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Dynamic and Impact of Major Insect Pests on *Jatropha curcas* L. in two Cropping Systems with Contrasting Characteristics in the Province of Kinshasa (DRC)

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Keywords: *Jatropha curcas*- Pest dynamics- Yield- Kinshasa- D.R. Congo

Summary

The dynamic and impact of the major insect pests on Jatropha curcas *L. were studied on two plantations located in the province of Kinshasa, the first in pure stand without irrigation (Mbankana site), the second under irrigation in combination with other crops (N'sele site). In Mbankana, after being planted during the long rainy season (October-December), the plants suffer significant attacks by crickets* Brachytrupes membranaceus *Drury (Orthoptera, Gryllidae), which cause a mortality rate of 10-40%. The first half of October and second half of December are the best planting periods when it comes to limiting these losses. At N'sele, cricket attacks during planting are controlled by the farmers who eat these insects. After being planted at both sites, the plants are attacked by leaf miner caterpillars* Stomphastis thraustica *Meyrick (Lepidoptera, Gracillariidae) and flea beetles* Aphthona sp. *(Coleoptera, Chrysomelidae), which consume the leaf blades and buds. The size of these two pest populations and resulting damage reach a peak during the wettest time of year. On adult plants at N'sele, insect pests observed include flea beetles, leaf miners, and shield-backed bugs* Calidea sp. *(Heteroptera, Scutelleridae). These bugs cause damage to flowers and capsules. In the absence of insecticide treatments, yield losses reached 90% in Mbankana and 60% in N'sele.*

Résumé

Dynamique et impact des principaux insectes ravageurs de *Jatropha curcas* L. dans deux systèmes de culture aux caractéristiques contrastées de la province de Kinshasa (RDC)

La dynamique et l'impact des principaux insectes ravageurs de Jatropha curcas *L. ont été étudiés dans deux plantations installées dans la province de Kinshasa; la première en culture pure sans irrigation (site de Mbankana); la deuxième sous irrigation en association avec d'autres cultures (site de N'sele). A Mbankana, lors de leur mise en place pendant la grande saison des pluies (entre octobre et décembre), les plants endurent d'importantes attaques de crickets* Brachytrupes membranaceus *Drury (Orthoptera, Gryllidae) qui induisent des mortalités variant entre 10 et 40%. La période de plantation la plus propice pour limiter le niveau de ces pertes se situe lors de la première moitié du mois d'octobre et lors de la deuxième moitié du mois de décembre. A N'sele, les attaques de grillons au moment de l'installation de la plantation sont contrôlées par les agriculteurs, qui consomment ces insectes. Une fois installées, les plantes subissent dans les deux sites des attaques de chenilles mineuses des feuilles* Stomphastis thraustica *Meyrick (Lepidoptera, Gracillariidae) et de chrysomèles* Aphthona sp. *(Coleoptera, Chrysomelidae), consommatrices du limbe des feuilles et des bourgeons.*

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The discussion focuses on what causes the different pest impact levels recorded between the cropping systems and methods used to limit the main types of damage caused by insects on J. curcas *in the Kinshasa region.*

L'importance des populations de ces deux ravageurs et leurs dégâts culminent lors de la période la plus pluvieuse de l'année. Sur les plantes adultes à N'sele, en plus de attaques de chrysomèles et de chenilles mineuses des feuilles, on observe la présence de punaises à bouclier Calidea sp. *(Heteroptera, Scutelleridae). Les punaises causent des dégâts aux fleurs et aux capsules. En l'absence de traitements insecticides, le niveau des pertes de rendement occasionnées atteignaient 90% à Mbankana et 60% à N'sele. Les causes des différences de rendement enregistrées et les mesures pour limiter les dégâts des principaux ravageurs de* J. curcas *dans la région de Kinshasa sont discutées.*

Introduction

Jatropha curcas L. (Euphorbiaceae) is a shrub that originates from Central America and produces non-edible oil, which is used as a fuel that can fully or partially replace fossil fuels. All parts of the *J. curcas* plant contain toxic compounds, such as phorbol esters, curcin and trypsin inhibitors (16). The toxic and anti-nutritional properties of *J. curcas* seeds are used in traditional medicine for removing parasites and as a purgative (4). When it is cultivated, the toxicity and biocidal properties of *J. curcas* do not protect it against attacks from pests and other organisms, which may have an impact on yields (1, 10).

