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Comparative effects of deltamethrin and Neem kernel solution treatments on Diamondback moth and *Cotesia plutellae* (Hym., Braconidae) parasitoid populations in the Cotonou peri-urban area in Benin

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Abstract: A comparison between deltamethrin and Neem kernel solution treatments on *Plutella xylostella* (L.) populations was made in the Cotonou peri-urban area. Diamondback moth populations were 10 times larger in deltamethrin plots, than in Neem plots after treatment. The number of marketable cabbages from Neem-treated plots was 1.5 times greater than the number from deltamethrin-treated plots. There was no apparent effect of either treatments on *Cotesia plutellae* (Kurdjumov) populations, the only parasitoid of the pest that was present in the area.

1 Introduction

The diamondback moth (DBM), *Plutella xylostella* (Lep., Yponomeutidae), is the most important pest of Brassicaceae worldwide (TALEKAR and SHELTON, 1993) and for the last few years has damaged the main cabbage-growing areas in the Cotonou peri-urban area (GOUDEGNON and BORDAT, 1992). In most cases injudicious use of chemicals to control larval populations has led to a rapid increase in DBM resistance to insecticides (CHENG, 1981; FAUZIAH et al., 1990; SUN, 1990) and even recently to *Bacillus thuringiensis* Berliner formulations (FERRÉ et al., 1991; SHELTON and PEREZ, 1993; LIU et al., 1995). Recent research has emphasized the selection of natural insecticides from plants (ASCHER, 1996) with the aim of reducing chemical treatment in order to limit resistant populations of insect pests and the destruction of their natural enemies. Several species from the Meliaceae family are known for their bioactivity against many insect families. Among these, Neem, *Azadiracta indica* A. Juss, from India is the most frequently used (ADHIKARY, 1985; SINGH, 1987; SOMBATSIRI and TEMBOONKEAT, 1987; LESKOVAR and BOALES, 1996). This species originated from India (SAXENA, 1987) was introduced into Benin about 20 years ago and has become acclimatized. Solutions of Neem kernel extracts have been used by vegetable growers in the Cotonou peri-urban for many years (GOUDEGNON, personal communication), despite qualitative and quantitative differences in quality of the extracts kernels depending of the origin of the tree (SINGH, 1987).

This study compares the actual efficacy of these solutions with that of deltamethrin synthetic pyrethrinoid in reducing DBM populations. Observations were also made on the effects of these treatments on *Cotesia plutellae* (Kurdjumov) (Hym., Braconidae) the only parasitoid of DBM larvae in the area.

2 Materials and methods

This study was carried out in Benin, on a growers plot in the Cotonou peri-urban area, situated at Kouhounou. The test area consisted of 24 patches of three lines, each containing 21 plants of K K Cross cabbages, the genotype most used in Benin. The local researchers used the same cultivation techniques (ploughing, planting, introducing of fertilizer, spraying, etc.) as those used by the vegetable growers.

The sprays (water for the control, deltamethrin and Neem extracts) were started 2 weeks after planting and carried out every week, until the last week before harvesting. These applications were carried out using a knapsack sprayer. Every patch was treated with the same quantity of solution, 0.5 l from planting to the eight-leaf stage and 1.5 l from the nine-leaf stage until 1 week before harvest. When rain arrived less than 24 h after spraying, spraying was carried out again the following day. For the pyrethrinoid, a local formulation of K-Othrin (1.8% of deltamethrin) was used. The solution of Neem extract was of local manufacture. After crushing of the seeds, 500 g of kernels, in which the azadirachtin level was equal to 0.61% (w/w), had been measured by high-performance liquid chromatography analysis, were crushed and put in 10 l of water for 24 h. The following day, the solution was filtered and sprayed onto the plants. This solution contained an azadirachtin level of 0.302 g/l measured by the method of SCHIFFERS et al. (1997).

