

Effects of the Binary-Insecticide, Capt 88 (Cypermethrin + Acetamiprid), On the Non-Target Fauna in Horticultural Crops of Niger

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Abstract: The study of the biological efficacy of a binary insecticide (Cypermethrin 76 g a.i/l + Acetamiprid 12 g a.i/l), used to control horticultural crops insects on non-target insects was led from July to December 2011 in Tillabéri, Niger (14°24'43N/01°44'68W). The main objective of the study was to evaluate the harmful effects of this insecticide on ants, termites and parasitoid wasps. The experimental device used is the plan in complete random block (CRBD). The experimental units are squares of 1 ha. Three treatments were carried out *viz.* 1) Capt 88 EC with the amount of 0.5 l per/ha; 2) the karate 5EC with the dose of 0.4 l per ha and 3) untreated plots. The results of the study showed that the Capt 88 EC applied at the dose of 0.5 l per ha had variable effect according to the non-target insects. The catches of beetles were equally important in the treated plots than in untreated plots in the first two follow-up intervals; the insecticide had no effect on Beetles ($E < 0$). The assessment of the impact of insecticide on *Prionyx* spp. (Hymenoptera: Sphecidae) were strongly affected by chemical treatments. The data analysis showed a significant differences between the Capt 88 EC and the unsprayed plots ($p = 0.001$). The decrease of populations was very high ($> 80\%$) with the two pesticides (Capt EC 88 and the reference product). Capt 88 EC at the dose of 0.5 l per ha caused a strong reduction of the activity of *Odontotermes*, culminating in high mortality at 1-8 days and 12-16 days post-spray. The colony mortality was 53; 62 and 2,4%, respectively, in Capt 88 EC, reference product and unsprayed plots at 1-8 days. At 12-18 days post-spray, we observed a significant decline in the relative abundance of *Odontotermes* in Capt 88 EC plots with effective reductions (compared with pre-spray levels) of 75 and 8%. In the interval III, there was non-significant effect of treatment, $p = 0.412$. The result on ants at 1-8 days post-spray showed that the Capt 88 EC was very noxious; the mortality was 98% compared the un-spray-plots (6%). At 24-28 days post-spray, an early recovery of the population was observed in treated plots. The present study provides evidence of food chain perturbations induced by Capt 88 EC (Cypermethrin 76 g a.i/l + Acetamiprid 12 g a.i/l).

Key words: Cypermethrin • Acetamiprid • Vegetables • Chemical control • Insect pests • Niger

INTRODUCTION

The harvest losses due to several factors, including horticultural pests, were very important in Niger [1, 2]. Even if the scale of horticultural pests impact has been debated, *e.g.* it has been argued that the pest seldom has an economic effect nationally but affects local socio-economics [3], the species is generally regarded as a pest of significant economic status that needs to be controlled or managed [4]. Coordinated control efforts using chemical insecticides are still perceived as the main means of reducing horticultural pests' populations.

The immediate beneficiaries of control operations are the local people as the control campaign reduces the threat of food insecurity. The environmental impact of pesticides is often greater than what is intended by those who use them. Over 80% of sprayed insecticides reach a destination other than their target species [5], including non-target species, air, water, bottom sediments and food. Though there can be benefits using pesticides, inappropriate use can counterproductively increase pest resistance and kill the natural enemies of pests. The use of pesticide is noxious of the environment [6-8] or to human health [9-13]. In present agro ecosystems,

pesticides commonly used are non-selective. They kill both targeted and useful insects that are very important in agricultural crop production. Beside the direct harmful effects on the biological systems, pesticides pollute surface and underground water, soil and the atmosphere. Therefore, farmers, farm advisors and other decision-makers require systematic methods for assessing the relative environmental impacts of pest-control methods.

To get a better grasp on the selectiveness of the commonly used pesticides, a study was undertaken to assess the effects of the binary insecticide, Capt 88 EC (Cypermethrin 72 g a.i/l + Acetamiprid 16 g a.i/l) on the non-target fauna tested in farmers' fields.

Adverse environmental impacts of insecticides used for pest control is a concern world-wide and for a range of organisms of pest status. Practically it makes it very difficult to handle this type of experiment in open field or in any ecological system as the number of living organisms is extremely large. In order to meet ecological representativeness and experimental feasibility, specific insect species have been selected for the *in-situ* experiments. The main aim of this study was to identify faunal organisms that are vulnerable under natural conditions to conventional insecticides used for controlling horticultural pests.

