International Scholars Journals

International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 16 (3), pp. 001-007, March, 2026. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Comparative Efficacy of Two Binary Insecticides Against Major Horticultural Pests in Niger

Abdou Mamadou[1], Kadri Aboubacar[2], Hamé Abdou Kadi Kadi[3], Idrissa Gamatché[1], Xavier Brigodiot[4], Moumouni Abou[1]

[1]Direction Générale de la Protection des Végétaux, BP 323 Niamey (Niger)
[2]Faculté d'Agronomie, Université Abdou Moumouni de Niamey
[3]Institut National de la Recherche Agronomique du Niger.
[4]Alm International 3, bis Quai aux fleurs 75004 Paris.

Accepted 17 January, 2026

Study of biological efficacy of CAPT FORTE 184 WG and CAPT 88 EC used to control insect pests of horticultural crops was conducted in March 2010 in the urban city of Tillabéri in Niger. The main objective of this study was to assess the biocide effect of these insecticides on the major insect pests of horticultural crops. The results of this study have shown that CAPT FORTE 184 WG and CAPT 88 EC had a reducing effect of capturing the insects in the treated plots, whereas the population of these insects increased in the check plot. The cumulated death rates at 21 days after chemicals applications are 75.19 ± 3.5% et 90.66 ± 2.9% with respectively the treatments CAPT FORTE 184 WG with all the confounded doses and the treatments CAPT 88 EC with all the doses.

Keywords: Insecticides, insect pests, horticultural crops, biocide effect, Niger.

INTRODUCTION

Agriculture occupies an important place in the agricultural economies of Sahelian countries in general and those of Niger in particular. It contributes for approximately 41% of the GDP and occupies 85% of rural sector. The main cereal crops are pearl millet, sorghum, cowpea and maize; and the principal horticultural crops are: tomato, cabbages, fresh bean and sweet peppers. The essential of agricultural product is used for self-consumption. Except, the agronomic, technical and climatic constraints, these crops are subjected to parasitic pressures, mainly those of the insect pests, which depreciate the harvests quantitatively and qualitatively, thus contributing in certain years, to a large extent with decreasing the production, with a result of a corollary food deficit. Pests destroy about one third of the world's food crops during growth and storage (Snelson, 1977). In many African and Asian countries locusts, e.g., the Desert Locust, *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididae), grasshoppers, e.g., the Senegalese Grasshopper, *Oedaleus senegalensis* (Krauss) (Orthoptera: Acrididae) and horticultural crops are among the most important insect pests, causing severe damage in agro-ecosystems and natural ecosystems such as semi-arid grasslands and pastures (Mestre, 1988; Geddes, 1990; Lomer et al., 1999).

The control methods used presently to control these insect pests remain primarily on a chemical basis (FAO, 2001, 2003; Thiollet-Scholtus, 2004; Mamadou, 2007).

Since the 1940s, synthetic pesticides became the major tool to control pests and weeds in both developed and developing countries (Flint and Van den Bosch, 1981; Whitten and Oakeshott, 1991). In the early 1950s, organochlorine and organophosphorous insecticides became dominant, starting with the use of DDT in Switzerland as well as other important organochlorines such as lindane and dieldrin in the United States and the organophosphates malathion and parathion in Germany (Flint and Van den Bosch, 1981). Because of the high persistence of organochlorine insecticides in the environment and their subsequent accumulation in the

*Corresponding author Email : abdoumamadou@yahoo.fr

food chain (Edwards, 1973; Steven et al. 2006; Krauthacker et al. 2009), the use of DDT was banned in the USA and in Europe in 1973, followed by the ban of aldrin and dieldrin in 1975 (Römbke and Moltmann, 1996). Carson (1962) highlighted the environmental risks associated with the use of organochlorine pesticides. Birds of prey and other vertebrates of higher trophic levels were found to be particularly vulnerable by showing a reduced reproductive success due to the accumulation of DDT which, among others, caused the thinning of eggshells. In some cases, secondary pests of crops became primary pests because their natural enemies were more severely affected than the target pests (Schüpp et al., 1990; Mamadou, 2007). Organochlorine insecticides used in pest control were after the ban mainly replaced by less persistent but equally or even more toxic organophosphates, pyrethrinoid, benzoic urea and phenyl-pyrazol. These is currently the most frequently used to control insect pests (Prior et al., 1992; Langewald et al., 1999; FAO, 2006).