The disposition of the patches within the blocks was randomized, the observations were carried out on the cabbages in the central line of each patch, except for the cabbages at each end of the lines, namely on 19 cabbages per patch. The experiment consisted of eight replicates and data was obtained from 456 cabbages. The number of holes in the leaves, number

Table 1. *Number of holes per leaf,* Plutella xylostella *after treatment, in cabbage-growing areas in peri-urban area of Cotonou (eight replicates)*

Treatments	Holes/leaf	*P. xylostella*
Control	1380[b]	911[b]
Neem	914[a]	180[a]
Deltamethrin	3952[c]	1695[c]

[a,b,c], significant in Neuman–Keuls test (5%).

Table 3. *Number of* Plutella xylostella, Cotesia plutellae *and ratio of* Cotesia plutellae *to* Plutella xylostella *after treatment, in cabbage-growing areas in the peri-urban area of Cotonou (eight replicates)*

Treatments	*P. xylostella*	*C. plutellae*	CP/PX
Control	911[b]	1020[b]	0.53[a]
Neem	180[a]	196[a]	0.52[a]
Deltamethrin	1695[c]	3276[c]	0.66[b]

[a,b,c], in each column significant in the Newman–Keuls test (5%).
CP/PX, ratio of *Cotesia plutellae* to *Plutella xylostella*.

of DBM (larvae and pupae), number of *C. plutellae* cocoons, weight of head cabbages and number of marketable cabbages were recorded. The data was subjected to analysis of variance and differentiated by the Newman–Keuls test (5%).

3 Results and discussion

The Neem extract solution used was efficacious for control of DBM populations. The number of larvae and pupae on the cabbages from patches treated with deltamethrin, Neem and the water control were different. The number of holes in the leaves also differed (table 1). Naturally the number of marketable cabbages produced was higher in the Neem-treated patches, than in the deltamethrin-treated patches and finally in the control (table 2). There was no significant difference in weight of head cabbage obtained in the three cases (table 2). The number of *C. plutellae* cocoons observed in each treatment was also different, in the Neem-treated patches, in the control and in the deltamethrin-treated patches (table 3). The relationship between the number of *C. plutellae*/*P. xylostella* was not significantly different in the Neem-treated patches and in the control, but it is different in the deltamethrin-treated patches (table 3). In the three cases, control, deltamethrin and neem extracts, the *C. plutellae* and DBM populations were correlated (figure).

The kernel extract of Neem seeds used in this study was efficient in controlling DBM in the cabbage fields of the Cotonou peri-urban area. However this work did not address the question of whether the diminution in the observed populations of DBM in the Neem-treated patches was due to the azadirachtin antifeedant property (DILAWARI et al., 1994) or due to its insecticidal properties (SOMBATSIRI and TEMBOONKEAT, 1987; CHEN et al., 1996). Laboratory studies will be required to resolve this problem. During the experiment, DBM larval populations showed resistance to deltamethrin. This pesticide has been used regularly for many years to control vegetable pests in general and so the appearance of DBM populations that were resistant to this insecticide was not unexpected.

The weight of cabbage heads produced in the patches of each treatment was not significant. This result is probably due to several parameters which were too difficult to check: (i) heterogeneity of the plants due to the genotype used, KK Cross, growing in Cotonou climate conditions; (ii) heterogeneity of the plants from the nursery, those used by the vegetable grower were selected from unthinned plants; and (iii) the presence of other pests in the cabbages, particularly *Hellula undalis* (F.) (Lep., Pyralidae), whose larvae eat the terminal bud of newly planted cabbages, thus inducing growth of the axillary buds which produce unmarketable multiple heads at harvest. Despite this, more marketable cabbages were recorded in the Neem-treated patches. This phenomenon has already been observed in Togo (ADHIKARY, 1985) and in Texas (LESKOVAR and BOALES, 1996).

