Effects of sun exposition on the infestation levels of bruchids population in cowpea (*Vigna unguiculata* (L) WALP) storage system in Niger

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Summary

Bruchidius atrolineatus PIC. and *Callosobruchus maculatus* FAB. (Coleoptera, Bruchidae) are the most important pests of cowpea beans, *Vigna unguiculata* (L.) WALP., in the Sahel. Cowpea infestation by these two bruchid species starts in the field at the beginning of the plant fruit bearing and continues during storage, resulting in dramatic damage if no control action is taken. In this study, the effect of the exposition to the sunlight on infestation levels of *B. atrolineatus* and *C. maculatus* and their parasitoids in cowpea storage system was examined. We tested whether different periods of exposure (1-4 weeks) of cowpea bean pods to the sun would reduce the abundance of bruchid beetles and their parasitoids. The results showed that the infestation levels depend on the time of exposition to the sunlight. When increasing the exposition time, the number of eggs laid and the number of bruchid and parasitoïd adults decreased drastically. Thus, the exposition to the sunlight of the pods and seeds seems to be an excellent and simple method to prevent bruchids infestation during the storage of cowpea beans pods and seeds.

Keywords: control method, sun exposition, bruchids, parasitoids, Niger.

Introduction

Studies carried out by FAO on the food situation of the developing countries showed that 10 countries of sub-Saharan Africa, including Niger, with a population of 220 million people, had a lower feed ration at least necessary (FAO, 1991). These populations suffer specifically from protein deficiencies (POLEMAN, 1975). In fact, leguminous crops, as important sources of proteins, are intended to be the best and least expensive solutions.

It is known that the cost of plant proteins is two to three times lower than that of animals and leguminous seeds contain two to three times more proteins than cereals (LIENARD & SECK, 1994). They also contain the 24 amino acids essential to food in the proportions corresponding to the human needs (except for the sulphur amino acids). Moreover, the edible leaves are rich in vitamins and mineral salt. All these features are some interesting aspects enabling the extension of leguminous crops as food supply in our countries. In tropical Africa, cowpea seems to be the most cultivated leguminous crop.

Unfortunately, in the sahelian belt, the conservation of pods and seeds is a daily challenge for farmers because of the presence of two bruchid species, *B. atrolineatus* and *C. maculatus*. The infestation of the pods by these insects starts in the field at the beginning of plant fruit bearing stage. According to ALZOUMA (1981), females of *C. maculatus* prefer to lay eggs on the sidewalls of the yellowing pods. Females of *B. atrolineatus* rather have an opportunistic behaviour by depositing their eggs on the most abundant phenologic stage in the cultures. These eggs of lengthened form are deposited along the joinings of the pods (HUIGNARD, 1985).

After the blossoming, the larva penetrates inside the seed by perforating the tegument of the pod and then that of the seed. Once inside, larvae develops by consuming the reserves contained in the cotyledons of the seeds (ALZOUMA, 1981; HUIGNARD, 1985; MONGE *et al.*, 1988). The duration of development stage of the four larval and nymphal stages varies according to the conditions under which they develop. (BOUBACAR, 1985). In sahelian area, the average developmental time is 28 days (BOUBACAR, 1985). The infestation starts in field and continues during the storage of the products where the damage can be considerable if no protection measures are taken. ALZOUMA (1981) stressed that 60 to 70% of the pods are degraded at the end of 8 months of storage in the area of Niamey in Niger.

Many attempts are made to control the infestations by bruchids such as the use of resistant varieties, biological and chemical controls and the application of plant extracts or plants oils (DOUMMA, 1998; SOU, 1998). In rural area, the lack of funds and adequate infrastructures of storage strongly limits the use and the effectiveness of these methods. Consequently, the bruchids cause significant damage to pods and seeds of cowpea bean. An attempt to develop a preventive, efficient, environmentally and cheap method to control the bruchids would be highly desirable. Sands or wood ash are often mixed with stored seeds in the granaries. This may reduce the movements of the insctes within the stores and suffocate the adults (CHINWADA & GIGA, 1997). Peanut or neem oils are also used for coating the seeds in the stores. Farmers traditionally introduce aromatic plants in granaries at harvest time. These plants release insecticidal or repellent volatiles (GOLOB & WEBLEY, 1980).

