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Comparative Performance of Traditional Post-harvest Practices on the Development of *Callosobruchus maculatus* in *Vigna unguiculata* and *Phaseolus vulgaris* Seeds in Paoua (Central African Republic)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors LAT, EKM and MS designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Authors LAT, IZ and OS managed the analyses of the study. Authors LAT, SPW, SFBO, SS and MS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Cowpea seeds are an important source of nutrients for human and animal. However, part of the seed production is lost due to insect attacks, mainly by the weevil *Callosobruchus maculatus* (Coleoptera: Bruchidae), (Fabricius) a major pest of stored cowpeas. The objective of this work

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was to study the impact of traditional pest management on the development of *C. maculatus* infestation. The insects were collected on 100 g of infected seeds of *Vigna unguiculata* and *Phaseolus vulgaris* in post-harvest traditional systems from farmers in different villages of Paoua. The insect's size was determinate with the standard DSLR camera combined into a 3D model using a computer. A Generalize Linear Model (GLM) with the Poisson error distribution was fitted to data to analyse the impact of storage conditions on the insect growth in the presence of the two species of bean. The results of analysis of variance (ANOVA) of the *C. maculatus* development in traditional post-harvest practice showed that the body length of *C. maculatus* was a very highly significant variation according to the traditional post-harvest practice ($P < 0.001$). Though the effect on the body width of the interaction count, storage and species was a very highly significant variation ($P < 0.001$) and implies that the body length of *C. maculatus* development depends on the nature of traditional post-harvest practice. *Vigna unguiculata* is the most sensible to the attack of *C. maculatus* for these two post-harvest practices (polypropylene bag and plastic barrel). Though the plastic barrel limits the development of *C. maculatus* in the sense of length and width.

Keywords: Traditional pest management; legume crop; Callosobruchus maculates.

1. INTRODUCTION

Vigna unguiculata and *Phaseolus vulgaris* production provides essential micronutrients lacking in the diets of millions of persons [1,2]. These two tropical legume crop are rich in health promoting compounds [3] and assist in combating micronutrient deficiencies and malnutrition. *Vigna unguiculata* and *Phaseolus vulgaris* also contribute to food security and income generation among the subsistence and semi-commercial farmers in Central African Republic (CAR) and an essential component of cropping systems in the drier regions and marginal areas of the tropics and subtropics. Legume crop production is constrained by pests and diseases which severely impact the quantity and quality available in the value chain in the world and *V. unguiculata* and *P. vulgaris* is no exception.

C. maculatus is reported to be the most damaging pest of stored legume seeds, especially cowpea *V. unguiculata*, in the tropics and subtropics [4,5,6,7,8,9,10]. Infestation of freshly harvested grains in the store begins in the field where eggs are lay on green or drying pods by adults [11,8] or contamination of the materials through which they are brought to the store from the field. At least twenty species of the genus *Callosobruchus* originated mostly from Africa and Asia, occurring mainly in the tropical and subtropical regions of the world [12,4]. The pest can cause up to 100% damage to legume seeds during storage [5,13]. An average pulse damage of 5-10% and 20-30% for temperate and tropical countries caused by bruchid insects during storage [9,14]. The female adults, lays eggs on the surface of the grain and the larvae hatching from eggs use their mouthparts to penetrate the pod wall or the seed testa [15]. Storage pest damage to grains reduced the grain weight (dry matter reduction), makes them unsuitable for human and animal consumption, food contamination with live or dead insects, dejection and fragments, and depreciation of the nutritional and commercial values of the infested product and cause poor germination ability [16,17,18,2,14].

The use of synthetic insecticide remains the primary means for controlling economical damage to crops, but this practice has come under scrutiny as it may pose potential oncogenic risks and in CAR farmers are so poor and have no access to chemical products, so they use traditional practices for controlling *C. maculatus* damage. Focusing on the importance of *V. unguiculata* and *P. vulgaris* in rural area of CAR, the objective of this work was to study the impact of traditional pest management on the development of *C. maculatus* infestation.

2. MATERIALS AND METHODS

2.1 Choice of Surveyed Site

Paoua (Fig. 1) has been considered for this study because of their high production in cereals (sorghum, millet, fonio, corn) and legumes (groundnuts, cowpea, sesame) in North-West of CAR.

