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Study of the efficacy of two biocidal substances, made from *Calotropis procera* and *Crataeva religiosa*, on major cabbage destroyers

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Abstract
The aim of this study had been to appraise efficacy of biocidal substances, made from aqueous essences of *Calotopis procera* and *Crataeva religiosa*, on main pests to cabbage. Tests concerned essences of *Calotopis procera* or *Crataeva religiosa* used alone, and a mixture of both substances. Results point out that essence from *Calotopis* has shown a significant effect on *Plutella xylostella* and *Hellula undalis* grubs, with P-values of 0.0289 and 0.0253, respectively, both inferior to 0.05, threshold of significance. Essence from *C. religiosa* has been effective on *Spodoptera littoralis*, but has got a limited impact on *Plutella* and *Hellula* with respective P-values of 0.36 and 0.54. The mixed product, for its part, has not given any significant effect on these pests. Besides their biocidal effect, essences from *Calotropis* have had an impact on both crops maturation and weight. The other biocidal matters have influence on plants weight too, but in a moderate way, compared to *Crataeva*.

Keywords: cabbage, bio-aggressors, biocidal, fight

Introduction

In West Africa, market gardening plays an important role in human food, and significantly contributes to families' income (Yarou *et al.*, 2017) [1]. It is fundamentally centred on vegetables producing (Mondedji *et al.*, 2014) [2]. Among these vegetables, round cabbage (*Brassica oleracea*) is of the utmost importance. In Senegal, round cabbage forms part of the most cultivated and consumed vegetables, owing to its relatively short vital cycle (60 to 90 days after planting out), and the possibility of cultivating it all year (Labou, 2016) [3]. This production enable market gardener not only to meet national need, but to export across the sub-region. It is almost daily eaten in households in that it goes into most of the meals (Sakho, 2013) [4].

For this purpose, Niayes area, favourite zone in market gardening, has asserted itself as the pace-setter of the upturn of the horticultural development, because it constitutes an agro-ecological zone par excellence (Sakho, 2013) [4]. However, market garden produce, more particularly cabbage, are strongly threatened by bio-aggressors. *Plutella xylostella* Linnaeus, 1758 (Lepidoptera, Plutellidae), *Hellula undalis* Fabricius, 1794 (Lepidoptera, pyralidae), and *Spodoptera littoralis* Boisduval, 1833 are seen as major devastators (Diome *et al.*, 2019) [5]. The heavy parasitic pressure put on cultivations, by these bio-aggressors, impels market gardeners to the search of solutions consisting in an irrational use of synthetic pesticides. This practice paved the way for serious environmental and public health problems (Cissokho *et al.*, 2015) [6].

The results appear as resistance of insects to a number of pesticides, food poisoning problems, and environmental pollution (Cissokho *et al.*, 2015) [6].

This worrying situation, resulting from bad practices, has given rise to a wake-up call for resorting to better farming practices with nil or negligible side effects. For instance, the first orientations have targeted pesticide plants. This practice seems to be ancestral in Africa. Actually, numerous plants were known and used for biocidal effects (toxic, repellent, anti-appetizing) vis-à-vis a large range of bio-aggressors (Yarou *et al.*, 2017) [1]. Likewise, bio-pesticides represent a strong support for limiting damages, too. In Senegal, some of authors have already pointed out the extent of biocides in the protection of cultivations and stocked food products, as well (Thiaw and Sembène, 2007; Diome *et al.*, 2019; Ngom *et al.*, 2020)

[7, 5, 8]. Thus, our study is in keeping up with the dynamics of searching other options to face the manifold damages stemming from excessive use of synthetic pesticides. So, in this study, we propose a contribution to the understanding of the efficacy on cabbage main pests, of biocidal products, derived from two plants: *Calotropis procera* and *Crataeva religiosa*.

Materials and Methods

Study site

This study has been carried out in the commune of Malika, suburban zone of Dakar (Fig. 1). This area is conspicuous by its peculiar landscape characterized by dunes and depressions, settled on a superficial water table; with a hydrographic net formerly rich in lakes and ponds. In that, Malika is a continuation of Niayes zone, an agro-ecological zone of prime importance in Senegalese economy.

