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INSECTICIDE SPRAYING REGIME TO CONTROL INSECT PEST OF COWPEA: MANAGEMENT AND MONITORED APPLICATION OF CYPERMETHRIN IN LOMAMI PROVINCE, DR CONGO

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ABSTRACT

Cowpea is one of the most important grain legumes growing in Lomami province, DR Congo. Despite the high potential for production in this region, insect pests are the main problems of cowpea producers. They most often belong to the following categories: pod borers (*Maruca vitrata*), pod-sucking bug (PSB) complex of which *Riptortus dentipes* and *Apium varium*. A study was conducted to evaluate the efficacy of three spray regimes of Cypermethrin on the density of *M. vitrata, A. varium and R. dentipes* and the performance of yield components of cowpea. Trials were conducted at three different sites, one controlled (INERA) and two peasant sites (Mpiana and Yamba). Three genetically improved varieties called Mujilanga, CNGKASC2-1-1-T, and CNGKASA7-2-M of cowpea were used. The tests were conducted using a split-plot device with three repetitions. Results demonstrate that Cypermethrin is effective against insect pests of cowpea, the population of all target pest were found to decrease in the plot treated to the untreated plot. Application of insecticide three times recorded the highest increased grain yield between 93 and 169 %. The average yield for spray regime recorded 689.1 kg, 651.8 kg and 553.3 kg for D1, D2 and D3 sprays. Famers can use two or three spray regimes of Cypermethrin to manage the pest, this option may reduce the cost, in order to achieve a sustainable level of agricultural and a high level of environmental and human health protection in cowpea field in DR Congo.

Contribution/Originality: This study is one of the very few studies which have investigated the chemical spraying regime to a cowpea insect pest in the field in the central part of DR Congo. The results finding that insect pest were below the economic threshold and grain yield is highly significant with the tree or two sprayings of Cypermethrin.

1. INTRODUCTION

Insects' pests of crops occupy a prominent place following the direct and indirect damage they cause to seasonal crops in the province of Lomami, Democratic Republic of Congo (D.R.C). Several authors have reported that everywhere in the world especially in the tropics and subtropical insects pest are recurrent problems on the crops

[1-4]. The direct consequences of arthropod pest are destroyed about 25 % of world's annual crop production [5] losses crops production quantitatively and qualitatively and reduce overall the value merchant [6].

In this context, they supply sufficient and healthy food to become a major problem in all areas of food production in the country. The repercussions of this situation at the overall level of the DRC are characterized by malnutrition (36% of the population), poverty (3%), underweight in children under 5 years (23.4%) especially in rural areas and in the end severe food insecurity for more than 6.4 million people [7].

The scarcity of animal protein or the high price of this product aggravates the malnutrition and food insecurity. To break with these situations, it is necessary to give a high priority to the production of food legumes as a partial solution of the protein-rich food supply in the DRC or malnutrition and food crisis. Cowpea is one of the food legumes that play an important role in human nutrition in Africa and Asia because of the high protein content. The biological value of its dry seeds contains 26.61% protein, 3.98% fat, 56.24% carbohydrate, 8.60% moisture, 3.84 ash, 1.38% crude fiber, 1. 51% crude energy and 54.85% nitrogen in a crude extract [8].

Among the essential amino acids are lysine, tryptophan and methionine [9, 10]. Cowpea seeds are easy to handle, transport and store. It plays an important role in the supply of nitrogen to the soil in cereal crops (maize, millet, sorghum) [11] and as green manure to maintain soil productivity [12]. Because of its strengths, it must make available this food. Efforts will have to be directed in improving its yield per unit area while substantially reducing losses due to pests.

In the study area, cowpea production is more practiced by small-scale producers (60%), working on reduced areas whose yield is equivalent to about 1/5 of those obtained by farmers in major production areas worldwide. The National Institute of Statistics (INS) report in the DRC supports that agricultural production of dominant crops based on roots and tubers, cereals, pulses and other industrial plants, fruit and vegetable crops are often made according to a system of rain-fed production of substance and contributes to more or less 40.3% of GDP and occupies about 70% of the population [13]. This system is subject to hazards of all kinds that affect the performance of agriculture [14]. These alarming signals show that the ultimate challenge facing agriculture in the world and in Lomami province in particular is to increase production in order to provide food products without disruption.

However, according to Mukendi, et al. [15] the cowpea yield is low in several production areas to meet the need for food in the DRC. It is mainly insect pests that are the main agents that cause losses in cowpea yield in the DRC [16]. Thus, more and more the presence and the management of insects on the cowpea cultivation affect the farmers (modality of control), the consumers (quantity offered and quality of the product) and the merchant (out of stock). This culture offers great potential for food security, generates income and reduces poverty in Lomami province. Domestic production was estimated at 68,094 Tones, 48% of which was produced in the agricultural area of Lomami [16]. At the African and world level, Nigeria and Niger are the largest producers with less than 50% of production [17]. Outside Africa, this crop is cultivated in Asia and the Americas [18].

Although it has many agronomic, socio-economic and nutritional advantages, its production in the countryside is hampered by various challenges. The plan of management of pest and pesticide (PGPP) of 2018 estimates that several animal and plant pests, as well as fungal diseases, are rampant in cowpea farming in this agricultural area as reported by farmers. The study report was done by Mukendi, et al. [19] in Ngandajika territory confirms that insect pests are to be largely responsible for cowpea yield loss. They most often belong to the following categories: (i) pod borers (*Maruca vitrata*), pod-sucking bug (PSB) complex of which *Riptortus dentipes* and *Anoplocnemis curvipes*, thripidae *Megaluropthrips sjostedti* are the most damaging; (ii) aphids (*Aphis craccivora*), (iii) beetles (*Ootheca*, *medyia*) ect.

Insects pests pose the greatest threat to cowpea production and attack this crop from germination to storage [20, 21] ranging from plant leaf attack, stem mining, plant collapse, flower suckers, seed mummification and pods, internal rots, damaged seeds, and a high proportion of poor quality cowpea seed. Indirectly, they transmit diseases causing significant damage to crops [22]. Therefore, adequate measures to evade and protect cowpea enemies in the field are imperative to capitalize on the benefits of this crop. All the time, obtaining a good yield and avoiding infestation by insect pests rely either on the use of resistant varieties or on the use of chemical molecules.

Theoretically, according to Li, et al. [23] the use of productive and pest-tolerant varieties is compatible with the use of insecticides. Omolehin, et al. [24] claim that pesticides are unique sources of protection among pest. They do not directly affect productivity but serve to eliminate the factors that directly reduce the productivity of the crop. This method achieves high yields, although efforts are intensified to reduce the amount of chemical insecticides used worldwide through the introduction of IPM. Adeola, et al. [25] stated that pesticide treatments will probably remain the most important component of crop protection programs in the foreseeable future of agriculture, even in the face of new control methods exploiting the genetic resistance of plants and biological control.