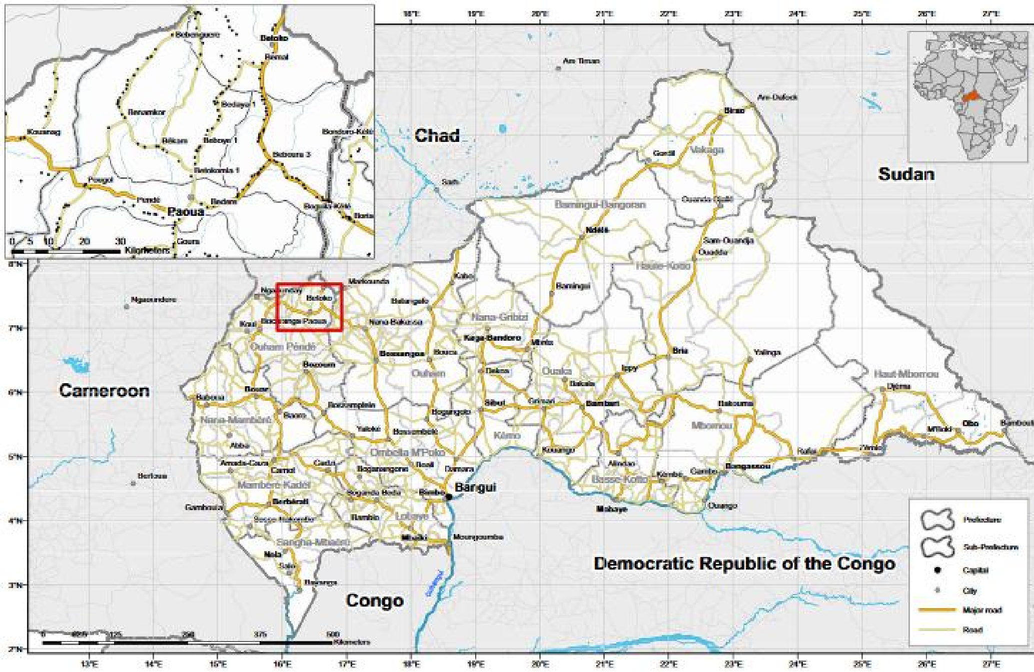

Fig. 1. Location of Paoua (Humanitarian and Development Parthnership Team, Central African Republic)

2.2 Sample Collection

A questionnaire was prepared and used as a tool for the collection of information with 217 farmers. The questionnaire focused on farmers' practices to fight against stored product pests in general and about the *C. maculatus infestation on V. unguiculata* and *P. vulgaris* in particular. Basing on the data collecting from questionnaire (time of storage between 3 to 5 months after storage the *C. maculatus* development was spectacular according to the farmers), only 26 samples of *V. unguiculata* and *P. vulgaris* were collected according to the time of storage of 4 months.

The insects of any sex were collected on 100 g of infested seeds of *V. unguiculata* and *P. vulgaris* in post-harvest traditional systems (Figs. 2, 3, 4 and 5) from farmers in different villages of Paoua.

The Fig. 2 shows the traditional post-harvest practice using polypropylene bag in Paoua. The seeds of *P. vulgaris* and *V. unguiculata* after drying were putted in the polypropylene bag for waiting the potential buyers.

The Fig. 3 shows the traditional post-harvest practice using plastic barrel in Paoua. The seeds of *P. vulgaris* and *V. unguiculata* after drying were putted in the plastic barrel for waiting the potential buyers. Though the dried bean pods were putted in the metallic barrel for sowing next year.

The Figs. 4 and 5 show the *P. vulgaris* and *V. unguiculata*, the two major of cultivate Cowpea in Paoua. In general in this case of insect's damage, the Cowpea lose sits market value.

Each sample was placed in a plastic bag and kept in a freezer at -50°C for one for a week so that the insects lose their mobility before scanning.

2.3 Measurement of Size of Insect

52 samples of infected beans were collected, including 26 infected seeds of *V. unguiculata* and 26 infected seeds of *P. vulgaris*. For each sample, 3 random insects were measured. Thereby 78 *C. maculatus* (26 x 3= 78) from *V. unguiculata* and 78 *C. maculatus* from *P. vulgaris* were measured.

