects on the first month of storage to 10 insects on the third month. Whereas in whole stored seeds, there was a sharp rise in pest population from 900 in first month of storage to over 10,000 on third month.

Key words: Cultural management, *Callosobruchus chinensis*, *Cajanus cajan*

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) ranks fifth among the pulse crops in world production (Whiteman et al., 1985). In East Africa, it is the second most important grain legume after beans (*Phaseolus vulgaris* L.) with total production of about 133,000t produced from over 249,000 ha (Nene and Sheila, 1990). Many pigeonpea attributes have contributed to its widespread use in the semi-arid tropics, of which the most important is its grain, which contains between 17 and 28% protein. The grain is thus an important diet supplement for resource poor farmers, who eat mainly low-protein cereal and root crops.

Pigeonpea productivity is low mainly due to the poor agronomic conditions, drought stress and the losses due to pests and diseases (Tuwafe et al., 1994). In the field, the most serious insect pests are pod borers {*Helicoverpa armigera* (Hubner) and *Maruca testulalis* (Geyer)}, pod sucking bugs (*Clavigralla* spp.) and podfly (*Melanagromyza* spp) (Minja, 1996). In the post-harvest systems, storage pests, especially bruchids (Coleoptera: Bruchidae) are the major source of losses to pigeonpea (Singh and Jambunathan, 1990). These severely reduces seed storage life, thus limiting seed and food availability.

Among the Bruchidae, the genus *Callosobruchus* cause greatest damage to pigeonpea (Mphuru, 1978; Lateef and Reed, 1990; Singh and Jambunathan, 1990). In Asia, *C. maculatus, C. chinensis, C. analis* and *C. theobromae* are the most common (Khaire et al, 1992). In Hawaii (Bridwell, 1918) and E. Africa, both *C. chinensis* and *C. maculatus,* have been reported, in addition to *C. rhodesianus* and *C .analis* which were recorded in Tanzania (Mphuru, 1978). Past records in Uganda indicated that *C. maculatus* and *C. chinensis* are the most serious (Davies, 1960), however, recent surveys (Silim Nahdy, 1995) has indicated that although *C. chinensis*, *C. maculatus* and *A. obtectus* are associated with stored pigeonpea seeds, *C. chinensis* is the most serious.

Very heavy damage on pigeonpea seeds by *Callosobrucus* has been observed in several studies. In India, Mookerjee et al. (1970) reported that 32.6% seed damage is observed in only four months of storage if not protected. Because of the heavy damage to pigeonpea seeds in storage, various management options are recommended. These include the use of synthetic and non-synthetic pesticides, biorationals, physical and cultural practices (Taylor, 1981). These recommendations have been met with varying levels of usage and degrees of success. The more modern pest control options (insecticides and fumigants), though very effective, are not very much used because they are often beyond the reach of the resource poor peasant farmers in developing countries (Kitch et al.

1992). Moreover most of the stored grain seeds are for continuos consumption, and so, the use of harzadous insecticides are normally unacceptable (Khaire et al., 1992). In addition many strains of pests are resistant to a broad range of insecticides (Giga and Mazarura, 1990). As an alternative to chemical control, farmers adapt various methods to prevent losses. These include use of biorationals (Nazan, 1983) such as neem and vegetable oils (Girish, et al. 1974; Sangappa, 1977), cultural practices and a variety of storage systems and methods (Srivastava, et al. 1991; Booker, 1967; Caswell, 1968). The choice of any storage methods and systems by farmers is frequently based on its ability to reduce pest damage. The storage method or system may be in terms of the mode of storage, how stored and where stored. In cowpea (*Vigna unguiculata*), for example, traditional hermetic and semi-hermetic storage and pod storage have been found to reduce damage by *C. maculatus* (Booker, 1967; Caswell, 1968; Caswell, 1974). In pigeonpea, some of the methods reported include storage in traditional mud silo, pod storage and storage of split seeds (Silim Nahdy, 1995).

Although some of the storage methods have been shown to reduce cowpea damage, few of them have found widespread acceptance (Murdock and Shade, 1991), and in many instances their use is declining. In pigeonpea the efficacy of the storage methods have not been evaluated under laboratory and field conditions. Therefore the efficacies of various cultural practices in use in Uganda (sealed storage, traditional mud-straw-cowdung silo "tua", pod storage and storage of split seeds) were investigated to identify the best on-farm storage methods and systems.