The Neem extract solution used in this study does not affect the *C. plutellae* populations, the only endoparasite natural enemy present. The absence of any disturbing effects due to azadirachtin on the parasitoid populations has been already reported by some authors (SCHMUTTERER, 1990; LESKOVAR and BOALES, 1996). The field results show that the Braconidae populations were not affected by the weekly deltamethrin sprays. Although maybe not yet resistant, it is possible that *Cotesia* populations have developed an acquired tolerance over years of contact allowing the adults to continue to search for DBM larvae to parasitize. Future studies will look at the 50% lethality concentration (LD_{50}) of deltamethrin

Table 2. *Weight of cabbage heads and number of commercial cabbages after treatments in the peri-urban area of Cotonou (eight replicates)*

Treatments	Total head weight (g)	Mean weight/cabbage	Saleable cabbages
Control	27 048 NS	178 NS	71 b
Neem	43 230 NS	284 NS	123 a
Deltamethrin	52 583 NS	346 NS	84 b

In the same column, values followed by the same letter are not significantly different according to the Newman–Keuls test (5%).
NS, not significant.

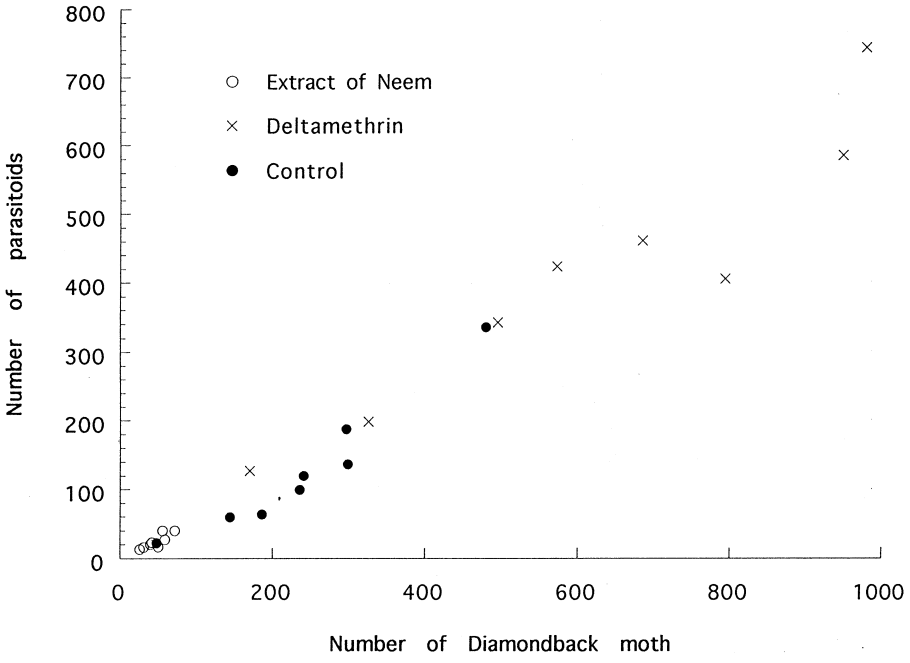

Figure. *Correlation between Diamondback moth and its parasitoid, present in cabbage-growing areas in Cotonou (eight replicates)*

for *C. plutellae* populations, from the Cotonou peri-urban area.

The Neem extract solution had a systemic effect and significantly reduced the populations of *Lipaphis erysimi* (Kaltenbach), aphids which are often observed on the plant leaves. The mechanical effect of washing during the sprays cannot be the reason for this reduction in numbers because in each spraying, the cabbages of the control patches had been sprayed with water but still carried large aphid populations. Tests carried out in the laboratory on leafminer populations (*Liriomyza*) have shown a systemic property of the Neem kernel extract solutions (BORDAT, personal communication). Leafminer larval populations (inside blotch mines), reared on beans watered with Neem kernel solution were completely destroyed whereas those reared on beans sprayed with Neem solution only decreased very slightly. This phenomenon has been confirmed in New Caledonia on DBM populations, where sprays of commercial formulations possessing Neem seed extracts have shown less efficacy than pesticide formulations (DALY, personal communication). In the present study, the Neem-treated leaves were treated until run off and an important part of the product was absorbed by the soil and consequently by the roots of the cabbages.

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