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Assessment of the insecticidal activity of aqueous extracts of two local plants for the management of Leucinodes orbonalis Guenee, (Lepidoptera : Pyralidae), pest of eggplant (Solanum aethiopicum), in guinean area of Côte d'Ivoire

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ABSTRACT

Leucinodes orbonalis is a major pest of eggplant (Solanum aethiopicum). Control tests with aqueous extracts of two local plants have been carried out on this pest in Azaguié located Guinean area of Côte d'Ivoire. The experimental design used was a randomized block with three replications consisting in total of seventeen sub-plots corresponding to sixteen treatments and untreated control. After spraying with different concentrations of extract, two groups were distinguished in comparison with the chemical insecticide (K-optimal 35 EC). The group of extract witch permitted to obtain the best results than the chemical insecticide was composed of aqueous extract capsules R. communis (50 and 60 g / l). At these concentrations of 50 and 60 g / l, the highest percentage of the reduction of shoot infestation were respectively 94.71 ± 1.12 % and 93.14 ± 0.85 % (stage before flowering), 95.78 ± 1.07 and 94.40 ± 0.76 % (flowering stage) and 94.73 ± 0.86 and 94.22 ± 0.57 % (fruiting stage). As for the higher fruit percentage of the reduction of shoot infestation were respectively 85.68 ± 1.64 % (60 g / l) and 86.80 ± 1.51 % (50 g / l). The highest numbers of healthy fruit ranged from 206.81 ± 6.16 (50 g / l leaves of C. papaya) and 237.10 ± 6.96 10 fruits per plant (50 g / l seed capsule of R. communis). The aqueous extract of the R. communis seed capsule could be used for integrated pest management against L. orbonalis.

Keywords : Leucinodes orbonalis, Solanum aethiopicum, aqueous extracts, insecticidal activity, seed capsule of Ricinus communis.

1.INTRODUCTION

Eggplant, Solanum aethiopicum (Solanaceae) is a fruit vegetable cultivated in ropical Africa and South America [1]. It is an important source of vitamins and the third vegetable most consumption after tomato and onion [2]. In Côte d'Ivoire, it is cultivated for its fruit and leaves that are used in various culinary techniques [3]. Unfortunately the cultivating of eggplant is subject to attack by many insect pests which an major pest is the shoots and fruits borer, Leucinodes orbonalis. The larvae of this pest attack the plant to stage before flowering, flowering stage and fruiting. They cause importants damages to shoots and fruits, where they feed and grow until the chrysalis [4]. The percentage of fruits infestation can reach 56.29 % and 69.89 % in the shoots and fruits respectively [5]. In Côte d'Ivoire chemical control is the effective method to manage against pests of the eggplant among others L.orbonalis [6]. In addition to control the population of L.orbonalis, the use of chemical insecticide, have unfortunately many disadvantages. These are the presence of residues in fruits, pollution of the environnement, development of insect resistant to chemical insecticides, and nuisance to human health [7, 8, 9]. It is therefore important to seek non-polluting alternative methods for the use of chemical insecticides in the control L.orbonalis. With this in mind we envisaging to evaluate the insecticidal activity of aqueous extracts of the two plants (Carica papaya and Ricinus communis) to control the population of L.orbonalis.

2. MATERIALS AND METHODS

2.1. Study Area

The study was conducted in the locality of Azaguié (5 ° 37 north latitude, 4 ° 02 'west longitude) south of Côte d'Ivoire. This locality have the sub-equatorial climate which is characterized by four seasons [10, 11] ; a long dry season from December to March ; a long rainy season from April to mid-July ; a small dry season from mid-July to mid-September ; a small rainy season, from mid-September to November. The investigation was carried out from April to November 2014, at temperatures varying from 24.7 to 28.3 ° C, the relative humidity ranging between 81.9 and 89.9 % and a rainfall of 1844.49 mm.

2.2. Preparation of aqueous extracts

The leaves of Carica papaya, Ricinus communis and seeds capsule of R. communis seeds were harvested in the locality of Azaguié. These leaves and seeds capsule were dried in the shade for three to four weeks. Leaves and seeds capsules were then crushed by a blender for to obtain powder. For each plant 100 g of powder obtained by organ was diluted in 200 ml of distilled water. The powder and distilled water were then homogenized in the mixer for five minutes. The result mixture was then filtered using poplin. Two others filtrations were made respectively with Whatman paper (3MM) and a funnel containing a cotton. The product obtained in these three filtration was put in melam plates, and concentrated by evaporation in an oven set at 50 ° C for 48 hours until a dry residue.

2.3.Determination of concentrations

The dry residue obtained by organ of each plant has permitted to prepare five concentrations of aqueous extracts : 20 g / l ; 30 g / l ; 40 g / l ; 50 g / l ; 60 g / l. These concentrations were used to treat the elementary plots. For chemical insecticide (K-optimal 35 EC), the recommended dose for the treatment of plants is 4 ml diluted in 1.5 liters of water. This corresponds to a concentration of 0.093 g / l.