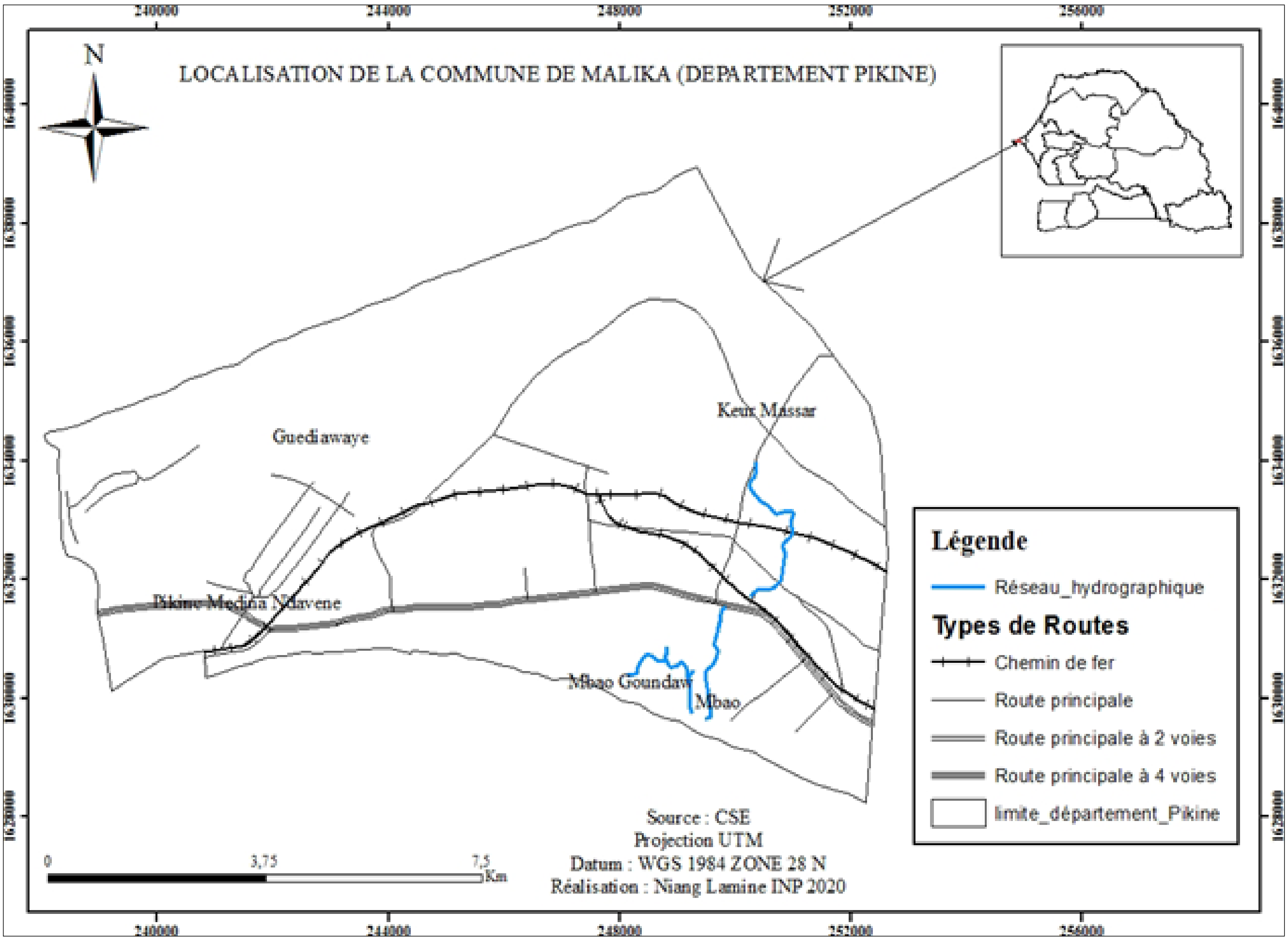

Fig 1: Malika commune localisation

Experimental system

The system, established over a surface of 55 m2, is composed of three blocks: BI, BII, and BIII. Each block is formed from four elementary parcels named T0, T1, T2, and T3. Blocks are distant from each other by 1 m; and this is the same between elementary parcels within each block. Each elementary parcel extend over 2 m long and 1 m wide. One parcel compound 3 lines of 7 stalks per line, which consists of 21 stalks per parcel. Lines are separated by a distance of 40 cm; and in each line, stalks are distant from one another by 30 cm. A margin 10 cm is left between the extreme stalks and the ramps of the parcel. For each block, T0 corresponds to the control parcel; T1, the parcel treated with essences from *C. procera*; T2, the parcel treated with essences from *C. religiosa*; and T3, the parcel treated with the mixture of the former essences. To identify pests, we sampled stalks within every parcel. For instance, at random, 10 stalks have been meticulously examined. Species that were encountered have been identified, then enumerated, in order to follow their development.