The insect's size was determinate with the standard DSLR camera combined into a 3D model using a computer. The 3D images revealed the fine structure of the pupa anatomy as the insects matured, including the tracheal airways, the antennae and the midgut [19].

Fig. 2. Traditional post-harvest conservation in polypropylene bag in Paoua

Fig. 3. Traditional post-harvest conservation in plastic barrel and metallic barrel in Paoua

Fig. 4. *Phaseolus vulgaris* selled in Paoua market

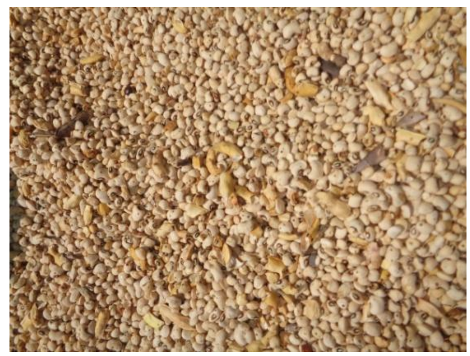

Fig. 5. Attack of *Callosobruchus maculatus* (Fabricius) *on Vigna unguiculata* in Paoua

2.4 Data Analysis

Collected data were not normally distributed (Shapiro test, P<0.05) and variances were not homogeneous (Bartlett test, P<0.0001). A Generalize Linear Model (GLM) with the Poisson error distribution was fitted to data to analyse the impact of storage conditions on the insect growth in the presence of *P. vulgaris* and *V. unguiculata*. Statistical analyses (level of significant 0.005) and figures were generated using R software version 3.2.3 [20].

3. RESULTS

The results of analysis of variance (ANOVA) of the *C. maculatus* development in traditional post-harvest practice showed that the body length of *C. maculatus* was a very highly significant variation according to the traditional post-harvest practice ($P < 0.001$). Though the effect on the body width of the interaction count, storage and species was a very highly significant variation ($P < 0.001$) and implies that the body length of *C. maculatus* development depends on the nature of traditional post-harvest practice (Table 1).

The Figs. 6, 7, 8, 9 and 10 show the evolution of the body length and the body width of *C. maculatus* development according to the traditional post-harvest practice. *V. unguiculata* is the most sensible to the attack of *C. maculatus* for these two post-harvest practices. Though the plastic barrel limits the development of *C. maculatus* in the sense of length and width.

Table 1. Results of analyses with a GLM with Poisson error distribution

	P value	
	Effect on the body length	**Effect on the body width**
count/species	<0.0001	0.363
count/storage	<0.0001	0.345
count*storage*species	<0.0001	<0.0001

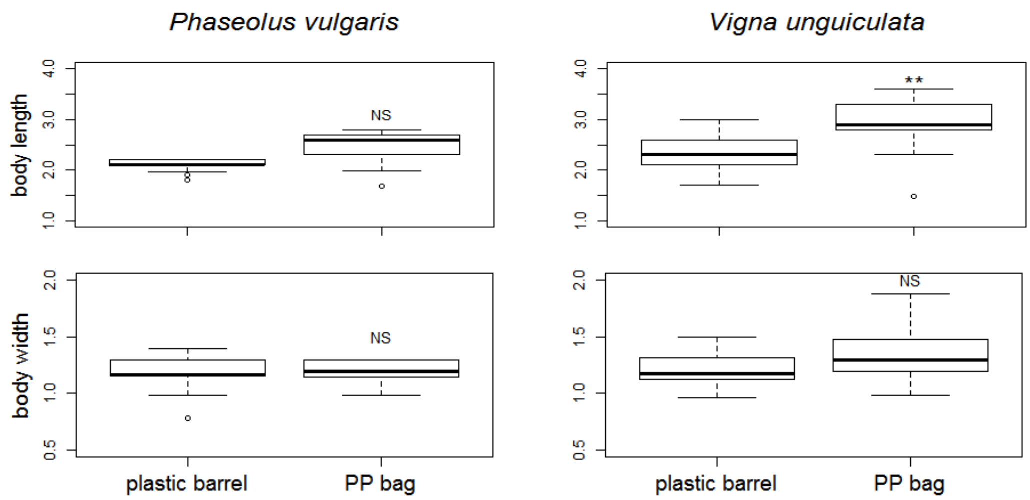

Fig. 6. Impact of storage conditions on *Callosobruchus maculatus* (Fabricius) growth (body length and body width). *PP bag* = Polypropylene bag; asterisks indicate a significant difference (GLM with Poisson errors distribution, P=0.005) between body lengths of *C. maculatus* in the presence of *vigna*; *NS* = non-significant difference