2.4. Experimental design

The Kotobi variety of the species Solanum aethiopicum was used. The experimental design is a randomized block with three replications. The experimental plot (10 m x 66 m) is composed of three blocks separated from each other of 2,5 m. Each block consists of 17 sub -plots corresponding to sixteen treatments (Ti, T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14} T_{15}) and control plot untreated (To) (Figure 1). For to avoid contamination during treatments, the sub-plots were spaced two meters. Each sub plot consisted of three rows of 5 plants spaced to one meter. An total 15 plants per sub-plot were treated.

2.5.Application of treatments

For to treate the plants four hand sprayers with a capacity of one liter were used. One sprayers labeled T K-opt was used to apply the K-optimal 35 EC (chemical insecticidal). The others three sprays, labeled T leave C.p ; Tleave R.c and Tcap R.c were used for to apply respectively of aqueous extracts of C .papaya leaves, leaves and seed capsules of R.communis. The different concentrations of each aqueous extract were sprayed one after other. After each treatment, the material used for to apply a concentration has been thoroughly cleaned before to do other appllication. Treatments were performed every two weeks from 23 th day after transplanting (DAT) until 198 th DAT.

2.6. Effect of aqueous extracts on L. orbonalis

For to assess the effectiveness of the aqueous extracts with different concentrations (20 g / l ; 30 g / l ; 40 g / l ; 50 g / l ; 60 g / l), every week after each treatment, 10 randomly selected plants per sub - plot are observed to counted all shoots and identify those that are attacked by larvae of L. orbonalis. At the fruiting satge, in addition to counting the attacked shoots, all fruits on 10 randomly selected plants are harvested to count attacked and unattacked fruits. The percent shoot and fruit infestation reduction, percent of the fruit infested were calculated using the following formula :

$$P_{shoot} = \frac{Po_s - Pr_s}{Po_s} \times 100 \qquad P_{fruit} = \frac{Po_f - Pr_f}{Po_f} \times 100 \qquad P_{fruit\ infested} = \frac{Nb_{fi}}{Nb_{tf}} \times 100$$

P_{shoot}: percent shoot infestation reduction ; Po_s : Number of infested shoots in the control plot ; Pr_s : Number of infested shoots in the treated plot ; P_{fruit} : percent fruit infestation reduction ; Po_f : Number of infested fruit in the control plot ; Pr_f : Number of infested fruit in the treated plot $P_{fruit\ infested}$: percent of the fruit infested ; Nb_{fi} : Number of infested fruits ; Nb_{tf} : Number of total fruits

2.7. Statistical analysis

All data were subjected to ANOVA using the Statistica 7.1 software. The comparison of means was performed by the test of Newman - Keul at the 5 % threshold.

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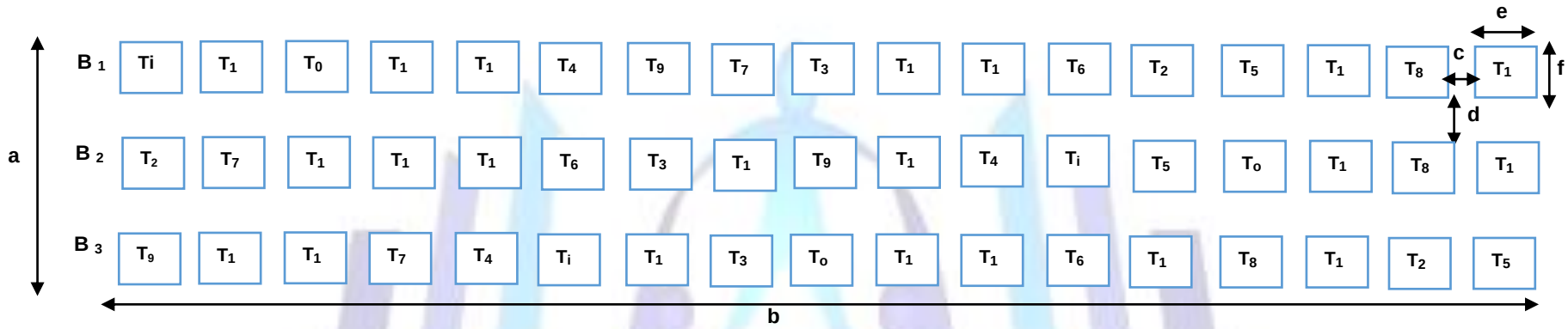

Figure 1 : Experimental design

B_1 : Block 1 B_2 : Block 2 B_3 : Block 3

a = 10 meters ; **b** = 66 meters ; **c** = 2 meters ; **d** = 2,5 meters ; **e**= 2 meters ; **f** = 2 meters

a : lenght of the plot ; **b**: wide of the plot ; **c :** distance between the subplots ; **d** : distance between the blocks ; **e** : wide of the subplot ; **f** : lenght of the subplot

leaf of *C. papaya* : T_1 : 20 g / l ; T_2 : 30 g / l ; T_3 : 40 g / l ; T_4 : 50 g / l ; T_5 : 60 g / l.

