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Biocidal activity of *Crataeva religiosa* based substances against the major lepidoptera cabbage pests

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Abstract
Plutella xylostella (L.), *Hellula undalis* (F.) et *Spodoptera littoralis* (B.) are the main pests of cabbage (*Brassica oleracea* L. var capitata). Chemical control was mainly used, but it did not allow effective control of these pests. Biological control alternatives relied primarily on the use of parasitoids, predators and pathogens. The aim of this study was to test the biocidal effect of aqueous extracts of *Crateava religiosa* on these pests. The study was conducted on 14 cabbage lots in Niayes area, located between october 2017 and march 2018. Three formulations were used : the fresh leaves based formulation of *C. religiosa* with a single concentration 200g/l marked F, the dry leaves based formulation of *C. religiosa* with three concentrations 200g/l (C1), 150g/l (C2) and 100g/l (C3) and the soapy formulation with two solutions namely soap control marked S and soap with *Crateava religiosa* marked Sc. Our results showed that the fresh leaves based formulation (F) is the most effective among the three formulations tested. In addition the combined effects of *Crateava* and soap were also effective. However, the dry leaves-based formulation recorded the highest yield although it has the larvae little effect on. The efficiency of treatments was greater on *P. xylostella* and *S. littoralis* and *H. undalis*.

Keywords: Pests, cabbage, biocidal substances, efficiency

1. Introduction

In Senegal, market gardening occupies a very important place and takes place according to two periods, the against cold season from october to March and the hot counter season from april to June [1]. Cabbage (*Brassica oleracea* L.) is one of the most cultivated vegetable, however its production is threatened by several predators such as arthropods and especially insects that often pose real problems to farmers by the damages that they caused [2.3]. The most damaging pests of the crucifer *Brassica oleracea* (L.) are the Lepidopteran species : *Plutella xylostella* (L.), Pieris rapae (L.) and *Hellula undalis* (F.) [4]. However, *P. xylostella*, commonly known as the diamondback moth, is cosmopolitan, and it is considered the most important worldwide, causing production losses of up to 60% [5.4]. The use of pesticides is the most commonly used control method against these pests, often with adverse environmental consequences and the development of resistant strains in pests [6]. This practice has led to the development of multiple resistance by *P. xylostella* to virtually every insecticide in use worldwide [7]. (IPM) programmes are considered as options to reduce insecticide use in the control of the pests (Pratissoli *et al*. [6]. However, there have been attempts at combining various strategies centred on biopesticides and plant products to control the pests in Senegal. There has been no development and implementation of biological control nevertheless Diouf *et al.* [8] confirmed the insecticidal effect of *Crataeva religiosa* against insects such as *Sitophilus zeamais* and *Callosobruchus maculatus.* Its insecticide effect has also been demonstrated by Mbaye *et al.* [9] on *Dermestes ssp* and Faye *et al.* [10] on *Callosobruchus maculatus.* Indeed, biocidal plants constitute a group of insecticides who is easily biodegradable and their use in crop protection is a sustainable alternative to synthesis products [11, 12, 13, 14, 15,16]. It is in this context that between our study which aims to test the efficacy of extracts of *C. religiosa* on the main pests of cabbage in cultivation in order to make available to the maraichers an accessible and reliable method of control.

2. Materials and Methods

2.1 Experimental layout

Different concentrations of fresh leaves: 100g/l, 150g/l and 200g/l were used and respectively, marked C3, C2, and C1. Furthermore another formulation composed 100g of *C. religiosa's* dry leaf extracts mixed with 25g of soap, added by a litre of water will the SC concentration. To obtained the soap control solution (S), 25g of soap is added to a liter of water. The maceration is keeped for six hours and the liquid has been recovered by sieving. For the crushed products from fresh leaves (concentration F), an amount of 200g has been weighted and the extraction was made by infusion during é' hours.

2.2 Treatments
The treatments were performed on wednesday using a sprayer. Treatment was conducted on fourteen elementary planes. Lots 1 and 2 were treated with C1 solution, lots 3 and 4 were treated with C2 solution, lots 5 and 6 were treated with C3 solution, lots 7 and 8 were not hauded : they represented the control parcels (marked T). Lots 9 and 10 were treated with solution F, lots 11 and 12 were treated with solution S and lots 13 and 14 were treated with the SC solution.