In addition to, the problems relating to a low capacity to take into account and to effectively manage the problem of insect pests of major crops within many services, arises also the problem of choosing the appropriate insecticide. Indeed, this choice must reconcile the requirements of a good biological efficacy in terms of reducing the populations of insect pests to those of the safeguarding of human health, animal and environment.

In view of this, the aim of the present field study was twofold. The first objective was to assess the biocide effect of the synthesis insecticides CAPT 88 EC and CAPT FORTE 184 WG on the major insect pests of horticultural crops at different time intervals. The second objective was to specify under our conditions of study their persistence.

MATERIALS AND METHODS

Study Zone

The experimentations were conducted at the urban city of Tillabéri (14°24'43N/01°44'68E), located about 140 km North- west of Niamey. The Tillabéri region has a surface area of 91 199 km² and a population of more than 2 million inhabitants, but the Tillabéry city has a population estimated at 20 000 inhabitants. This zone was selected because of its horticultural potential and the recurring problem of the insect pests on the crops that caused damages each year with much acuity. The area of Tillabéry region belongs to the Sahelian zone and even Sahelo-Saharan (in north). The annual rainfall recorded in 2009 by the synoptic station of Tillabéry is 259.8 mm.

The major rainfall was recorded between July and August (total of 143.8 mm), these two months account for 52% of recorded total volume. The average annual temperature recorded in the synoptic station of Tillabéry in 2009 is 38.15 ± 2.9°C. As for whole Niger, the highest temperatures were recorded in 2009 by the synoptic station of Tillabéry, in May, April and June (40°C). The mean wind velocity recorded in 2009 is 1.55 ± 0.88 m/s. During the experimentation period (February 2010), the average temperature recorded is of 38.5 ± 0.75°C, the winds peed is 2.17 ± 0.15 m/s. These climatic parameters are similar to those recorded in 2009 by the synoptic station of Tillabéri.

The soil of the study station has a structure overall sandy-clay. The floristic composition is essentially made up of cabbage, sweet pepper, tomato, corn, fresh bean, cassava.

Pesticides application

EC and WG formulations were applied in a total cover using a pressure maintained apparatus carried on the back. All the treatments were applied on February 16, 2010 between 8h00 ' to 11h00 ' when the temperature is relatively low. Indeed, when the temperature is higher than 40°C, ascending currents (current of convection) can drift the droplets apart from the target zone. The treatment of CAPT FORTE 184 WG was repeated 14 days after the first treatment, on March 1st, 2010. All the nominal doses were really applied (nominal doses = real doses).

Experimental design

The experimental design used is a complete random block (CRB). Four blocks were distant between 30 m and 10 m between the experimental units which are rectangles of 40 m² (10 m x 4 m). The blocks are set up perpendicular to the gradient of heterogeneity. The evaluation of the density in each experimental unit is done in the square of observation of 1 m². Eight (08) treatments were made of: CAPT 88 EC at a dose of 0.2 l/ha (**1**) ; CAPT 88 EC at a dose of 0.3 l/ ha (**2**) ; CAPT 88 EC at a dose
0.5 l/ha (**3**) ; CAPT FORTE 184 WG applied at a dose of 62.5 g/ha (**4**) ; CAPT FORTE 184 WG at a dose of 112,.5 g/ha (**5**) ; CAPT FORTE 184 WG at a dose of 125 g/ha (**6**), Karate 5 EC at a dose of 0.4 l/ha **(7)** as a reference product and the Control **(8)** where no synthesis pesticide was not applied.