leaf of *R. Communis* : T_6 : 20 g / l ; T_7 : 30 g / l ; T_8 : 40 g / l ; T_9 : 50 g / l ; T_{10} : 60 g / l

seed capsule of *R. Communis* : T_{11} : 20 g / l ; T_{12} : 30 g / l ; T_{13} : 40 g / l ; T_{14} : 50 g / l ; T_{15} : 60 g / l

Treatment with chemical insecticidal : T_i : 0,093 g / l and Control : To.

3. RESULTS

3.1. Effects of aqueous extracts on the number of shoots

3.1.1. Stage before flowering

• Number of infested shoots

On the control plot the number of infested shoots was 29.50 ± 1.41 shoots per 10 plants. The numbers of infested shoots obtained at all concentrations of the three aqueous extracts were lower than the untreated plot. With reference chemical insecticide, number of infested shoots was 6.81 ± 0.50 shoots per 10 plants. Statistical analysis showed highly significant differences between the numbers of infested shoots after application of aqueous extracts at different concentrations and K-Optimal (F = 125.75, df = 16; P = 0.000). This permitted to classify extracts into two groups an comparison with chemical insecticide. The first group consisted of aqueous extracts of the leaves C. papaya and R. communis (all concentrations) and the R. communis seed capsule (20, 30 and 40 g / l). This first group aqueous extracts allowed to obtain higher numbers of infested shoots than the one obtained with the chemical insecticide. These numbers were included between 6.41 ± 0.41 (40 g / l of R. communis seed capsule) and 22.87 ± 1.01 (20 g / l of C. papaya leaft) shoots per 10 plants . The second group consisted of capsule aqueous extract of R. communis at concentrations 50 and 60 g / l. With this group, the numbers of shoot infestations (1.38 ± 0.28 and 1.44 ± 0.20 shoots per 10 plants) were lower than number of shoots registered with chemical insecticide (6.81 ± 0.50 shoots per 10 plants) (Table 1).

• Shoots infestation reduction percentages

The percentage of the reduction of shoot infestation recorded with the chemical insecticide was 76.74 ± 1.59 %. Statistical analysis showed highly significant differences between of shoots infestation reduction percentages after spraying to different concentrations of aqueous extracts and chemical insecticide (F = 55, 73; df = 15; P = 0.000). This permitted to classify aqueous extracts into two groups. The first group of aqueous extract (all concentration leaves of C. papaya, R. communis and 30, 40 g / l R.communis seed capsules) allowed to obtain lower percentages of shoot infestation reduction than the one obtained with the chemical insecticide. These percentages ranged from 22.10 ± 2.2 % (20 g / l leaft of C. papaya) and 77.80 ± 1.63 % (40 g / l of seed capsule of R. communis). The second group consists of aqueous extract of seed capsule of R. communis (50 and 60 g / l) allowed to record the higher percentages of shoot infestation reduction (93.14 ± 0.85 % : 60 g / l and 94.71 ± 1.12 % : 50 g / l) than the one recorded with the chemical insecticide. (Table 1).

3.1.2. Flowering stage

• Number of infested shoots

The number of infested shoots recorded on the untreated plot was 36.41 ± 1.83 shoots per 10 plants. The aqueous extracts allowed at all concentrations of record lower numbers shoot infestation than the one the untreated plot. On the plot treated with chemical insecticide the number of infested shoot was 6.07 ± 0.36 shoots per 10 plants. Analysis of variance revealed highly significant differences between the numbers of infested shoots after application of aqueous extracts at different concentrations and the chemical insecticide (F = 177.32; df = 16; P = 0.000). This permitted to classify aqueous extracts into two groups. The first group was represented by aqueous extracts leaves of C. papaya and R. communis at all concentrations and the R. communis seed capsules at concentrations of 20 and 30 g / l. With this group of aqueous extracts numbers of infested shoots were higher than the one registered with the chemical insecticide. These numbers ranged between 8.35 ± 0.36 (40 g / l R. of communis seed capsule) and 23.49 ± 0.80 (20 g / l of C. papaya leaf) shoots per 10 plants. The second group consisted of aqueous extracts of R.communis seed capsule at the concentrations of 50 and 60 g / l permitted to record the lower numbers of infested shoots (1.45 ± 0.32: 50 g / l and 1.52 ± 0.21: 60 g / l shoots per 10 plants) than the one obtained in the plot treated with chemical insecticide (Table 1).