The most frequently observed potential insect pests on *J. curcas* in the Kinshasa region are the cricket *Brachytrupes membranaceus* Drury (Orthoptera, Gryllidae), flea beetles of the *Aphthona genus* (Coleoptera, Chrysomelidae), the leaf miner *Stomphastis thraustica* Meyrick (Lepidoptera, Gracillariidae) and shield-backed bugs of the *Calidea genus* (Heteroptera, Scutelleridae) (Figure 1) (25).

Crickets are phytophagous insects, which are widespread in tropical Africa, live in extensive underground tunnels and are rarely visible during the day (15, 30). At night, they sever young, freshly-planted *J. curcas* plants at the root collar and drag the leaves or entire plants into their burrows.

Flea beetles cause serious damage to *J. curcas* in Africa. The adults attack the foliage and developing fruits, while the larvae penetrate the roots (10). Leaf miners have been sighted in almost all regions where *J. curcas* is cultivated in Africa (31).

Their tiny larvae eat away and dig tunnels in the leaf blades. During major attacks, they cause the plant to defoliate (11). Shield-backed bugs (adults and larvae) cause the flowers to fall off, fruit malformation and seed abortion (2, 31). Seeds in infested fruits are small in size/weight and low in oil content. In Africa, there is a lack of information on the dynamic of *J. curcas* pests and their impact on yields.

The aim of this study is to determine the dynamic, during the year, of populations of major insect pests attacking *J. curcas* and their impact on yields in two cropping systems with contrasting characteristics in the Kinshasa region, in order to identify when major outbreaks of these pests occur, quantify the scale of their damage and propose steps to be taken so that the crops produce a better yield.

Material and methods

Location of study sites

The study was conducted on *J. curcas* plantations located at N'sele (30 ha, 4°25′ latitude south, 15°30′ longitude east and 280 m altitude) and Mbankana (3 ha, 4°47′ latitude south, 16°12' longitude east and 684 m altitude).

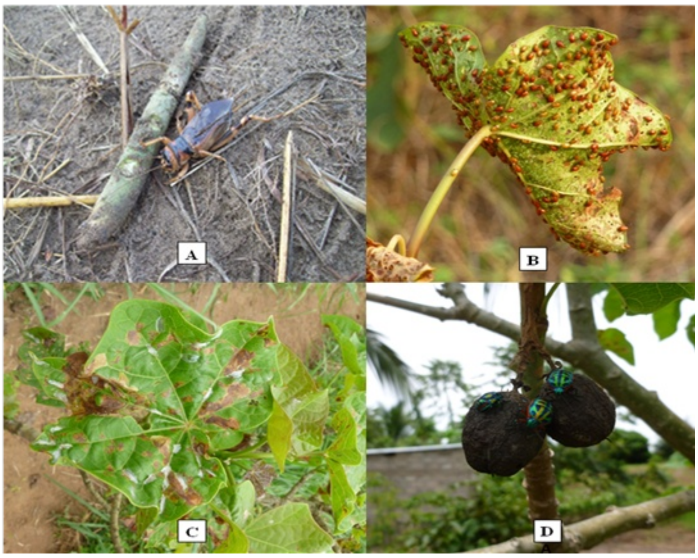


Figure 1: Major insect pests affecting *J. curcas* in Kinshasa.

A (seedling cut down by *B. membranaceus*), B (leaf attacked by *Aphthona* sp.) C (leaves attacked by *S. thraustica*), D (fruits attacked by *Calidea* sp.).