2.3 Actual sampling
Recordings are performed twice a week i.e. on wednesday before the processing and on saturday after treatments. These latest are made during the period from 13 december 2017 to 03 february 2018. The recorded parameters are the number of corroded leaves, the number of larvae and their location on each foot but also the weight of the harvested apples in order to determine the abundance, incidence, frequency of occurrence and damages Incidence = Pi/Pt with Pi (number of infested plant feet by a given species) and Pt (total number of plant feet). The occurrence frequency = Se/St with Se (number of outputs by species) and St (total number of outputs).

2.4 Statistical analysis
The raw data are recorded in microsoft the Excel spreadsheet as a database for the analyses. The statistical tests are performed the R program 5.0.0. Quantitative data was submitted to the Shapiro-Wilk normality test using at the threshold of 5%. The results of this test allowed to perform non parametric test of Wilcoxon and Kruskal-Wallis rank sum test. The first one allowed to determine the significant differences between the calculated means of two samples. The second was used to test the significant differences between the calculate means of many samples. These tests were carried out on the numbers of pests and the number of corroded leaves. Then completed were the analyses with a Spearman correlation test to see the links between the number of pest larvae and the number of corroded leaves. Diagrams are made using the Excel pivot table.

3 Results
3.1 Effects of treatments on pests larvae
3.1.1 Effects of treatments on the number *Plutella xylostella's* larvae
The analysis of variance generally showed a highly significant effect ($P < 0.01$) of the treatment on the number of larvae of *P. xylostella*. Lots treated with the aqueous extract of dry leaves of *C. religiosa* between the concentrations C1 (200g/l), C2 (150g/l) and C3 (100g/l) showed no significant differences. In contrast a highly significant difference ($P = 0.001$) is observed between F and T and another very significant between F and C1 ($P = 0.03$) but not significant between C1 and T ($P = 1$). Soapy formulations i.e. soap (S) and soap plus *C. religiosa* (SC) showed a significant difference ($P = 0.04$) from their mean but multiple comparison statistical analysis has giving a large difference ($P = 0.002$) between SC and the control T. For solution of 100g/l of *C. religiosa* (C3 and SC) the difference in the number of larvae was not significant ($P = 1$).

3.1.2 Effects of treatments on the number of *Hellula undalis's* larvae
With this species, no significant differences were noted between these different treatments ($P = 0{,}5374$). Comparison two to two showed no significant difference between these three treatments.

3.1.3 Effects of treatment on the numbers of *Spodoptera littoralis*'s larvae
The effects of solutions C1 (200g/l), C2 (150g/l) and C3 (100g/l) of aqueous extract of dry leaves of *C. religiosa* did not present any significant differences. Solutions from *C. religiosa* 200g/l: no significance is noted between dry leaves formulation (C1) and fresh leaves formulation ($P = 1$). A highly significant difference between the soapy formulations, SOAP plus Crateava (SC) and the soap (S) indicator ($P = 3.10^{-4}$) was noted. The paiwise comparison tests showed significant differences between C1 and SC ($P = 0.004$), C2 and Sc ($P = 0.04$) and S and Sc ($P = 0{,}0003$). The mean number of the larvae according to the different concentrations are shown in Figure 1.

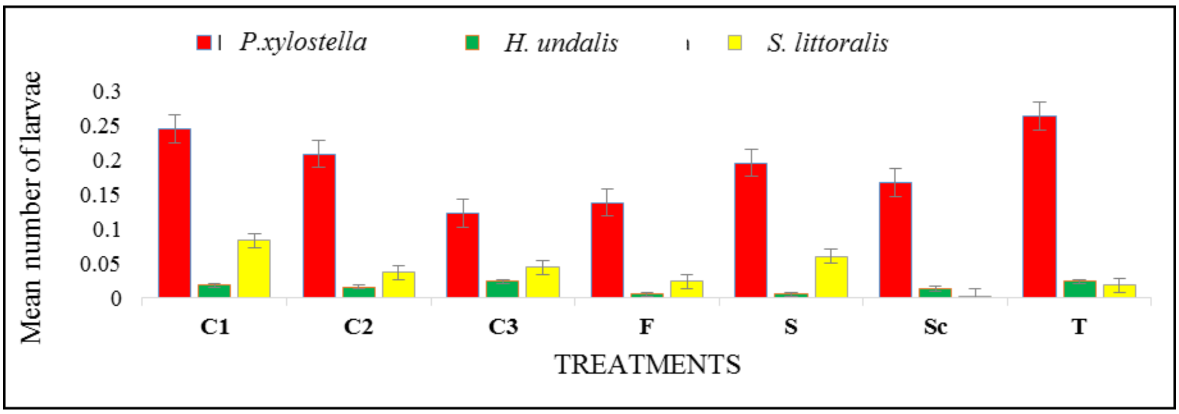

Fig 1: Mean number of larvae based on applied treatments

3.2 Effects of treatments on the number of corroded leaves
The non-parametric test of Kruskal-Wallis revealed a highly significant effect ($P = 6.10^{-7}$). According to pairwise comparison tests, the significant differences are noted