However, the effectiveness of pesticides depends mainly on their level of use in relation to the market price. This is in practice through the use of the recommended and approved molecules for use in cowpea cultivation in the country. But the choice of a molecule that offers the characteristics of efficiency and used security are lacking at the level of producers for this region of DR Congo. Pesticides are often used indiscriminately by users who do not know how to read the labels or the recommended use rates. It is therefore agreed that farmers can acquire the technical knowledge of pesticide use by adjusting the level of use in relation to the price in the market. This method must inevitably go through the evaluation of the efficiency and effectiveness of existing chemical molecules by researchers following the standards of integrated pest management. However, these methods are until now limited, unclear and needs further investigations in cowpea crops at Lomami province, DR Congo. Although the use of pesticides is much more widespread in market gardening to control pests and diseases anarchically, which can endanger human, animal and environmental health.

Generally, the control of insect pests in the field by the farmers of Ngandajika agricultural zone, particularly in the province of Lomami is not directed, only the chance of nature and providence is the rule observed. This attitude suggests a control through natural enemies. Overall, the damage is highly variable, as cowpea pests in cultivation vary greatly between field and year. However, the poor yield obtained in their fields suggests that this so-called natural control itself does not allow them to provide adequate protection as pointed out by Kamara, et al. [6]. Thus, the yields are low between 50 and 250 kg / ha [19] and in some cases zero yield. In fact, in all cowpea areas, the use of insecticides has been the mainstay of pest control and it is considered the most effective and dependable once insects have exceeded the economic injury level [11, 25]. Although some data can be gathered from general studies on pesticides used at the African level, in the DRC in particular, it is difficult to have global data about their use in the control of cowpea pests. If they still exist, this information is not available to researchers as a baseline. This state reflects a lack of knowledge at the level of research and peasants with regard to the management pest by use of chemical molecules in this area of production.

However, in most cowpea production systems against the pest complex, chemical control alone or in the context of an integrated pest management program is required. Therefore, the effectiveness of chemical control on cowpea pests would be considered essential to put in place in order to provide a solid foundation for further scientific research on the efficiency and effectiveness of chemical control in Lomami province. The results of this work will provide a basis of judicious use of chemical pesticide application on cowpea crop and can be found an option in integrated pest management programs. This argument would help increase the yield of more leguminous thus contributing to household and DRC food security.

2. RESEARCH QUESTIONS

What are effects of spraying regime with Cypermethrin on population of insect pests (*R. dentipes*, *M. vitatra* and *A. varium*) and yield components of cowpea?

2.1. Goal

The objective of this study is to apprehend within the framework of a sustainable agriculture, the performance of the reduction of the frequencies of the chemical treatment in the protection against *A. varium*, *M. vitrata* and *R. dentipes* insects pests of cowpea. Specifically, the aim is to evaluate the efficacy of three spray regime of Cypermethrin on density of *M. vitrata*, *A. varium and R. dentipes* and the performance of yield components of cowpea under chemical control.

2.2. Hypotheses

To achieve this goal, we have developed hypotheses about the frequency of application that is thought to be appropriate for controlling insect pests of cowpea. These assumptions were made as follows:

1. There is a relationship between spraying frequencies of Cypermethrin and density of *A. varium*, *R. dentipes* and *M. vitrata* in cowpea field

2. There is a relationship between spraying of Cypermethrin at the sensitive stage of cowpea and components yield of cowpea.

3. MATERIALS AND METHODS

The study was conducted in the South Central Ecological Zone of DRC in the Lomami province, Ngandajika Territory. The territory has a subtropical climate of the Aw4 type according to the Köppen classification, with an average annual temperature of 25 °C and has a bimodal rainfall distribution. The first rains are mid-August with peaks in November and the second rains begin in mid-January to mid-May. This allows to realize two seasons of cultures in a year. However, the annual rainfall varies between 1200 and 1800 mm and a growing season of 140 - 120 days respectively for season A and season B. The dominant rainfed crops are sown at the beginning of September and the harvest at the end of December. Soils in the territory are variable and generally have fertile and infertile places. The soil type is a ferralsol according to the INEAC classification [26].

The organic matter content is low and the nutrient macros such as nitrogen and phosphorus are limited in some places. The results of soil analysis in Ngandajika area by Muyayabantu, et al. [27] confirms this observation.Trials were conducted at three different sites Figure 1 one controlled and two peasant sites. The controlled environment is located at the Station of the National Institute for Agricultural Research and Research (INERA) of Ngandajika which has been used for experiments.In peasant environment it is the village of Mpiana and the village of Yamba Figure 1. These are areas of older agricultural exploitation, more advanced in the process of artificialization of the natural environment by deforestation, erosions, significant parasite pressure. The selection of these sites is linked to the proximity of the agricultural research center, the nucleus of agricultural innovation in the region. The accessibility of farmers from two villages to the research station was considered necessary to facilitate interactions between farmers and researchers during the experimental phase.

The research center of INERA Ngandajika is located at (6º 45 South latitude, 23º 57' longitude and 790 m of altitude). The Mpiana site is located at (6° 36 'South latitude, 23 ° 56' East longitude, 685 m altitude) 28 km from the INERA center while the Yamba site is located at (6° 46 'South latitude and 24 ° 01' East longitude at 700 m altitude) at 11 km from agronomic research center. Both sites are historically well known for the production of rainfed crops and cowpeas. These sites face the problem of infestation of the cowpea culture by different insect pests that there is reason to approach the method of chemical control which is practiced without adequate knowledge in a peasant environment.