This study examines the effect of sun exposition on the infestation levels of bruchid populations in cowpea storage system in the objective to determine the exposure time which is sufficient to allow an efficient protection of cowpea stored products. It also analyses the effect of this treatment on the bruchid parasitoids during the storage period. Eventually, we also considered how the results of this study could be translated into practical information that can be transferred to growers or extension agents for proper managing.

Material and methods

Vegetable material

The study was carried out with a batch of a local variety of *V. unguiculata* collected in the district of Gaya (350 km in the South-West of Niamey, Niger) known for its relatively wet climate. They were collected in the same field. Almost, these pods were naturally infested from the field with different developmental stages of the bruchids and their parasitoids.

The pods were then brought at Niamey where the experiment was conducted and exposed immediatly to the sunlight.

Studied batches and followed parameters

Five treatments noted S0, S1, S2, S3 and S4 were studied. Each treatment represented a batch. S0 was the standard batch where the pods are stored without being exposed to the sunlight. The pods were exposed directly to the sun during one week, two, three or four weeks (S1 to S4, respectively) before being stored in the experimental boxes. For each treatment replicated four times, four plastic boxes containing each 200 naturally infested pods were prepared. The box, acting as a storage structure, provided a favourable condition by allowing dispersal and preventing immigration of insects. The pods were exposed directly to sunlight before their introduction in the box according to the treatment. At the period of the experience the temperature was about 40°C outside and 32°C in the laboratory.

On each of the pods, the total number of eggs and adults of bruchids were counted. An indirect method of evaluation consisting of the evaluation of the number of holes where adults emerged was used as signs to determine the number of parasitoids adults. The pods were then kept in the laboratory with a temperature of 30°C. Monthly, The numbers of eggs laid, of bruchid adults and emerged parasitoids were recorded.

Statistical analysis of the data

For all parameters, data were analysed by using the multiple comparison test of Duncan ($P = 0.05$).

Results

Global results

The analysis of the results points out that in all treatments (Tab. 1, Figs. 1 and 2), more eggs of *C. maculatus* were observed than those of *B atrolineatus*. In addition, the numbers of bruchid eggs, adult bruchids and parasitoids depend on the exposure time of the pods to the sun. Indeed, the analysis of the results in Table 1 shows that these numbers vary according to the exposure time of the pods to the sun. More the pods are exposured in the sun, more these numbers become low.

Table 1. The number of bruchids eggs, bruchids adults and parasitoids adults observed in the different treatments after five months of storage

	Number of *B. atrolineatus* eggs	Number of *C. maculatus* eggs	Total number of eggs	Number of bruchids adults	Number of parasitoids adults
S0	**181 a**	**6102 a**	**6283 a**	**875 a**	**131 a**
S1	**152 ab**	**3625 b**	**3777 b**	**675 ab**	**55 b**
S2	**112 ab**	**1854 c**	**1966 c**	**365 bc**	**27 bc**
S3	**82 bc**	**784 d**	**866 d**	**125 d**	**12 cd**
S4	**69 bc**	**689 de**	**758 de**	**76 de**	**16 cd**

The values in the same column followed by the same letters are not significantly differents (according to Duncan test, p = 0.05).

Evolution of the egg laying activity of bruchids

Analysis of the results of figures 1 and 2 points out that the activity of laying of bruchids depends on the exposure time of the pods to the sun. For the two species, the activity of egg laying which is low at the beginning of storage increases considerably in the S0 batches and S1 and in a very weak way values in the batch S2. On the other hand in the batches S3 and S4 the activity of egg layings remained relatively negligible for all the period of storage.

The analysis of the results obtained with the batches S0 and S1 shows that the evolution of the activity of layings of the two species of beetles was different. Indeed for *B. atrolineatus*, the analysis of the results shows a significant activity of layings during the first month of storage whereas for *C. maculatus*, the activity of layings remained relatively weak during the first month of storage, increases in a progressive way during all the rest of the storage period.