between: C1 and T (P=23. 10^{-5}), C3 and T (P=23. 10^{-5}), F and T (P=15. 10^{-6}) and Sc and F (P=0,04). Between the concentrations of 200g/l of fresh leaves (F) and dry leaves (C1), there was no significant differences, whereas between F and T, the difference are highly significant (P=15. 10^{-6}) and between C1 and T (P=23. 10^{-5}). The mean number of corroded leaves according to different concentrations are shown in Figure 2.

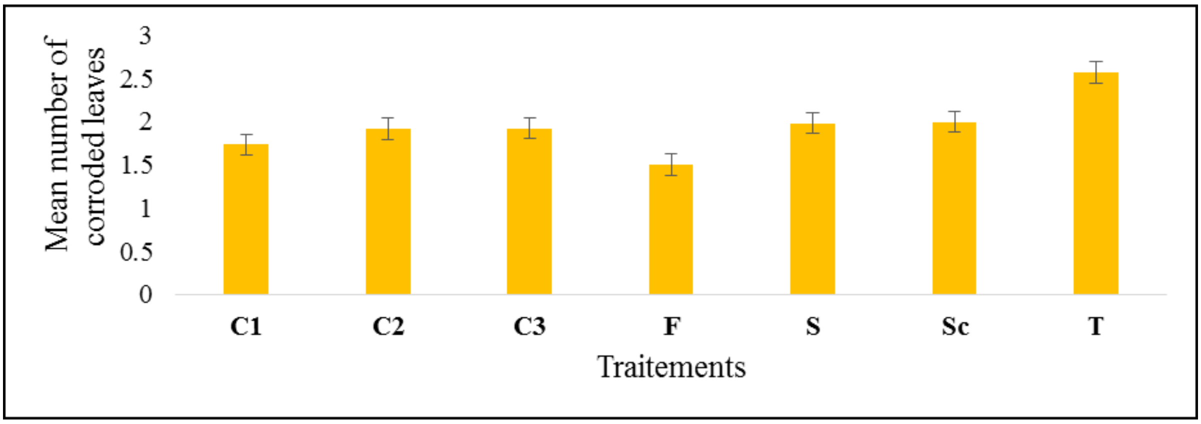

Fig 2: Mean number of corroded leaves based on applied treatments

3.3 Correlation between the number of larvae and the number of corroded leaves

The correlation tests between the number of larvae of these three insect pests and the number of corroded leaves showed a positive and highly significant correlation ($P < 0.001$ and $r = 0.26$) between the number of *Plutella xylostella* larvae and the number of the corroded leaves. In contrast, quasi unlikely correlation between the number of *Spodoptera littoralis* larvae and the number of corroded leaves ($P < 0.001$ and $r = 0.11$) was observed as well as the number of Hellula undalis larvae and the number of corroded leaves ($P = 0.01$ and $r = 0.04$).

3.4 Effects of treatments on the weight of cabbage apples

On 168 plant, only 127 or 75.6% are harvested for a total weight of 120.9 kg. The remainder that represented 24.4% of the repiked feet has been destroyed. Among these 41 unharvested feet, 11 feet were destroyed by *H. undalis* or 26.8%, 7 feet by *S. littoralis* or 17.1%, 14 feet by rodents or 34.1% and 7 feet by other pests or 17.1% (aphids (6) and *Helicoverpa armigera* (1). In addition, one plant foot without cabbage apple and another wilting one were recored. The graphical analysis of the accumulated weight of cabbage apples harvested according to the applied treatments showed that the highest total weights are obtained with the solutions at the higher concentration (200g/l). These solutions (C1) and (F) recorded 23, 4 and 19,9 kg, respectively. The solutions C1 (200g/l), C2 (150g/l) and C3 (100g/l) of aqueous extract of dry leaves from *C. religiosa* recorded 23.4, 17, 15kg and 13.75 kg, respectively. The T control (untreated) recorded the lowest weight (Figure 3).