Structure and composition of insect pests population before the treatments

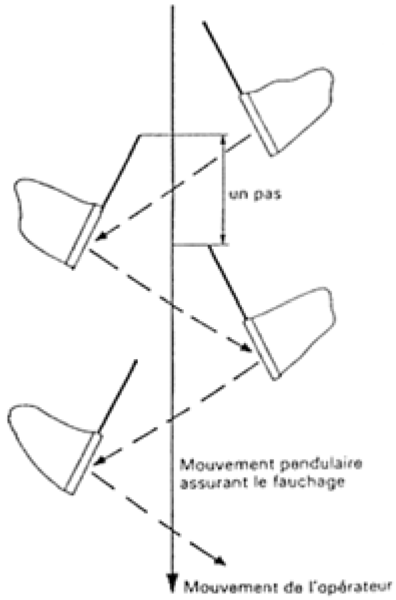
Before the synthesis pesticides application, preliminary we checked the structure and the composition of the insect pests' population in all the experimental units. Then, we have proceeded to capture of the insect pests with the sweeping net with very resistant meshes. We carried out 80sweeps in each block, according to the method as a zigzag, the sweeps were distant by 1 m (military step) of each one (Figure 1).

Density of insect pests population before treatments

With the objective of checking the infestation level of experimental field before pulverizations, we have evaluated the density of insect pests' population. Sampling was carried out 1 day before the treatments of 1 m-sided squares. On the whole, in each block, we sampled 50 squares distant of 3m between them.

Pesticides persistence

To appreciate the persistence of the various pesticides of synthesis used in these tests, we placed at one day after the treatments, two cages (1.20 m x 1.20 m) of persistence in an experimental unit treated with the CAPT 88 EC at the dose of 0.2l/ha, and two other cages in an experimental unit treated with CAPT FORTE 184 WG at the dose of 62.5 g/ha. Thirty insects (5 *Bemisia tabaci*, 5 *Epilachna sp*, 5 *Plutella xyllostella*, 5 *Helicoverpa armigera*, 5 *Pyrgomorpha sp*., 5 *Acrotylus blondeli*) captured out of experimental field were released in each cage.



Un pas=military step mouvement perpendiculaire assurant le fauchage= perpendiculaire movement to assure the sweeping mouvement de l'operateur=sweeper's movement

Figure 1**:** Sampling method of insect pests with sweeping net

The observations were carried out at various time intervals after the installation of the cages (D+3 and D+6). It should be noted that the cages were placed in places where the vegetation is still green, in order to allow the insects to feed. This experimental design will enable to evaluate the products' persistence on the vegetation.

Pesticides' biocide effect

Counting was carried out on diagonals from 1 m from the center (to avoid its effect). Five (5) square of 1 m-sided was sampled in each diagonal that is a total of 10 squares per observation plot. The squares are distant between them by 2 m.
Counting was carried out at various time intervals before and after the treatments: D0 and D-1 (right before and 1 days before treatment), D+1 (one day after treatment), D+3 (three days after treatment), D+6, D+9, D+12, D+15, D+18, D+21. At D0, the structure of the insect pests' population was evaluated, to better determine their fluctuation density before treatment. To minimize the errors of counting, at each time interval, the same observer counts in the same diagonal and in the same direction.

Data analysis

The analysis of the variance is selected to carry out a statistical comparison based on principle BACI (Before-After-Counting-Impact) (Stewart-Oaten et al., 1986; Stewart-Oaten et al., 1992; Stewart-Oaten and Bence, 2002; Underwood, 1991, 1992, 1994), followed by multiple comparison test de Student-Newman- Keuls (SNK) if the hypothesis H0 is rejected at $\alpha = 0.05$. In order to keep a statistical validity, the observations before and after the treatments must be carried out in each experimental unit. The expressed values of absolute numbers were transformed by the relation $y = \text{Log}(1 + X)$ and those expressed in percentages were transformed in the form $y = arcsin \sqrt{x}$ to homogenize the variances and assure that distributions for normality do not go to the right (Sokal et Rholf, 1981, 1995). The value of 0 % will be replaced by $1/4n$ and the value 100 % by $100 - 1/4n$, where N represents the denominator used to calculate the percentage, i.e., the size of the reference population. The data entry and processing are carried out using the software SPSS 17.0 Windows.

