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Compared efficacy of two aqueous essences from leaves of *Calotropis procera* and *Crataeva religiosa* in the fight against tomato destroyers

Armanda Amy SAMB[1], Mamecor FAYE[2*], Toffène DIOME[1] and Mbacké SEMBÈNE[1]

[1]Team Genetic for Population Management, Department of Animal Biology, Faculty of Science and Technology, Cheikh Anta Diop University, Dakar, Senegal.
[2]Laboratory of Parasitology, Department of Animal Biology, Faculty of Sciences and Technology, Cheikh Anta Diop University, Dakar, Senegal.
[*] Corresponding author; E-mail: mamefaapdanamou@gmail.com

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ABSTRACT

Tomato has become one of the most consumed vegetables across the world. However, insect attacks check its growth. Chemical treatments recommended by experts appear to be ineffective, in that insects develop capacities of resistance, needless to evoke the harmful effect of pesticides on the environment. To limit damage caused by insects, organic fight has been used as an alternative solution. This work aims to contribute to the understanding of the tomato entomofauna, and the fight against this speculation devastator insects in Dakar suburban zone. The study was carried out according to a randomised Fisher block mechanism in three repetitions, with four formulas: T1 (400g/l of essences from fresh leaves of *Calotropis procera*), T2 (200g/l of essences from fresh leaves of *Crataeva religiosa*), T3 (mixed solution), and T0. Results showed that treatment with the mixed solution (T3) appeared to be effective on winged greenflies and on *Chrysodeixis chalcites* larvae, but had no impact on *Bemisia tabaci, Spodoptera littoralis*, and *Liriomiza sp*. T2 seemed to be more effective against *C. chalcites* larvae and winged greenflies. The different formulas have no significant effect on *Helicoverpa armigera* larvae. T1 was without effect on destroyer insects, but enhances yield.

Keywords: Bio-aggressors, biocides, tomato, organic fight, yield.

INTRODUCTION

In Senegal, diversification of market gardenings offers in dry season advantageous alternatives. That is the case for tomato, melon, and onion (Falle et al., 2009). Tomato count among the most consumed vegetables. In terms of vegetable expenses, fresh tomato comes in fourth position behind onion, potato, and cabbage; that is to say 7% of households' vegetable consumption (Huat and David-Benz, 2000). However, it is prone to numerous depredations, notably ravaging insects (Shankara et al., 2005) of which, the most important are lepidopteron, in particular the "Noctua of tomato", *Helicoverpa armigera* (Hübner), and the "South-American under minor", *Tuta absoluta* (Meyrick) which can lead to losses up to 100% of harvest (Ba et al., 2019). Chemical fight is the major strategy for market gardeners to protect their crops, but

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these practices are really harmful both for human beings and the environment. The current tendency consists to fight against insects in using natural products, in order to preserve the environment and human health (Naïka et al., 2005). These last years, plant natural substances have been used as insecticides to reduce damage caused by these destroyers, and results are encouraging (Ba et al., 2019; Diome et al., 2019; Ngom, 2019). These substances have the advantage of being biodegradable, non-remanent in the environment, and are within the reach of minor producers (Traoré et al., 2015). It is in such a context that this study has been undertaken, consisting in using natural products such as aqueous essences from *Calotropis procera* and *Crataeva religiosa*, to fight against tomato destroyers and, in doing so, preserving human health and the environment.

MATERIALS AND METHODS

Localisation of the experimental site

The commune of Malika has a surface of 805 hectares 24 are 17 square meters; this is to say 9.4% of Pikine Department (ANDS, 2007). It is located in Niayes zone, a subdivision of Pikine, 22 km from Dakar. It is bordered to:

- the East and the South by the commune of Keur Massar,
- the West by the commune of Yeumbeul-Nord,
- the North by the Atlantic Ocean (Niass, 2009).

Experimental materials

To delimit parcels, a cord, a decameter, a hammer, and pegs were used. As ploughing tools, a pick, a rake, a shovel were used; and to provide water, we used a watering can. Sheets of paper were used for data recording. After harvesting, a mechanic scale was used to weigh fruits.

