Journal of Applied Biosciences 84:7723 – 7729

ISSN 1997–5902

Effect of solar drying on the biological parameters of the cowpea weevil, *Callosobruchus maculatus* Fab. (Coleoptera-Bruchinae), in Sahelian area.

Moumouni D.A., Doumma A. and Seyni I.S.
Université A.M. de Niamey-Faculté des Sciences BP. 10662 Niamey, Niger.
Correspondent: E-mail: moumounidanmairoadamougmail@yahoo.com, admoumouni@yahoo.fr

Original submitted in on 1st October 2014. Published online at www.m.elewa.org on 29th December 2014

ABSTRACT
Objective: Callosobruchus maculatus Fab. (Coleoptera: Bruchinae) is a major pest of cowpea seeds (*Vigna unguiculata* (L.) Walp) in the Sahelian zone. The grain infestation by this insect pest starts in the field at the beginning of fructification of the plant and continues in storage where the damage can be significant if no protective measures are taken. In order to prevent the damage caused by *C. maculatus* in storage of cowpea, farmers commonly expose the seeds and pods to the sun radiations for several days before storing them. Therefore, the aim of this study is to investigate the impact of sun radiation on the egg laying and development of weevils in general and particularly *C. maculatus.*
Methodology and results: To achieve this goal, experiments were conducted to determine the biological parameters of two batches of this pest respectively exposed to sun radiations and in the laboratory environment. The investigated parameters include longevity, fertility, infertility rate, eggs, development time, larval survival rate and emergence rate. This study results indicated that the different biological parameters studied were significantly affected when the insects were reared under sun radiations. In fact, it appears under this study experimental conditions that sun exposure significantly inhibits egg laying, embryonic development and postembryonic development of *C. maculatus* resulting in complete inhibition of the emergence of the offspring.
Conclusion and application of results: Thus, solar drying seems to be an effective method of preventing weevil damage during cowpea storage.
Keywords: Cowpea; *Callosobruchus maculatus*; solar drying; Sahelian area.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is a food legume widely cultivated in the world with an estimated 3.3 million tons (FAOSTAT, 2011) of dry seeds of which 64% are produced in Africa. The worldwide-cultivated area is estimated to be more than 12.5 million hectares annually, with about 9.8 million hectares in West Africa. This region is therefore the largest producer and consumer of cowpea in the world (FAOSTAT, 2011). Leguminous food crops in general and cowpea in particular, have been recognized as the best and cheapest solution in the fight against food insecurity mainly because of their high protein content. Moreover, the price of vegetable proteins is two to three times lower than that of animal proteins. Grains of leguminous seeds contain two to three times more protein than cereals, and contain 24 of the essential amino acids in required proportion for human needs (except for sulphur-containing amino acids). In addition, edible leaves are rich in vitamins and minerals. For these reasons, high interest has been given to the production of leguminous food crops, with preference given to cowpea in Tropical Africa. Despite these tremendous benefits, the post-harvest conservation of cowpea remains a constant challenge for farmers in the Sahelian area. Two coleopteran species, including *Bruchidius atrolineatus* (Pic) and *Callosobruchus maculatus* (F.) are responsible for major loss of cowpea seeds during storage. Adults of these two insect species appear in the farms at the beginning of flowering and fruiting stages. The females gradually lay their eggs on young pods and those ripening (Huignard, 1985; Huignard *et al*, 1985; Alzouma 1987). During the harvest, the pods or seeds, some of which infested by larvae are stored in traditional barns (Amevoin *et al*., 2005). The development of these larvae in the cotyledons of the seeds causes significant damage during storage of cowpea (Doumma 1998). Of these two species, *C. maculatus* cause the most significant damage in the storage of this crop because of reproductive diapauses that affects adults of *B. atrolineatus* during the first month of storage. Through its non-flying stage, this species can remain in stockpiles throughout the period of cowpea storage (Ouedraogo *et al*., 1991, 1996; Sanon *et al*, 1998). Several generations of reproductive adults overlap in storage depending on the quality of cowpea seeds. Caswell (1961) noticed that in Nigeria, primary infection rate of less than 10% of cowpea seeds by *C. maculatus* was enough to destroy 60 to 70% of the crop a few months later. In Togo (Glitho, 1990) as well as Burkina Faso (Ouedraogo *et al*., 1996; Sanon *et al*, 1998), studies have shown that weight losses of cowpea seeds could be higher than 80% after six to seven months of storage. To address this situation, several control measures were developed, including the use of weevil-resistant varieties, biological control, chemical control and traditional control methods (Doumma, 2012). However, in rural areas, lack of financial resources and adequate storage facilities severely limit the effectiveness and usage of these methods. Because of these reasons, farmers have always relied on preventive traditional techniques, including repeated exposure of cowpea to sun radiations before storing them. Moreover, it is common to observe that in Africa farmers expose the pods and seeds of cowpea before storing them in the barns. In this study, we investigate the impact of solar drying of cowpea pods on biological parameters of *C. maculatus*. Results from this study will significantly help to the valorisation of this pest management technique.