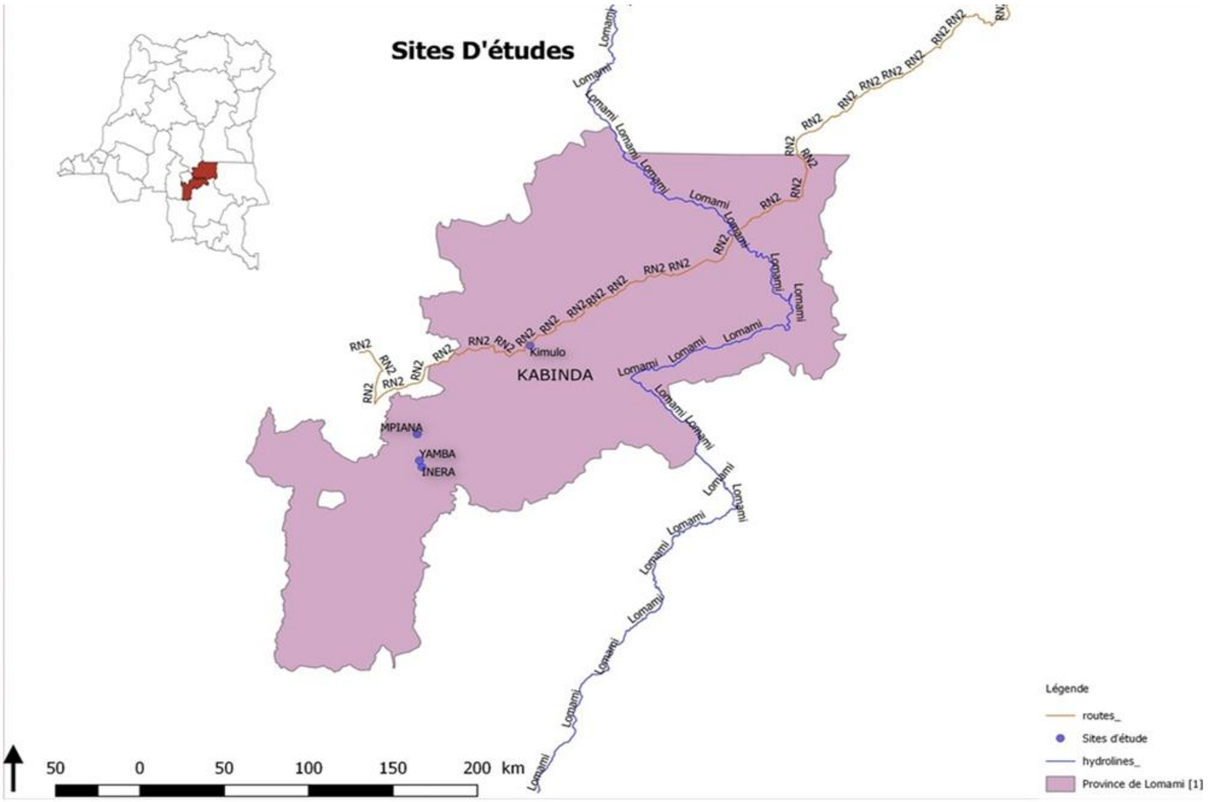

Figure-1. Study Sites.

Source: authors' illustration based on data obtained with Global Position System.

The soil of these 3 sites (INERA, Yamba and Mpiana) of studies presents a sand-clay texture with heavy clay. It is of red to ocher red color, and of good structure.

The clay fraction is small and varies by locality. The soil pH varies from 5.2 to 6.8.

Three genetically improved varieties of cowpea were used in this study. These are Mujilanga, CNGKASC2-1-1-T, CNGKASA7-2. These genotypes have presenting a yield stability and are less or resistance to the devastating bugs in Ngandajika zone according to the results of exploratory survey makes by Mukendi, et al. [16] of which the test of yield in field under chemical control didn't make the object of assessment again in Ngandajika. These are fixed lines within the legume antenna at the INERA Ngandajika research station using ecotypes from IITA and INERA.

All these varieties have an erect growth habit, with an average vegetative cycle of 3 months and a smooth texture with brown seeds. The phytosanitary applications were carried out in medium volume treatment (12.5 l / 500 m 2) from 25 days in the crop cycle where it is estimated that the plant will start the initiation of flower buds, a period of great attractiveness insects by the plant when pod-like insects have been seen feeding on young shoots, peduncles and green pods in development.

The evaluation of the effectiveness of the Cypermethrin 10 CE chemical treatment (12.5 ml / 10 l) in the experiment was done in three frequencies on the divided plots according to the following schedule:

(i) One application at 25 days of growth;

(ii) Two applications on the 25^{th} day after sowing then on the 35^{th} day of growth;

(iii) Three applications that begin on the 25th, 35th and 50th days of development and;

(iv) A parcel without insecticide application or control.

The application rates of insecticides were based on the three critical periods in cowpea growth and development, i.e. growing, blooming and pod development.

The first chemical spraying with Cypermethrin at 25 days after sowing was recommended by Egho and Enujeke [28]. It has been used to estimate the rational use of pesticides in cowpea cultivated in Ngandajika.

For each spraying regime, an insecticide formulation was applied with Unispray-Us-16, 15-liter manual pressure sprayer manufactured by Bloom Industrial Plastics Pvt Ltd'.

The coverage of the mixture at each application is 12.5 l / 500 m2 as recommended [29].

The tests were conducted using a split-plot device [30] with three repetitions.

The size of the main plots is 3m x 14.6 m and the subplots are 3 m x 2.4 m. Seeding was done at 60 cm x 20 cm spacing's as recommended by Mukendi, et al. [15]; Mukendi, et al. [31]. Each line had 16 stand, 14 of which were inland, and each plot had 4 lines, a density of 128 plants per experimental plot at the rate of 2 plants per stand.

The tests were carried out in pure culture. No basic fertilization was applied. The effects of chemical insecticide application on economically important pests of cowpea and the assessment of yield were observed.

4. MEASURED VARIABLES

Density of pest populations (*R. dentipes*, *M. vitrata and A. varium*)

Insect sampling started at the initiation of flower buds, a period of great attractiveness of insects by the plant and was carried out every week. Plants in the selected area were carefully examined by carefully returning the leaves, flowers and pods for evaluation. This operation was conducted between 07h30 and 10h00 hours, when the insects were relatively less active and flew less when disturbed. Evaluation of insect density was physically counted at each visualization during the cowpea crop cycle.

The number of adult *R. dentipes* bugs when observed, were counted separately in the middle two rows of each sub-plot each week between 8 and 10 hours but pooled before data analysis because their food-related damage could not be distinguished on the time of data collection.

Similarly, monitoring of the density of *M. vitrata* larvae was estimated weekly from the flowering period to the maturity of the pods. His field observation was made by inspection of the plant showing *M. vitrata* on the flowers and pods or a quick visual examination of each plant was done to search for the insect, but also by the collection of the 10 flowers in each random plot, open on-site and examined for presence of entry or exit holes, *M vitatra* larvae and / or the presence of excreta.

The infestation was evaluated once a week between 8h00 and 12h00 from the beginning of flowering. Counts were expressed in number of *M vitatra* per 10 flowers. A visual examination was performed on mature pods to determine the extent of damage caused by *M vitatra. A. varium* was also counted in the two middle rows when the insects were observed in the field.