Organic and biological materials

This study was carried out using aqueous essences from fresh leaves of *C. procera* (T1), *C. religiosa* (T2), and a mixed solution of *C. religiosa* and *C. procera* (T3). Tomato (*Lycopersicum esculentum*) F1 Mongal was used as host plant for insect destroyers. Larvae of destroyers served as animal biological material.

Experimental design

A randomised Fisher block, in three repetitions with four treatments is the design which was used. The parcel (11m x 5m = 55m²), subdivided into 12 elementary parcels, received four treatments repeated three times. The elementary parcel (1m x 2m = 2m²) included 2 lines with 5 saplings in each line. Spacing between seed hole was 40 cm apart, and 60 cm apart between lines. Saplings were numbered counter clockwise from 1 to 10. Elementary parcels in the same block are spaced 1m apart, and repetitions are separated 1m apart.

Extraction of biocidal substances

Leaves were picked early before sun rise, at about 07 H am. Leaves of *Calotropis procera* were collected from the 'Voie de Dégagement Nord' (VDN) road and those of *C. religiosa* were harvested at the botanical garden of Cheikh Anta Diop University of Dakar. Fresh leaves were conveyed to the laboratory within sacks, weighed, rinsed, and then ground with the help of a mixer. Ground leaves were then soaked in two different buckets for 24 hours, at a concentration of 400g/l for *C. procera*, and 200g/l for *C. religiosa*. Tap water was used as liquid of extraction. The mixture was filtered with a small-mesh sieve (0.01 mm × 0.01 mm). The final product was stocked within two labelled different buckets. The mixed solution was obtained by mingling one litre of *C. procera* solution and one litre of *C. religiosa*.

Collection and observation of caterpillars

To inventory insects present in the field, two methods of sampling were used:

Adult trapping

To catch male adults, air traps were set. So, in each elementary parcel, one trap was settled. Every week, counting of captured insects was done and thus, for each parcel, an inventory of the number of captured specimens were made.

Sampling and counting larvae

Surveys of larvae were carried out from the second week after the planting out until a fortnight before harvesting. During these surveys, all the ten (10) tomato plants of each parcel were examined. On the ten (10) first leaves under the apex of these latter, the following elements were registered: the number of mines, the number of mined leaves, the number of *Tuta absoluta* caterpillars, the number of maggots of *Liriomiza sp.*, the number of *Helicoverpa armigera* caterpillars, the number of *Spodoptera littoralis* caterpillars, the number of fruits attacked by *H. armigera*, the number of *Bemisia tabaci* adults, and the number of winged greenflies. Furthermore, specimens that could not be identified on-site and then were conveyed with leaves to the laboratory and examined with a binocular magnifying glass.

Statistical analyses

Gathered data were compiled in Excel 2013. This software allowed us to plot graphics, and the R software, version 3.5.2 (Core Team, 2005), to make statistic tests. Shapiro-Wilk test of normality was first applied to our data, to check whether they follow the normal law. These results led to carrying out the Kruskal-Wallis test, in order to establish the effects of the different essences on each species. For *C. chalcites* larvae and winged greenflies, a Dunn test was done to see couples of means treatment which show significant difference. For fruits attacked by *H. armigera*, normality test directed us to do the ANOVA test, in order to see whether a significant difference occurred between the attack mean rate and treatments. The Pairwise test was done to identify treatments which showed significant differences of mean. The difference between two values was considered significant, when the P-value is inferior to 5% ($p < 0.05$).

RESULTS

Inventory of destroyers living on tomato farming

Abundance of species

Over the experimental parcel, 3659 specimens, belonging to seven species, distributed over five families (Agromyzidae, Aleyrodidae, Aphidoïdae, Gelechiidae, Noctuidae), and three orders of insects (Diptera, Hemiptera, Lepidoptera), were identified (Table 1). Table 1 points out that winged greenflies and *B. tabaci* represent majority species with 46% and 30%, respectively. For the order of Lepidoptera, *H. armigera* was majority, followed by *C. chalchites* with 6% and 2%, respectively. Occurrence of *T. absoluta* and *S. littoralis* was nearly nil during the whole study.