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• Percentage of the reduction of shoot infestation

The percentage of the reduction of shoot infestation recorded with the chemical insecticide was 83.03 ± 1.22 %. The statistical analysis showed highly significant differences between the percentages of reduction of infested shoots after application at different concentrations of aqueous extracts and chemical insecticide (F = 32.77; df = 15; P = 0.000). This allowed to classify aqueous extracts into two groups. The first group represented of aqueous extracts of the C. papaya , R. communis leaves (all concentrations) and seed capsule of R. communis (20, 30 and 40 g / l). The second group of aqueous extracts was composed of R. communis seed capsules at concentrations of 50 and 60 g / l. The percentages of the reduction of shoot infestation obtained with the first group aqueous extract were lower than the one registered with the chemical insecticide. These percentages ranged from 33.41 ± 5.65 % (20 g / l of C. papaya leaf) to 83.53 ± 2.03 % (40 g / l of R. communis seed capsule). With the second group of aqueous extracts, the percentage of the reduction of shoot infestation were higher (94.40 ± 0.76 : 60 g / l and 95.78 ± 1.07 % : 50 g / l) than the one obtained with the chemical insecticide (83.03 ± 1.22 %) (Table 1).

Table 1. Numbers of infested shoots and percentages of the reduction of shoot infestation

		Phenological stages					
		Stage before flowering		Flowering stage		Fruiting stage	
Aqueous extracts of plants	Concen-trations (g / l)	Number of infested shoots per 10 plants	percent shoot infestation reduction (%)	Number of infested shoots per 10 plants	percent shoot infestation reduction (%)	Number of infested shoots per 10 plants	percent shoot infestation reduction (%)
Carica papaya (leaf)	20	22.87 ± 1.01 ^{b}	22.10 ± 2.2 ^{f}	23.49 ± 0.80 ^{b}	33.41 ± 5.65 ^{m}	26.53 ± 1.09 ^{b}	37.63 ± 2.56 ^{j}
	30	21.37 ± 0.67 ^{b}	26.59 ± 3.12 ^{f}	21.11 ± 0.75 ^{c}	40.17 ± 5,13 ^{l}	19.22 ± 0.72 ^{c}	54.29 ± 2.24 ^{i}
	40	17.63 ± 0.39 ^{c}	39.06 ± 3.23 ^{e}	16.51 ± 0.50 ^{d}	53.45 ± 3.32 ^{k}	15.60 ± 0.33 ^{d}	62.50 ± 1,96 ^{h}
	50	15.75 ± 0.69 ^{c}	45.14 ± 4.23 ^{e}	12.98 ± 0.58 ^{e}	63.20 ± 3.25 ^{h}	11.05 ± 0.40 ^{f}	73.45 ± 1,60 ^{f}
	60	16.06 ± 0.54 ^{c}	44.07 ± 4.01^{e}	13.47 ± 0.50 ^{e}	61.78 ± 3.34 ^{i}	11.62 ± 0.36 ^{f}	72.13 ± 1.48 ^{f}
Ricinus communis (leaf)	20	16.22 ± 0.83 ^{c}	44.33 ± 2.99 ^{e}	14.18 ± 0.44 ^{e}	59.86 ± 3.16 ^{j}	13.79 ± 0.30 ^{e}	66.97 ± 1.57 ^{g}
	30	13.10 ± 0.72 ^{d}	54.90 ± 2.90 ^{d}	12.01 ± 0.58 ^{ef}	65.79 ± 3.44 ^{g}	11.05 ± 0.21 ^{f}	73.44 ± 1.39 ^{f}
	40	11.76 ± 0.54 ^{de}	59.91 ± 2.30 ^{cd}	10.07 ± 0.33 ^{fg}	71.34 ± 2.58 ^{ef}	9.83 ± 0.20 ^{fg}	76.29 ± 1.39 ^{e}
	50	10.9 ± 0.40 ^{de}	62.52 ± 1.80 ^{cd}	9.14 ± 0.32 ^{g}	74.15 ± 2.07 ^{d}	7.88 ± 0.22 ^{gh}	81.20 ± 0.92 ^{d}
	60	11.38 ± 0.45 ^{de}	56.16 ± 2.43 ^{d}	9.58 ± 0.27 ^{g}	72.98 ± 1.94 ^{e}	8.33 ± 0.22 ^{gh}	80.09 ± 0.98 ^{d}
Ricinus communis (seed capsule)	20	11.08 ± 0.42 ^{de}	63.12 ± 1.46 ^{cd}	10.40 ± 0.39 ^{fg}	70.55 ± 2.44 ^{f}	9.93 ± 0.20 ^{fg}	76.01 ± 1.37 ^{e}
	30	9.45 ± 0.39 ^{e}	67.60 ± 1.49 ^{c}	8.35 ± 0.36 ^{g}	76.57 ± 1.52 ^{c}	7.65 ± 0.21 ^{gh}	81.73 ± 0.89 ^{d}
	40	6.41 ± 0.41^{f}	77.80 ± 1.63 ^{b}	5.73 ± 0.41 ^{h}	83.53 ± 2.03 ^{b}	6.28 ± 0.22 ^{hi}	84.91 ± 0.91 ^{b}
	50	1.38 ± 0.28 ^{g}	94.71 ± 1.12 ^{a}	1.45 ± 0.32 ^{i}	95.78 ± 1.07 ^{a}	2.13 ± 0.33 ^{j}	94.73 ± 0.86 ^{a}
	60	1.44 ± 0.20 ^{g}	93.14 ± 0.85 ^{a}	1.52 ± 0.21^{i}	94.40 ± 0.76 ^{a}	2.36 ± 0.17 ^{j}	94.22 ± 0.57 ^{a}
Chemical insecticide (Ti)	0.093	6.81 ± 0.50 ^{f}	76.74 ± 1.59 ^{b}	6.07 ± 0.36 ^{h}	83.03 ± 1.22 ^{b}	5.12 ± 0.20 ^{i}	87.80 ± 0.63 ^{b}
Control (To)		29.50 ± 1.41 ^{a}	-	36.41 ± 1.83 ^{a}	-	43.61 ± 2.11 ^{a}	-