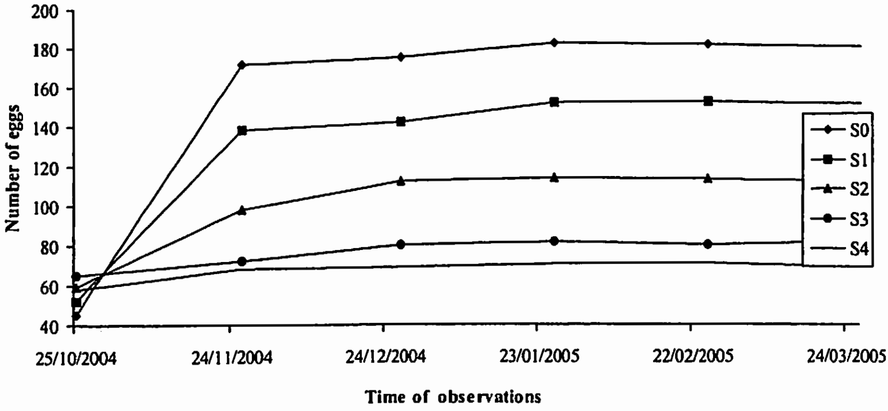

Fig. 1. Evolution of egg laying activity of *B. atrolineatus* during the storage period.

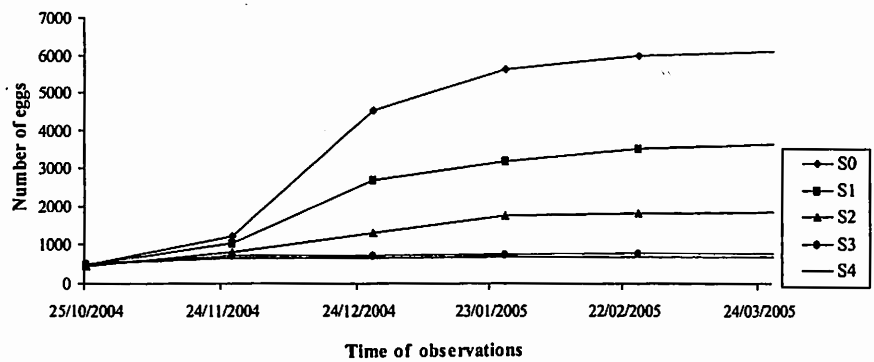

Fig. 2. Evolution of egg laying activity of *C. maculatus* during the storage period.

Evolution of the adults of beetles

The examination of the results of figure 3 shows that for all batches considered, the average number of adult bruchids from the pods was low during the first month of storage. From November 24, one notes a progressive increase of the number of bruchids adults in the batches S0, S1 and S2 with more significant result in the batches S0 and S1. On the other hand in the batches S3 and S4, the number of bruchids adults remained relatively neglagible during all the experimental period.

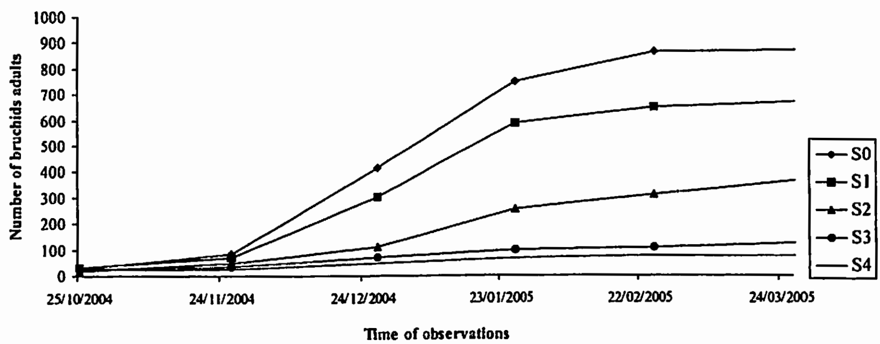

Fig. 3. Evolution of the number of bruchids adults during the storage period.