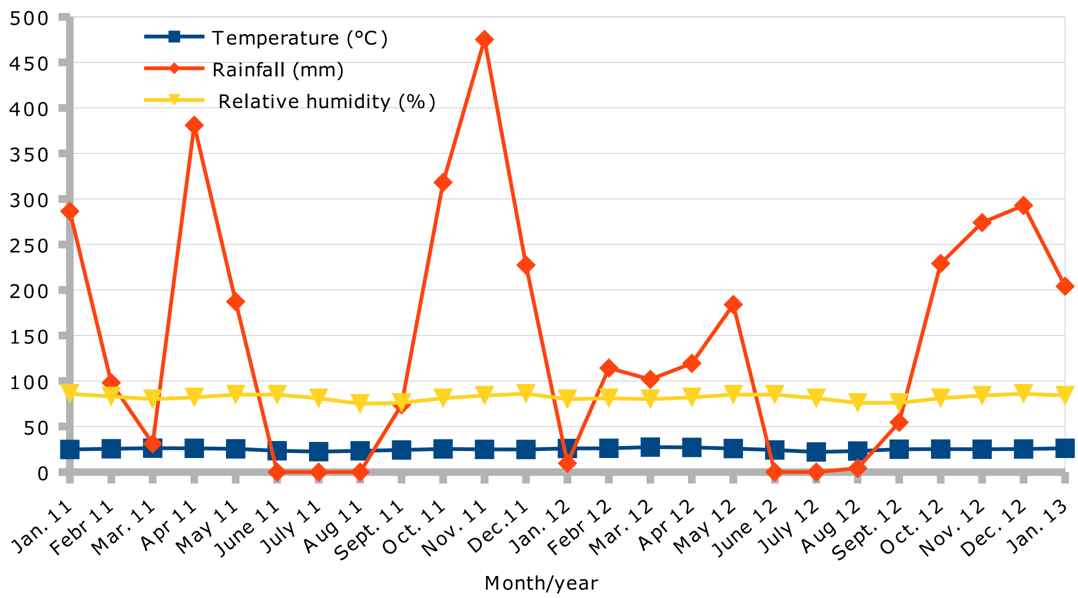


Figure 2: Variations in temperature, rainfall and relative humidity in the study zone from January 2011 - January 2013.

Climate

The climate is of the AW_4 type, according to Köppen's classification. This humid tropical climate is characterised by a rainy season that lasts from mid-September until mid-May and is interrupted by a brief dry season between mid-January - mid-February. The long dry season lasts four months - from mid-May until mid-September (5).

The climate records for the study area, provided by the Agence Nationale de Météorologie et de Télédétection par Satellite (METELSAT) of the Democratic Republic of the Congo, are shown in Figure 2.

Soils and vegetation

At Mbankana, *J. curcas* is cultivated on poor soil, which contains over 90% sand in the arable horizon. At N'sele, the soil is also very sandy (95% sand). Plant formations at Mbankana consist mainly of shrub savannahs, which alternate with grassy savannahs (35).

At N'sele, they naturally consist of grassy savannahs interspersed with gallery forests along the rivers.

Plantations

The two sites differ in terms of their cropping systems (Figure 3). At Mbankana, the *J. curcas* plants were planted in October 2009, under rainfed agriculture conditions with a density of 2,500 shrubs per ha^{-1}. On the other hand, at N'sele, the crops were planted in September 2008 with a density of 2,000 shrubs per ha^{-1} in an area, in which it is cultivated with spring onions throughout the year (*Allium fistulosum* L.), cultivated on 30 m x 1.2 m beds, and the following fruit species: mango tree (*Mangifera indica* L., 4 trees per ha^{-1}), bush butter tree (*Dacryodes edulis* (G. Don) H.J. Lam, 10 trees ha^{-1}) and mangosteen tree (*Garcinia mangostana* L., 20 trees per ha^{-1}). At this site, the spring onion plots are irrigated and large quantities of fertiliser are added (0.1 kg of NPK 17-17-17 + 0.1 kg of urea + 1.5 kg of pig manure m^{-2} $year^{-1}$).

The *J. curcas* seedlings planted at the two sites were grown from seeds harvested from subspontaneous shrubs (province of Bandundu) and sown in the nursery. The plantations had been protected by insecticide treatments (dimethoate 40%) between planting and when the tests began.

Identification of insect pests

Apart from crickets, samples of the major insect pests found at the two experimental sites were determined at the Functional and Evolutionary Entomology Unit at Gembloux Agro-Bio Tech - University of Liège, as part of Jonathan Nyst's (25) master thesis on bio-engineering, using the identification keys developed by Delvare & Aberlenc (8), Mike *et al.* (22), Lecoq (20), Launois & Launois-Luong (18), Launois-Luong & Lecoq (19) and Zahradnik (37).

