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Sensibility of *Caryedon serratus* Ol. (Coleoptera, Bruchidae) to three synthetic insecticides

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Abstract

The management of cereal and legumes stocks is a real food security problem in Africa. In Senegal, groundnut is one of the main cash crops and is constantly threatened by *Caryedon serratus*, its most dangerous pest. Chemical control, which has remained by far the most effective to fight against this trouble faces problems of the resistance of these stored-product pests due to the constant increase in the doses of insecticides used. The aim of this study is to assess the sensibility of this pest to three synthetic insecticides. The insects used come from two localities of Senegal (Saint Louis and Sedhiou) and products belong to Pyrethroids, Carbamates and Organophosphorus families. Results showed that the sensibility of *C. serratus* to the different products depends on the exposure time of the beetle to the products and not on its origin. The highest mortalities are obtained within 48 and 24 hours after treatment. The results also show some resistance to Deltamethrin and Traore Powder with which less than 50% of mortality is recorded with the reference doses.

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Introduction

Groundnut (*Arachis hypogaea* L. Fabaceae), legume native from Latin America (Kouadio, 2007) is the sixth most important cultivated oleaginous crop. It contains 48-50% fat, 26-28% protein and is rich in fiber, minerals and vitamins (FAO, 2003). In Senegal, where it occupied more than half of the arable land (Sembene, 2000), its production experienced significant declines related to the various agricultural policies, market fluctuations, soil degradation, declining rainfall and climate change (Amouzou and Ndiaye, 2012, Noba *et al.*, 2014). In addition, peanut products account for only 4% of exports (Ndéné, 2011), but it remains the leading agricultural production and continues to play a key role in the rural economy.

To these factors are added the problems of stock management. The post-harvest losses caused by insect pests of stored foodstuffs amounted to 10% in average on a global scale for an annual monetary value estimated about 58 billion USD (Goergen in Fandohan *et al.*, 2005). Moreover peanut undergoes several attacks which the most important are caused by a beetle of the family of Bruchidae, Caryedon serratus commonly called groundnut seed beetle, which by its polyvotin character generates losses of up to 83% in only four months of storage (Ndiaye, 1991).

Chemical control, which has remained by far the most effective, is nowadays confronted with the development of the resistance of the principal pests linked to the use of increasing quantities of insecticides. This resistance can have three origins: physiological, behavioral or biochemical. The aim of this study is to assess the resistance of groundnut seed beetle to three insecticides of the Carbamate, Pyrethroid and Organophosphorus family.

Material and methods

Study areas

Insects used for this study are pulled from peanut seeds purchased from storage facilities in Saint Louis (16 ° 04'00 " N latitude and 16 ° 30'00 " W longitude) and Diana Malary located in Sedhiou region (12°50'54 " N latitude and 15 ° 14'59 " W longitude).

These localities belong respectively from the agro ecological zone of the Senegal River Valley situated in the north and characterized by low and irregular rain and from the lower Casamance agro-ecological area in the South characterized by a high potential in natural resources with an important water resources.

Mass breeding

In order to obtain a fairly large number of insects for the tests, a mass breeding was carried out with the adults coming from the peanut samples reported from the different study areas. A large number of adults (male and female) are introduced in Petri dishes glass containing seeds of groundnut previously frozen (in order to eliminate any trace of primary infestation) and brought back to ambient temperature. The insects of each locality were removed 48 hours later and placed in new boxes containing healthy seeds. The previous boxes are left on the bench at room temperature (28 to 31.5°C) with a relative humidity of 40 -68% until the appearance of cocoons, which will be isolated in boxes with, wells by reason of one per hole until emergence of adults. The name of localities is mentioned above each box. The breeding boxes are left at laboratory temperature.

Evaluation of the sensibility of Caryedon serratus

Toxicity tests are carried out by contact in Petri dishes (95mm Ø) in ambient temperature conditions. They are made with five (5) couples of individuals of *C. serratus* (generation F1) in the presence of 30g of groundnuts. These couples are exposed to different doses and each test is repeated three times. The control tests are made for each locality.

- For PROPOXUR (Carbamate), formulation in powder, eight (8) doses are applied: D1= 0.01 g; D2= 0.02 g; D3= 0.1g; D4= 0.2 g; D5= 0.4 g; D6= 0.6 g; D7= 0.8g and D8 = 1g.
- For TRAORE POWDER (mix between Organophosphorus and Pyrethroid) four (4) doses are applied: D1=10mg; D2=15mg; D3= 20mg and D4=25mg.

Each dose is powdered in boxes in presence of 30g of groundnuts and all is homogenized well before the introduction of couples.

