American Journal of Agriculture and Forestry
2024, Vol. 12, No. 4, pp. 282-288
https://doi.org/10.11648/j.ajaf.20241204.16

Research Article

Effect of Capsicum Chinense Powder in the Preservation of Maize and Groundnut Grains in Stock Against Sitophilus Zeamaïs and Aphis Craccivora, Case of the Boke Region (Republic of Guinea)

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Abstract

In Guinea, forest resources (native plants) are of great importance to rural populations, who are highly dependent on these native species as they are used in addition to the conservation of agricultural produce for food, pharmacopoeia, fodder, handicrafts, housing and domestic energy. In our previous studies, a total of 14 native plant species were identified, to know Capsicum chinense, Capsicum frustescens, Capsicum annuum, Capsicum baccatum, Capsicum pubescens, Hyptis suaveolens, Hyptis spicigera, Ocimum americanum, Ocimum basilicium, Allium cepal, Zingiber officinal Rosc, Combretummicranthum, Cymbopogon schoenanthus and Azadirachta indica. Over the last two decades, a great deal of work has been carried out to find gentler food protection methods that respect human health and the environment. The most widely used for preserving agricultural produce is Capsicum chinense (98%). Post-harvest losses of these commodities in Guinea, and more particularly in the Boke Region, are still a real problem. The solutions found in this study to combat pests of agricultural stocks were the increasing use of doses (5g; 10g; 15g; 20g) of Capsicum chinense fruit powder against Sitophilus zeamaïs, a pest of maize grain, and Aphis craccivora, a pest of groundnut grain. During evaluation of the insecticidal effects of Capsicum chinense powder, the doses (5g; 10g; 15g and 20g) used per 100 kg of maize and per 100 kg of groundnuts resulted in considerable mortality of Sitophilus zeamaïs and Aphis craccivora.

Keywords

Native Plants, Agricultural Commodities, Pests, Insecticidal Effects and Mortality

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Received: 24 June 2024; **Accepted:** 15 July 2024; **Published:** 6 August 2024

1. Introduction

Man has been dependent on wild flora since the beginning of his existence, two million years ago, through the intensification of agriculture, which has led to biological imbalances and soil sterilization. Wild flora are a fundamental part of biodiversity, forming the basis of the food chain and ensuring the production of biomass by transforming solar energy through the process of photosynthesis. Indigenous species provide several types of ecosystem service, the best known of which is the production of molecules used in the design of medicines, and they are also the initial genetic support for the improvement of cultivated plant varieties for food and industry [1].

Guinea's forest resources are also important in terms of their contribution to socio-economic and cultural development, and their impact on the balance of ecosystems. They play a key role in people's daily lives, thanks to their multiple uses. Native plants are used for food, medicine, fodder, handicrafts, housing, domestic energy and preserving agricultural produce.

In the case of African countries, where over 30% of production is lost between harvesting, storage and consumption, this is due to heavy infestation of stored foodstuffs, which is justified by the inadequacy of techniques for storing agricultural produce over a long period [2, 3]. The conservation of harvested produce using techniques that respect the environment and protect the user remains one of the key factors, given that synthetic phytosanitary products expose handlers to multiple intoxications and environmental pollution. To this end, the use of plants with insecticidal properties for food storage will be a practice that will protect both users and consumers, thereby reducing the risks of contamination for human health and the environment, and making food virtually available for most African countries, such as Guinea. An appropriate phytosanitary policy needs to be put in place to avoid the risk of food shortages during the agricultural off-season, and also to secure seeds for future cropping seasons [4].

Insect pests such as Sitophilus zeamaïs and Aphis craccivora can considerably reduce the quality of stored food products. It should be noted that infestations begin in the field and continue during storage [2]. The damage caused by these agricultural pests results from the fact that the females lay their eggs on the pods and the larvae penetrate the grains, which continue to develop and ripen during storage. At the end of their development, the larvae destroy the inner envelope of the grain to form a pupal lodge. As a result, losses of stored foodstuffs can reach 100% in Africa [3]. The damage and losses caused by these insect pests, both in the field and in storage, can only expose producers to food insecurity and precariousness. It is therefore necessary to increase yields while limiting losses due to the enemies of agricultural products, notably insect pests. It is imperative to envisage a gradual replacement of synthetic pesticides by natural substances (bio-pesticides) that are less polluting, less toxic and less costly for preserving foodstuffs such as corn and groundnuts. And this practice of replacing synthetic products is gradually taking hold in the Boke Region.