Cultural technics

The first activity we dealt with was the nursery preparation started on November, 16th, 2019. For that, compost was used as substrate and alveoli as stands. At our disposal, we had one sack of compost and four alveolar tablets, each one containing 72 alveoli, that is to say 288 stalks of cabbage strewn, whereas we only needed 252 stalks; extra stalks were necessary in prevision of potential losses. On December, 11th, 2019, 252 cabbage patches, scattered over 12 parcels, were planted out and freshly watered.

Preparation of aqueous essences

In this part, new leaves of *C. procera* and *C. religiosa* are picked before sun rise. The same day, these leaves were crushed with the help of a mixer, and proportioned at the rate of 200g/l for *C. religiosa* and 400g/l for *C. procera*. The use of these concentrations is proved by anterior works on these two plants: Diome *et al.* (2019) [5], about *C. religiosa*; and Ngom *et al.* (2020) [8], about *C. procera*. The solution is left steeping for 24 h in ambient temperature, and then percolated through a narrow-mesh strainer. Liquids that are obtained from filtration correspond to biocidal essences; these are kept for 24 h to 48 h before application.

Treatment of plants in parcels
The first treatment was dealt with 10 days after planting out. Afterwards, essences were applied every fortnight, until emergence of heads of cabbage. Treatments, which consist in pulverizing, were executed afternoons after watering, when the latter would occur. The same quantity of biocide has been applied over all treated parcels, and the same volume of water used for the control parcel.

Inventory of cabbage pests
To make an inventory of pests occurring in the cabbage farming, examinations have been carried out the day before and the day after every plant treatment. Ten plants, chosen at random in every parcel, have been carefully examined, in search of ravaging insects, and that, on the upper and lower parts of leaves. For every species we came across, larvae were counted.

Statistical analysis
Statistical analysis of data has been processed with R Software, version 3.5.2. First, raw data are recorded in a Microsoft Excel 2013 spreadsheet; then the test of normality is applied. Results (P-value > 0.05) have pointed out that data follow the normal law. Thus, Student's test has been applied to assess the difference between the number of larvae before and after treatment with the various substances. Nevertheless, this difference is compared to the point of significance (5%). The difference is considered significant when the P-value < 0.05.

Results
Populations of pests' dynamics
Figure 2 shows the fluctuation in populations of *P. xylostella*, S. *littoralis*, and *H. undalis* in terms of the various records made. Analysis of results disclose that only caterpillars of *P. xylostella* have colonized the area from the first ten days of the study. The other species' larvae appearing in the fifteen following days. *Plutella xylostella* reveals two peaks of appearance of which, the first happen at the beginning of the survey, and the second one on the fourth record. The peak of *H. undalis* occurs at the second record, when *P. xylostella* larvae take a tumble. As for *S. littoralis* populations, they do not undergo a noticeable fluctuation in the course of time.