MATERIALS AND METHODS

Experimental conditions: All experiments in this study were conducted on the campus of Abdou Moumouni University of Niamey either in the laboratory environment or under sun exposure. The study was conducted during the months of October, November and December 2013, and it was during this time of the year that farmers exposed the pods and seeds of cowpea in the sun before storing them in the barns. The minimum and maximum temperatures varied respectively from 24.2 ° C to 37.8 ° C in October and 16.7 °C to 33.3 °C in December (Table 1).

Table 1: Temperature and relative humidity of the insect collection site

		October	November	December
Temperature (°C)	**max**	24.2	19.5	16.7
	min	37.8	36.2	33.3
Relative humidity (%)		9.7	0.7	0.0

Origin of the strain of *C. maculates:* The strain of *C. maculatus* used in this study experiments was collected from infested cowpea seeds obtained from farmers in the area of Balleyara, located about 100 km north-east of Niamey, Niger. For this purpose, a sample of 6 kg of infested seed was collected and stored in the laboratory in a rectangular Plexiglas box (260×130×77 cm) until the emergence of adults, which were used for subsequent rearing.

Insect rearing: For insect rearing, 100 to150 adults of *C. maculatus* obtained from infested seeds were introduced into a rectangular Plexiglas box (18 cm QUOTE 5.5) containing 150 g of healthy seeds of a variety of cowpea purchased from a local market in the fifth district of Niamey. Healthy seeds meant seeds that were stored in a freezer for at least ten days to eliminate any source of contamination. After 48 h, insects were collected, and the remaining infested seeds were allowed to incubate until the emergence of adults, which were in subsequent experiments.

Experimental procedures: In order to study the influence of solar radiation on biological parameters (lifetime, growth parameters.), we introduced a couple of *C. maculatus* in a rectangular Plexiglas box (9×6×2 cm) containing 20 healthy seeds of a local variety of cowpea (variety KVX). The experiment was repeated 10 times. The boxes were exposed to the sun radiations during the entire course of the experiment. Boxes prepared under the same conditions as described previously were kept in the laboratory environment as controls. The boxes were daily checked and mortality was recorded. At day 10, after the eggs were laid we counted the fertile and sterile eggs. Sterile eggs differed from fertile egg by the translucent appearance of a seed. The seeds were then kept in their boxes until the emergence of adults. The boxes were daily monitored and the number of emerging adults were recorded and sorted according to their sexes in each box for 14 days. After these experiments, the following parameters are determined:

- The adult life span: The time between emergence and death of the insect
- The number of eggs laid per female during its life time (N).
- The eggs infertility rate: The number of infertile eggs over the total number of eggs.
- Larval survival rate: The number of emerging adults over the total number of fertile eggs
- Emergence rate (ER): The number of emerged adults over the total number of egg laid.
- Development time (T): The time between the laying of an egg on a seed and the emergence of the adult.
- The sex ratio (R) corresponds to the ratio between the number of male and female in the offspring.