RESULTS AND DISCUSSIONS

Structure and composition of the insect pests' population of horticultural crops

Before the application of the different synthesis pesticides, we have first checked the structure of the insect pests' population in the experimental field. The composition and the structure of the population in the study zone are illustrated in Figure 2.This composition has a strong dominance (37.5%) of white fly (*Bemisia tabaci*).The caterpillars *Helicoverpa* sp. with 17.82% and *Plutella* with 18.13%, have a good standing in the insect complex.

Density of insects population before treatments

Before the treatments, we preliminary evaluated the infestation level in the different experimental units in order to check the homogeneity of the experimental field. The results of the statistical analysis showed that there is no significant difference between the experimental units F (3/12) = 1.10 p = 0.473. The experimental units are thus homogeneous for the insects' infestation level.

Pesticides' biocide effect at different time intervals

The assessment of the insect pests' population of horticultural crops related to the population density

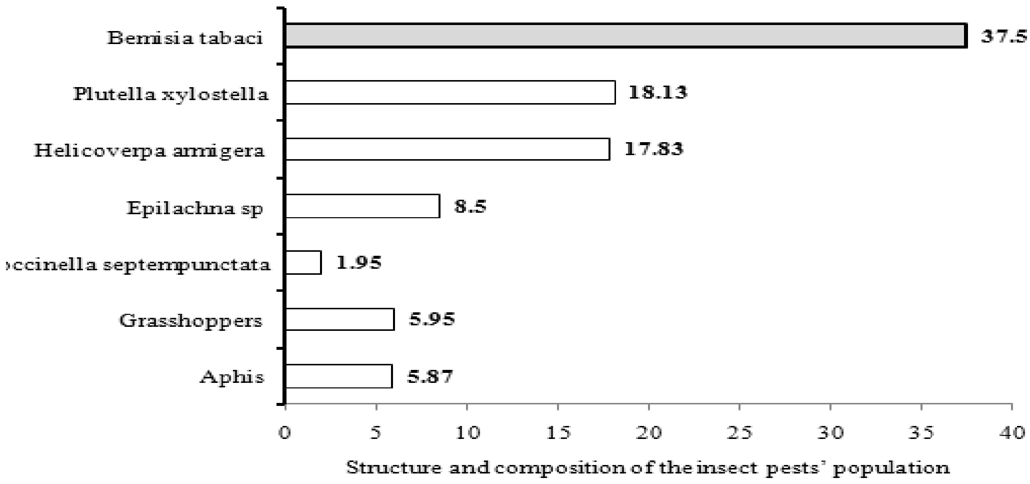


Figure 2: Structure and composition of the insect pests' population in the study zone

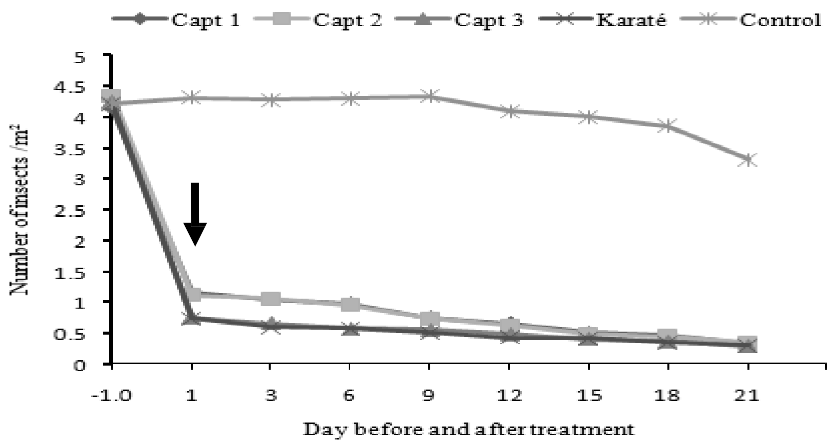


Figure 3: Evolution insect pests' population density before and after treatment with CAPT 88 EC. The arrow indicates the day after treatments.