Materials and methods

All the studies were conducted at Kawanda Agricultural Research Institute, 14 km North of Kampala, Uganda. In all the trials, freshly harvested pigeonpea variety "Apioelina", a local land race, obtained from Lira and Gulu districts was used. Prior to the treatment all damaged pods/seeds were hand sorted and discarded. To get rid of all internal infestation, clean pods/seeds were bulk disinfested by fumigation using aluminium phosphide tablets at a dosage rate of 5 gt^{-1} for four days under gas tight fumigation chambers and later aerated for 24 hours.

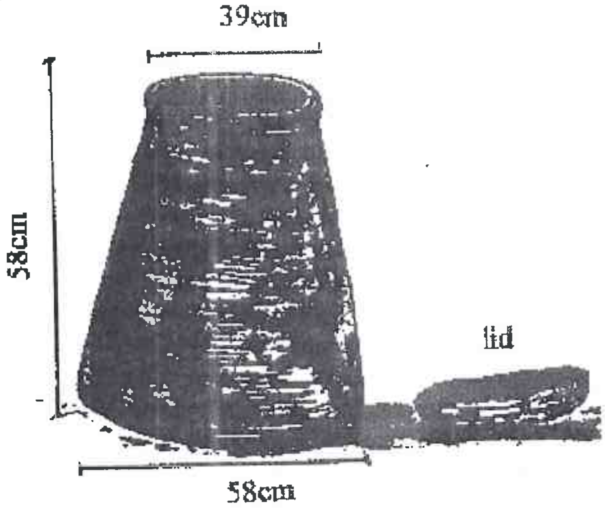

Fig. 1 The traditional mud-straw silo "tua" used for pigeonpea grain storage.

Effect of sealed storage: traditional mud-straw-cowdung silo "tua"

The materials used for the construction of the silo were, strands of grass locally known as "ochwici" or "lumbugu" (*Digitaria* sp.), red clay soil from an ant-hill and cowdung. Before construction, grass strands were softened by covering with banana leaves for two days and made in to bundles (approx. 3.00 cm thick) which were immersed in and smeared with the soil paste. These were then moulded in a continuos but circular motion, similar to clay pot making, to the desired silo shape and size. First to be made was the flat bottom made to sit on a flat wooden pallet, followed by the wall and finally a separate lid. After the construction, the structure was smoothened with mud and finally cow-dung and left to dry. The average volume of the silo made was 150 litres, and made in a semi-conical shape with a slight bulge in the middle (Fig 1).

The treatments made were; gunny bag storage, "tua" storage with loosely placed cover, "tua" storage with the cover sealed using a clay/cowdung mixture. For each treatment, 40kg pigeonpea seed samples replicated three times was infested with 24 pairs of one-day old adult *C. chinensis* and stored for three months under ambient conditions. At the end of the storage period, the temperature within each container was taken. The seeds were thereafter sieved and the total insect number determined. The percentage seed damage was also determined from representative sub-sample of 250 g obtained from the main sample using a Boener divider. Thereafter seed viability test was conducted on 200 representative seed sample from each treatment.

Effect of pod storage on *C.chinensis* infestation and damage

Pods used were divided in to 25 kg treatment samples, replicated four times, by conning and quartering. There were two treatments; pod storage (unshelled) in open reed traditional granaries, and seed storage (shelled) in cloth bags. During shelling in the second treatment, the number of adult *C. chinensis* were recorded and from a 200g representative samples, percentage seed damage was determined. These were done to determine "initial infestation (II)" and "% initial seed damage (% ISD)" as correction factor for determining true in storage infestation (TISI)" in pod stored pigeonpea and true (actual) in storage seed damage (TISD)" in both pod and seed stored pigeonpea. The shelled seeds were standardised to 15kg before infestation.

In all the treatments, pigeonpea were infested with 24 pairs of 24 hour old adult *C. chinensis* and stored for three months. At the end of the storage duration, seed stored pigeonpea were sieved and count made of emerged adult *C. chinensis* and from a representative sample of 200g (taken using a Boerner divider) the number of damaged seeds determined, and the percentage seed damage was calculated. Seed viability test were thereafter conducted from 200 seed samples.

In pod-stored treatment, after three months, the total number of insects was obtained from the sum of the insect obtained from sieved unshelled pods, and those obtained during pod hand shelling. From a representative sample of 200 g (taken using a Boerner divider) of shelled seeds, the number of damaged seeds was determined from which the percentage seed damage was calculated.