In the same column the means followed by the different letters are significantly different (Newman-Keuls test at the threshold of 5 %)

3.1.3. Fruiting stage

• Number of infested shoots

The number of infested shoots on the control plot was 43.61 ± 2.11 shoots per 10 plants. As in the stage before flowering and flowering stage, the numbers of infested shoots, after treatment with the three aqueous extracts at all concentrations, were lower than the one obtained in the control plot. With the the chemical insecticide, infested shoots was 5.12 ± 0.20 shoots per 10 plants. statistical analysis showed highly significant differences between the numbers of infested shoots after application the aqueous extracts at different concentrations and chemical insecticide ($F = 239.68$, $df = 16$; $P = 0.000$). This allowed to distinguish two groups of extracts in comparison to the chemical insecticide. The first group was composed of aqueous extract of C. papaya leaf R. communis at all concentrations and the R.communis seed capsule at concentrations of 20, 30 and 40 g / l. The numbers of infested shoots obtained with this group aqueous extracts were higher than the one registered with the chemical insecticide. The numbers ranged from 6.28 ± 0.22 (40 g / l of seed capsule of R. communis) to 26.53 ± 1.09 (20 g / l of leaf C.papaya) shoots per 10 plants. The second group was represented the aqueous extract of seed capsule R.communis at concentrations of 50 and 60 g / l. With this second group shoots the numbers of infested shoot (2.13 ± 0.33 : 50 g / l and 2.36 ± 0.17: 60 g / l shoots per 10 plants) were lower than the one obtained on the plot treated with chemical insecticide (5.12 ± 0.20 shoots per 10 plants). (Table I).

• Percentage of the reduction of shoot infestation

The percentage of the reduction of shoot infestation obtained with chemical insecticide was 87.80 ± 0.63%. Analysis of variance showed highly significant differences between the percentages of reduction of infested shoots after application at different concentrations the aqueous extracts and chemical insecticide ($F = 102.45$; $df = 15$; $P = 0.000$). This allowed to distinguish two groups of aqueous extracts. The first group composed of aqueous extracts of leaves of C. papaya, R.communis (all concentrations) and the R. communis seeds capsule (all concentrations), the percentages of reduction of infested shoots were lower than the one recorded with chemical insecticide. These percentages ranged from 37.63 ± 2.56 (20 g / l of leaf of C. papaya) to 84.91 ± 0.91 % (40 g / l of seed capsule of R. communis). The second group represented of the aqueous extract of seed capsule of R. communis at concentrations 50 and 60 g / l. The percentages of reduction of infested shoots recorded with this second group were higher (94.22 ± 0.57: 60 g / l and 94.73 ± 0.86% 50 g / l) than the one obtained on the plot treated with chemical insecticide (87.80 ± 0.63%) (Table 1).

3.2. Effects of the aqueous extracts on the number of fruits

3.2.1. Number of fruits

• Total number of fruit

The total number of fruits harvested on the control plot was 194.05 ± 13.25 fruits per 10 plants. The three aqueous extracts (all concentrations) allowed to have the higher numbers of fruits than the one obtained on the control plot. The total number of fruits obtained with the chemical insecticide was 231.57 ± 6.95 fruits per 10 plants. Statistical analysis showed significant differences in the numbers of fruits after spray with different concentrations of aqueous extracts and chemical insecticide ($F = 2.60$; $df = 16$; $P < 0.01$). This permitted to classify two groups of aqueous extracts. The first group consists aqueous extracts of leaves of C. papaya, R. communis (all concentrations) and seed capsule of R. communis at concentrations of 20 and 30 g / l. The second group consists aqueous extract of R.communis seed capsule (40, 50 and 60 g / l). The treatment with the first group permitted to register the lower numbers of fruits or statistically equal than the one obtained with chemical insecticide. The treatment with the second group permitted the higher numbers of fruits than the one obtained on the plot treated with the chemical insecticide. These numbers were 235.67 ± 6.95 (40 g / l), 244.24 ± 7.21 (60 g / l) and 244.38 ± 7.20 (50 g / l) fruits per 10 plants (Table 2).