before and after the treatments. The death rates at different time intervals in the experimental units treated with the synthesis pesticides are calculated by taking into account the density in the Check plots.

Biological efficacy of CAPT 88 EC®

Figure 3 shows global trend of the evolution of the insect pests' population. One day after the treatments, the density of population in the observation plot sharply fell compared to the Check plots, where an increase in the population was noted. This notable fall of density of population of insect pests observed at one day after treatments with CAPT 88 EC at the dose of 0.2 l/ha; 0.3 l/ha and 0.5 l/ha, denote their shock effects on the insect pests of horticultural crops (Cf. Fig.3). This numerical reduction of population continues gradually to reach its lowest value at D+21 in all the treated experimental plots. On the other hand, at the same time intervals, the density of population of insect pests continues to increase in the experimental plots left as Control. The death rate at D+1 after the treatments is 72.29%; 74.25% and 79.82% respectively with the CAPT 88 EC at the dose of 0,2 l/ha (CAPT 1), CAPT 88 EC at the dose of 0.3 l/ha (CAPT 2) and CAPT 88 EC at the dose of 0.5 l/l (CAPT 3). The reference product (Karate 5 EC at the dose of 0.4 l/ha) as well behaved at a similar rate (79.27%) with that of CAPT 88 EC to the amount of 0.5 l/h (Figure 3). In this same time interval, the natural death rate is 0.47% in the Check plots. It should be noted that this slight reduction of the populations of insect pests observed in the check plot is not due to the pesticides (because it was not treated), maybe due to natural causes or a phenomenon of migration. At D+6, these rates are respectively higher than 85% for all the treatments. In all the treated experimental units, we observed that it is starting from

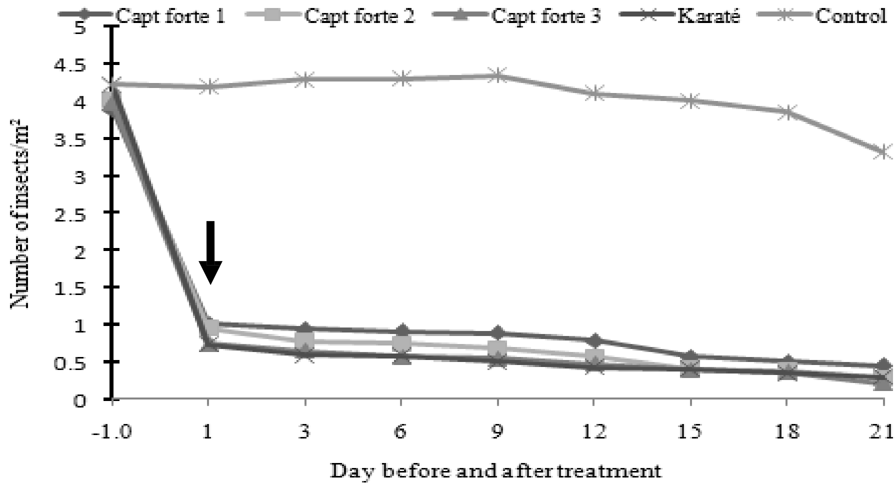


Figure 4: Evolution insect pests' population density before and after treatment with CAPT FORTE 184 WG. The arrow indicates the day after treatments.