To obtain "true in-storage infestation (TISI)" in pod stored pigeonpea, the "overall infestation" (OI) were corrected from "initial infestation" (II) using the formula 'TISI = OI - II'. To obtain the "true in-storage percentage seed damage" (% TISD), for both pod and seed stored pigeonpea, the "overall percentage seed damage" (%OSD) were corrected from the "initial percentage seed damage" (%ISD) using the formula '%TISD = %OSD - % ISD'.

Effect of split seeds on bruchid infestation

Fifty kilograms of pigeonpea seeds were used for the study. The seeds were bulk disinfested as in the above and divided in to two samples using a Boener divider. The sample lot was split using the traditional method between grinding stones. These were sieved (in 1.5mm mesh?) to remove small particles and hand sorted to remove all broken cotyledons and non-split seeds. These were soaked in water for 10 minutes and the remaining testa rubbed off by hand. Thereafter the split seeds were sun dried for about two hours (to about 14% mc). The second sample (at 14% mc) was unsplit and used as the control. Each sample was divided into four (replicates) and standardised to 5kg treatment samples. Each treatment sample was placed separately in tightly knitted cotton cloth bags, infested with 10 pairs of 24 hour old *C. chinensis* and stored for three months within the closed cloth bags.

At monthly intervals insect numbers were determined and all dead insects discarded and live ones returned to the container. At the first count, the initial number of insects used during infestation was deducted to get the actual emerged insects during the storage duration. At each subsequent insect count the number of live insects returned were deducted to get the actual emerged insects subsequent to the last count.

Results

Effect of sealed storage: traditional mud-straw-cowdung silo "tua"

Significant differences ($P<0.05$) were observed in the final temperature within the containers (Fig. 2). The highest temperature was recorded in sealed "tua" (36.2°C), this was followed by loosely covered "tua" (31.8°C) and gunny sack (25.5°C). The differences in infestation and seed damage between pigeonpea seeds stored in sacks, loosely covered "tua" and sealed "tua" was also significant ($P<0.05$) (Fig. 3). The highest infestation and damage was recorded in sack stored pigeonpea with 75,727 insects and 17.6% seed damage respectively. In loosely covered "tua", lower seed infestation and damage were recorded (2,512 insects and 3.81% damage). Least infestation and damage was recorded in pigeonpea seeds stored in sealed "tua" (56.3 insects and 0.06% seed damage respectively) and all insects were dead. Seed viability (Fig. 4) was also significantly low ($P<0.05$) in sack stored seeds (35.0%) and high in loosely covered (76.3%) and sealed "tua" (72.7%).

Effect of pod storage on C. chinensis infestation and damage

The result showed that pod storage was very effective in controlling *C. chinensis* infestation (Table 1). It

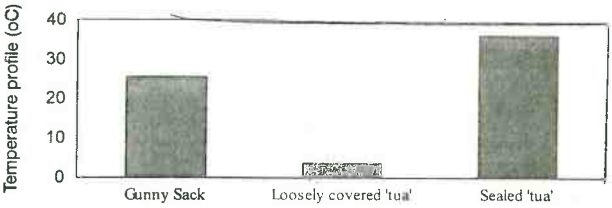

Fig. 2. Temperature profile °C in *C. chinensis* infested pigeonpea seeds stored for three months in gunny sacks, loosely covered and sealed "tua".

Table 1. **Mean number of *C.chinensis* emergence and percentage seed damage in pod stored and seed stored pigeonpea after two months of storage**

Form of storage	Mean no. of emerged adults	Mean % seed damage	% seed viability
Seed form	45,000	19.80	45.1
Pod form	4	0.04	85.8

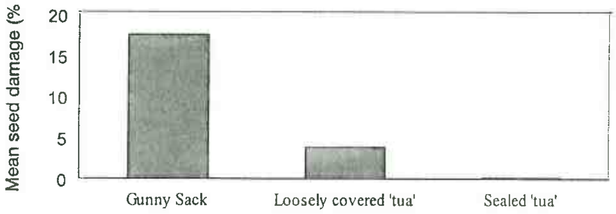

Fig. 3. Mean damage by *C. chinensis* pigeonpea seeds stored for three months in gunny sacks, loosely covered and sealed "tua"