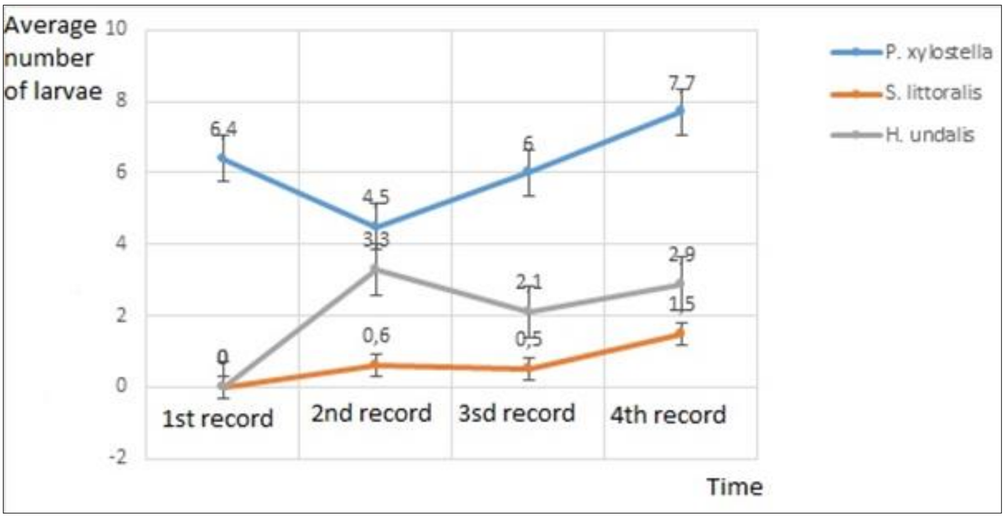

Fig 2: Dynamics of *Plutella xylostella*, *Spodoptera littoralis*, and *Hellula undalis* populations in the course of time

Compared efficacy of biocides on pests
Comparing the efficacy of the various essences comes to compare species number of larvae before and after the four treatments carried out, and this to follow species evolution in the treated parcels in terms of the control parcel.

On *Plutella xylostella*
Results from figure 3 shows that control parcels have recorded the highest number of *P. xylostella* caterpillars, while in treated parcels, the number of larvae of this species has weakly decreased in the course of time (P-value = 0.82). Larvae evolution in the various treated parcels displays that biocidal essences from *C. procera* has more effect on *P. xylostella* because it is the only biocide which has significantly reduced, after treatment (AFT), the number of larvae recorded before treatment (BFT), with a P-value of 0.0289. On the other hand, we can notice that the mixed biocide has induced a better result compared to the substance from *C. religiosa*, because in T3 parcels, the number of *P. xylostella* larvae has decreased, but not in a significant way at every record after treatment, whereas in T2 parcels, the diminution is restricted to the two first treatments. After on, the number of larvae keeps increasing in these parcels. The extracts from *C. religiosa* have shown its inefficacy on *P. xylostella* larvae which it does not significantly reduce.