Statistical analysis: For statistical analysis of the data, the STAT VIEW software. rar. Version 1999 was used to calculate the means (ANOVA or MANCOVA). Pair-wise comparison of the means were performed using Fisher least significant difference (Fisher test, P= 0.05).

RESULTS

Life span of *C. maculatus* exposed to solar radiation: Analysis of the results (Table 2) showed that when insects were exposed to solar radiations, the average life span was 4.5± 0,88 days while for the control group it was 5.40 ± 1.46 days. Thus, insects exposed to the solar radiations died relatively earlier than those kept in the laboratory did. However, statistical analysis of the results showed no significant difference between the life span the insect under the two experimental settings.

Table 2: Life span of *C. maculatus* adults depending on the experimental setting**.**

	Life span of males (days ± SD)	Life span of females (days ± SD)	Global average life span (days ± SD)
Sun radiation	5.80 ± 1.75a	5.00 ± 1.05a	5.40± 1.46a
Laboratory	4.50 ±0.85a	4.50± 0.97a	4.50± 0.88a

Means followed by the same letter in the same column indicate no significant difference (Newman- Keuls test, α=0.05).

Furthermore, analysis of adult mortality (Figure 1) indicated that all insects remained alive during the first three days regardless of the experimental condition. Thereafter, insects started to die, and by day 9 there were no survivors in the boxes for each of the two experimental conditions.

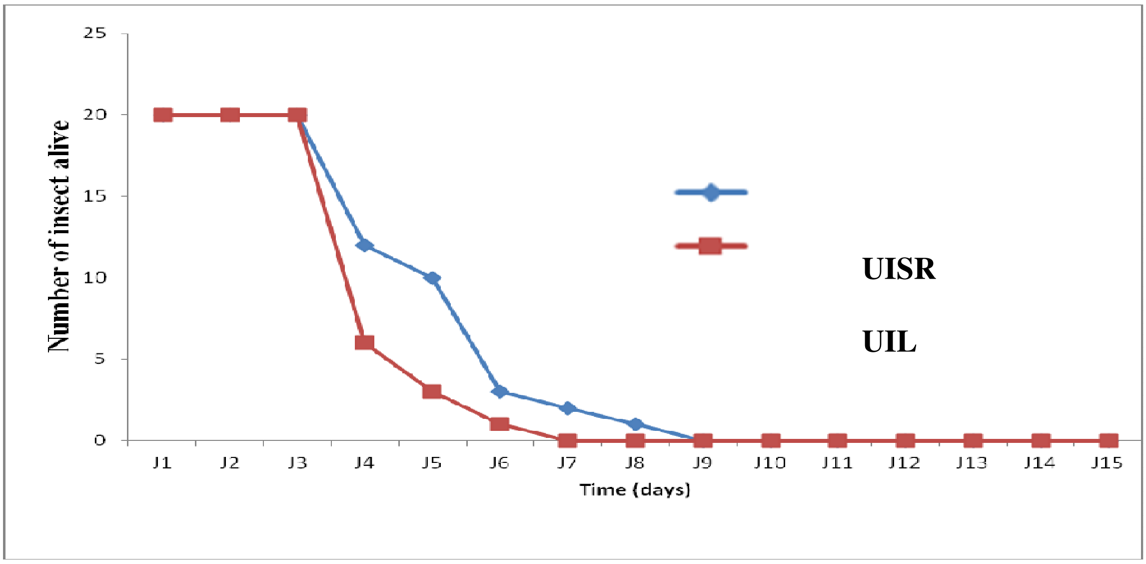

Figure 1: Survival of *C. maculatus* depending of the experimental. UISR: Unfed insects exposed to sun radiations, UIL: Unfed insects maintained in the laboratory.