Evaluation of damage caused by crickets

The impact of damage caused by crickets on the replanted seedlings was evaluated over three successive years (from 2009 - 2011) at Mbankana, using a randomised complete block design with young plants planted at the start of the 1st and 2nd two weeks of each month between 1 October - 31 December. The observations focused on 125 plants from each date of planting.

The evaluation involved identifying the number of cut or destroyed plants after 15 days out the total number planted. Fifteen days after being replanted, plants are firmly rooted in the soil and can no longer be dug up or cut down by crickets. The damage caused by crickets was not evaluated at N'sele, as crickets are eaten by the local populations who regularly remove them from their land.

Dynamic of *Aphthona* sp., *Stomphastis thraustica* and *Calidea* sp. populations

The dynamic of insect pest populations was evaluated at the sites at Mbankana and N'sele over two years from January 2011 until January 2013. Only the above-mentioned 3 major insect pests were counted. Other insects present on an occasional basis on *J. curcas* plants were identified. The evaluation involved counting the insects present on the shrubs without catching them. In the case of leaf miners, any larvae present on the leaves were counted. The counting time was 5 minutes $shrub^{-1}$ and was determined after two tests conducted previously. The observations were made between 6.30–11.30 am, with 2 visits $month^{-1}$, which made it possible to calculate the average number of insects $month^{-1}$.

At each site, two 0.3 ha plots were selected at random. The first plot (P1) was not given any insecticide treatment, while the second plot (P2) was treated three times $year^{-1}$ (April, September and December) with dimethoate 40% (1 litre ha^{-1} $treatment^{-1}$). On plot P1, which numbered 750 plants at Mbankana and 587 plants at N'sele, 30 plants were selected at random at each observation, in order to count the number of insects $shrub^{-1}$. No counts were conducted on plot P2, as the number of insecticide treatments used prevents any outbreaks of insect pests on the shrubs.

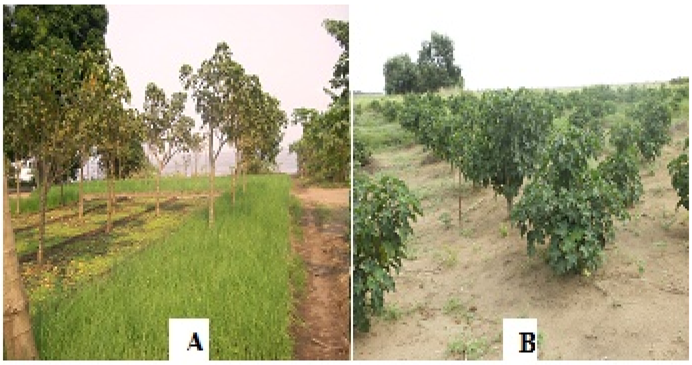


Figure 3: *J. curcas* plantations.

A (*J. curcas* combined with vegetable crops at N'sele)

B (*J. curcas* cultivated as a sole crop at Mbankana)

Evaluation of the impact of insect pest attacks on the vegetative development of *J. curcas* and yields

The impact of insect pests on *J. curcas* vegetative development was evaluated in two ways. Firstly, by counting the number of leaves on the 3rd branch from the root collar, on 30 plants selected at random on each plot (treated and untreated) twice month^{-1} (on the 1st and 30th day) throughout the year. This count was conducted between January 2011 and January 2013. Secondly, by measuring, from the beginning (January 2011) until the end of the study (January 2013), the size, number of branches and root collar diameter of the same randomly selected 30 plants from each plot. The iimpact of the pests on yields was evaluated by comparing yields from all plants on the unprotected plot (P1) with those from the plot that had been protected with an insecticide (P2).

Data processing and analysis

The collected data was processed and analysed using Excel 2010 and MINATAB 16. A variance analysis and average comparison test (LSD: Least Significant Difference) were conducted with a probability threshold of 5%. The linear regression made it possible to check correlations between climatic factors (independent variables) and data on the dynamic of major insect pests on *J. curcas* (dependent variables).

The Student's t-test was conducted in order to compare average data concerning the vegetative development of *J. curcas* (diameter, height and branches).