D+12 after the treatments that the death rates exceeded 90%. However, it is necessary comparatively to note that the values of the highest death rates were obtained with CAPT 88 EC at the dose of 0.5 l/ha and Karate 5 EC at the dose of 0.4 l/ha, CAPT 88 EC at the dose of 0.2 l/ha and CAPT 88 EC at the dose of 0.3 l/ha. The cumulated death rates obtained are 89.12 ± 1.33%; 88.75 ± 3,53%; 94.11 ± 2.68% respectively with the CAPT 88 EC at the dose of 0.2 l/ha; CAPT 88 EC at the dose of 0.3 l/ha and CAPT 88 EC at the dose of 0.5 l/ha. The reference product gave a cumulated death rate of 92.17 ± 1.29%. On the other hand, in the Check plots, the natural cumulated death rate is 4.06 ± 0.35%. These results confirm that the preeminence of the dose of 0.5 l/ha of CAPT 88 EC on the doses of 0.2 l/ha and 0.3 l/ha of CAPT 88 EC, and this at any time interval.

The general statistical analysis of the results of the density evolution of the insect pests' population of horticultural crops in the treated plots show that there is a major effect of the treatments F (3,12) = 3520 p = 0,001. Treatments CAPT 1 and CAPT 2 belong to the same homogeneous group, they are not significantly different ($p > 0.05$), and in other words, these treatments are rather comparable as for their biological effectiveness on the population of targeted insect pests. The treatments CAPT 3 and Karate 5 EC with the dose of 0.4 l/ha, belong to the same homogeneous group and the Check plots belong another distinct homogeneous group. All the treatments gave higher death rates compared to those noted in the Control plots, where no application was made.

Biological efficacy of CAPT FORTE 184 WG®

The assessment of the population of insect pests related to the fluctuation of the density before and after the treatments. Figure 4 shows a strong reduction of the population densities of the of insect pests one day after the treatments in all the treated plots compared to the Checks where an increase in the density is noted. At D+3, we note that the population reduction is accentuated to reach higher values at D+6 to D+21, whereas at the same time interval the population density continues to increase in the experimental plots constituting the Control. The highest numerical reductions are recorded respectively in the experimental plots treated with CAPT FORTE 184 WG at the dose of 125 g/ha (Captforte 3), with CAPT FORTE 184 WG at the dose of 112.5 g/ha (Captforte 2) COLLECTS and with CAPT FORTE 184 WG at the dose of 62.5 g/ha CAPT FORTE 184 WG (Captforte 1). The reductions of population of insect pests in the experimental plots treated with Karate 5 EC at the dose of 0.4 l/ha are rather comparable with those obtained with Captforte 3.

The death rate at one day after the treatments increased in all the treated plots compared to the Check plots where this rate is about null (0.47%). It is respectively 74.03% for Capt forte 1; 76.05% for Capt forte 2; 81.1% for Capt forte 3. The death rate obtained in the treated plot with Karate 5 EC at the dose of 0.4 l/ha is similar (79.27%) with that obtained with CAPT forte 3. These rates continue to increase according to the time interval, to reach at D+9, 77.12% for Capt forte 1; 83% for Capt forte 2; 86% for Capt forte 3. Also, at the same time interval, Karate 5 EC at the dose of 0.4 l/ha is rather comparable (87%) with CAPT forte 3. Twenty one days after the treatments, these death rates are 88.43% for Capt forte 1; 92% for Capt forte 2 and 94% for Capt forte 3. With the reference product, the death rate is 92.83%. On the other hand, in the pilot pieces where no chemical application was made, we observed slight fluctuations of the populations which are certainly due to natural regulations, because no xenobiotic substance was used into these plots.

The cumulated death rate obtained is ≥ 75% in all the treated plots. On the other hand, in the Check plot, the natural death rate due to the population dynamics of insects is 4,06 ± 0,35%.