Effects of solar radiation and sucrose based-diet on life spa: Analysis of the results (Table 3) indicated that the average lifespan of adults of *C. maculatus* could be extended by a sucrose-based diet. This study results indicate that of the average lifespan can be extended by two days when insects were fed on sucrose-based diet.

Table 3: Average life span of *C. maculatus* exposed to solar radiations.

	Life span of males (days ± SD)	Life span of females (days ± SD)	Global average life span (days ± SD)
Fed insects and fed and exposed to sun radiations	6.50 ± 3.34 a	8.44 ± 4.50 a	7.421 ± 3.94a
Unfed insects and exposed to sun radiations	5.80 ± 1.75a	5.00 ± 1.05b	5.40 ± 1.46b

Means followed by the same letter in the same column indicate no significant difference (Newman- Keuls test, α = 0.05).

Eggs laid by adults: Results (Table 4) showed that the average number of eggs laid by adult *C. maculatus* depends on the environment of exposure of insects. Moreover, the number of eggs laid was two-fold higher for the batch of insects maintained in the laboratory than those exposed to the sun radiations, with respectively 94.60± 31.49 and 49.44 ± 34.28 eggs. The average number of sterile eggs per female was also dependent upon the environmental condition of adults' exposure. In fact, this number was more important for insects kept under sun radiations with 28.90 ± 8.02 sterile eggs per female, (64.30 ±12% infertility rate), as compared to adults maintained in the laboratory where the average number of sterile eggs was only 2.80 ± 1.03 eggs per female, (4.80 ± 02% infertility rate).

Table 4: Number of eggs laid and infertility rate depending on the condition of exposure.

	Number of eggs per female	Number of sterile eggs per female	Infertility rate (%)
Laboratory	94.60 ± 31.49 a	5.00 ± 2.35 a	4.8 ± 0.02 a
Sun radiations	49.44 ± 34.28 b	28.± 9.94 b	58.45 ± 0.13b

Means followed by the same letter in the same column indicate no significant difference (Newman- Keuls test, α = 0.05).

Effect of sun exposure on the development of *C. maculates:* Analysis of this study results (Table 5) showed that no adult emerged from seeds that were exposed to sun radiations, resulting to almost in no larval survival. Nevertheless, for insects maintained in the laboratory, the larval survival and the emergence rate were relatively high, with respectively 43.6 ± 0.14 % and 41.1± 0.13. Dissection of the seeds showed in average two dead larvae per seed. The lack of emergence of adults under sun exposure did not allow us to determine the development time under this particular condition.

Table 5: Larval survival rate and rate of emergence of adults of *C. maculatus* observed depending on the medium of exposure

	Average number of eggs per female	Average number of fertile eggs	Average number of emerged adults	Larval survival rate	Emergence rate
Sun radiations	49.44 ± 34.28 a	0 a	0%		0%
Laboratory	94.60 ± 31,49 b	89.60 ± 30.29 b	38.50 ± 14.81	43.6 ± 0.14	41.1 ± 0.13

Means followed by the same letter in the same column indicate no significant difference (Newman- Keuls test, α=0.05)