MATERIALS AND METHODS

Experimental Site and Design: The field trial was carried out in the suburban district of Tillabéri (14°24'43N/01°44'68W), in the Northwest of Niamey (Republic of Niger). The suburban district of Tillabéri is 104 245 km². This area is chosen according to the main problem of horticultural crops pests. The region of Tillabéri belongs to the Sahelian savannah. The temperature ranged from 32 to 38°C in the experimental site and no rainfall was recorded. The experimental design used is a complete random block (RCBD). The distance between blocks is 10 m and 20 m between the experimental units which are one hectare. Three treatments were carried: i) Capt 88 EC at the dose of 0.5 l per ha; ii) karate 5 EC (reference insecticide) at the dose of 0.4 l per ha; iii) the untreated plots.

Treatments: Full-cover spraying using standard equipment EC application was used in all of the experimental plots. All treatments were carried out between 07:00 and 10:00. The emission height was 1 m above ground.

Dosage rates of 0.5 l per ha of Capt 88 EC (cypermethrin 72 g a.i/l + acetamiprid 16 g a.i/l) were used for tomatoes and sweet pepper insects control. In all cases the volume of insecticide at the start of spraying and the volume left post-spray were measured to calculate the total volume applied.

The Assessment of the Impact of Insecticide On Beetles:

The assessment of the relative abundance of beetles was performed with tube traps. The use of tubes or *pitfall* is the standard method for evaluating the relative abundance of terrestrial arthropods especially walking insects [14-17]. The polypropylene tubes (Length = 11.5 cm, diameter = 4.5 cm, volume = 175 ml) contained first 10 ml of 0.5% formalin (Conservative liquid to prevent swelling of invertebrates trapped), 10 ml of detergent liquid (to reduce evaporation) and 90 ml tap water. The *pitfall* was buried in the ground, taking care to adjust their top edge to soil surface. The location of each tube was indicated by a metal rod. In each plot, *pitfall* was placed 2 m apart along the diagonal lines (10 traps / diagonal), starting 2 m from the center. The follow-up rates were 2 days. The entire follow-up interval was 20 days (2 days before and 18 days after treatment) or D-2, D0 (before) and 1DAT (day after treatment), 2DAT, 4DAT, 6 DAT, 8 DAT, 10 DAT, 12 DAT 14 DAT, 16 DAT, 18 DAT. For each interval of time of monitoring, the content of each tube is emptied and replaced. Insects are collected and sorted by taxonomic groups, counted and samples maintained in ethanol at 70° for later identification in the Laboratory. In order to assess the short-term (I), medium (II) and long-term (III) effects of pesticides on insects, the post-treatment period was divided in three phases: phase I (1-6 days), phase II (day 8 to day 14 day) and phase III (16 day to day 18 day).

The Assessment of the Impact of Insecticide On parasitoid Wasps:

Yellow plastic traps (20 x 40 cm), with glue have been used to assess the relative abundance of flying insects. Each trap is mounted on a metal rod at 80 cm from the soil surface, perpendicularly with the direction of the wind prevailing (270°). Twenty traps per plot are placed (10 traps / transect). The distance between traps is 2 m and 3 m between transects, starting 2 m from the border to avoid border effect. The observations are carried out at different intervals of time before the insecticide application (D-1, D0) and after application (1 DAT, 4 DAT, 8 DAT, 12 DAT, 16 DAT, 20 JAT, 24 DAT, 28 DAT,). As before, in order to assess the (I) short-term, (II) medium term and

(III) long term of pesticides effects on insects, the post-treatment was divided in three phases: Phase I (day 1 to day 8), Phase II (day 12 to day 20) and Phase III (day 24 to day 28).