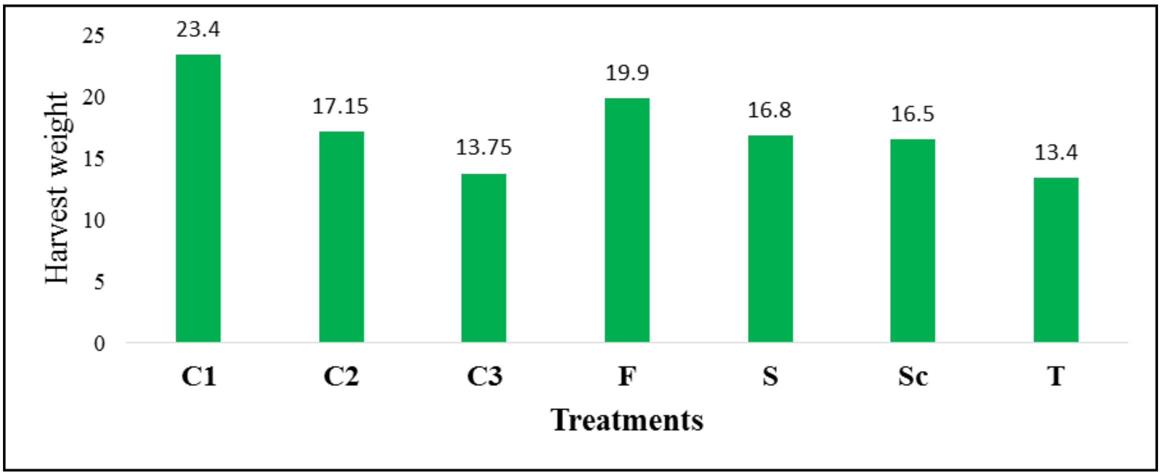

Fig 3: Harvest weight based on applied treatments

4 Discussion

The evaluation of the biocidal actvity of aqueous extract of *C. religiosa* on the main cabbage pests namely *Plutella xylostella*, *Hellula undalis* and *Spodoptera littoralis* in the Niayes area was the purpose of this study. The results revealed that the three formulations of dry leaves C1, C2 and C3 have no effect on the three pests. However there was a significant difference between the two soapy treatments, on the larvae of *P. xylostella* and *S. littoralis*, but not *H. undalis*. These results confirmed those of Faye *et al.* [17], according to them, black soap is a physical control method againts *Tuta absoluta*, tomato Leaf miner. Similarly Tabone *et al.* [18] showed the insecticidal effect of soap on the control of the aphid *Myzus persicae*. This efficacity could be due to the combined effect of soap and Crateava because no significant differences were observed between C3, S, and T treatments.

Generally the treatment with the fresh leaf formulation has an effect on the larvae of *P. xylostella*. This could mean that the fresh leaf formulation was the most effective compared to the two other. Yarou *et al.* [16] showed the efficiency of aqueous extract of fresh leaves of Crateava on the Bruche of Cowpea *Callosobrochus maculatus*. However, there was only a significant difference between one of the T and F treatments on the one hand, and C1 and F on the other hand.

The number of corroded leaves is positively correlated with the number of larvaes. The attacks corresponded more to those of *P. xylostella* larvae but a non negligible action of *S. littoralis* was noted in contrast with *H. undalis.* Indeed, the two first have similar damages contrary to those of *H. undalis*. According to Douan *et al.* [19], *P. xylostella* causes the same damage as *S. littoralis* with, impressiveness defoliation of the attacked plants. There is also a presence of *S. littoralis* droppings on the leaves of plants newly attacked by this pest. Djomaha et Ghogomu [21] assert that the percentage of total damage caused by *P. xylostella* from the leaf area varies from 0 to 50%. Control lots (T) had low weight compared to the six treatments and there was a dose effect for dry leaf formulation. This could be explained by the effect of treatments on the weight of the crop. These results are not in line with those of Douan *et al* [19] who showed that the higher doses gave more mortality. A positive correlation is noted between the number of leaves corroded and the weight of the crop for the treated lots. The control lots produced the lowest yield. These results also corroborate those of [21]. To sum up the phytosanitary treatments have a positive effect on the crop yield. The results obtained show that among our most interesting formulations in the management of larval populations of cabbage pests is that with fresh crushed leaves. This wording may be recommended in IPM programs.

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