DISCUSSION

Analysis of the results obtained in this study showed that in this study experimental condition, sun radiations did not have a lethal effect on adults of *C. maculatus.* Moreover, the data did not show significant differences between the insects exposed to sun radiations and those kept in a laboratory environment. These results are different from those obtained by Sembène *et al*. (2006) on groundnut where the authors showed that under extreme temperatures over 33°C, one hour of exposure to sun radiations in a device like Murdock *et al*. (1991) was sufficient to kill all stages of *Caryedon serratus*. The results obtained on the life of *C. maculatus* in this study experimental conditions, can be explained by the relatively moderately varying temperatures observed between 19.5 ° C and 36.2 ° C during the month of November during the time over which the study was performed. This hypothesis can be confirmed by tests conducted on cowpea by Lale *et al*. (2003) who obtained a total adult mortality of *C. maculatus* and *C. subinnotatus* (Pic) after 6 h of exposure to 50 ° C. Furthermore, the solar exposure used in these study experimental conditions does not prevent the contamination of seeds by adult *C. maculatus*. These results can be explained by the nature of the boxes used, that did not allow the insect to escape. Under these conditions, the insect can hide under the seeds during the day and lay their eggs seeds during the night. However, the sun exposure significantly reduces the level of infestation of seeds by *C. maculatus* adults with an average number of eggs laid by adult exposed to the sun radiations significantly lower than that deposited by adults have reared in the laboratory condition. This low level of infestation of seeds by female *C. maculatus* sun radiations can be explained by the behaviour of these insects that prefer to hide under the seeds during daytime instead of laying (Doumma, unpublished data). Furthermore, it appeared from the analysis of the egg laying adults exposed to sun radiations, that this technique inhibits the hatching of deposited eggs leading to a higher high rate of abortions and affect larval development. The resulting effect of the sun radiations led to a complete inhibition of the emergence of the offspring. There was no insect emerging from seeds exposed to sun radiations. This absence of emergence of larvae is not only dependent upon the intensity of the sun radiations that penetrated in the seeds as only two dead larvae were found in these seeds in average. It could also be related to the difficulty encounter by the newly hatched larvae in penetrating the seeds either because of the heat or because of an increase in the hardness of the seeds after the loss of their moisture content. This should result in natural conditions in a significant reduction of the initial infestation rate of the seeds before storing them. Thus, sun radiations , by negatively influencing the growth parameters of *C. maculatus* appears to be an effective preventive measure of seeds store from cowpea weevils in general and *C. maculatus* in particular. The results obtained in this study allow the explanation of the observations of Doumma (2007) showing that exposure of cowpea pods to sun radiations for up to four weeks considerably limits the evolution of populations of weevils and their parasitoids. The effect of this method on the various biological parameters of *C. maculatus* is related to a reduction of the water content of the seed; According to Cruz and *al*. (1988) when the water content of the seeds is very low, the eggs hatching is inhibited, and the larvae fail to develop. This method also promotes the departure of adult weevils that cannot tolerate extreme heat or intense sunlight (in stock, insects are often confined in darker areas).

REFERENCES

Alzouma I 1981. Observations on the ecology of *Bruchidius atrolineatus* and *Callosobruchus maculatus* (Coleoptera-Bruchinae) in Niger. In: The ecology of Bruchids attacking legumes (pulses). Labeyrie, V. (ed.). Junk the Hague: 205-213.

Alzouma I 1987. Systèmes traditionnels de stockage et conservation des denrées alimentaires en Afrique. Actes du premier colloque inernational du réseau africain de recherché sur les bruches. Lomé du 10 au 14 Février 1997. Ed. Isabelle Adolé GLITHO. PP. 58-74.

Amevoin K, Sanon A, Apossaba M, Glitho IA 2007. Biological control of bruchids infesting cowpea by the introduction *of Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae) adults into farmers' stores in West Africa. Journal of stored product research. 43 (3). 240.247.

Caswell GH 1961. The infestation of cowpeas in the Western region of Nigeria. Trop. Sci. 3: 154-158.

Doumma A, 2012. Influence de deux méthodes traditionnelles de luttes sur les capacités *Callosobruchiduis maculatus* Fab. (coleoptera-bruchidae), ravageur du niébé (*Vigna unguiculata* (L) walp), Thèse de Doctorat – Université Abdou Moumouni 136p

Doumma A, 2007. Effects of sun exposition on the infestation levels of bruchids population in cowpea (*Vigna unguiculata* (L) Walp) storage system in Niger. Belgian journal of entomology. Vol. 8

Doumma A, 1998. Contribution à la recherche de méthodes de lutte contre *Bruchudius atrolineatus* Pic. et *Callosobruchus maculatus* Fab. (Coleoptera: Bruchidæ), Ravageur de niébé (*Vigna unguiculata* (L.) Walp) en zone sahélienne. Thèse de doctorat. Univ. Abdou Moumouni de Niamey. 136p.