4.1. Damage to Pods

The mature pods were harvested from all plots. During harvest, the infested pods were separated from the healthy pods and their number and recorded. The presence of insect pests was used to evaluate pod damage (shriveling, twisting, stunting, constriction, and entry / exit holes of lepidopteran bugs on pods) assessed by examining 20 pods selected randomly from ten plants per sampling area. The damage was then expressed as a percentage of the total number of pods assessed per plot.

The determination of grain yields was made on each plot at harvest. All 10-plant pods were randomly selected from the middle two rows to determine various yield parameters and injury. The data collected included the number of pods per plant, the number of pods per peduncle, the pod length, the number of seeds per pod, and the weight of the one hundred seeds. The grains obtained after threshing the pods were sun-dried to a moisture content of 12%. Cowpea grains from each plot were weighed and the results were extrapolated in kilograms per hectare (kg / ha) for each treatment. The weight of pods and seeds was determined using a sensitive weighing scale. The formula of Ahmed, et al. [32], Sujatha and Bharpoda [33] was used to calculate the percentage increase in yield over control.

$$\% \text{ increase over control} = \frac{\text{mean value of the treatment} - \text{mean control}}{\text{mean value control}} \times 100 \quad (1)$$

4.2. Data Analysis

All data were exposed to analysis of variance (ANOVA) using the R3.5 software. To normalize the data and stabilize the variances before any analysis, the mean numbers of insect pests as well as the average proportions underwent a transformation Log10 (x + 1) (2) and square root √x + 0.5 (3), where x = numbers of insects, or x = percentage of damaged seeds. Comparison of treatments, and in case of significant difference, the Tukey HD test was used to separate the averages. All these analyzes were performed at the 5% level.

5. RESULTS AND DISCUSSION

Field efficacy data for the frequency of application of Cypermetrin against *R. dentipes*, *A. varium* and *M. vitatra* of cowpea in tree locations are presented in the Table 1.

Table-1. Density of pest pressure of cowpea (*R. dentipes, M. vitatra, A. varium*) in tree locations.

		R. dentipes			***M. vitatra***			***A. varium***	
					SITES				
Genotypes	**Doses**	**INERA**	**MPIANA**	**INERA**	**INERA**	**MPIANA**	**YAMB**	**INERA**	**YAMBA**
V1	D0	7,3 ± 8,9	11 ± 0,0	17,6 ± 5,0	1,6 ± 0,5	1,7 ± 0,5	0,6 ± 1,5	17,6±5,	2,6 ±1,5
	D2	4,0 ± 2,0	9,3 ± 0,5	9,3 ± 2,5	0,0 ± 0,0	1,2 ± 0,3	0,6 ± 1,5	9,3±2,5	6,0 ± 2,6
	D3	1,0 ± 0,0	4,3 ± 2,3	2,0 ± 1,7	0,0 ± 0,0	0,8 ± 0,4	0,3 ± 0,7	2,0± 1,7	5,0 ± 4,0
	D1	3,0 ± 2,0	9,7 ± 3,0	8,6 ± 3,5	1,6 ± 1,5	1,4 ± 0,8	1,0 ± 1,3	8,6± 3,5	7,0 ± 5,0
V2	D0	5,6 ± 4,3	8,3 ± 1,1	15,6 ± 8,3	1,0 ± 0,5	1,2 ± 0,2	1,6 ± 0,5	15,6±8,	1,3 ±1,5
	D2	3,6 ± 4,3	7,3 ± 3,7	11,0 ± 5,2	0,3 ± 0,7	1,0 ± 0,6	0,8 ± 0,0	11,0±5,	5,3 ± 4,9
	D3	0,6 ± 0,7	5,0 ± 3,6	6,6 ± 2,3	0,0 ± 0,0	0,4 ± 0,4	1,9 ± 0,5	6,6± 2,3	8,0 ± 1,7
	D1	5,0 ± 2,5	6,3 ± 1,1	10,0 ± 5,2	0,3 ± 0,5	1,0 ± 0,4	1,0 ± 1,3	10,0±5,	4,3 ± 5,7
V3	D0	4,3 ± 1,2	10,0 ±1,7	9,6 ± 6,0	1,6 ± 2,9	1,6 ± 0,4	0,6 ± 1,1	9,6± 6,0	5,6 ± 2,0
	D2	3,0 ± 3,0	7,0 ± 1,7	7,3 ± 4,7	0,0 ± 0,0	1,0 ± 0,8	0,6 ± 0,5	7,3± 4,7	7,6 ± 4,1
	D3	0,0 ± 0,0	4,3 ± 4,5	4,6 ± 1,52	0,0 ± 0,0	0,2 ± 0,3	0,4 ± 0,0	4,6±1,5	3,0 ± 3,6
	D1	4,0 ± 1,0	5,7 ± 3,7	5,6 ± 1,52	0,0 ± 0,0	1,2 ± 0,5	0,3 ± 0,8	5,6±1,5	3,0 ± 2,6
Mean of Sites		3,4 ± 3,5b	7,60± 3,1a	9,0±5,6a	0,5 ± 1,1b	1,1±0,6a	0,8±0,9b	9,0±5,6a	4,9±3,6b
Mean V1			7,36±5,5a			0,94±0,9b			4,8±5,6a
Mean V2			7,05±5,1a			0,93±0,9b			5,1±6,0a
Mean V3			5,11±3,2b			0,66±1,0a			3,8±4,1a
Mean D0			9,48±5,9b			1,37±1,0a			5,85±7,4a
Mean D1			6,55±3,7b			0,65±0,6a			5,18±4,9ab
Mean D2			3,48±3,4c			0,46±0,7b			3,25±3,24
Mean D3			6,51±3,4b			0,88±1,0a			4,29±4,6b
p-Sites			0.00169			0.0015			0.000
p-Genotype			3.36e-07			0.0015			0.672
p-Dose			6.82e-10			0.0165			0.000
S x G			0,1532			0,183			0,2062
S x D			8,8E-01			0,197			4,25E-05
G x D			0,4853			0,658			0,6708
S x D x G			0,5145			0,954			0,3846

The average density of *A. varium* cowpea pest during the observation period with the application of Cypermethrin shows that the population varies between 3.4 to 9.0 individuals between the 3 sites; 3.5 to 5.1 individuals between the 3 varieties and 3.2 to 5.8 between doses of insecticides. These results indicated that all treatments reduced the pest population compared to untreated controls throughout the observation period.

Insecticide doses applied in two and three frequencies during the crop cycle significantly affect density *A. varium* compared to untreated plots.

The lowest density was observed at two frequencies with 3.2 to 5.8 on untreated plants in the trial. Similarly, the site factor showed the existence of a very significant difference (p = 0.000) with respect to the density of *A.*

varium. But the genotype factor does not show any significant effect compared with the infestation of *A. varium* (p = 0.6).