Occurrence and impact of species

Analysis of Table 2 shows that *B. tabaci* and winged greenflies occurred permanently in the parcel with a frequency of 100%, and impacts of 39% and 47%, respectively. *Liriomiza sp.* and *C. chalcites* follow with a frequency of 88%. *Liriomiza sp.* presence was noticed from the 10th day after planting, but a large reduction of its population was ascertained from the 5th week of prospecting and that of *C. chalcites* from the 2th week after planting, with impacts of 20% and 7% respectively. Presence of *H. armigera* was noted on and after fruition, with a frequency of 63%. *T. absoluta* and *S. littoralis* were both encountered once over the whole study.

Diversity indexes

The experimental parcel of tomato presented a fair and abundant distribution of species, with a Shannon index of 1.80. A high variability of insect species is as well noted, with a Simpson λ index of 0.33 which testifies to the strong diversity even if species like *T. absoluta* and *S. littoralis* were weakly present over the parcel (Table 3).

Effect of treatments on destroyers

Assessment of the impact of treatments on the average number of the major destroyer insects encountered

Statistical analysis (Table 4) have pointed out that there is no significant difference of treatments on *H. armigera, T. absoluta, B. tabaci, S. littoralis*, and *Liriomiza sp.* (p > 0.05). However, treatments have revealed a significant difference on winged greeflies and *C. chalcites* (p<0.001). This significance appears for winged greenflies between T0 - T1 (p = 0.013), T0 - T2 (p = 0.0001), T0 - T3 (p =0.0094), and between T0 –T 1 (p = 0.0034), T0 - T2 (p = 0.0000) T0 - T3, (p = 0.0054), T1-T3 (p = 0.0054) for *C. chalcites*. Compared with the non-treated parcel (T0), treatments allowed to keep a low level of infestation for winged greenflies or *C. chalcites* larvae. In T2 and T3 parcels, in comparison with T0, it was noted a significant decrease in the winged greenflies population, with 48% and 38%, was noted respectively. On the other hand, in T1, the treatment had no significant impact on species, with a reduction of only 26%, compared with T0; the same phenomenon was noted with *C. chalcites* where the treatment with T2 and T3 yielded good results by reducing larvae to 77% and 50%, in comparison with the control parcel (T0). T1 seemed to be less effective for this species (47% of reduction), compared with other treatments. Treatments did not have significant effect against *H. armigera* larvae (p = 0.14). It is worthy to be noted that T3 seemed reducing winged greenflies and *C. chalcites*, but particularly T2 was the most effective against these two species, compared with other treatments. T1 had lesser impact against winged greenflies and *C. chalcites*.

Number of caterpillars before and after treatment

Results revealed that only caterpillars of *C. chalcites* were in majority on the site of experimentation until 40 days after planting. However, infestation by *H. armigera* started two days before the third treatment (BT3), coinciding with the beginning of fruition. Figure1 shows that caterpillars of *H. armigera* underwent a strong diminution after the third treatment (AT3) and the fourth one (AT4) for the different formula. Likewise, the number of *C. chalcites* caterpillars saw a considerable reduction and even got to nil for parcels treated with T2 after the fourth treatment (AT4). Effect of treatments on *C. chalcites* was significant (p = 0.0007).

Effect of treatments on fruits

Percentages of fruits attacked by H. armigera

Damage caused on fruits by *H. armigera* larvae were assessed for each parcel. Results revealed that the different treatments had significant effects on fruits attacked by *H. armigera* (P- value = 0.0391). Comparison in twos shows the non-significance between T0 - T1 (P-value = 1.000), T0 - T2 (P-value = 0.233), T0 - T3 (P-value = 1.000), T1-T2 (P-value = 0.233), and T1 - T3 (P-value = 1.000). However, there is a significant difference between T2 andT3 (P-value = 0.034).

Yield and production according to treatments

After harvest, tomato weight has been valued and corresponded to 230.1 kg in total; yield for each elementary parcel has as well been determined. Thus, better yields were obtained with parcels treated with T3 (118 t/ha) and T1 (93 t/ha), while a lower yield was obtained in the parcel treated with T2 (72.3t/ha). Fruit losses were lower in T2 where only 10 kg of fruit had been attacked, compared to T1 and T3 where bigger losses had been recorded with 15.3 kg and 17.3 kg, respectively (Table 5).

Table 2: Abundance of the different encountered species.