FAOSTAT 2011. Agricultural production, crop primary database. Food and Agricultural

Glitho IA 1990. Les Bruchidae ravageurs de Vigna unguiculata Walp. en zone guinéenne. Analyse de la diapause reproductrice chez les mâles de *Bruchidus atreolineatus* Pic. Thèse de Doctorat, Univ. F. Rabelais, Tours, 100 p.

Huignard J 1985. Importance des pertes dues aux insectes ravageurs des graines: problèmes posés par la conservation des légumineuses alimentaires, sources de protéines végétales. Cah. Nutr. Diét. XX, 3: 193-199.

Huignard J, Leroi B, Alzouma I, Germain JF 1985. Oviposition and development of *Bruchidius atrolineatus* P. and *Callosobruchus maculatus* F. (Coleoptera-Bruchidae) in *V. unguiculata* cultures. Insect Sci. Aplication, 6 (6): 691-699.

Lale NES and Vidal S 2003. Simulation studies on the effects of solar heat on egg-laying, development and survival of *Callosobruchus maculatus* (F.) and *Callosobruchus subinnotatus* (Pic) in stored bambara groundnut *Vigna subterranea* (L.) Verdcourt. J. Stored Prod. Res., 39, 447-458.

Monge GP, Germain JF, Huignard J 1988. Importance des variations thermiques sur l'induction de la diapause reproductrice chez *B. atrolineatus* Pic (Coleoptera-Bruchidae). Acta oecol., Oecol. Apl., Vol. 9, N°3: 297-307.

Murdock LL and Shade R.E 1991. Eradication of cowpea weevil (Coleoptera: Bruchidae) in cowpeas by solar heating. Am. Entomol., 37(4), 228-231.

Ouedraogo AP 1991. Le déterminisme du polymorphisme imaginal chez *Callosobruchus maculatus* (Fab.) (Coleoptera : Bruchidæ). Importances des facteurs climatiques sur l'évolution des populations de ce Bruchidæ dans un système expérimental de stockage de graines de Vigna unguiculata (Walp.) Thèse de Doctorat. Université de Cote d'Ivoire. 117pp.

Ouedraogo AP, Sou S, Sanon A, Monge JP, Huignard J,Tran B, Credland PF 1996. Influence of temperature and relative humidity on population of *Callosobruchus maculatus* (Coleoptera: Bruchidae) and its parasitoid *Dinarmus basalis* (Pteromalidae) in two climatic zones of Burkina Faso. Bull. Entomol. Res., 86, 695–702.

Sanon A, Ouedraogo PA,Tricault Y, Credland PF, Huignard J 1998. Biological control of bruchids in cowpea stores by release of *Dinarmus basalis* (Hymenoptera: Pteromalidae) adults. Environmental Entomology 27, 717–725.

Sanon A, Garba M, Auger J, Huignard J, 2002. Analysis of the insecticidal activity of methylisothiocyanate on *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and its parasitoid *Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae). J. Stored Prod. Res., 38, 129-138.

Sanon A, Sou S, Dabire´ LCB, Ouedraogo AP, Huignard J 2005. Combining *Boscia senegalensis* Lam. (Capparaceae) leaves and augmentation and the larval parasitoid *Dinarmus basalis Rondani* (Hymenoptera: Pteromalidae) for bruchids control in stored cowpea. J. Entomol., 2(1), 40-45.

Sembène M, Momar TG, Delobel P, Abdoulaye S, Delobel A, 2006. Désinsectisation des stocks d'arachide infestés par *Caryedon serratus* (OL.): utilisation de la solarisation en zone sahélienne. J. Sci., 6(1), 1-11.

Sou S 1998. Étude des populations de bruches et de leurs parasitoïdes dans un agrosystème sahélien au Burkina Faso: Mise en place de méthodes de lutte intégrée. Thèse 3e cycle. Université de Ouagadougou. 127 pages.