• Number of healthy fruits

The number of healthy fruits on the untreated plot (control) was 122.48 ± 6.43 fruits per 10 plants. After application of the three aqueous extracts (all concentrations), numbers of healthy fruits were higher than the one obtained in the control plot. 221.29 ± 7.24 fruits per 10 plants were obtained with the chemical insecticide. The statistical analysis revealed significant differences in the numbers of fruit after spray with different concentrations of aqueous extracts and chemical insecticide. (F = 13.71, df = 16, P = 0.000). This allowed to classify two groups of aqueous extracts. The first group consisted of aqueous extracts of leaves C. papaya, R.communis (all concentrations) and seed capsule of R.communis (20, 30 and 40 g / l). This first group numbers of healthy fruits were lower or statistically equal than the one recorded with the chemical insecticide. The numbers of healthy fruits obtained with this group of aqueous extracts ranged from 166.38 ± 10.42 (20 g / l, leaf of C. papaya) to 210.14 ± 5.59 (40 g / l seed capsule of R.communis). The second group was composed of seed capsule of R.communis (50 and 60 g / l) allowed to register higher numbers of healthy fruit compared the one obtained with the chemical insecticide. These numbers were 236.43 ± 6.03 (60 g / l) and 237.10 ± 6.96 (50 g / l) fruits per 10 plants (Table 2).

• Number of infested fruits

On the control plot the number of infested fruits was 70.29 ± 9.20 fruits per 10 plants. The numbers of infested fruit after treatment with the three extracts at all concentrations were lower than the one obtained in the control plot. With chemical insecticide, 10.29 ± 0.63 fruits infested per10 plants were obtained. Analysis of variance revealed significant differences in the numbers of infested fruits after pulverization with different concentrations of aqueous extracts and chemical insecticide (F = 33.28 ; df = 16, P = 0.000). This allowed to classify aqueous extracts in two groups. The first group consisted of extracts leaves of C. papaya, R.communis (all concentrations) and seed capsule of R.communis (20, 30 and 40 g / l). The second group consists seed capsule of R. communis (50 and 60 g / l).The treatments with the first group of extracts registered higher numbers (17.95 ± 0.96 to 35.67 ± 2.79: leaves of C. papaya ; 15.67 ± 0.52 to 30 ± 1 66 : leaves of R. communis ; 13.43 ± 0.64 to 27.10 ± 1.28: seed capsule of R. communis) than the one obtained the chemical insecticide. The treatment with the the second group of aqueous extracts registered lower numbers infested of fruits than the chemical insecticide. These numbers were 7.29 ± 0.43 and 7.81 ± 0.48 fruits per 10 plants at concentrations of 50 and 60 g / l respectively.

3.2.2. Percentage of fruits infestation

The percentage of fruits infestation registered in the control plot was 33.93 ± 2.44 %. The percentage infested of fruits after application aqueous extracts at all concentrations were lower than the one obtained in the untreated plot (control). With chemical insecticide, percentage of fruits infestation was 4.54 ± 0.23 %. Statistical analysis showed highly significant differences between the percentages of fruits infestation after pulverization with different concentrations of aqueous extracts and chemical insecticide (F = 124.74; df = 16; P = 0.000). In comparison with chemical insecticide, aqueous extracts have been classify into two groups. The first group consisted aqueous extracts of leaves of C. papaya, R. communis (all concentrations) and seed capsule of R. communis (20, 30 and 40 g / l). With this group of extracts the percentages of fruits infestation were higher than the one recorded with the chemical insecticide. These percentages ranged from 7.8 ± 0.19 (50 g / l) to 17.41 ± 0.56 % (20 g / l) for leaf of C. papaya ; ranged from 6.83 ± 0.19 (50g / l) to 14.88 ± 0.33 % (20 g / l) for leaf of R. communis and ranged from 5.67 ± 0.17 (40 g / l) to 12.43 ± 0.16 % (20 g / l) for seed capsule of R. communis. The second group was composed seed capsule of R.communis (50 and 60 g / l) permitted to obtain lower percentages of fruits infestation than the one obtained with the chemical insecticide. These rates were 2.97 ± 0.14 (50 g / l) and 3.1 ± 0.18 % (60 g / l).