Species	*Liriomiza sp.*	Winged greeflies	*B. tabaci*	*T. absoluta*	*H. armigera*	*C. chalcites*	*S. littoralis*	Total
Number (ni)	569	1673	1109	1	237	68	2	3659
Abundance (pi)	16%	46%	30%	0%	6%	2%	0%	100%

Table 3: Occurrence and impact of species.

Orders	Families	Species	Impact	Occurrence
	Gelechiidae	*T. absoluta*	**0.1%**	**13%**
Lepidoptera		*H. armigera*	**14%**	**63%**
	Noctuidae	*S. littoralis*	**0.2%**	**13%**
		C. chalcites	**7%**	**88%**
Diptera	Agromyzidae	*Liriomiza sp.*	**20%**	**88%**
Hemiptera	Aleyrodidae	*B. tabaci*	**39%**	**100%**
	Aphidoïdae	Winged greeflies	**47%**	**100%**

Table 4: Diversity indexes.

Species	***T. absoluta***	***H. armigera***	***S. littoralis***	***C. chalcites***	***Liriomiza sp.***	***B. tabaci***	**Winged greeflies**	**Total**	**H'(p)**	**λ**
Pi Log2 Pi	-3.2. e-0.3	-0.24	-6. e-0.3	-0.11	-0.42	-0.52	-0.51	-1.80	1.80	
(Pi) 2	0.00	0.00	0.00	0.00	0.03	0.09	0.21	0.33		**0.33**

Table 5: Impact of treatments on the average number of destroyers.

Treatments	**Average number of insects ± SD**						
	Liriomiza sp.	**Winged greeflies**	***B. tabaci***	***T. absoluta***	***H. armigera***	***C. chalcites***	***S. littoralis***
T0	0.45±1.19	2.42±3.52	1.35±2.64	0.00±0.00	0.3±0.74	0.13±0.34	0.00±0.06
T1	0.8±0.17	1.79±3.08	1.19±2.07	0.00±0.06	0.28±0.60	0.07±0.28	0.00±0.00
T2	0.58±1.55	1.25±2.13	1.05±1.94	0.00±0.00	0.17±0.04	0.03±0.17	0.00±0.00
T3	0.54±1.60	1.5±2.19	1.03±2.10	0.00±0.00	0.24±0.71	0.06±0.24	0.00±0.06
P-value	0.93	0.002	0.31	0.39	0.14	0.001	0.57
Significantness	NS	S	NS	NS	NS	S	NS

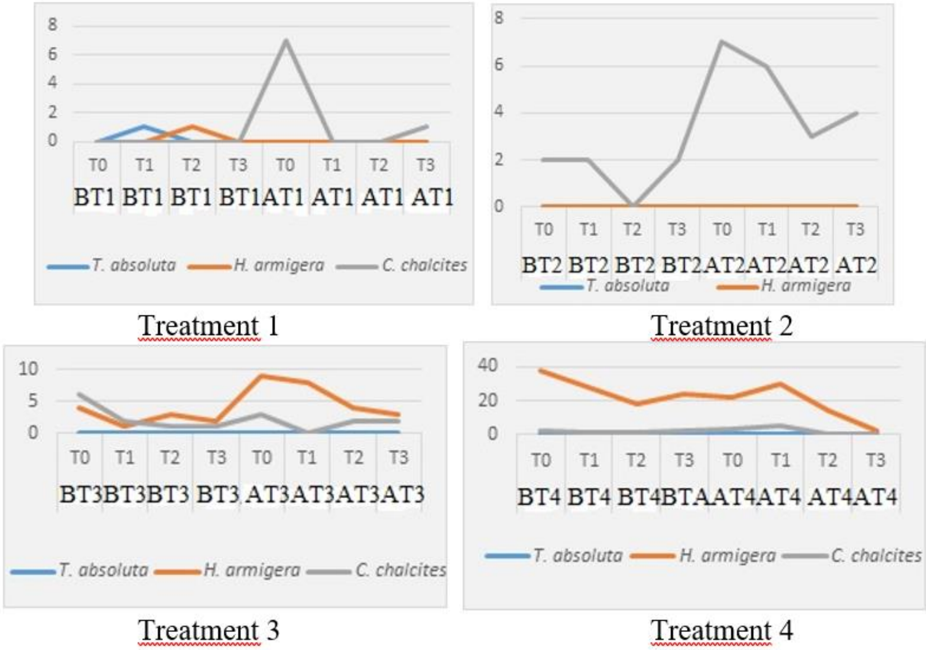

Figure 1 : Variation of the number of caterpillars before and after treatment.