The Assessment of the Impact of Insecticide On termites:

To assess termites' foraging activities, wooden sticks (40 cm long, 10 cm wide, 2 cm in diameter) were used in three parallel transects separated by 20 m. The sticks were buried to a depth of 10 cm in the ground. Transects were placed at approximately 50 m inside the border of each plot to avoid edge effects. In each transect row, 20 sticks were placed 5m apart. A total of 180 sticks were thus used in the nine experimental plots. Monitoring of termite activity was carried out for 28 days, 4 days before and 24 days after treatment. The sampling interval was 4 days; this interval was adopted after a preliminary test in the experimental site. The site showed that this was sufficient time for all of the sticks to be attacked by termites. Three observers were used for counting, each appointed to the same transects throughout the study. Termite activity was assessed between 06:00 and 10:00. After 10:00 temperatures are so high that the activity of the termites is affected. In this study, only sticks showing termite attacks or damage with individual termites still present were taken into account. At each observation the most seriously damaged sticks were replaced. They were collected every 4 days over a period of 28 days (4 days before and 24 days after treatment), or -4 DAT, 1 DAT, 4 DAT, 8 DAT, 12 DAT, 16 DAT, 20 DAT and 24 DAT. In this study, only attacked sticks by termites were taken in account. At each interval of time, all the heavily attacked sticks were replaced. The intervals of time after treatment were divided into three parts: Period I, 1-8 days after treatment (1-8 DAT), Period II, 12-20 days after treatment (12-20 DAT) and Period III 24-28 days after treatment (24-28 DAT). A sample of termites was collected and preserved in 70% alcohol for identification at the Agrhyment Regional Center in Niamey, Niger.

The Assessment of the Impact of Insecticide On Ants:

The *Pitfall* method described above was used, however, the duration of the experiment was 29 days (one day before and 28 days after treatment). The observations were made at different intervals of time before treatment (D-1, D0) and after applications (1 DAT, 4 DAT, 12 DAT, 16 DAT, 20 DAT, 24 DAT and 28 DAT). As above, in order to assess the (I) short- term, (II) medium and (III) long term effect of pesticides on ants, post-treatment periods were divided in three phases, Phase I,

1-8 days after treatment (1-8 DAT), Phase II, (12-20 DAT) and Phase III, (24-28 DAT).

Data Analysis: We used one-way ANOVA followed by a Student- Newman-Keuls multiple range test if the null hypothesis was rejected at $\alpha=0.05$. The use statistical comparison based on Before-After- Control-Impact (BACI) principle [18, 19, 20, 21, 22, 23, 24]. To distinguish between early, delayed and late effects of insecticides, observations during the 28 days after treatment were divided into three time intervals, viz. I (1-8 days), II (12-20 days) and III 24-28 days). To express population variations, the numbers of sticks showing termite attack with presence of individuals were computed for each individual plot and sampling interval by comparing the number of sticks before and after treatment using the formula:

$$C = \log(TBb0+1) - \log(TBa0+1)$$

where *TBb* is the total number of sticks for an interval after the treatments and *TBa* the number before treatment. Negative values of *C* indicate that the number of sticks attacked after treatment was lower than before treatment, while positive values indicate the opposite. The effect of these insecticides on termite activity (*E*) in each time interval was calculated according to the formula [25].

$$E (\%) = 100 [1 - ((Cb.Ta)/(Ca.Tb))]$$

where *Cb(Tb)* = the sum of the sticks in all experimental plots before treatment and *Ca(Ta)* the sum of the sticks after the treatments in Intervals I, II and III. The environmental impact of these insecticides was classified as high (75%), medium (25-75%) or low (<25%) according to the FAO guidelines [26] for terrestrial invertebrates. Statistical analysis was done using SPSS 16.0 software. The data were $\log(x + 1)$ transformed to account for normality and homogeneity of variance [27-29].

RESULTS AND DISCUSSIONS

Impact of Capt 88 Ec on *Scarabaeus* Spp (Coleoptera: Tenebrionidae): Dung beetles (*Scarabaeus* spp.) are eminently useful insects as they contribute very effectively to the improvement of environment by the physical removal of excrement of all kinds, either by direct consumption of excrement or by their burial. The tunnels formed by these insects' activities allow soil aeration and fertility increase. In this study,