Results and discussion

Impact of damage caused by crickets on *J. curcas* seedlings

The impact of damage caused by crickets (expressed as a percentage of cut seedlings) on *J. curcas* is shown in figure 4. Attacks by crickets are high after the rains return, with the impact reaching a peak in the second half of November (30.8±4.6%) and the first half of December (38.3±5.5%). The variance analysis showed significant differences ($P<0.05$) in terms of impact of damage caused by crickets recorded during planting periods. Our results are in line with those obtained by Büttiker and Bünzli (7) in Zimbabwe. They confirm that, from June until October, which is the dry season when food is often scarce, the development of crickets is delayed and they reach maturity during the rainy season between November and December. According to Taylor (33), crickets reach adulthood during the rainy season, which coincides with the period from October until December in the Kinshasa region.

Attacks by crickets are more severe in areas with sandy soil (7). Crickets represent one of the major pests for many crops in Africa (33, 36).

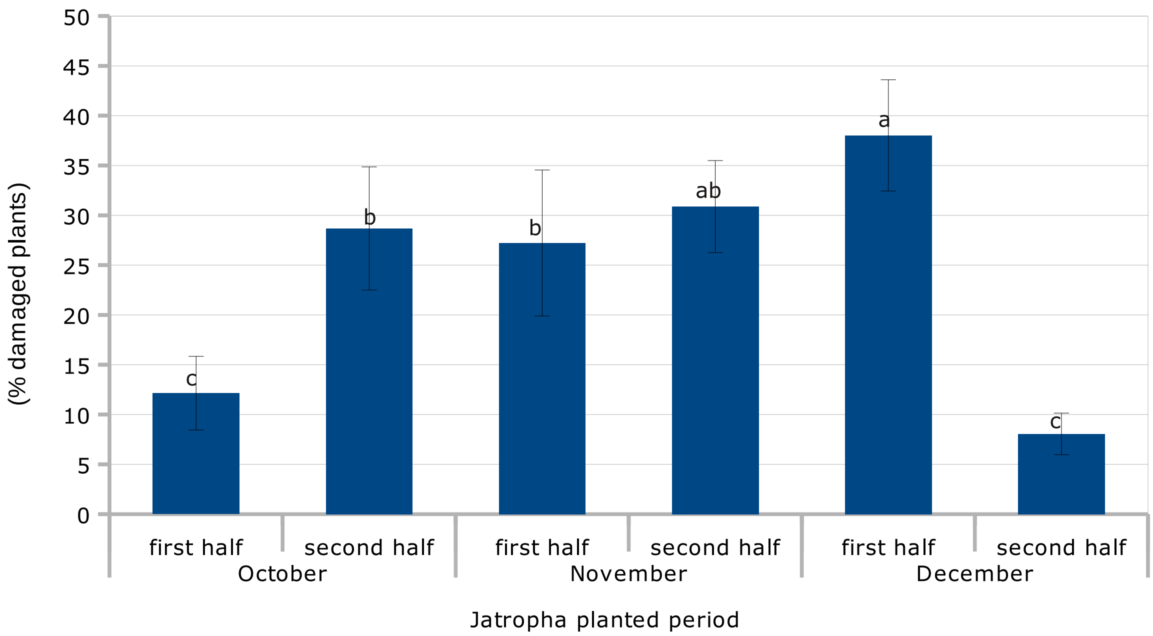


Figure 4: Impact of damage caused by crickets, according to *J. curcas* planting periods.