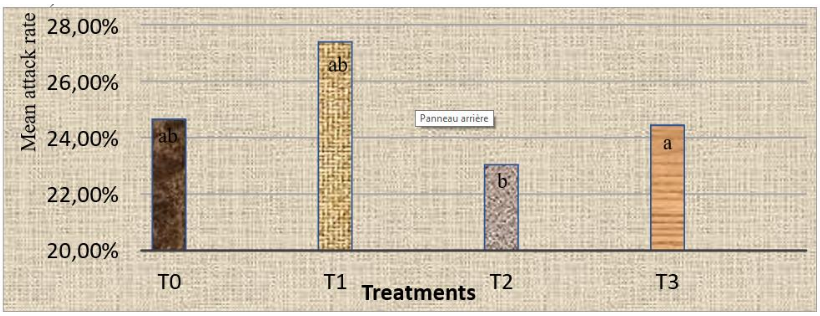

Figure 2 : Fruits attack rate.

Table 5: Total production and yield according to treatments.

Fruits		Treatments			
		T0	**T1**	**T2**	**T3**
Total	Attacked	14.8	15.3	10	17.3
	Sound	45.3	40.6	33.4	53.5
Total production (kg)		60.1	55.9	43.4	70.8
Yield (kg/m²)		10	9.3	7.2	11.8
Yield (t/ha)		100	93	72.3	118

DISCUSSION

Insect species living on tomato farming

The aim of this study was to test effectiveness of natural aqueous essences from leaves of *Calotopis procera* and *Crataeva religiosa*, on tomato destroyer insects, in the suburban zone of Dakar. The inventory carried out during our study revealed the occurrence of many destroyer insect families over the area (Agromyzidae, Aleyrodidae, Aphidoïdae, Gelechiidae, Noctuidae). Indexed insects were numerous and diverse; this is confirmed by Simpson (λ=0.33) and Shannon (1.80) indexes. Results of the present study are similar to those of (Chougourou et al., 2010) who pointed out that tomato farming contain numerous species of ravager insects belonging to many different families. Results show that Aleyrodidae and Aphidoïdae families (Hemiptera) and that of Agromyzidae (Diptera) were the most representative, which is in congruence with results from (Son, 2018). The highest incidence was obtained with *B. tabaci* (39%) and winged greenflies (47%). The study shows that, in the order of Lepidoptera, *H. armigera* was more abundant (77%). As early as fruition, one remarked a high rate of infestation by *H. armigera* caterpillars, in spite of the presence of cabbage cultivation; which agrees with results from Nibouche (1994) who pointed out that tomato is the preferred host for this ravager, even associated to other farming sap as okra, string bean, aubergine, and cabbage. *Tuta absoluta* was nearly absent from the study site. This would be linked to the fact that this species is from temperate zones thus, low temperatures are propitious to its development (Diatte et al., 2016), when experimental works took place at the beginning of the dry season, in more or less high temperatures (November – January). This is in accordance with results from (Sylla, 2018) in Niayes area which indicated that infestation of tomato farming by *T. absoluta* is weak at the beginning of the dry season (October – January), and that population hotbeds are registered at the end of the dry season (February - May).