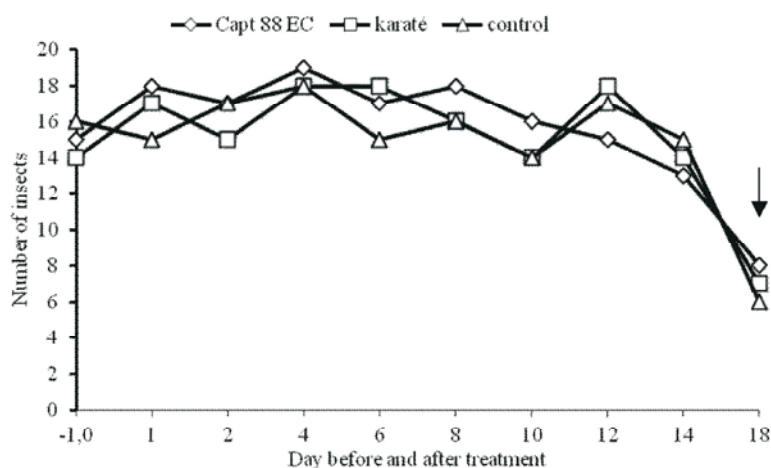


Fig. 1: Total cattch of *Scarabaeus* spp before and after treatments. The arrow shows the decline of population.

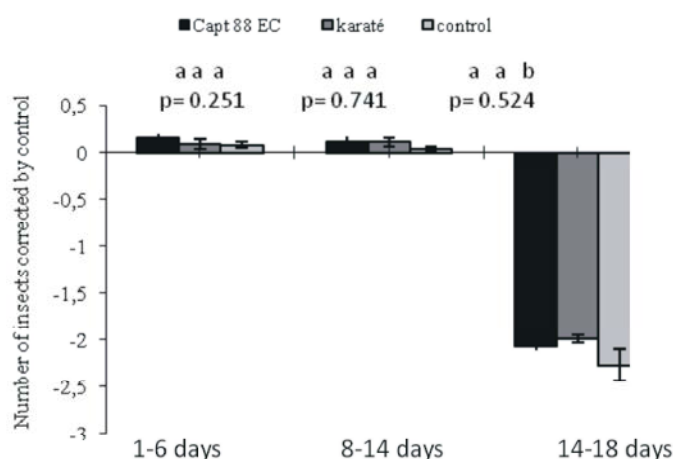


Fig. 2: Total catch of *Scarabaeus* spp (mean \pm S.E.) calculated using C formula during three post-treatments intervals. Values not sharing the same letter are significantly different at the level $P < 0.05$.

the catches of *Scarabaeus sacer* and those of *Scarabaeus* sp were combined, especially as their relative abundance was not significantly different ($p = 0.712$).

Fig. 1 showed that Capt 88 EC, at the dose of 0.5 l per ha, did not affect the abundance of beetles. Indeed, the statistical analysis of the interaction treatments and species, has not generated a significant difference ($p = 0.376$). The number of catches is equally important in the treated plots than in controls (Fig. 1 & 2) in the first two follow-up intervals. The lack of pesticides effect on Beetles ($E < 0$) could be explained by the strength of their shells, which can be a difficult barrier to the chemicals. We hypothesized that it can also be explained by the fact that the doses of pesticides used had not sufficiently contaminated their food to reach lethal doses. These insects are not directly exposed to pesticides due to their nocturnal behavior. But from 18 DAT (18 days after treatment), we observed a remarkable

decrease in the relative abundance of beetles in all plots (Fig. 1). The reduction of the number of beetles may be attributed to the temperature drop during that period.

Impact of Capt EC 88 on *Prionyx* Spp. (Hymenoptera: Sphecidae): *Prionyx* spp. are predators of locusts and observations done in revealed that, in Tamesna (North Niger), *Prionyx crudelis* and *P. nigropectinatus* have been observed hunting larval stage of locusts [30]. These observations of the predatory role of *Prionyx* spp. confirm those of several authors [31, 32, 33]. The results obtained in this study are recorded in the Fig. 3. They show that *Prionyx* spp. (Hymenoptera: Sphecidae) were strongly affected by chemical treatments. Indeed, the number of catches dropped sharply one day after the applications in the treated plots compared to control plots. The result supports earlier studies on *Prionyx* sensitiveness to pesticides particularly