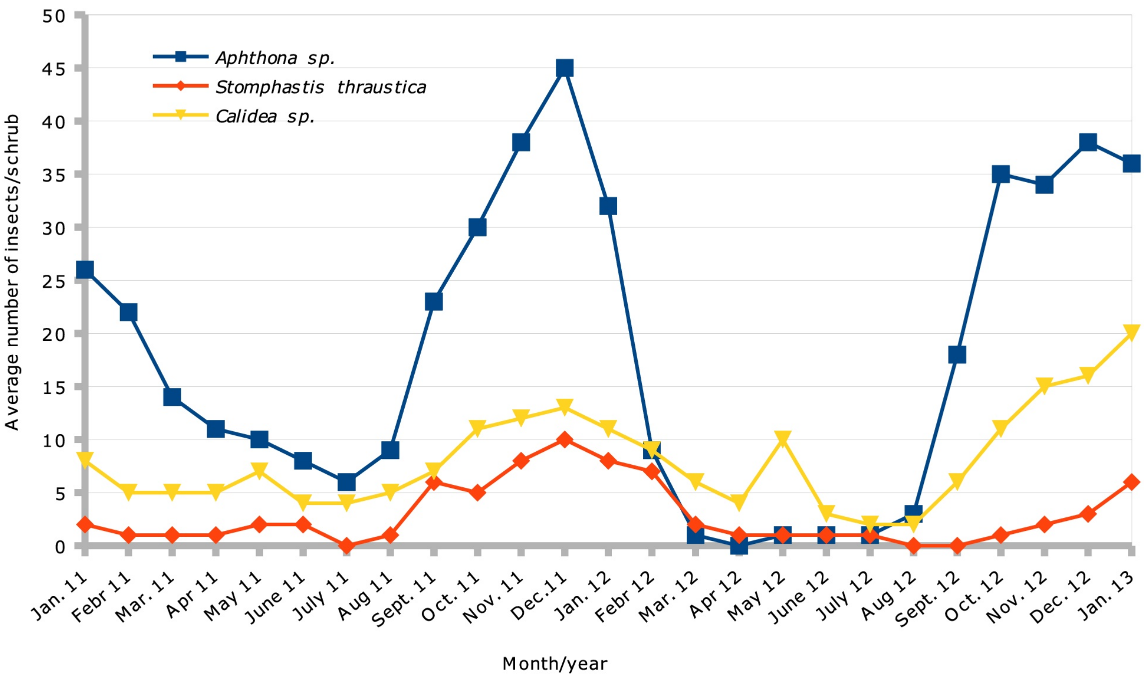


Figure 5: Monthly fluctuations in *Aphthona* sp., *S. thraustica* and *Calidea* sp. populations at the N'sele site.