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3.2.3. Percentage of the reduction of fruit infestation

The percentage of the reduction of fruit infestation obtained with the chemical insecticide was 81.40 ± 2.09 %. Statistical analysis showed highly significant differences between the percentage of the reduction of fruit infestation after application at different concentrations of aqueous extracts and chemical insecticide ($F = 15.10$; $df = 15$; $P = 0.000$). This allowed to classify two groups of aqueous extracts. The first group consisted aqueous extracts of leaves of C. papaya, R. communis (all concentrations) and seed capsule of R. communis (20, 30 and 40 g / l). The second group consisted of seed capsule of R.communis (50 and 60 g / l). The treatment with first group of aqueous extracts permitted to obtain the lower percentages of the reduction of fruit infestation than the one obtained with the chemical insecticide. These percentages ranged from 41.36 ± 3.74 (20 g / l) to 66.73 ± 4.06 % (50 g / l) for leaf of C. papaya ; 48.04 ± 3.95 (20 g / l) to 70.10 ± 3.60 % (50 g / l) for leaf of R. communis and 52.28 ± 3.82 (20 g / l) to 74.93 ± 3.02 % (40 g / l) for seed capsules of R..communis. The second group of aqueous extracts permitted to obtain higher percentages of the reduction of fruit infestation (60 g / l : 85.68 ± 1.64 % ; 50 g / l: 86.80 ± 1.51 %) than the one recorded with the chemical insecticide.

Table 2. Number, percentage of infestation and percentage of the reduction of fruit infestation

Aqueous extracts of plants	Concentrations (g /l)	Number of fruit per 10 plants			Percentage of fruit infestation (%)	Percentage of the reduction of fruit infestation (%)
		total	healthy	infested		
Carica papaya (leaf)	20	202.05 ± 12.94 ^{i}	166.38 ± 10.42 ^{k}	35.67 ± 2.79 ^{b}	17.41 ± 0.56 ^{b}	41.36 ± 3.74 ^{m}
	30	211.95 ± 7.96 ^{g}	179.95 ± 9.86 ^{i}	32 ± 2.21 ^{c}	14.71 ± 0.36 ^{c}	46.61 ± 3.55 ^{l}
	40	209.19 ± 9.72 ^{gh}	185.24 ± 8.98 ^{h}	23.95 ± 1.25 ^{f}	11.53 ± 0.46 ^{d}	57.44 ± 3.72 ^{i}
	50	224.76 ± 6.99 ^{d}	206.81 ± 6.16 ^{e}	17.95 ± 0.96 ^{hi}	7.8 ± 0.19 ^{ef}	66.73 ± 4.06 ^{f}
	60	224.05 ± 7.24 ^{d}	205.43 ± 6.51 ^{e}	18.62 ± 0.98 ^{h}	8.27 ± 0.27 ^{e}	65.52 ± 3.72 ^{f}
Ricinus communis (leaf)	20	206.10 ± 11.11 ^{h}	176.10 ± 9.55 ^{j}	30 ± 1.66 ^{d}	14.88 ± 0.33 ^{c}	48.04 ± 3.95 ^{k}
	30	212.95 ± 9.66 ^{g}	185.71 ± 8.47 ^{h}	27.24 ± 1.34 ^{e}	12.76 ± 0.27 ^{d}	51.69 ± 4.22 ^{j}
	40	215.90 ± 8.91 ^{f}	196.19 ± 8.28 ^{f}	19.71 ± 0.92 ^{h}	9.22 ± 0.31 ^{e}	63.10 ± 4.10 ^{g}
	50	231.95 ± 6.27 ^{c}	216.10 ± 5.90 ^{c}	15.67 ± 0.52 ^{i}	6.83 ± 0.19 ^{ef}	70.10 ± 3.60 ^{d}
	60	231.76 ± 6.27 ^{c}	215.43 ± 5.87 ^{c}	16.52 ± 0.58 ^{i}	7.13 ± 0.19 ^{ef}	68.58 ± 3.70 ^{e}
Ricinus communis (seed capsule)	20	217.10 ± 9.64 ^{e}	190 ± 8.40 ^{g}	27.10 ± 1.28 ^{e}	12.43 ± 0.16 ^{d}	52.28 ± 3.82 ^{j}
	30	230.67 ± 6.16 ^{c}	210.14 ± 5.59 ^{d}	20.52 ± 0.70 ^{g}	8.89 ± 0.17 ^{e}	61.22 ± 4.48 ^{h}
	40	235.67 ± 6.95 ^{b}	222.24 ± 6.44 ^{b}	13.43 ± 0.64 ^{j}	5.67 ± 0.17 ^{fg}	74.93 ± 3.02 ^{c}
	50	244.38 ± 7.20 ^{a}	237.10 ± 6.96 ^{a}	7.29 ± 0.43 ^{l}	2.97 ± 0.14 ^{h}	86,80 ± 1.51 ^{a}
	60	244.24 ± 7.21 ^{a}	236.43 ± 6.03 ^{a}	7.81 ± 0.48 ^{l}	3.19 ± 0.19 ^{h}	85.68 ± 1.64 ^{a}
Chemical insecticide	0,093	231.57 ± 6.95 ^{c}	221.29 ± 7.24 ^{b}	10.29 ± 0.63 ^{k}	4.54 ± 0.23 ^{gh}	77.40 ± 2.09 ^{b}
Control (To)		194.05 ± 13.25 ^{j}	122.48 ± 6.43 ^{l}	70.29 ± 9.20 ^{a}	33.93 ± 2.44 ^{a}	-