Evolution of the parasitoids adults

The evolution of the number of parasitoids also depends on the exposure time of the pods to the sun. Indeed, parasitoids adults low at the beginning of storage increases in a significant way in the batch S0 and in a low way in the batch S1. On the other hand in the batches S2, S3 and S4, these numbers remained relatively constant.

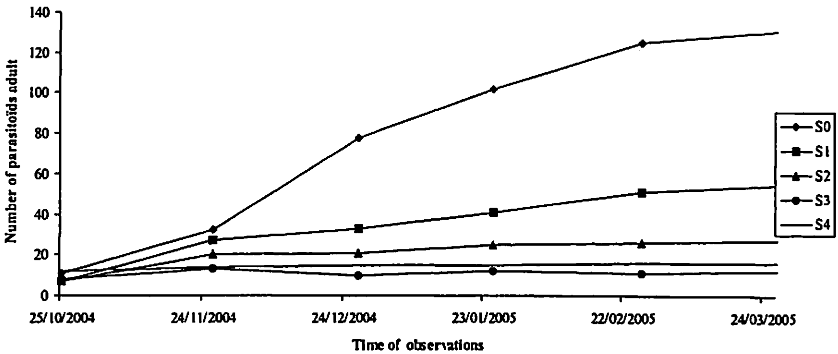

Fig. 4. Evolution of the number of parasitoids adults during the storage period.

Discussion

Our study provides evidence that the preliminary exposure of seeds to sunlight is an effective method to reduce the damage by bruchid pest during seeds storage. The analysis of the activity of egg laying of the bruchids, shows that independently of the species, the number of eggs deposited by these insects on the pods varies according to the exposure time of the pods to the sun. More the exposure time of the pods to the sun was important, more the numbers of eggs deposited were low. The same results are observed for bruchids and their parasitoid adults.

Moreover, the most significant results are observed when the pods underwent a preliminary exposure of at least two weeks. What lets suppose that two weeks of exposure of the pods to the sun are necessary to ensure an effective protection of the stocks of cowpea against the beetles.

Many authors studied the impact of solar drying on the development of the insects in general. According to ALZOUMA (1996), drying is significant for the food products to be stored because it reduces to a significant degree the water content of seeds with as a consequence an inhibition of the larval development of the insects. CHINWADA & GIGA (1997) showed that in a (solar) heater, or in plastic bags exposed to the sun, where a temperature of at least 57°C can be reached for more than one hour, all the stages of bruchids are killed where as the cooking properties and the beans are not negatively influenced. At 51.5°C for 15 minutes or at 47.5°C for four hours all adults females beetles are killed (ILOBA & OSUJI, 1996). First development stages of the beetles are most susceptible to such a heat treatment. This treatment inhibits the transformation from pupae to adult and induces adult mortality (KHELIL 1994).

Solar drying seems to have two consequences on the environment of the insect: a rise in the temperature and a decrease of the relative humidity of seeds. According to HOWE (1965), many pests attacking the food products during the storage are unable to reproduce at an ambient relative humidity of 50%. MCCOY (1962) pointed out that for the fruit fly *Drosophila melanogaster* it is the moisture which plays the most significant role in the activity of the adult, since raised water contents supports the laying on tomato. According to KUMAR (1994), high temperatures are lethal for the insects. The repeated exposure to the sun allows the escape of the insects in addition thus preventing to them from laying on the pods. The same effect is observed for the parasitoids. This seems to explain the low number of parasitoid adults observed. So that one of the disadvantages of this practice is that it is a non-selective method because it has an effect on bruchids as well as on their parasitoids, as showed by FLINT & VAN DEN BOSH (1977). However, it can be used in synergy with the biological control in a perspective of integrated pest management of bruchids.

Furthermore, the analysis of the results obtained shows that in all the batches, there were more eggs of *C. maculatus* than of *B. atrolineatus*. This result is in contrary with those usually observed in the sahelian area and which show that *B. atrolineatus* is the dominant species (ALZOUMA, 1981; DOUMMA, 1998). As showed by IDI (1994), this seems to be in relation with the origin area of the pods characterised by a relatively wet climate. The author pointed that in wetland, the activity of egg laying of *C. maculatus* is more significant than that of *B atrolineatus*.

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