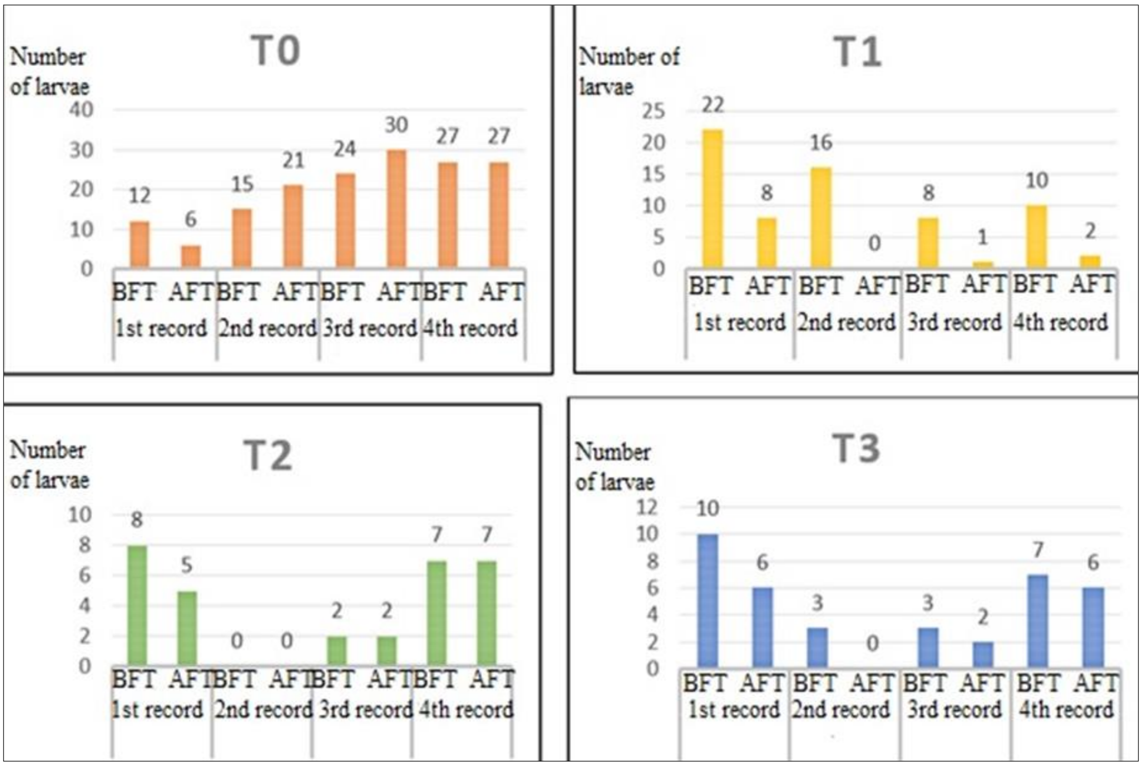

Fig 3: Comparison of biocides efficacy on *Plutella xylostella* larvae

On *Hellula undalis*

Figure 4 analysis reveals that *H. undalis* is in the majority in the control parcels compared to the treated ones. From Fig. 4 diagrams, we draw as well that extracts from *C. procera* have real impact on this species larvae by significantly reducing them (P-value = 0.013). As for the other biocides, that from *C. religiosa* (P-value = 0.5), and the mixed one (P-value = 0.18), their action on this species is not significant, despite their small occurrence in parcels.

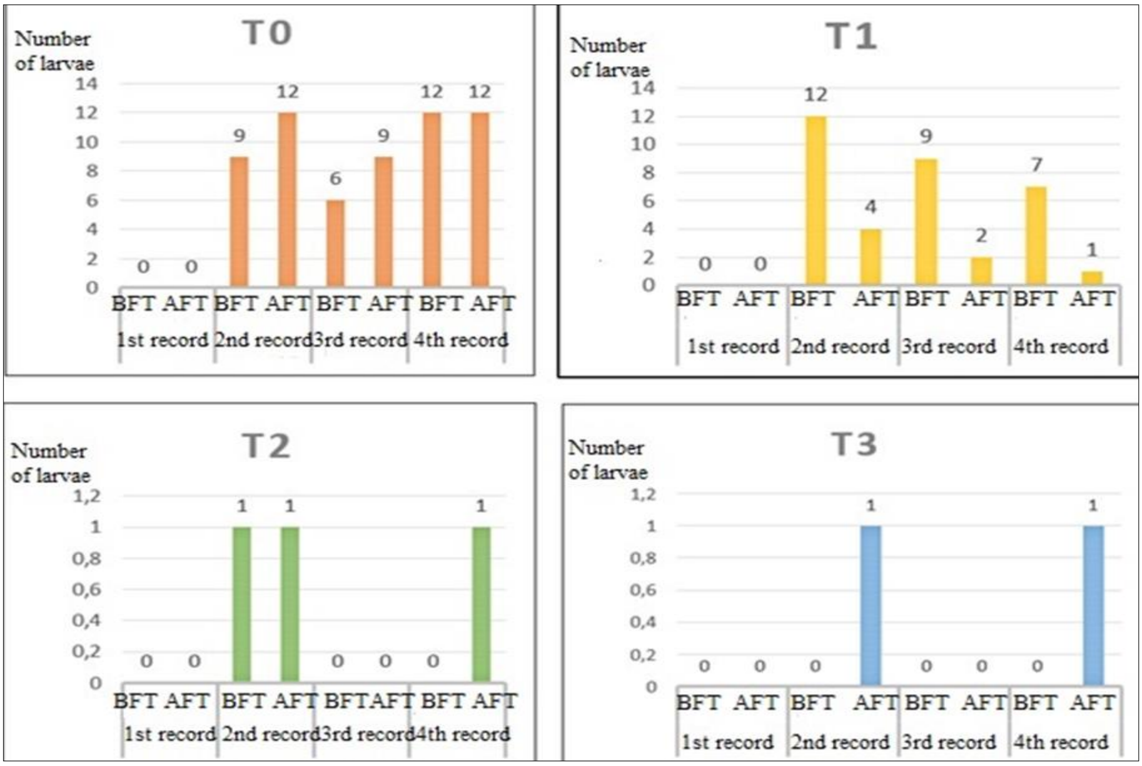

Fig 4: Comparison of biocides efficacy on *Hellula undalis* larvae

On *Spodoptera littoralis*

Figure 5 exhibits that *S. littoralis* occurs in parcels simultaneously with our study. Evolution of this pest populations in parcels treated with aqueous essences from *C. procera* does not show difference vis-a-vis the control parcels. This allows us then, to draw a conclusion that this substance does not act on *Spodoptera littoralis* larvae (P-value = 0.12). On the other hand, analyses from T3 parcels go in the same direction as the results drawn from T1 parcels. *Spodoptera littoralis* is not sensitive to the mixed biocidal, too. Extracts from *C. religiosa* seem to control populations of *S. littoralis* in that, since treatment application, this pest has never been recorded in T2 parcels again. So, we can note that essences from *C. religiosa* are more effective on *S. littoralis* larvae than the other biocides.