The effectiveness of insecticidal plants depends not only on the quantity of grain to be stored, but also and above all on the active ingredient, which varies from one family to another, and on the different parts (organs) of the plant used [5]. For ecological and economic reasons, this calls for the development of methods to replace synthetic pesticides with bio-pesticides in the control and protection of crops in the field and in storage [3, 5, 6]. It is with this in mind that the present study was initiated and carried out to assess the efficacy and persistence of Capsicum chinense fruit powder in the preservation of agricultural products, in particular maize and groundnuts.

Figure 1. *Sitophilus zeamaïs and Aphis craccivora [7].*

Figure 2. Capsicum chinense [8].

Figure 3. Capsicum chinense powder + products (corn or peanuts), (Taken by Bangoura L. A. 2022).

Figure 4. Products (maize and peanuts) treated with Capsicum chinense powder.

2. Materials and Methods

This study was carried out in the Boke Region (Republic of Guinea). The Boke Region is an administrative subdivision of Guinea, with the town of Boke as its capital. Its surface area is 3,118,600 ha = 31,186 km^2. It is located between 11°15' north and 14°15' west. Its population density is estimated at 38 inhabitants/km^2

1,190,724 according to the General Census of Population and Housing (RGPH) conducted in 2017.

The Boke Region comprises 5 Prefectures; 32 Sub-Prefectures; 394 Districts/Quartiers; 2.045 Sectors; 5 Urban Communes and 32 Rural Communes [9].

2.1. Plant Material

Procedure

Capsicum chinense fruits were harvested in the Boke Region (Boke, Boffa and Fria) during the month of September 2022.

They were dried in the shade and in the open air for two (2) months (October-November). The dried fruits were then ground in a wooden mortar. The powder obtained was weighed in order to determine the different doses which will be used in our analyses for the evaluation of insecticidal activity on maize and peanut grains:

D: Dose;

D0: control (without Capsicum chinense powder);

D1: 5g/kg product (maize or peanut);

D2: 10g/kg product (corn or peanut);

D3: 15g/kg product (corn or peanut);

D4: 20g/kg product (corn or peanut).

The trials were carried out over a two-week period in the laboratory of the University Gamal Abdel Nasser of Conakry (UGANC)/ Republic of Guinea. Jars were used to condition maize and peanut kernels.

Weigh 100kg of maize (or peanut) kernels and place in jars previously marked T0 (control); D1, D2, D3, D4 (different doses of powder). The powder is then weighed at masses of 5g, 10g, 15g and 20g respectively, and placed in the various jars. The control jars (T0) were left untreated after weighing. Mix the fruit powder with the corn and peanut kernels and shake to homogenize. Then introduce fifty (50) adult insects into each jar and cover with muslin cloth for good aeration. Finally, seal with elastic fronds to prevent external contamination and continue the operation for one day [10].

2.2. Data Collection

After two (2) weeks, the contents of the jars were observed to determine the toxicity of Capsicum chinense fruit powder according to the doses administered (5g, 10g, 15g and 20g). For each product (corn and peanut), a batch of five (5) jars was made up. Four (4) jars were treated, plus one as a control; this corresponds to 10 samples for a two-week trial. Each jar had received 100kg of corn or peanut grain at the start of the experiment. The jars were sieved to extract adult weevils. At the same time, dead insects were counted and there were no living insects out of the fifty (50) that were introduced into the jars. An insect was considered to be dead if it stopped moving after repeated touching of the legs and antennae with a syringe or needle [10].

The germination rate carried out at the start of the experiment gave an average germination rate of 99.95 %. Insecticidal activity was measured in relation to the control, and the choice of powder-based formulation was guided by the possibility of producing a formulation that was simple to prepare and inexpensive under local conditions of use. The following variables were studied: the percentage mortality rate, the viability test for preserved kernels and, finally, the effect of bio-pesticides on the germination of maize and peanut kernels. The storage period ran from December 15, 2022 to July 15, 2023.

Determination of evaluated parameters [11]

$$H\% = \frac{P_a - P_b}{Pe} x\ 100 \quad (1)$$

H% = Percentage of moisture; Pb = Weight of capsule + sample before drying;

Pa= Weight of capsule + sample after drying; Pe = Weight of test sample.

Toxicity calculation:

Two (2) weeks after introduction of maize grains + Sitophilus zeamaïs and peanut grains + Aphis craccivora into different jars; mortalities in treated boxes (Mbt) were determined according to Abott's formula (1) in corrected mortalities (Mc), taking into account natural mortalities observed in control boxes (Mt).

According to the following formula [11]:

$$\mathrm{Mc} = \frac{\mathrm{Mbt-Mn}}{\mathrm{100-Mn}} \text{x } 100 \quad (2)$$

Where: Mc is corrected mortality; Mbt is mortality in treated boxes and Mn is mortality in control boxes.

Estimating damage:

The two criteria for assessing damage are: Percentage of attack and percentage of weight loss.