There was significant interaction between site and regime spray (S x D) (p = 0.000) for *A. varium* density at each Cypermethrin spray rate. However, the interactions S x G, G x D and S x G x D were not significant. The density of *R. dentipes* had shown populations of 3.4 to 8.6 between sites, 5.1 to 7.6 for varieties and 3.4 to 9.4 individuals for pesticide frequencies. The pressure exerted by this insect was stronger between the sites, the varieties and the doses of pesticides. The differences observed were very significant (p = 0.001). Referring to the pesticide frequency two applications showed a very low density of *R. dentipes* 3.2 to 9.4 individuals counted on non-pesticide treated plots in the study.

Table-2. Effects of insecticide spray regimes on seed aborted and pod damage.

		% Seed damage			% aborted seed		
				SITES			
Genotypes	**Doses**	**INERA**	**MPIANA**	**YAMBA**	**INERA**	**MPIANA**	**YAMBA**
V1	D0	46,5 ± 0,7	40,9 ± 1,5	72,3 ± 6,5	30,4± 1,7	21,3 ± 2,2	65,0 ± 2,0
	D2	29,7 ± 1,1	14,8 ± 1,3	83,3 ± 4,0	22,5± 1,0	10,6 ± 1,3	22,3 ± 5,0
	D3	28,7 ± 1,2	9,0 ± 2,0	77,3 ± 1,8	13,5± 3,0	12,6 ± 1,3	16,6 ± 2,4
	D1	32,5 ± 0,8	13,1 ± 1,7	72,0 ± 1,5	21,1± 1,6	18,4 ± 4,3	30,7 ± 3,6
V2	D0	26,7 ± 3,5	23,0 ± 2,5	73,6 ± 8,8	13,7± 1,9	12,5 ± 1,8	18,4 ± 0,5
	D2	13,9 ± 2,5	24,1 ±1,8	84,6 ± 6,1	7,96± 1,7	21,3 ± 0,6	26,8 ± 1,6
	D3	20,1 ± 1,4	19,6 ± 5,3	75,9 ± 3,6	19,0± 2,2	11,1 ± 1,3	16,7 ± 1,7
	D1	14,0 ± 4,9	21,3 ± 1,3	53,0±39,1	24,7± 1,9	20,4 ± 0,9	23,8 ± 2,4
V3	D0	40,7 ± 3,4	16,5 ± 0,5	85,9 ± 6,9	30, ± 1,9	21,1 ± 1,9	28,4 ± 6,4
	D2	7,8 ± 1,7	25,1 ± 4,9	72,0±10,8	14,9± 1,4	10,7 ± 1,5	21,0 ± 1,1
	D3	8,4 ± 3,0	15,7 ± 2,8	83,0 ± 4,8	13,3± 1,3	19,5 ± 1,7	40,6 ± 6,4
	D1	26,3 ± 1,3	47,5 ± 16	72,3 ± 2,4	14,5± 1,0	16,5 ± 1,8	18,4 ± 0,7
Mean Sites		24,6±11,8b	22,5±11,8c	75,4±13,5a	18,8±7,1b	16,3 ± 4,7c	27,4±13,6a
Mean V1			43,36±26,03a			23,78±14,2a	
Mean V2			37,52±27,61a			18,05±14,2a	
Mean V3			41,8±29,22a			21,81±8,6	
Mean D0			47,37±23,9a			26,87±15,3a	
Mean D1			39,52±30,2a			17,57±6,6bc	
Mean D2			37,53±30,4a			18,16±8,8c	
Mean D3			39,15±25,2a			20,96±5,1ab	
p-Sites			0.00169			0.0497	
p-Genotype			0.2091			0.3732	
p-Dose			0.23152			0.0033	
S x G			0,000216			5,88E-11	
S x D			3,10E-06			6,38E-09	
G x D			0,00017			2,00E-16	
S x D x G			0,00016			2,00E-16	

The genotype effect shows that V3 is less infested with 5.1 individuals than the two varieties V1 (7.3 individuals) and V2 (7.0 individuals). However the significant interaction was between the site and the doses used were detected for the number of *R. dentipes*. While no significant interaction between the site and the genotype, genotype x dose and site x genotype x doses was detected on the density of *R. dentipes*. In the same period, the population of *M vitatra* was very significantly affected by the site effect, the genotype effect and the dose effect of pesticides (p = 0.001) Table 1. The results further show that interaction effects for *M. vitatra* density with respect to S x G, S x D, D x G and S x G x D are without significant differences.With regard to the density of *M. vitatra* observed in the table of result-2, it emerges that the sites showed a very significant difference (p = 0.001). The

Mpiana site appears to have had a very strong 1.1 individual density compared to both individual INERA 0.5 and Yamba 0.8 individual sites. Similarly for the pesticide dose effect, application at two frequencies seems to have fewer individuals 0.46 against 1.37 individuals in the control plot that received no dose of cypermethrin. Variance analysis supports the existence of a very significant effect (p = 0.001). The genotype effect with respect to *M. vitatra* infestation seems to be strongly evidenced by the existence of a very significant difference (p = 0.0001). The V3 genotype showed a low rate of individual%. *Vitatra* 0.6 to. 0.9 individual on the V1 and V2.

Table 2 shows the effects of pesticide regimes on the percentage of seed damaged and seed aborted during the study at the three sites represented by INERA, Mpiana and Yamba. The observation with respect to the average percentage of damaged seeds in pods in this study showed different levels of damage in relation to Cypermethrin spray rates at the three sites. The percentage of seed damaged according to the ANOVA model, the preliminary results of the data show that the site has very significant averages, varying between 22.5 % (Mpiana) and 75.4 % (Yamba) (p = 0.001) as recorded in Table 2. While the dose effect averaging between 37.53% (D2) and 47.3% (D0) and the genotype effect showed variability that was 37.5% (V2) and 43.3% (V1), but the analysis of the variance did not significant (p = 0.2) for the genotype and the dose effect, respectively. However, the interaction phenomenon, reveals that the S x G, S x D, G x D and S x G x D have very significant effects of the number of damaged seeds (p = 0.0001).

Similarly, the percentage of seeds aborted per pod in this study Table 2 shows significant effects (p = 0.049), 16.3% at Mpiana site against 27.4% at Yamba site. But pesticide doses were very significant (p = 0.003). However, the genotype effect does not show a significant effect (p = 0.37) compared to the percentage of seed aborted in this study. While the interactions between S x G, S x D, G x D and S x G x D were very significant (p = 0.0000) Table 2. Podpedo: pod per peduncle, podplant, pod per plant, pod length: pod height seedpod: seed per pod: genotype, D: dose spray, S: site, p: plus value, Analysis of variance for yield components of cowpea under doses spray in three locations as shown in Table 3. The effect of insecticide spray regimes on the yield components of cowpea in this study were significantly (p = 0.001) between sites. We also note that the number of pods per peduncle between genotype, dose spray and the interactions between the effects involved in the study were no significant Table 3.The observation of the number of pods per plant showed significant effects by site, genotypes, doses spray and interaction G x D factors Table 3. But interactions between S x G, S x D and S x D x G were no significant effects on pods per plant.