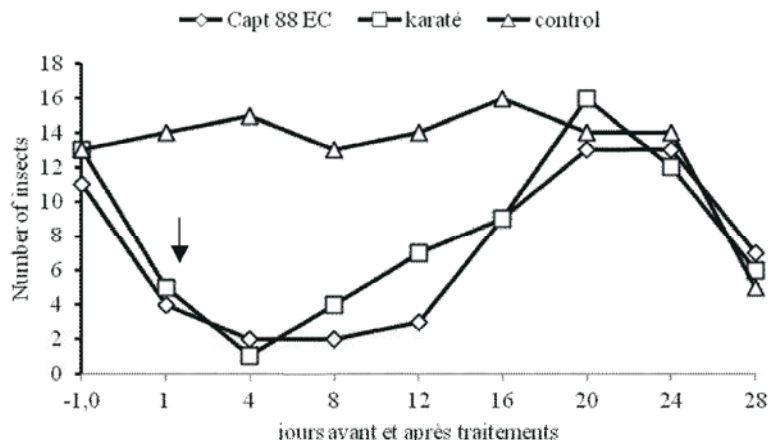


Fig. 3: Number of *Prionyx* before and after treatment. The arrow indicates the effect of Capt 88 EC one day after treatments.

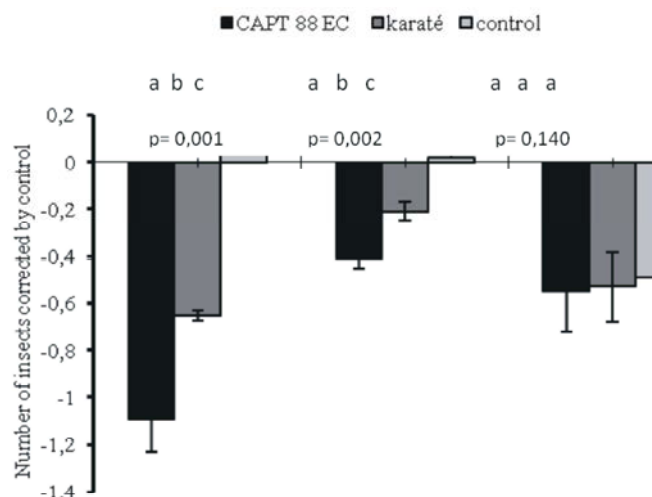


Fig. 4: Total catch of *Prionyx* (mean \pm S.E.) calculated using C formula during three post-treatments intervals. Values not sharing the same letter are significantly different at the level $P < 0.05$.

chlorpyrifos-ethyl as described by Mamadou *et al.* [13]. This shock effect was more important in Phase I (1-8 days) (Fig. 3). In this time interval, the data analysis showed that there was a significant difference between treatments ($p = 0.001$) on *Prionyx* spp (Fig. 4). The multiple comparison test ranked Capt 88 EC at the rate of 0.5 l per ha and the reference product in one homogeneous group with respect to their effects on *Prionyx* spp. Reductions in populations were very high (>80%) with the two pesticides (Capt EC 88 and the reference product) on *Prionyx*.

In phase II, (12-20 days after treatment), a significant difference was observed between treated and untreated plots ($p = 0.002$) (Fig. 4). Reductions in populations are high (> 75%) with the two pesticides (Capt EC 88 and the reference product). In this phase an early recovery of the

insect population was observed. 24 to 28 days after treatment (phase III), reducing of the number of captures was very low in all treated plots and untreated- plots (Fig. 4).

The decreasing of catches observed in phase III (Fig. 3) could not be attributed to the pesticides effects, since the captures decreased also in the untreated plots. Other factors could explain this phenomenon.

Impact of Capt 88 Ec on Ants (Hymenoptera: Formicidae):

During the experiment carried out from January 20 to February 24, 2011, 2781 \pm 123 individuals were captured, of which 87% consisted of *Camponotus* sp. The relative abundance of ants dropped sharply one day after pesticide application (shock effect), while it increased in the control plots (Fig. 5).