We consider a batch of 100 kernels, which we separate into healthy and attacked kernels.

-Attack percentage (A%): This percentage consists of separating a batch of 100 healthy kernels from a batch of 100 attacked kernels. It is expressed by the formula [11]:

$$\mathrm{A}(\%) = \frac{\mathrm{Na}}{\mathrm{Ns+Na}} \text{x } 100 \quad (3)$$

Where Ns is the number of healthy kernels and Na is the number of attacked kernels.

Percentage weight loss P (%): This is calculated using the formula below [11]:

$$P(\%) = \frac{PsNa - PaNs}{Ps(Na+Ns)} \times 100 \quad (4)$$

Where Ps represents the weight of healthy kernels; Pa represents the weight of attacked kernels. We can also apply the method of determining the weight of treated grains after the last emergence of C. maculatus individuals and that of control batches using a precision balance. This method is applied using the following formula [11]:

$$\mathrm{P\%} = \frac{\text{Poids initial}}{\text{Poids initial - Poids}} \text{X } 100 \quad (5)$$

3. Results and Discussion

Table 1 below presents the data relating to the evaluation of the toxicity of Capsicum chinense powder on maize and peanut pests in stock.

During the evaluation of the insecticidal effect of Capsicum chinense powder, all doses (5g; 10g; 15g and 20g) used per 100 kg of maize resulted in Sitophilus zeamaïs mortality with respective rates of 75 %; 80%; 90% and 100%. The same doses were used for 100kg of groundnuts and also resulted in mortality of Aphis craccivora at rates of 80%, 85%, 90% and 100% respectively. At the end of our two (2) week experiments, 100% mortality was recorded for the dose of 20g/kg of product (maize or peanut). This shows that increasing the dose considerably reduced the lifespan of Sitophilus zeam ἓ and Aphis craccivora. These results corroborate those found. In general, depending on the dose and the number of dead insects, Capsicum chinense appears to be more toxic to Sitophilus zeam ἓ and Aphis craccivora, making it an excellent bio-pesticide for the conservation of stored maize and peanut grain.

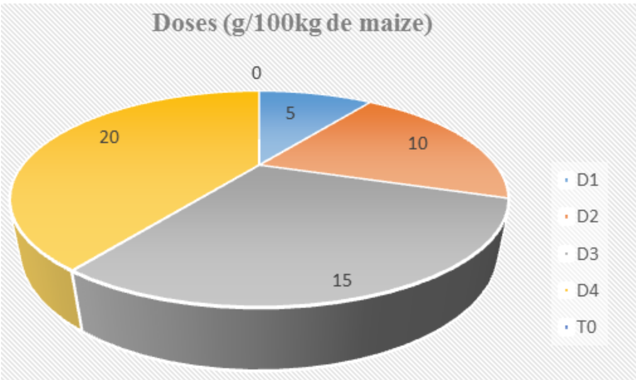

Figure 5. *Effect of Capsicum chinense powder on Sitophilus zeama ἓ.*

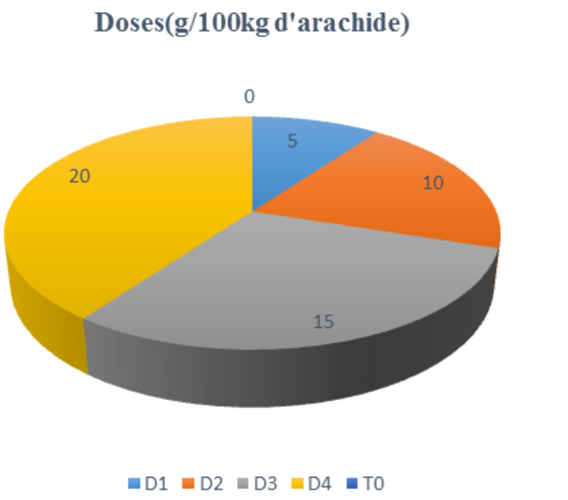

Figure 6. *Effect of Capsicum chinense powder on Aphis craccivora.*

Table 1. *Effect of Capsicum chinense powder on pests.*

Treatment	Doses (g/100kg maize)	Average mortality rate (%)
D_1	5	75
D_2	10	80
D_3	15	90
D_4	20	100

Treatment	Doses (g/100kg peanuts)	Average mortality rate (%)
D_1	5	80
D_2	10	85
D_3	15	90
D_4	20	100
Indicator	0	0

Table 1. shows the different germination rates of the products (corn or peanut).