. In the same column the means followed by the different letters are significantly different (Newman-Keuls test at the threshold of 5 %)

4.DISCUSSION

During the three phenological stages, the number of infested shoots and percentage of the reduction of shoot infestation varied with treatment. The statistical analysis allowed to distinguish two groups of aqueous extracts in comparison with chemical insecticide. The aqueous extract of leaf C. papaya belonging the first group, induced the percentages of the reduction of shoot infestation ranged from 22.87 to 73.45 % against 87.80 % for the chemical insecticide. The percentages of the reduction of fruit infestation ranged 41.36 to 66.73 % against 86.80 % for the chemical insecticide. This extract controlled less the population of L. orbonalis than chemical insecticide. This would be due to the fact that active substances such as lambda cyhalothrin (15g / l) and Acetamiprid (20 g / l) contained in the chemical insecticide control L. orbonalis better than the aqueous extract of C. papaya . The insecticide effect of the leaves of C. papaya was demonstrated by several authors [12, 13]. Gnago et al. (2010) reported in their study that the aqueous extract of leaf C. papaya is a selective insecticide, that did not control the pest insects of okra at all the concentrations. According these authors, the aqueous extract of leaves of C. papaya, the active substance which is papain, effectively controlled the aphids. As for Tahiri et al., (2010), they mentioned the toxicity of alcoholic, hexane and aqueous extracts of seeds and the leaves of C. papaya on the termite Macrotermes bellicosus. The aqueous extract of leaf R. communis belonging also the first group, allowed to obtain the percentages of the reduction of shoot infestation ranged 44,33 to 81,20 %, and the percentages of the reduction of fruit infestation ranged 48.04 and 70.10% against 87.80% for chemical insecticide. This aqueous extract of leaf R. communis have been less effective than the chemical insecticide. However the insecticidal effect of the aqueous extract of leaves R. communis was demonstrated by Aouinty et al., (2006) [14]. on the larvae of Culex pipiens, Aedes caspius, Culiseta longiareolata and Anopheles maculipennis. These authors reported a remarkable effectiveness of the aqueous extract of leaves R.communis on the larvae of C. pipiens . Aqueous extract of seed capsule of R.communis at concentrations of 50 and 60 g / l belonging the second group of extract was obtained the higher percentages of the reduction of shoot infestation and the percentages of the reduction of fruit infestation than those registered with aqueous extracts of leaves of C. papaya, R.communis and chemical insecticide. This aqueous extract of seed capsule of R. communis was more effective in control of L. orbonalis than the other two extracts and chemical insecticide. Similar results on the effectiveness of aqueous extract of seed capsule R. communis had been obtained by Tano et al., (2012) [15]. Indeed these authors, in their study in the control Coelaenomenodera lameensis major insect pest of oil palm, have reported that the highest mortality rate of adults were obtained with the aqueous extract of capsule seed R. communis to the concentration of 0.8 g / ml. The insecticidal effect of aqueous extracts of the leaves and seed capsule R. communis is due to ricin, one of their main components. Several authors have reported that ricin induced irreversible inhibition of protein synthesis in insect cells by inactivation of ribosomes, causing cell death [16,17,18]. Other works on the use of aqueous extracts to control L. orbonalis were conducted by several authors. Chitra et al. (1993) [19]. observed after pulverization the aqueous extracts of leaf Azadirachta indica, the percentage of infestation of 0.1 % against 69.55 % for the control. Ghatak et al. (2009) [20]. reported the percentage of the reduction of fruit infestation of eggplant an using of aqueous extract of leaf Annona squamosa. Regarding the fruits harvested on different plots, Aqueous extract of seed capsule R. communis at concentrations of 50 and 60 g / l permitted to obtain a higher number of healthy fruits than chemical insecticide. This could be explained by the fact that these concentrations would contain a significant quantity of active substance, ricin which controlled effectively the population of L. orbonalis. Similar results were reported by Ashadul et al. (2014) [21]. reported that in their study that the higher number of healthy fruits were obtained with aqueous extract of leaf A. indica at concentration of 50 g / l.

5.CONCLUSION

This study showed that percentages of the reduction of shoot and fruit infestation varied with treatment. During the three phenological stages that percentages of the reduction of shoot infestation were higher at 94 % with the seed capsule of R. communis at concentrations of 50 and 60 g / l. At these same concentrations and the same aqueous extract, the percentage of the reduction of fruit infestation was 85 %. The higher number of healthy fruits was obtained with the aqueous extract of seed capsule R. communis (50 and 60 g / l). This extract was therefore more effective than the aqueous extracts of leaves of C. papaya R.communis and chemical insecticide. The aqueous extract of the R. communis seed capsule could be used for integrated pest management against L. orbonalis.

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