The statistical analysis emphasizes a principal effect of the treatments F (2.12) = 34000 p = 0,001 on the population density of insects. The Student Newman-Keuls test classified CAPT FORTE 184 WG at the dose of 62.5 g/ha and CAPT FORTE 184 WG at the dose of 112.5 g/ha in two distinct homogeneous groups. Whereas, the treatments CAPT FORTE 184 WG at the dose of 125 g/ha and Karate 5 EC at the dose of 0.4 l/ha, are classified in the same homogeneous group, that is to say, there is no a significant difference between these treatments ($p > 0.05$), therefore these doses had a rather similar effect on the insects.

Comparison between CAPT FORTE 184 WG and CAPT 88 EC

Eventhought these two synthesis pesticides are differently formulated, with different active substances, we tried to make a close up between them. Even if it is known that nothing obliges us to adopt such step.

The overall results of statistical analysis of all treatments (CAPT 88 EC and CAPT FORTE 184 WG), indicate that the different treatments are significant F (7.24) = 28000 p = 0,001. Tests SNK for multiple comparison of the means emphasize that CAPT 88 EC at the dose of 0.2 l/ha and 0.3 l/ha, belongs to the same homogeneous class. Treatments CAPT 88 EC at the dose of 0.5 l/ha, CAPT FORTE 184 WG at the dose of 125 g/ha and Karate 5 EC at the dose of 0.4 l/ha, are put in the same homogeneous group, they are comparable for their effect on the insect pests of the horticultural crops. The treatment CAPT FORTE 184 WG at the dose of 62.5 g/ha, CAPT FORTE 184 WG at the dose of 112.5 g/ha belongs each to a distinct homogeneous group like the Control.

Pesticides' persistance

Six days after introducing the insects into the cage of persistence, we noticed a population reduction: 95% of cumulated death rate for the white flies; 89% of cumulated death rate for *Plutella;* 92% mortality of *Helicoverpa*; 87% mortality for *Epilachna;* 83% mortality for the grasshoppers (*Acrotylus blondeli* and *Pyrgomorpha* sp.) treated with CAPT 88 EC at the dose of 0,2 l/ha.

With the treatment CAPT FORTE 184 WG at the dose of 62,5g/ha, we recorded 92%; 85%; 89%; 80% and 81% cumulated death rate for *Bemisia tabaci*, *Plutella, Helicoverpa, Epilachna* and the grasshoppers, respectively. These results show that the different synthesis pesticides have a good persistence, which constitutes a best control method against the horticultural crops' insect pests.

ACKNOWLEDGEMENTS

We thank M.B. Coulibaly, T. Issaka, M. Abou and O. Garba for their contribution to the field work.We are also grateful to three referees for comments on earlier versions of this paper. This study was funded by the ALM international, Paris, France.

REFERENCES

Carson R (1962) Silent Spring. Houghton Mifflin Company, Boston, New York, 368 pp.

Edwards CA (1973). Persistent Pesticides in the Environment, 2nd ed. CRC Press Cleveland, 170 pp.

FAO (2001). Directives sur le Criquet pèlerin. Lutte antiacridienne. 2è Edition, 41 pp.

FAO (2003). Guidelines on minimum requirement for ground-based Locust and Grasshopper Sprayers, 20 pp.

FAO (2006). Les pesticides dans la lutte contre le Criquet pèlerin : peser le pour et le contre, 15 p.

Flint LM, van den Bosch R (1981) Introduction to Integrated Pest Management. Plenum Press, New York, 240 pp.

Geddes AMW (1990) The relative importance of crop pests in sub-Saharan Africa. Nat. Res. Inst. Bull. 36: 69 p.

Krauthacker B, Votava-Raic A, Herceg RS, Tjesic-Drinkovic D, Tjesic-Drinkovic DO, Reiner E (2009). Persistent Organochlorine Compounds in Human Milk Collected in Croatia Over Two Decades. Arch. Environ. Contam. Toxicol. 57 (3): 616-622.