Fig. 7. Dorsal view of *Callosobruchus maculatus* (Fabricius) *on Vigna unguiculata* from plastic barrel

Fig. 8. Dorsal view of *Callosobruchus maculatus* (Fabricius) *on Phaseolus vulgaris* from plastic barrel

Fig. 9. Dorsal view *Callosobruchus maculatus* (Fabricius) *on Vigna unguiculata* from polypropylene bag

Fig. 10. Dorsal view of *Callosobruchus maculatus* (Fabricius) *on Phaseolus vulgaris* from polypropylene bag

4. DISCUSSION

The results of analysis of variance (ANOVA) of the *C. maculatus* development in traditional post-harvest practice showed that the body length of *C. maculatus* was a very highly significant variation according to the traditional post-harvest practice ($P < 0.001$). Though the effect on the body width of the interaction count, storage and species was a very highly significant variation ($P < 0.001$) and implies that the body length of *C. maculatus* development depends on the nature of traditional post-harvest practice (Table 1).

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Previous studies showed that most of the cowpea varieties have a combined resistant ability not only to *C. maculatus* but also to other insect pests and weeds [21]. Such may indicate moderate resistance to this insect pest as shown in the study.

Another previously work [22,23] asserted that the larger grains supply more food and space for insect growth and that the smaller grains or grains with less mass offer more resistance to pests attack than the larger grains. In the present study, significance difference was observed in the development of body length of *C. maculatus* on *P. vulgaris* and *V. unguiculata* according to the post-harvest practice though *V. unguiculata* is the most sensible to the attack of *C. maculatus* for these two post-harvest practices.

The physical characteristics of seeds can determine the acceptability for oviposition but may not be related to the antibiotic nature of the seed [24,25,26,27]. Rough seeds were less acceptable to *C. maculatus* than smooth ones [28]. On the other hand, [5] indicated that varieties with smooth and glossy seed coat constantly were less preferable and therefore more resistant than rough seeded varieties. The present study showed that *V. unguiculata* is the most sensible to the attack of *C. maculatus* for these two post-harvest practices. The resistance in cowpea to bruchid infestation may not be attributed to the seed coat nature as suggested in earlier reports. In a similar report [29] had indicated that seed coat plays no role in the resistance of cowpea to bruchid infestation in their study.

It has been suggested that the growth and development of *C. maculatus* depends on the nutritional value of the seeds [30,31,12,17]. For example, chickpea, *Cicer arietinum*, has a higher fat content than other leguminous seeds such as *Phaseolus vulgaris, Vicia faba, Dolichos lablab, Glycine max*, and *Pisum sativum.*

Compared to the body length of *C. maculatus* on *V. unguiculata* for these two post-harvest practices (polypropylene bag and plastic barrel), *Phaseolus vulgaris* was not a favourable host for *C. maculatus* due to two post-harvest practices (polypropylene bag and plastic barrel), less long development body length. The physical texture of the seed coat, its size, colour and odour could have been responsible for the differential development as indicated by a number of authors [32,33,34,28].

The abundant literature references concerning the resistance mechanisms of plant tissues against insects strongly suggest that the ecological relationship between insects and plant tissues is a complex one with physical as well as chemical interactions. As far as the mechanism of seed resistance against bruchids is concerned, many strategies are used by seeds to protect themselves against insects. The seed may be too hard for newly hatched larva to penetrate [11,5]. The seed may physically be too small or with an inconvenient shape for the larva to reach full size [1,35,36]. The seed may contain too little food to support the larva and the seed may contain toxins or other substances in the cotyledons or its enveloping seed coat that inhibit the larval development [37,38,39]. There are conditions when these latter chemical defenses can be made inadequate, so bruchids are able to infest seeds [40,41,42,43,44].

5. CONCLUSION

The plastic barrel limits the development of *C. maculatus* in the sense of length and width. The plastic barrel could be encouraged in post-harvest in rural community.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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