- For DELTAMET 25 EC (Pyrethroid), liquid formulation containing 25g/L of active ingredient, six concentrations are applied. The recommended dosage is 40ml for 30L of water, dosage brought back to 1L of water allowed to determine the concentration Cx from which four (4) other concentrations are drawn: $C1=Cx/4=$ 0.325ml/L ; $C2=Cx/2=$ 0.65ml/L ; $C3=Cx=$ 1.3ml/L ; $C4=Cx\times2=$ 2.6ml/L et $C5=Cx\times4=$ 5.2ml/L.

For each concentration, 1ml is collected using a PIPETMAN and is introduced into the boxes before the insertion of couples.

Mortality rate

The number of dead insects is raised every 24 hours. An individual is considered as died when he does not react to a pressure exercised on him with the finger. In the opposite case it is in a state of knock down (kd). If there are survivors, they are left in boxes and are removed one week later. The mortality rate is calculated and corrected by the formula of Abbot, 1925:

$$\%\ \text{corrected} = \left(1 - \frac{\text{n in T after treatment}}{\text{n in Co after treatment}}\right) \times 100$$

Where: n= insect population T=Test Co=Control

Statistical analysis

The collected data were recorded on Excel and submitted to an analysis of variance (ANOVA) using XLSTAT software version 6.1.9. The multiple comparisons of means were done according to the test of Tukey-Kramer at the significant threshold of 5%.

Results

Evaluation of the sensibility of C. serratus to the different insecticides

Various signs are noted after introduction of *C. serratus* adults into petri dishes containing the insecticides. We note among others: an agitation of the individuals, a loss of the mobility, a Knock Down effect (KD): the individuals are lying on the back and sometimes move their antennas or their legs.

Sensibility to Propoxur

The results (Fig. 1) based on the estimated mortality averages show higher rates in Saint Louis locality. The latter are higher in the 24 hours following the treatment, the lowest rates being obtained with the two smaller doses (D1 = 0.01g and D2 = 0.2g). However the analysis made with the test of Tukey shows no significant difference for the localities and doses effects.

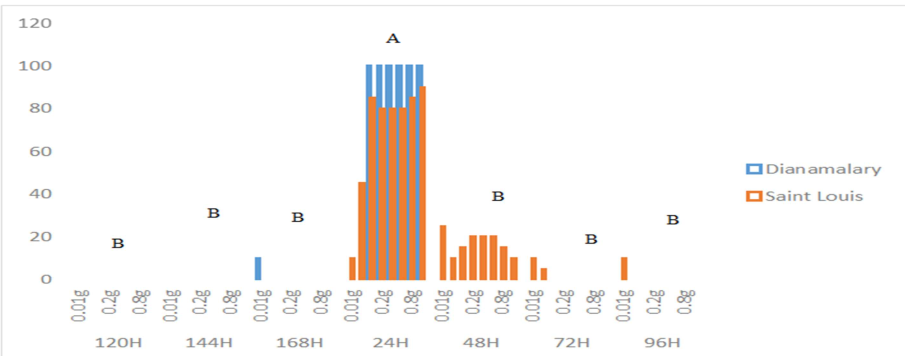

Fig. 1. Evolution of the mortality rate of *C. serratus* according to the doses of Propoxur applied.

Sensibility to Deltamethrin

Based on Tukey's comparison tests at the 5% threshold, only duration and dose provide significant information to explain mortality. However, the exposure time to the product is the most influential. Highest mortalities (Fig. 2) are obtained after 48 and 24 hours and with the highest concentrations 5.2 ml/L and 2.6 ml/L, note that the latter do not exceed 50%.

Sensibility to Traore Powder

The results (Fig. 3) based on the Tukey test show no significant difference in mortality relative to different localities, the latter would be explained by the effects of dose and exposure time to product; that of the exposure time being the most influential. The highest rates are obtained after 48, 24, 72 and 96 hours (decreasing order). For the dose, the only difference existing is between the different doses and the controls.

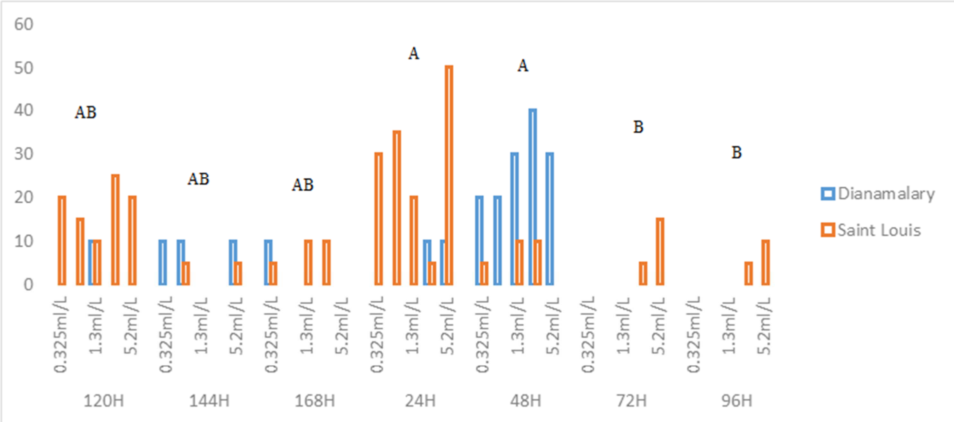

Fig. 2. Evolution of the mortality rate of *C. serratus* according to the doses of Deltamethrin applied.