The germination test carried out at the start of the trial gave an average germination rate of 98%. When corn and peanut kernels were in direct contact (treated) with Capsicum chinense powder, the average germination rate varied according to the doses administered. In jars treated with Capsicum chinense powder at doses of 5g, 10g, 15g and 20g per 100kg of peanuts respectively, the average germination rates of maize grains were 80%, 85%, 90% and 98% respectively. On the other hand, in the case of groundnuts, these average rates vary between 79.50%; 85%; 92% and 98%. The highest germination rate was recorded at 20g/kg of product (maize or groundnut), which could be explained by the fact that insect emergence was low, and most of the kernels had their seeds in the soil.

albumens intact, inducing a 98% germination rate of agricultural produce grains after preservation with capsicum chinense powder. These results are in line with those found by [2, 3, 10]. The remanence of agricultural products was set at 8 months for a Capsicum chinense-based formulation, and the efficacy of this bio-pesticide recorded a rate of 98% at the eighth month for the 20g/kg dose. This could be explained by the fact that Capsicum chinense has inhibitory effects on the growth and development of insect pests of stored maize and peanut grains.

Table 2. *Impact of Capsicum chinense powder on germination.*

Treatment	Doses (g/100kg maize)	Germination percentage (%)
D_1	5	80
D_2	10	85
D_3	15	90
D_4	20	98

Treatment	Doses (g/100kg maize)	Germination percentage (%)
Indicator	0	5

Treatment	Doses (g/100kg peanuts)	Germination percentage (%)
D_1	5	79,50
D_2	10	85
D_3	15	92
D_4	20	98
Indicator	0	5

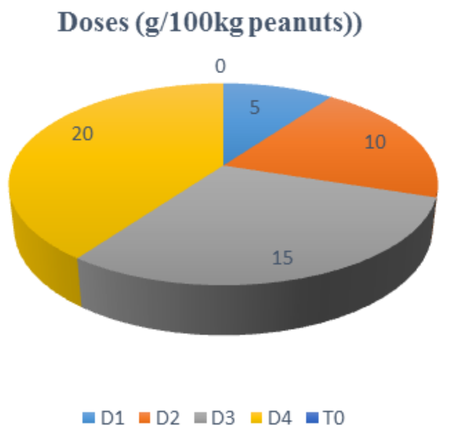

Figure 7. *Impact of Capsicum chinense powder on maize seed germination.*

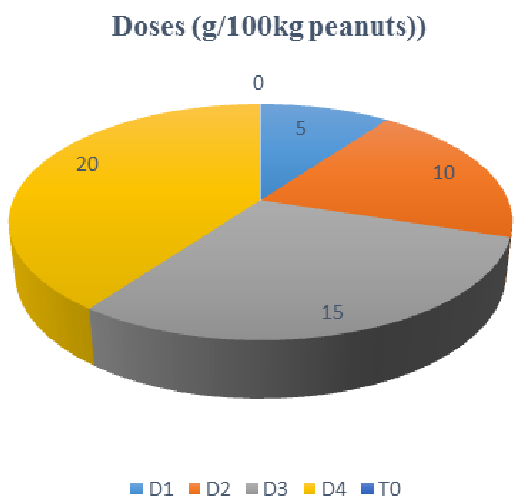

Figure 8. *Impact of Capsicum chinense powder on peanut seed germination.*

4. Conclusion

At the end of our experiments, we found that the dose (20g/kg) proved to be more effective than the other doses (D1, D2 and D3) for preserving maize and groundnut kernels. In fact, this dose had an undeniable effect on the lifespan of notorious pests by affecting various parameters: grain viability (high germinative power), its remanence was stopped at 8 months and its efficacy recorded a rate of 98% at the eighth month.

The results show that the natural substances used had an insecticidal effect on corn and peanut bruchids. The mortality and germination rates of these bruchids changed progressively as a function of the dose used. It would therefore be interesting to continue research into the synergistic action of Capsicum chinense powder against corn and peanut bruchids, as well as other insect pests of stored grain.

Acknowledgments

We would like to express our sincere thanks to all the people living in the study area, and particularly to the local customary authorities, for their cooperation. Our thanks also go to the Ministry of Higher Education, Scientific Research and Innovation of the Republic of Guinea for its financial assistance during this study. We would also like to thank the authorities of the Gamal Abdel Nasser University of Conakry and its Doctoral School, as well as the consultants.

Author Contributions

Lansana Abou Bangoura: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing

Aboubacar Diallo: Data curation, Formal Analysis, Methodology, Project administration, Resources, Supervision, Validation, Visualization

Mamadou Laho Bah: Data curation, Investigation, Methodology, Resources, Validation, Visualization

Adama Moussa Sakho: Formal Analysis, Methodology, Supervision, Validation, Visualization

Amadou Youssouf Bah: Formal Analysis, Supervision, Validation, Visualization

Abdoulaye Keita: Formal Analysis, Methodology, Resources, Supervision, Visualization

Conflicts of Interest

The authors declare no conflicts of interest.

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