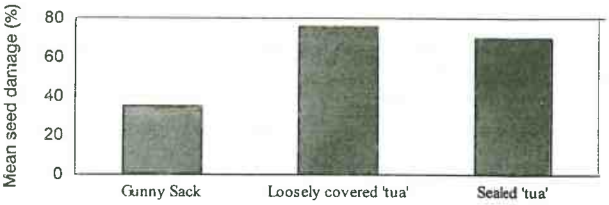

Fig. 4. Mean viability (%) of pigeonpea seeds infested with *C. chinensis* and stored for three months in gunny sacks, loosely covered and sealed "tua"

significantly reduced pest infestation ($P<0.05$), from 45,000 to 3.9 insects in seed and pod stored trials respectively, and seed damage from 19.8% to 0.04% in seed and pod storage respectively. Pod stored pigeonpea seeds also maintained very high viability (85.8%) as compared to stored pigeonpea whole seed (45.1 %) (Table 1).

Effect of pigeonpea seed splitting on *C. chinensis* infestation during storage

Pigeonpea splitting was found to have a negative effect on infestation by *C. chinensis*. There was significant reduction in pest infestation ($P<0.05$) in split seeds at all storage durations as compared to whole seed (Table 2). In split seeds, there was a reduction in pest numbers on each subsequent month of storage, from 320 insects on the first month of storage to 10 insects on the third month of storage. In whole stored seeds, there was a sharp rise in pest population number from 900 on the first month to over 10,000 insects on the third month of storage.

Discussions

Traditional mud-straw "tua" (sealed storage and loosely covered) and gunny sack storage

The multiplication rate of storage pests during storage have been attributed to several factors, amongst which the nature and quality of the storage structure has been considered important (Sinah, 1990). Vincente et al. (1972) reported that the percentage seed damage during storage was four times lower in plastic bags than in glass jars. Jalote and Vaish (1976) reported lower grain damage in gunny bag storage than in polythene bag storage. Caswell (1975) compared *C. maculatus* multiplication in four types of bags and found that the baft bags had the lowest number of insects followed by woven polythene, multiwall paper and jute bags, respectively. He reported that grain stored in steel drums had least damage provided the drum was full and the lid tightly fitted, This he reasoned, was due to reduction in O_2 quantity in the container. In Nigeria, storage of cowpea in plastic bags with cotton lining was shown to be very effective against *C. maculatus* infestations (Caswell, 1974). When these containers were completely filled with cowpea seed, O_2 concentration dropped to about 1% within two weeks because the insects used the O_2 within the container and as a result the beetles died. When O_2 concentration was about 1% and CO_2 concentration 10%, Storey, (1981) recorded 100% adult mortality in only two days of storage, four days for eggs, five days for 7-14 day old larvae and eight days of storage for older larvae and pupae).

Table 2. Mean adult *C.chinensis* emergence from split and whole seed

Form of storage	Adult emergence			
Storage duration (months)	1	2	3	Mean
Split	220.8	68.2	8.2	99.1
Whole seed	900.5	3,450.1	10,121.0	4823.9

Sinah (1990) compared the effect of five storage containers, namely, glass jars, tin containers, plastic containers, earthen pucca and earthen kaccha, on the population of *C .chinensis*. The highest number of adults after 35 days of storage was recorded in the earthen pucca, glass containers, earthen kuccha and plastic containers, respectively. He postulated that the differences in the micro-climatic conditions within the containers may have been responsible for the differences in pest population especially the level of available O_2 and other conditions such as temperature and humidity.

In the current study, the differences in infestation and seed damage after three months of storage, between pigeonpea seeds stored in sacks, loosely covered "tua" and in sealed "tua" were found to be significant. The highest infestation and damage was recorded in sack stored pigeonpea with 75,728 insects and 17.6% seed damage respectively. In loosely covered "tua", 30 fold reduction in insect population and 4.5 fold reduction in seed damage were recorded. In the sealed "tua" there were only 56 adults and all were dead and damage was less than 0.1%. Seed viability was also lower in sack stored seeds, and much higher in both loosely covered and sealed "tua". Probably as the insects multiplied within the sealed containers, there was a reduction in O_2 concentration and increase in CO_2 concentration, this could have not only stopped *C. chinensis* from multiplying but it resulted, in addition, to them suffocating to death. This was also reported for sealed drums (Caswell, 1975) and sealed plastic bags with cotton linings (Storey, 1981), where insects suffocated and died with time due to the hermetic effect. In loosely sealed containers it is probable that some degree of sealing may have been possible, depending on the tightness of the lid and smoothness of the contact surfaces, which kept sub-lethal levels of O_2. The higher final temperatures recorded in both sealed (36.2°C) and loosely covered "tua" (31.8°C) was considered too low to have a sterilising effect on *C. chinensis* as these were within the temperature range for development (17.5 - 37.5°C) (Howe and Currie, 1964)