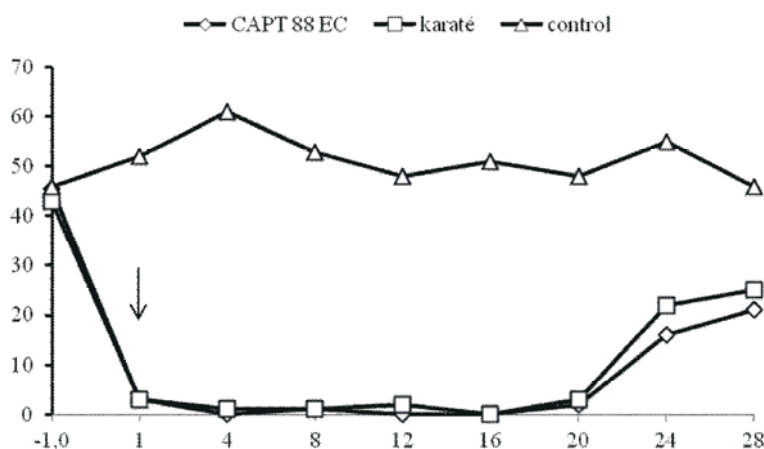


Fig. 5: Average catch of *Camponotus* at the pre-and the post-treatment. The arrow indicates one day after treatment.

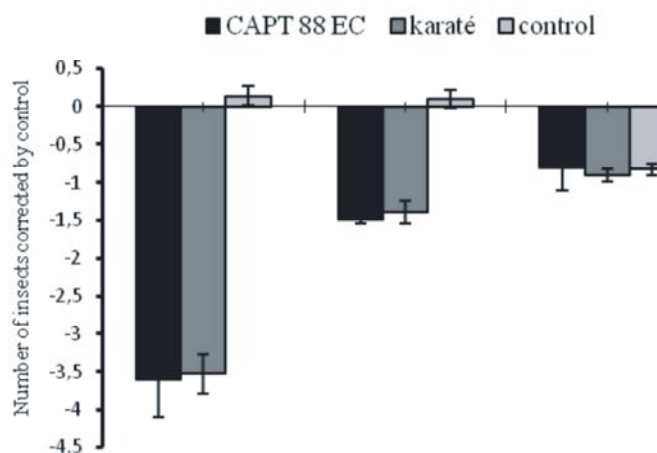


Fig. 6: Total catch of *Camponotus* (mean \pm S.E.) calculated using C formula during three post-treatments intervals. Values not sharing the same letter are significantly different at the level $P < 0.05$.

Capt 88 EC at the dose of 0.5 l per ha and the reference product had a very negative effect on the ants in Phase I, 1-8 DAT, (Fig. 5). It is well documented that Ants play a very important role in terrestrial ecosystems [34]. In fact, they are predators of many other insect pests [35, 36]. Statistical analysis (Fig. 6) shows that there is a significant difference between treatments ($p = 0.001$) with respect to their effect on the ants, genus *Camponotus*. The decrease of ants population was very high (>98%) within this period (1-8 days) for both Capt 88 EC at the dose of 0.5 l per ha and the reference product. In phase II (12-20 days), the number of catches dropped (Fig. 5) compared to Phase I, but the numerical reduction still remains important (up to 75% for the treated plots). 24-28 days after treatment, an early recovery of the population was observed (Fig. 5). Statistical analyses show (Fig. 6) in the interval I, Capt 88 EC at the dose of 0.5 l per ha and the

reference product are classified according to SNK in the same homogenous group, they do not differ significantly in their effect on genus *Camponotus*.

Impact of Capt 88 Ec on *Odontotermes* (Isoptera: Acrotermittinae): Termites play an important role in tropical ecosystems. They are part of soil organisms involved in the decomposition of organic matter and the evolution of the physical and chemical nature of the soil [37, 38, 39, 40].

Fig. 7 showed harmful effect of Capt 88 EC at the rate of 0.5 l per ha on *Odontotermes* one day after treatment. Indeed, a high reduction of the wood transportation activity of *Odontotermes* was observed following the application of pesticides, in the treated plots compared to control plots (Fig. 7). This reduction of activity of the ant gradually continued until the 24th day after treatment