The site factor was significant (p = 0.049), Mpiana had a higher number of seed pods (12), followed by INERA site 8 pod / plant and at Yamba site 4 pods / plant. The genotypes showed very significant differences between them (p = 0.001). V1 had 8.8 pod per plant, V2 with 7.7 pods per plant and V3 had 8.1 pods per plant in this study. The doses applied in this experiment also show the existence of a very significant difference (p = 0.000).

Table-3. Effect of yield components of the cowpea.

Sites	Genotype	Doses	Podpedo	Pod Plant	Pod length	Seed pod	Yield Kg/ha
INERA	V1	D0	1,3 ± 0,57	5,333 ± 1,52	15,5 ± 0,15	11,6 ± 0,57	318,4 ± 42,90
		D2	1,3 ± 0,57	9,67 ± 2,89	18,4 ± 1,41	13,6 ± 0,57	775,5 ± 106,3
		D3	1,0 ± 0,00	10,00 ± 2,65	16,6 ± 0,15	12,6 ± 0,57	750,0 ± 347,0
		D1	1,3 ± 0,57	6,67 ± 3,06	18,4 ± 0,15	13,6 ± 0,57	679,1 ± 314,0
	V2	D0	1,3 ± 0,57	7,00 ± 1,73	15,4 ± 0,26	13,6 ± 0,57	442,1 ± 166,9
		D2	1,3 ± 0,57	8,00 ± 2,65	16,2 ± 0,15	11,6 ± 1,15	773,0 ± 236,0
		D3	2,3 ± 0,57	8,33 ± 2,89	16,8 ± 0,10	12,3 ± 1,52	1081 ± 237,0
		D1	1,3 ± 0,57	7,66 ± 1,52	15,4 ± 0,36	11,6 ± 0,57	490,7 ± 160,2
	V3	D0	1,3 ± 0,57	5,66 ± 0,57	15,6 ± 0,57	13,6 ± 0,57	537,0 ± 154,7
		D2	1,0 ± 0,00	9,66 ± 1,52	16,8 ± 2,05	13,6 ± 0,57	1023,0 ± 262,0
		D3	1,3 ± 0,57	9,33 ± 3,06	15,2 ± 0,10	11,6 ± 0,57	745,3 ± 81,40
		D1	1,3 ± 0,57	8,66 ± 0,57	16,4 ± 0,10	13,6 ± 0,57	699,0 ± 306,0
Mean Site			1,3±0,5b	8,0±2,4b	16,42±1,2b	12,8±1,1b	692,8 ± 273,9b
Mpiana	V1	D0	1,0 ± 0,00	8,66 ± 1,15	15,5 ± 0,00	12,6 ± 0,57	633,0 ± 83,7
		D2	1,6 ± 0,57	15,67 ± 6,43	17,5 ± 0,00	13,6 ± 0,57	925,0 ± 52,3
		D3	1,6 ± 0,57	18,33 ± 4,62	18,0 ± 0,00	16,0 ± 0,00	895,1 ± 48,7
		D1	1,3 ± 0,57	9,66 ± 0,57	18,0 ± 0,00	15,6± 0,57	862,0 ± 29,3
	V2	D0	1,3 ± 0,57	9,66 ± 0,57	18,3 ± 0,28	13,6 ± 0,57	529,0 ± 69,5
		D2	1,3 ± 0,57	10,00± 0,00	18,5 ± 0,00	12,6 ± 0,57	917 ± 32,1
		D3	1,0± 0,00	13,67 ± 3,21	17,9 ± 0,11	11,6 ± 0,57	759,5 ±138,7
		D1	1,6 ± 0,57	11,67 ± 2,89	16,2 ± 0,52	13,6 ± 0,57	958,0 ± 241
	V3	D0	1,3 ± 0,57	10,66 ± 1,15	16,5 ± 0,00	14,6 ± 0,57	451,6 ± 63,2
		D2	1,7 ± 0,57	13,00 ±1,00	17,5 ± 0,00	12,6 ± 0,57	1101,0 ± 281
		D3	1,0± 0,00	11,67 ± 2,31	17,0 ± 0,05	12,3 ± 0,57	838,2 ± 114,8
		D1	1,7 ± 0,57	11,66 ± 0,57	15,5 ± 0,00	10,3± 0,57	721,5 ± 96,4
Mean Site			1,3±0,4b	12,02±3,5a	17,2±1,0a	13,3±1,6b	799,2 ±225,2a
Yamba	V1	D0	1,00 ± 0,00	2,66 ± 0,57	16,2 ± 0,20	14,0 ± 1,00	130,8 ± 59,3
		D2	1,00 ± 0,00	7,00 ± 0,00	17,5 ± 0,50	17,0 ± 0,15	265,6 ± 29,6
		D3	1,33 ± 0,57	7,00 ± 0,00	17,6 ± 0,26	18,0 ± 0,40	302,6 ± 52,0
		D1	1,00 ± 0,00	6,00 ± 0,00	16,4 ± 0,10	16,1 ± 0,10	253,6 ± 30,0
	V2	D0	2,00 ± 0,00	3,33 ± 0,57	14,9 ± 0,20	15,0 ±1,00	82,4 ± 22,6
		D2	1,66 ± 0,57	4,00 ± 1,00	16,2 ± 0,17	16,0 ± 1,00	207,3 ± 14,28
		D3	1,66 ± 0,57	5,00 ± 1,00	16,4 ± 0,25	15,6 ± 1,52	218,3 ± 70,9
		D1	1,66 ± 0,57	4,33 ± 0,57	15,4 ± 0,15	15,6± 0,57	125,4 ± 24,7
	V3	D0	1,00 ± 0,00	4,00 ± 0,00	14,0 ± 0,73	13,3 ± 0,57	131,2 ± 33,9
		D2	2,00 ± 0,00	4,33 ± 1,52	16,6 ± 0,26	14,3 ± 0,57	214,1 ± 59,0
		D3	1,33 ± 0,57	4,66 ± 0,57	16,8 ± 0,30	16,6 ± 0,57	277,0 ± 60,2
		D1	1,00 ± 0,00	4,66 ± 0,57	15,4 ± 0,20	15,0 ± 1,00	192,1 ± 64,6
Mean Sites			1,38±0,4b	4,75±1,4c	16,1±1,0b	15,5±1,4a	200,04±78,04c
Mean V1			1,25± 0,4a	8,88±4,8c	17,15±1,08a	14,56±1,9a	565,88±297,31a
Mean V2			1,55± 0,5a	7,72±3,4a	16,48±1,1a	13,61±1,7a	548,58±365,13a
Mean V3			1,33± 0,4a	8,16±3,4a	16,13±1,1a	13,5±1,6a	577,63±346,35a
Mean D0			1,29 ±	6,33±2,8b	15,79±1,1b	13,59±1,1a	361,71±210,2b
Mean D1			1,44 ±	9,03±4,2a	17,25±1,0a	13,93±1,7a	689,14±380a
Mean D2			1,40 ±	9,77±4,7a	16,94±0,8ab	14,11±2,4a	651,83±324a
Mean D3			1,37 ±	7,88±2,9a	16,36±1,1ab	13,93±1,9	553,31±315,1a
p-Sites			0.0016	0.0497	0.0016	0.0016	0.04978707
p-Genotypes			0.7361	0.0016	0.2091	0.3730	0.7794932
p-Doses			0.6086	0.0003	0.0165	0.9130	0.00094
S x G			0,0891	0,5193	3,00E-08	4,41E-06	0,2463
S x D			0,2597	0,376	1,35E-06	6,67E-09	0,00563
G x D			0,6877	0,003	4,06E-08	8,81E-11	0,38737
S x D x G			0,0645	0,471	1,66E-08	7,89E-09	0,07277