The results showed that the traditional method of pigeonpea storage in sealed "tua" is an effective pest management option. Even the loosely covered "tua" was partially found to be effective in controlling pest multiplication and seed damage.

Pod-storage

Storage of cowpea in pod form has been reported in several countries (Booker, 1967; Caswell, 1968 and Silim Nahdy et al., 1990) as effective in reducing *C. maculatus* populations and damage (Caswell, 1975). It was reported from northern Nigeria that cowpea pods sampled after nine months of storage had 32% damage compared to 87% damage recorded from seed stored cowpea, (Caswell, 1968). However pod-storage only offered partial protection against *C. maculatus* and additional protection were needed to reduce the losses. It was thought that the pod may have reduced infestation by either failure by the first instar larvae to locate a seed or the thickness and hardness of the pod.

The result in the current study showed that pod storage was very effective in controlling *C. chinensis* infestation. It significantly reduced pest multiplication (from 45,000 to 4 in seed and pod storage respectively) and seed damage (from 19.8% to 0.04% in seed and pod storage respectively) within a storage duration of three months. Pod storage also resulted in maintenance of very high seed viability (85.8%). Reduced infestation and seed damage in pod stored pigeonpea is most likely a result of the presence of numerous surface hairs on the pods which prevented egg attachment on the surface and pod penetration by the first instar larvae (Silim Nahdy, 1995). Secondly the pod itself could have acted as a barrier to both larval penetration and adult emergence (Silim Nahdy, 1995). Non location of seed for development immediately after pod penetration may have also resulted in reduced infestation. It is also probable that non-location of inner-pod wall for the purpose of cutting the emergence window by the last larval stage could have further reduced the opportunities for external emergence of adults.

The study has shown that pigeonpea pod storage as practised in Gulu district using traditional granaries is probably one of the most effective management methods for *C. chinensis* still in use, which shows why this form of storage has persisted in this part of Uganda. Although not reported here, for pod storage to be effective, there is need to have pods that do not shatter when dry.

Seed splitting

In India, pulses like pigeonpea (*C. cajan*), mung bean (*Vigna radiata*), chickpea (*C. arietinum*) and Urd bean (*Vigna mugo*) are split in to two halves known as "Daal" and stored in this way (Gokhale *et al.* 1990; Singh and Jambunahan, 1990). Split seeds with or without oil coating are reported to offer good protection against bruchid attack (Gokhale et al. 1990).

Investigations by several workers have been conducted to understand this phenomena. For example, Avidov et al. (1964), evaluated the effect of curvature and surface area on the oviposition responses of *C. chinensis* and concluded that curvature alone was responsible for the ovipositional preference. Gokhale et al. (1990), on the other hand, demonstrated that although physical stimuli (curvature) is a prerequisite for normal oviposition, once this requirement is met, then chemical stimuli alone exerted the influence on oviposition.

The current study showed that although oviposition and development was possible in split pigeonpea the infestation was considerably lower than in whole seeds. In split pigeonpea, in addition to the low infestation, there was a sharp reduction in infestation with prolonged storage time (220, 68, and 8 adults on the 1st, 2nd and 3rd months respectively) as compared to whole stored seed (900, 3,450 and over 10,00 on the 1st, 2nd and 3rd months, respectively).

The above trend in split pigeonpea is probably due to three factors. First the reduced surface curvature may have initially reduced the attractiveness of the split seed for oviposition thus limiting the rate of multiplication. Secondly, with the removal of the smooth seed coat, exposed cotyledon on the split seed surface which are rough, may not been ideal for egg attachment. Finally, since *C. chinensis* has to begin and complete development in a single seed, the split seed may have not afforded sufficient requirements both nutritionally and volume wise to complete development to adult. The combined effect would most likely, especially with extended storage time, reduced pest population to zero. It is concluded that, where pigeonpea is for food, storage of split seed would extend storage life considerably.

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