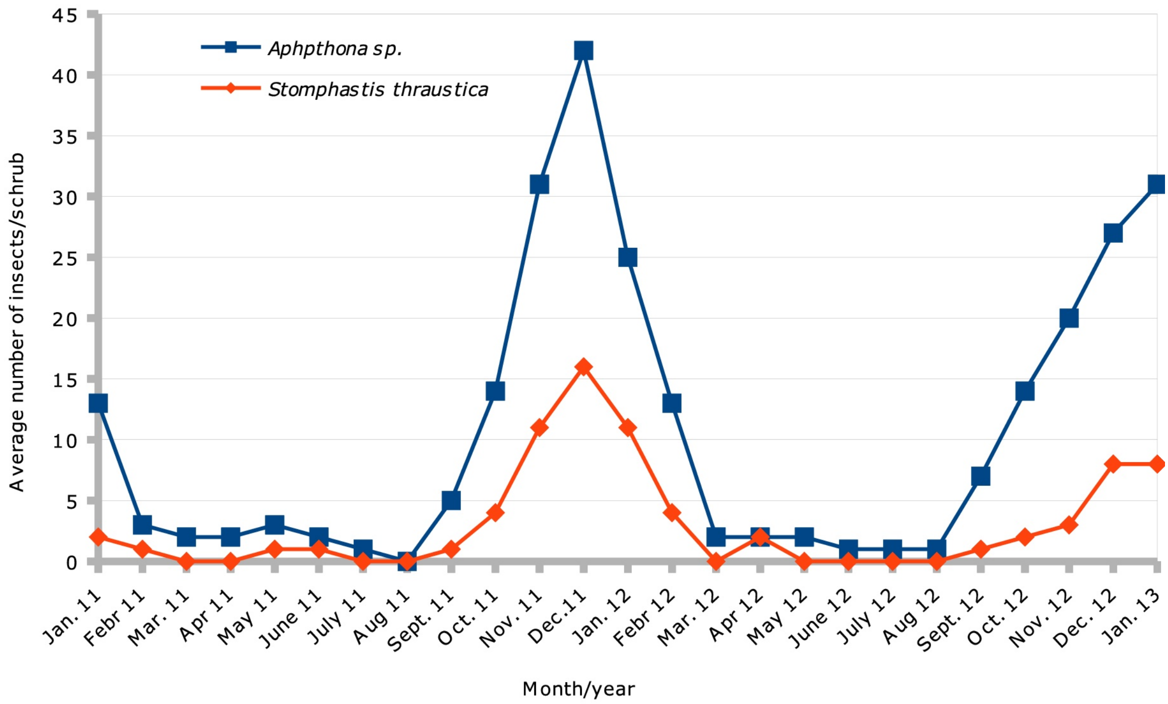


Figure 6: Monthly fluctuations in *Aphthona* sp. and *S.thraustica* populations at the Mbankana site.

At a *J. curcas* plantation (5 ha) situated 80 km from Kinshasa city centre and close to the city of Menkao, over 50% of seedlings were destroyed by crickets 10 days after final planting in October 2010. In China, Li Kun *et al.* (21) show that crickets can cause heavy damage to *J. curcas* crops.

The results of our study show that replanting *J. curcas* between October and December in the Kinshasa region requires a great deal of plant replacement. Significantly lower attack levels (10%) during the first half of October and second half of December make it advisable to plant during these periods. Delaying planting until the second rainy season (March-May) makes it possible to completely avoid attacks from crickets, but is less beneficial for the initial development of the plants, as the favourable period for growth after planting is far shorter.

Dynamic of major insect pests on *J. curcas*

Figures 5 and 6 show the variations in average insect pest populations shrub^{-1} month^{-1}, respectively, at the N'sele and Mbankana sites. Two pests are common to both sites covered by the study: flea beetles (*Aphthona* sp.) and leaf miners (*Stomphastis thraustica*). Shield-backed bugs (*Calidea* sp.) were present at N'sele, but were not observed at Mbankana. Population levels of insect pests on *J. curcas* were affected by marked seasonal variations.

The variance analysis showed significant differences ($P<0.05$) between average pest populations shrub^{-1} month^{-1}. The largest populations can be observed during the wettest time of year (between October and January). On average, there are less than 5 individual insects shrub^{-1} during the rest of the year. At N'sele, however, it should be noted that an increased number of bugs can be observed between April and June, as this period is when the capsules matured, which grow during the 2nd flowering peak. In terms of flea beetles, the largest populations were 41.2±4.9 at N'sele and 33.8±11.3 at Mbankana, while the smallest were 4.4±3.5 at N'sele and 1.3±0.1 at Mbankana. For leaf miners, figures ranged from 1.0±0.1 (April) to 6.7±2.9 (December) at N'sele and 0 (July and August) to 12.2±5.6 (in December) at Mbankana.

The largest *Calidea* sp. populations were 14.9±2.1 individual bugs shrub^{-1} (in December) and smallest populations were 3.1±4 individual bugs shrub^{-1} (in July).

Rainfall was affected by major variations during the year, from 0 mm in July and August to 374.5±142.2 mm in November (Figure 2). At both sites, the pest populations are significantly correlated (positive correlations) with rainfall (P<0.05%, R2≥50%) and very weakly correlated with relative humidity.

Rainfall is an important factor for the development of *J. curcas* (6). Rain and relative humidity impact indirectly on fluctuations (increases and decreases) of major insect pests on *J. curcas*, by influencing the physiological condition of the cultivated plants, due to its availability as a food source (leaves, flowers and fruits) for insects. The temperature and relative humidity saw minor variations during the study period. The relative humidity alone is certainly not sufficient to predict increases or reductions in insect pests. In Kenya, *J. curcas* plantations suffer many problems with pests during the rainy season (26). Kiy indou (17) confirms that rain is an important factor and responsible for fluctuations in homoptera populations in the Congo. The relatively stable temperature has not shown a significant correlation with fluctuations in pest populations (P>0.05). In a study focusing on the dynamic of heteropterans on *J. curcas* in Nicaragua, Grimm and Fuhrer (13) show that the density of populations of these pests varies according to the climatic season. Significant and positive correlations have been identified between the pest populations at each site (P<0.05, R2≥80%). The link between these pests may be explained by the fact that all of them depend on the availability of food (leaves, flowers and fruits), which is itself influenced by rainfall and relative humidity.