Source: own research (2016).

Similarly, pod height and number of seeds in pod were significantly affected by the locations (p = 0.001). The pod height varied from 16.1 cm at the Yamba site to 17.1 cm Mpiana. The table of means Table 3 revealed that Mpiana location had the highest mean pod height of 17.1 cm. There were no significant difference among the genotype effect for the pod height (p = 0.20) and seed size per pod (p = 0.37) Table 4. Highly significant difference among pod height and seed size were revealed between interactions for G x D, S x G, S x D and S x D x G Table 3. But the number of seeds are not influenced by the dose spray, the results was no significant (p = 0.91).

Cowpea grain yield ranged from 200 to 792 kg among different locations in the study Table 4. The analysis of variance showed a significant difference (p= 0.049). The average yields are 692.8 kg / ha; 799.2 kg / ha and 200 kg / ha respectively for INERA, Mpiana and Yamba. Effect of doses spray on the yield parameter of three cowpea varieties reported in Table 4, shows that there was a highly significant difference between yield per genotype (p = 0.0009). But there was no significant difference between the genotype effect (p = 0.77).

However, no significant differences were found among interactions between G x D, S x G and S x D x G for grain yield Table 3. But there was a significant difference among grain yield for interaction S x D (p=0.005). The doses spray with Cypermetrin showed that the average yields recorded give 361.7, 689.1, 651.8 and 553.3 kg / ha respectively with D0, D1, D2, and D3.

Table-4. Increase yield over control (%).

	Increase yield over control (%)				
Site INERA	**0 spray**	**1Spray**	**2Spray**	**3Spray**	**Means**
CNGKASC2-1-1-T	00	113	142	187	147.3
CNGKASE2-0-T	00	40	88	125	84.3
CNGKASC5-1-1A-M	00	53	112	196	120.3
Mean	00	42.3	114	169	
SITE MPIANA					
CNGKASC2-1-1-T	00	21	39	50	36.6
CNGKASE2-0-T	00	59	85	143	95.6
CNGKASC5-1-1A-M	00	25	69	87	60.3
Mean	00	35	64.3	93.3	
SITE YAMBA					
CNGKASC2-1-1-T	00	80	103	103	95.3
CNGKASE2-0-T	00	81	86	141	102.6
CNGKASC5-1-1A-M	00	52	151	164	122.3
Mean	00	71	113.3	135	

Source: own research (2016).

The efficacy of spray regimes of Cypermethrin against insect pests of cowpea reflected on seed yield Table 3 as well as percent increase in yield over treatments plot than untreated plot Table 4 of cowpea grain seed for each location. In each location, three spray regimes of Cypermethrin increased grain yield of all cowpea genotypes used. In INERA, application of insecticide three times increased mean general of grain yield by 169 %. In Mpiana, mean general of increased grain yield with three times of spray Cypermethrin was 93.3%. However in Yamba site three spray of Cypermethrin recorded the highest increased grain yield for 135%.

6. DISCUSSION

Generally, the phytosanitary treatments aim to minimize the economic loss caused by insects' pests in full culture by insecticidal effect or insect repellent. This study was conducted to examine the effect of insecticide spraying frequencies on density of cowpea insects' pest. Our experimental results demonstrate that plots that received no insecticide dose harbor a higher density of economically important pests of cowpea than on plots that received chemical treatment. This important presence of *A. varium*, *M. vitrata and R. dentipes* played a significant role in substantially reducing cowpea yield and yield components in this study. The unconditional presence of these three insects' *R. dentipes M. vitrata and A. varium* in the three sites reveals that these pests recruitment under natural field conditions have the importance as a pest of economic interest in the Ngandjika area of the DRC. This observation is in agreement with Mukendi, et al. [19]; Ezeaku, et al. [9] and Kamara, et al. [6].

The effectiveness of Cypermetrin in controlling this three pests monitored in cowpea culture showed that tree spraying frequencies are essential to keep pests below the threshold of economic. This result is in agreement with Egho and Enujeke [28]. In another experiment, Ahmed, et al. [32] found that tree spray regimes for SAMPEA 7 control heavy infestation by pod sucking bugs.

It is possible to dispense with the application of the first dose at 25 days if the entomophauna complex of cowpeas is not present in the phenological period. Regarding *R. dentipes*, a heteropterous (bug) very polyphagous usually seen resting on foliage or feeding on young shoots and green pods. This pest is mobile that passes quite easily from one crop to another. The various damage observed are sucking the sap from the developing young shoots and green pods causing seed deformation, premature seed drying seed abortion and pod shivelling with resulting economic loss of seed green stump bites that show internal rot, seed mummification, and a high proportion of poor quality cowpea seed [34] as is the case in cotton [35]. As for *M vitrata*, it is one of the most serious pests of the attacking cowpea, flower buds, flowers, pods as Jayasinghe, et al. [36]. With regard to the results of application of Cypermethrin, whatever the number of sprays in the control of *R. dentipes*, *M vitrata* and *A. varium*, it appears that cypermethrin seems to be effective on the pest. A result similar has also been found in previous studies of *R. dentipes* by Degri, et al. [34].