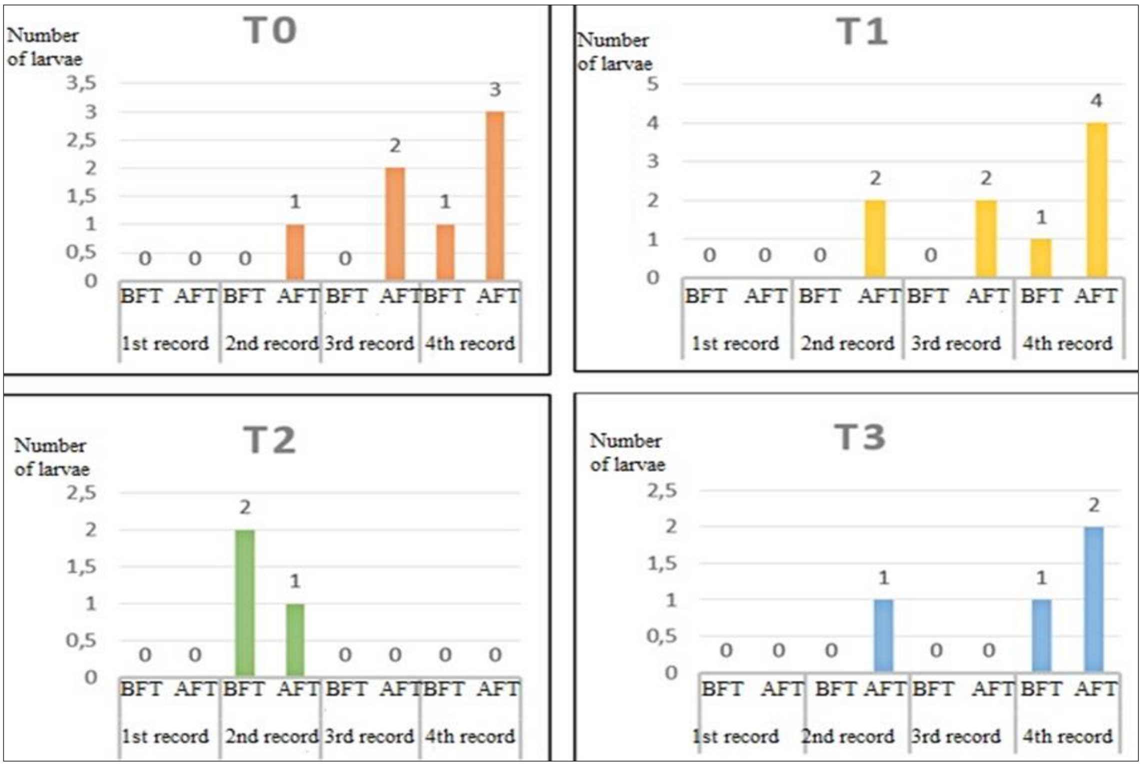

Fig 5: Compared efficacy of biocides on *Spodotera littoralis* larvae

Effect of biocides on cabbage weight

Figure 6 below represents the effect of various biocides on the weight of cabbage gathered in. One can Remarque that, not treated parcels yielded lesser than the others. Highest yields, 2.13Kg/m^2 and 1.35Kg/m^2, have been obtained with parcels T1 and T3, respectively. We have as well noticed a significant difference in weight between parcels treated with extracts from *C. procera* and the control parcels (P-value = 0.045). However, the other parcels do not reveal significant difference between them.