Effect of the different aqueous essences on ravager insects

The different treatments applied in the experimental site appeared ineffective against ravagers *H. armigera*, *B. tabaci*, *S. littoralis*, and *Liriomiza sp.* (P-value > 0.05). On the other hand, these had significantly reduced winged greenflies and *C. chalcites* (P-value < 0.001). As a matter of fact, essences from *C. religiosa* leaves and the mixed solution have, in a significant way, brought down the numbers of the two species. The bio-insecticidal action of *C. religiosa* has been proved by [8]? who indicated that fresh leaves of *C. religiosa* are effective against cabbage major ravagers (*Hellula undalis*, *Plutella xylostella*, and *Spodoptera littoralis*). A number of authors pointed out the insecticidal effect of aqueous essences from plants, among them Garba et al. (2017) who precised that a 37.5 kg/ha dose of fresh leaves of *Azadirachta indica* and 10 kg/ha of its seed turned out to be better than reference pesticides. In the same way, according to Traore et al. (2015), solution of *A. indica* is effective against *H. armigera* larvae on tomato. Results as well revealed that aqueous solution of *C. religiosa* allowed to bring down *H. armigera* caterpillars to 45%; what is different from results obtained by Ba et al. (2019) who made known that aqueous essences from leaves of *C. religiosa* significantly reduce average number of *H. armigera* larvae. It is worthy too to note that, in the present experimental conditions, essence from *C. procera* did not have significant effects against winged greeflies, *C. chalcites,* and *H. armigera*. Nonetheless, studies by Ngom (2020) revealed that aqueous essences from fresh leaves of *C. procera*, by reducing their populations, had significant effect against *C. chalcites*, *H. armigera, H. undalis, P. xylostella*, and against winged greenflies living on cabbage farming, too. In Morocco, Abassi et al. (2004) pointed out that a primary mixture of alkaloids from *C. procera* leaves is effective against larvae of fifth stage and against ovarian development of *Schistocerca gregaria,* and that a death rate of 100% had been reached after 15 days. Studies carried out in Burkina Faso by Abel (2002), showed biological efficacy of essences from

Azadirachta indica against *H. armigera* larvae too. All these results make way for the assumption that efficacy of aqueous essences from fresh leaves of *C. procera* against a ravager depends on the kind of aqueous essence, but on the grown speculation too.

Effect of treatments on production yield

At the end of the present experiment, the best yield was obtained with T3 (118 t/ha). Good outcome had been recorded with T1 (93t/ha) too. The lower yield came from T2 (72,3t/ha). In fact, essences from *C. procera* and the mixed solution seemed to be favouring fruition, compared to the parcel treated with essence from *C. religiosa* which had a more reduced damage on *H. armigera*, with a total weight of attacked fruits of 10 kg, presents the lowest yield (72,3t/ha). Similar results have been obtained by several authors, revealing *C. procera* properties which consist in favouring fruition (Ngom, 2019; Diome et al., 2019). These authors noted that treatment of a parcel of cabbage with the same product had given a better yield with an accelerating effect on hearts maturation. Otherwise, Amoabeng et al. (2014) made known that natural substances from plants can allow to increase yields comparable to those given by chemical pesticides. *Calotropis procera* appears ineffective for caterpillars of *H. armigera*, with bigger losses (27.39%) than the non-treated parcel (24.65%). On the other hand, parcels treated with *C. religisa* had a weaker attack rate (23.4%) compared with the other parcels. Similarly, the mixed solution minimizes damage but is less effective than T2 (24.44%) which corroborate studies by Ba et al. (2019) who saw that aqueous essences from *C. religiosa* drastically reduces attacks from caterpillars of *H. armigera*. According to Gahn (2018), *C. religiosa* reached its biggest effectiveness against *P. xylostella* larvae.

Conclusion

The results of this study show that the mixed solution of *Crataeva religiosa* + *Calotropis procera*, seems to be effective on winged greenflies and *Chrysodeixis chalcites*. By separating the extracts, it was found that the aqueous solution of fresh leaves of *C. religiosa* is effective on these two species compared to other treatments. *C. procera* has no effect on winged greenflies and *C. chalcites* species, but treatments T2 and T3 seem to limit the damage of *Helicoverpa armigera*. Best yields were obtained with plots treated with *C. religiosa* + *C. procera* (118 t/ha) followed by those treated with *C. procera* (93 t/ha). These two formulas seem to promote fruiting. Under our experimental conditions *C. religiosa* is the most effective substance compared to other formulas for controlling pests of tomato culture even if it gives the lowest yield. It is necessary to further study the aqueous extracts of *C. procera* on tomato speculation in order to better see if there is a particular dose that can be used in biological control of the main pests, especially since it seems to increase yield.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

AAS and TD: work on-site. MF: Results exploitation and writing. MS: Supervision of the work.

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