Our results corroborate with the Sharma [37] observations that seem to demonstrate that 10 to 15 days apart in the application of Cypermethrin are efficient against *M. vitrata*. [38] showed in soybean similar results with Tefluenzuron, Flubendiamine, Chlorantraniliprole + lambda-cyhalothrin and chloropyrifos on *M. vitrata*. Frequency of pesticide application generally affected the reduction of insect infestations and led to increases in cowpea yield. The present results are consistent with those of Ezeaku, et al. [9], Dzemo, et al. [39], Elizabeth, et al. [40] who reported that the efficient use of insecticides against insect pests of cowpea is beneficial. The degree of pest control with Cypermethrin results in reduced of damage to the cowpea pods including the newly developing young shoots, peduncles and green pods. This is in line with the results reported by Toffa, et al. [41], Degri, et al. [34]. In this study, applications of Cypermethrin at 35 and 50 days of sowing resulted in differences in the yield between 361 than 689 kg either a gain of 64% and 169% indistinctly of the sites and varieties. Our results corroborate with the Egho [42] who the Cypermethrin application proved effective in controlling insect pests, judging from the yields per ha^{-1} (517.90 kg ha-1 to 822.20 kg ha-1). Ajeigbe, et al. [43] who reported that Mono + Cyper + Cyper (Monocrotophos as 1st spray, Cypermethrin as 2nd and 3rd sprays) produced the highest grain yields which were significantly higher than yields obtained from 7 and 4 other treatments, respectively.

Our results are similar to those of Kamara, et al. [6] who found in their studies that pesticide application at the flowering stage increases yield by 72%, while application at flowering and pod formation show an increase of 126%. Our assumption is that control pest in the flowering phase and post flowering phase is essential if we want to obtain a good yield of cowpea crop. This observation is confirmed by the results of Dzemo, et al. [39] who observed that plots treated concomitantly with sowing, flowering and before pod formation did not differ significantly with plots treated once at flowering and twice at pod formation. This indicates that control at the flower phase and pods should be considered as potential because it limits very significantly the density of the insects and the damage on the yield components. Thus, in the present study, the use of Cypermethrin in 3 frequencies has made the control more efficient and considerably enhanced the grain yields obtained than those from the unsprayed control plots. The findings of this study are supported by Ogah [44] who reported that the control post flowering insect pests significant increase in grain yields.

M vitrata which despite its very short life cycle has a high reproductive potential, which allows it to maintain its species. The treatment made during the flowering phase, a period that often coincides with the explosion phase of *M. vitrata*, allowed its control in this study. This observation corroborates with the studies of Grigolli, et al. [38], Oghiakhe, et al. [45]. In addition, Cypermethrin is a pyrethrinoide, a stable, broad spectrum activity that works for 2 to 3 weeks, by contact and ingestion on a large number of insects at low doses. The low density results obtained from the insects in the treated plots confirm the effectiveness of Cypermethrin in protecting cowpeas in the field against the insects *R. dentipes M. vitrata* and *A. varium* which attack the flowers and pods. Compared to earlier practices of spraying 8-10 times a chemical insecticide in the insect pest control process in several cowpea production areas, reduction in 3 spray frequencies with Cypermethrin from flowering, and pod formation The theory of Sexton, et al. [46] concludes that the reduction in the number of frequencies is of critical importance from the point of view of cost reduction, environmental risks. However, our results corroborate with the findings of Ezeaku, et al. [9] who used cypermethrin and Dimethoate. They are in agreement with Egho [42]; Egho and Enujeke [28] who used in his study molecules based on Cypermethrin; Chlorpyrifos 480g / l E.C., Chlorpyrifos 475 + Cypermethrin 47.5, Dimethoate 400, Imidacloprid 70 WG to control cowpea pests. Oyewale, et al. [47] reported that Cymbush 10 EC effectively controlled insect pests during flowering. Dzemo, et al. [39] used Lambda Cyhalothrin; Liao and Lin [48] tested height insecticides the result reported that Deltametrin and carbaryl appeared more effective because increased the pod yield and reduced the heavy losses caused by *M. testulalis*. [49] making use of six Lambda-cyhalothrin on flower trhrips, pod bores and pod sucking bugs. The results showed that infestations of all target pest were significantly lower and offered the best protection resulting in higher grain yield. The different chemical molecules used alone or as a mixture seem to be the promising control agents against insects in different stages of growth and reproduction of cowpea. There were significantly better than untreated plots. The findings of these studies corroborate with the results obtained with simple Cypermethrin in the control of economically important pests of cowpea.

The results of this study clearly indicate that insect infestations during flowering and pod formation are factors that limit the production of sufficient cowpea in the production area. This observation is in agreement with Sujatha and Bharpoda [33] which showed that cowpea is more vulnerable to insects during the reproductive stage than at the vegetative stage. Application of insecticide treatments at these stages effectively controls *M. vitrata R. dentipes* and *A. varium* infestation and ensures optimum pod yield. It is assumed that the first spray protects the flowers against *M vitrata* infestation, leading to a drastic drop in the *M vitrata* population and a low percentage of damaged pods in the line by Oyewale, et al. [49]. This proves the effectiveness of Cypermethrin. This observation is in agreement with Sani and Umar [50]. While the second and third treatments have affected the maintenance below the economic threshold of the population of pests of economic importance compared to the untreated plots indistinctly of production sites and varieties. This led to a lower percentage of pod damage and seed abortion compared to the control. These results corroborate with Ahmed, et al. [32]; Oyewale, et al. [49].

The results of this study clearly indicate that insecticide application remains an effective strategy to control cowpea insect pests in the field.

The combination of this spraying regime can be used in conjunction with other pest management options to significantly improve cowpea seed yields as a source of vegetable protein in local diets, and to generate disposable income for subsistence farmers.

7. CONCLUSION

This study confirmed that pests (*A. varium, M. vitatra and R. dentipes*) were a major impediment to cowpea production in Ngadajika, Lomami province. The spraying regime of Cypermethrin have considerable potential for managing the pest of cowpea. The population of all target pest were found to decrease in plot control to untreated plot. Higher grain yield were recorded in plot with Cypermethrin treatments.

Hence, famers can use two or three spray regimes of Cypermethrin for effective pest control because the insect pests are maintain below the economic threshold. All spraying regimes reduced insect populations compared to the untreated control. Plots treated with Cypermethrin also recorded the highest yields of cowpea seed. Innovative of monitoring programs and thresholds for spray have been developed and can serve alternative pest management options for reducing the cost, in oder to achieve a sustainable level of agricultural and a high level of environmental and human health protection in cowpea field in DR Congo.

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