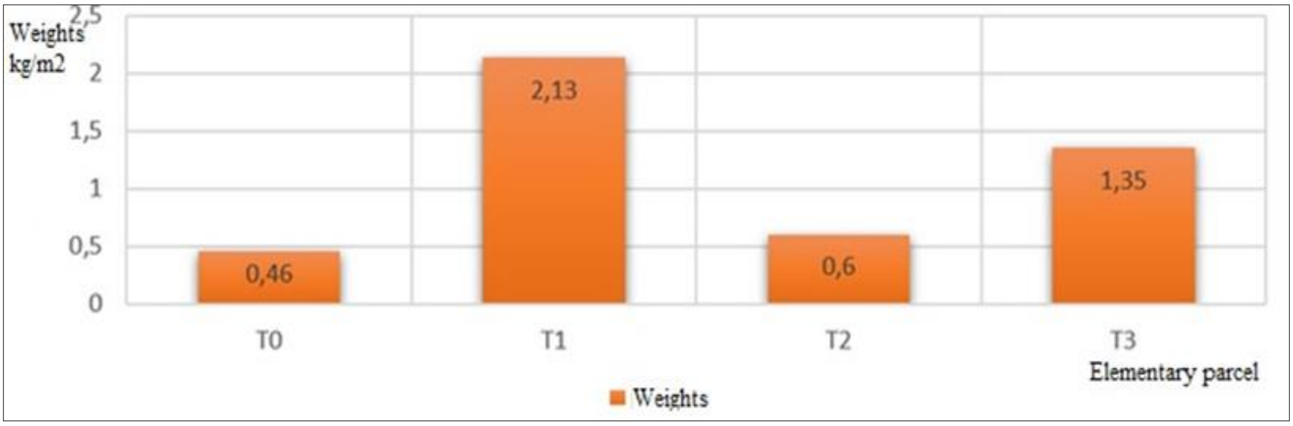

Fig 6: Effect of biocidal products on the harvest yield

Discussion

In the course of this study, a number of insects have been encountered. Among others there are *P. xylostella, H. undalis, S. littoralis, H. armigera*, and *C. chalcites*. Numerous greenflies, as well as auxiliaries such as spiders and ladybirds, have been listed. *Plutella xylostella* remains the most occurring species in our parcels. This corroborates results from Sarfraz *et al*. (2007) [9] that see *P. xylostella* as one of the most cosmopolitan pest of Brassicaceae. Fluctuation of pest populations is, above all, correlated to species bio ecology, environmental circumstances, and especially the impact of applied biocidal substances. The combined effect of these factors determines, in this way, the dynamics of pests' populations. *P. xylostella* has its peak at the beginning of the campaign, namely at the early stage of cabbage plants. These results are in accordance with data from Sow *et al*. (2013) [10] which stipulate that females of *P. xylostella* prefer young plants to lay. The second peak appears at the maturation period, when cabbage heads are well formed. Caterpillars of *Hellula undalis* have immerged from the third week of cultivation. The consequence of their occurrence was the apparition of additional heads on a number of stalks. *Spodotera littoralis* larvae, as for them, were weakly represented from their immerging, at the third week, until the end the study. In experimentation conditions, efficacy of products is globally assessed through the abundance of the populations of pests, or the severity of damages (Yarou *et al*., 2017) [1]. Our results have made appear that control parcels recorded the most important number of destroyers' larvae. The product from *C. procera* has more impacted *P. xylostella* in that, the day after each treatment, there is a significant reduction of the number of caterpillars (P-value = 0.0289). This biocide has, as well, effectively impacted *Hellula undalis* because its number has drastically decreased during treatments. These results are in perfect agreement with those of Ngom *et al*. (2020) [8]. which show that aqueous extracts from leaves of *C. procera* are actually effective on *P. xylostella* and *H. undalis* larvae. Only aqueous extracts from *C. religiosa* appear to be effective on *S. littoralis* larvae; they have systematically destroyed its caterpillars after application. This result agrees with that of Diome *et al*. (2019) [5]. Which states that aqueous essences from *C. religiosa* have a strong efficacy on *S. littoralis*. The mixed product has no satisfactory effect to limit major pests. This might result in the dilution of effective concentrations of each one of the both products. The control plots were more attacked by pests. Because of this, they yielded lesser. Parcels treated with aqueous essences from *C. procera* yielded more. Our results meet those from Ngom *et al*. (2020) [8]. Which show that besides their biocidal effect, aqueous extracts from *C. procera* conceal fertilising property on cabbage plants. The mixed product has given a no negligible yield, too. This may be due to the presence of *C. procera* aqueous substances.

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