Langewald J, Ouambama Z, Mamadou A, Peveling R, Stolz I, Bateman R, Attignon S, Blanford S, Arthurs S, Lomer C (1999). Comparison of an organophosphate insecticide with a mycoinsecticide for the control of *Oedaleus senegalensis* (Orthoptera: Acrididae) and other Sahelian grasshoppers at an operational scale. Biocontol Sci. and Technol. 9: 199-214.

Lomer CJ, Bateman RP, Dent D, De Groote H, Douro-Kpindou OK, Kooyman C, Langewald J, Ouambama Z, Peveling R, Thomas M (1999). Development of strategies for the incorporation of biological pesticides into the integrated management of locusts and grasshoppers. Agric. For. Entomol. 1: 71-88.

Mamadou A (2007). Les effets environnementaux de la lutte chimique contre le Criquet pèlerin (*Schistocerca gregaria* Forskål, 1775) (Orthoptera : Acrididae) dans la vallée du Tafidet au Niger. Thèse de doctorat ès-Sciences Agronomiques. Institut Agronomique et Vétérinaire Hassan II Rabat (Maroc), 169 pp.

Mestre J (1988) Les Acridiens des Formation Herbeuses d'Afrique de l'Ouest, CIRAD- PRIFAS, Montpellier, France, 330 pp.

Prior C, Lomer CJ, Herren HR, Paraiso A, Kooyman C, Smit JJ (1992). The IIBC/IITA/DFPV collaborating research programme on the biological control of locusts and grasshoppers in Lomer, C.J. and Prior, C. (eds.) Biological Control of Locusts and Grasshoppers. C.A.B. International, Wallingford, 8-20.

Römbke J, Moltmann JF (1996). Applied Ecotoxicology. Boca Raton : CRS Press, 282 pp.

Schüpp H, Dehn B, Ruegg J, Niggli U, Bodmer M (1990) Nebenwirkungen von Pflanzenschutzmitteln auf das Bodenökosystem. Bericht der Eidgenössischen Forschungsanstalt für Obst-, Wein- und Gartenbau 42, 161 pp.

Snelson JT (1977) The Need for and Principles of Pesticide Registration. FAO Plant Prot. Bull. 93-100.

Sokal RR, Rholf FJ, 1981. Biometry. The Principe and practice of statistics in biological research. 2nd edition. Freeman and Co. New York, 859 pp.

Sokal RR, Rohlf FJ (1995). Biometry. 3rd ed. W.H. Freeman, San Francisco, 887pp.

Steven NC, Linda L, Maria A, Kristina J (2006). Persistent Organochlorine Pollutants in Children Working at a Waste-disposal Site and in Young Females with High Fish Consumption in Managua, Nicaragua. J. Hum. Environ. 35(3):109-116

Stewart-Oaten A, Murdoch WW, Parker KR (1986). Environmental impact assessment: "pseudoreplication" in time? Ecol. 67 (4): 929-940.

Stewart-Oaten A, Bence JR, Osenberg CW (1992). Assessing effects of unreplicated perturbations: no simple solutions. Ecol. 73:1396-1404.

Stewart-Oaten A, James R, Bence (2002). Temporal and spatial variation in environmental impact assessment. Ecol. Monograph. 71(2): 305-339

Thiollet-Scholtus M (2004). Contribution d'un indicateur de qualité des eaux de surface vis- à-vis des produits phytosanitaire à l'échelle du bassin versant viticole. Thèse de doctorat. Institut National Polytechnique de Lorraine (France), 206 pp.

Underwood AJ (1991). Beyond BACI: experimental designs for testing human environmental impacts on temporal variations in Natural populations. Aust. J. Marine Freshwater Res. 42: 569-587.

Underwood AJ (1992). Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. J. Exp. Mar. Biol. Ecol. 161:145-178.

Underwood AJ (1994). On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecol. Appl. 4:3-15.

Whitten MJ, Oakeshott JG (1991). Opportunities for modern biotechnology in control of insect pests and weeds, with special reference to developing countries, FAO Plant Prot. Bull. 39 (4), 155-181.