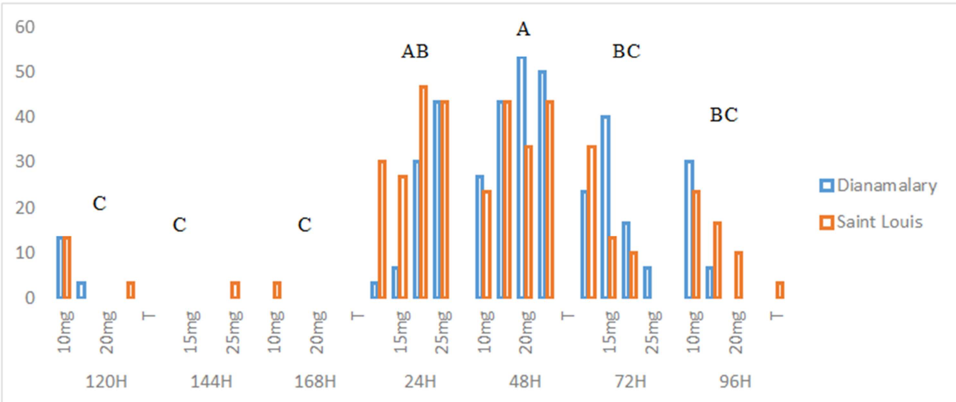

Fig. 3. Evolution of the mortality rate of *C. serratus* according to the doses of Traore Powder applied.

Discussion

The various tests comparing the sensibility of *C. serratus* to the three insecticides used show no significant difference between the two localities; this may suggest that these products are used in the same way. This sensibility depends highly on the exposure time of insects to insecticides used, highest mortality rates occurring within 48 and 24 hours after treatment.

Among the three products used Propoxur appears to provide better protection against *C. serratus* with mortalities up to 100% 24 hours after treatment. Mortalities caused by Deltamethrin and Traore Powder are relatively low and barely exceed 50% even with doses higher than those recommended for treatment (1.3 ml/L for Deltamethrin and 15 mg for Traore Powder).

In contrast, Kotabaji, 2012 and Bhogeesh *et al.*, 2014 achieved better results with Deltamethrin still on the same insect. Seck *et al.*, 1991 and Affo Dogo, 2013 also observed an efficacy of Deltamethrin on *Callosobruchus maculatus*. However, this last author underlines a resistance to Deltamethrin towards the recommended dose. The low mortality rates obtained with these two products could expose stocks to the appearance of new generations of *C. serratus* especially as Aïzan *et al.* showed in 2016 that certain concentrations of Deltamethrin did not have much influence on the laying of individuals rescued from the treatment.

This situation could be due to the action of various parameters but especially to the resistance of insects to these products.

Indeed a population of pests constantly exposed to insecticidal products (especially if they are used inappropriately) can develop mechanisms of adaptation that result in behavioral, physiological, or biochemical changes (Haubruge and Amichot, 1998). Evidence of bad use of insecticides were recently demonstrated by Aïzan and Sembene in 2017 in localities studied in this study, producers referring to their own appreciation to measure their products. In addition, the problem of insecticide resistance has become a major concern today.

This phenomenon has not only for consequence the enormous losses of harvests but also the increase of the use of these chemicals which leads to big risks of poisoning, environmental pollution but also to an increased risk of development of epidemics related to the parasitic pressure of strains that have become resistant. Indeed, several authors blame the use of massive amounts of Carbamates and Organophosphorus in agricultural areas in the development of resistance in Anopheles populations in West Africa (Diabaté *et al.*, 2002; Akogbeto *et al.*, 2005; Akogbeto *et al.*, 2006; Yadouleton *et al.*, 2009; Aïkpon *et al.*, 2014). In addition, when a population of insect vector or crops pests become resistant it causes control failures. Its management therefore requires the implementation of several measures to face the appearance of this resistance.

Conclusion

This study has allowed us to note that the sensibility of *Caryedon serratus* to the three insecticides used does not depend on the origin of insects but is strongly related to the exposure time of the beetle to the products. Among the three insecticides applied, Propoxur seems the most appropriate to fight against this pest which shows signs of resistance to Deltamethrin and Traore Powder. It would be advisable to limit the risk of resistance development in these pests to associate chemical control with alternative control methods such as the use of native plants with certain insecticidal properties or to other less expensive and quite so effective technics which will be able to limit the damage and preserve a less polluted environment. We will try in our later work to deepen the researches by trying to characterize the genes implied in this resistance.

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