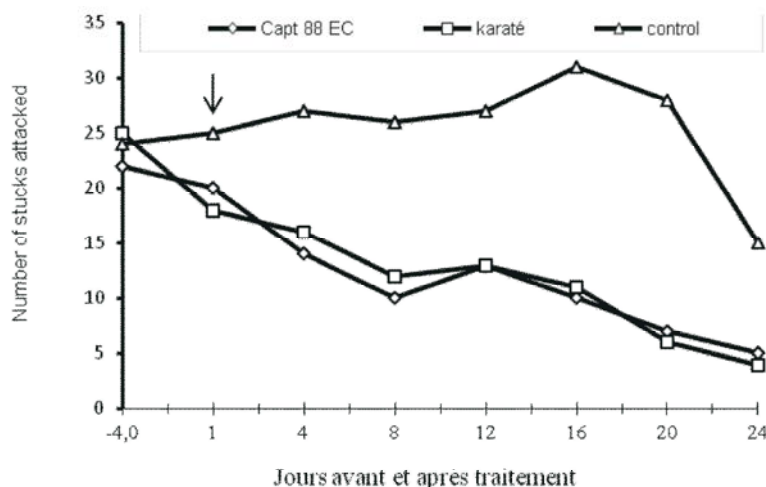


Fig. 7: Average catch of *Odontotermes* at the pre-and the post-treatment. The arrow indicates the day after treatment.

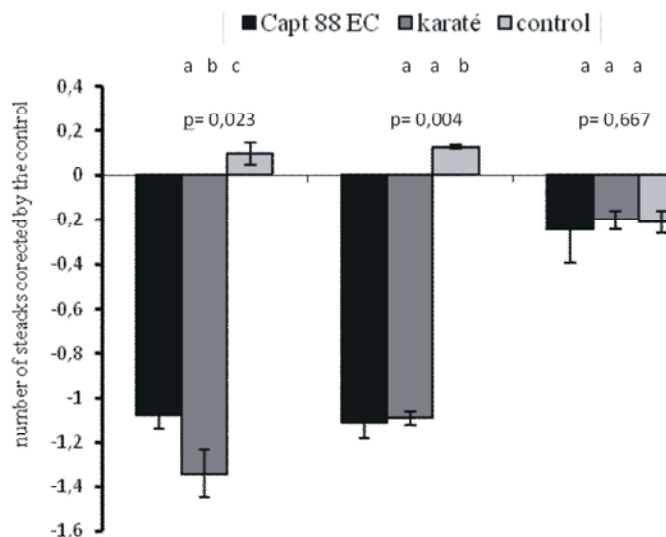


Fig. 8: Total catch of *Odontotermes* (mean ± S.E.) calculated using C formula during three post-treatments intervals. Values not sharing the same letter are significantly different at the level $P < 0.05$.

(24 DAT), while in the control plots, the activity continued until harvest (Fig. 7). These results indicated that Capt 88 EC at the dose of 0.5 l per ha and the reference product (karate 5EC at a dose of 0.4 l per ha) had a negative effect on *Odontotermes* activity in 1-8 days and 12-16 days post-spray, with a reduction in activity of 53% and 62% respectively with Capt 88 EC at the rate of 0.5 l per ha and the reference product in the period I and from 58 to 75% in the period II. There was a significant difference between treatments in periods I and II ($p < 0.05$). These results showed that the reference product, karate 5EC, is more harmful than Capt 88 EC at the dose of 0.5 l per ha. In the period III (20-24 DAT) a significant decrease in the activity of wood transportation in all experimental

units was observed; this could be related to climatic conditions, especially the decreasing of the temperature level during the same interval. At the interval 1-8 DAT statistical analysis (Fig. 8) is indicating that the most important effect of treatment ($p = 0.002$). The SNK test has classified Capt EC 88 treatment (0.5 l per ha) and the reference product in two distinct homogeneous groups, but the most harmful effects were recorded with the reference product. In the interval II (12-16 DAT), there was an important effect of treatment ($p = 0.001$) and the SNK test ranked the treatment Capt 88 EC (0.5 l per ha) and the reference product in the same homogeneous group. In the interval III, there was no main effect of treatment ($p = 0.412$).

CONCLUSIONS

The results of this study showed that the effect of Capt 88 EC (Cypermethrin 72 g a.i/l + Acetamiprid 16 g a.i/l) applied at a the dose of 0.5 l per ha on the relative abundance of parasitoid wasps of the genus *Prionyx*, on ants of the genus *Camponotus* and on termites, of the genus of *Ondontotermes* spp. was very noxious particularly on ants, wasps and termites. But, Capt 88 EC does not have a negative effect on dung beetles. Further studies need to be conducted to conclusively and definitively confirm the environmental effects of Capt 88 EC at the dose of 0.5 l per ha.

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