In Africa, according to Franken and Nielsen (10), *Aphthona* sp. causes serious damage to *J. curcas*. Many different species of Scutelleridae can be observed on *J. curcas* in most areas where it is cultivated in Mali, Kenya, etc. (4, 27). Terren *et al.* (34) have observed attacks by *Calidea panaethiopica* Kirkaldy (Heteroptera, Scutelleridae) on *J. curcas* in the lower valley of the Senegal river.

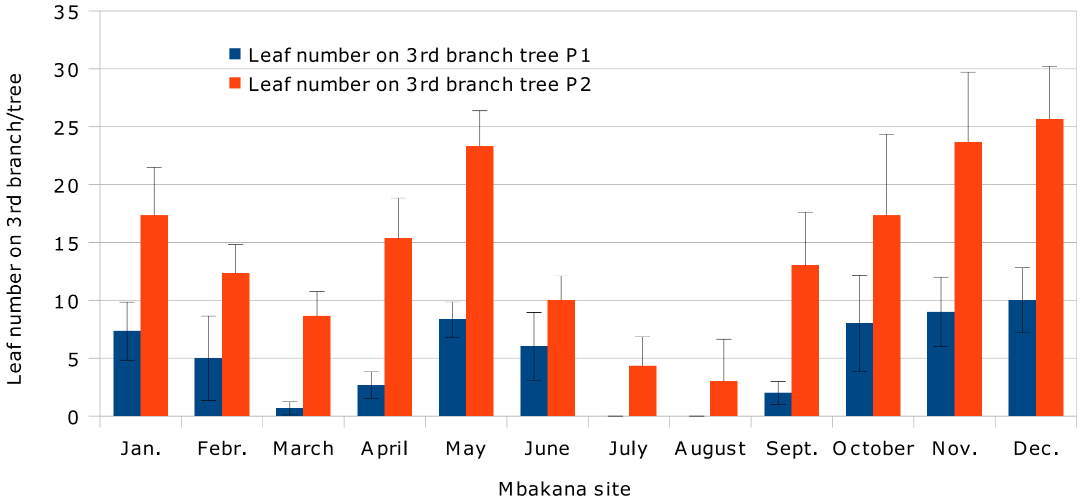
In July and August, leaf miners are almost non-existent at Mbankana, after the plants have fully defoliated, but they are present throughout the year at N'sele. Due to the irrigation at this site, the *J. curcas* plants do not lose all their leaves, which helps the leaf miner and flea beetle populations to remain high.

In order to control these pests, many chemical products are used (Dimethoate, Cypermethrin, Endosulfan, etc.). The best time to control these pests in the Kinshasa region is the end of the dry season. During this period, leaf development is insignificant and the product can easily reach all parts of the plant. This early protection promotes the rapid growth of leaves during the rainy season. In terms of biological control methods, Anitha and Varaprasad (3) show that using commercial solutions containing entomophagous nematodes can destroy flea beetle larvae, which feed on the roots and break the pest cycle. The hymenoptera *Notanisomorphella borborica* Giard and *Apleurotropis lamellata* Kerrich (Hymenoptera, Eulophidae) are major parasitoids of leaf miners in Mozambique (23). The parasitoids *Trissolcus* sp. (Hymenoptera, Platygastridae), *Beauveria bassiana* (Bals.-Criv.) Vuill. (Hypocreales, Ophiocordycipitaceae) and *Metarhizium anisopliae* (Metchnikoff) Sorokin (*Hypocreales, Clavicipitaceae*) make it possible to reduce bug populations (14).

Impact of attacks by insect pests on the vegetative development of *J. curcas*

The counts conducted at the two sites of the number of leaves present on the 3rd primary branch on the shrubs highlight the fact that the development of leaf cover is directly linked to the rainfall pattern (Figure 7). The different phases of annual defoliation take place immediately after the short dry season, which extends from mid-January until late March, and during the long dry season between mid-May and late September.

The number of leaves is lower on the plots which were not given any insecticide treatment than on those that were treated three times with dimethoate. This very marked difference probably results from major pest attacks, to which the untreated shrubs fall victim. At Mbankana, the untreated shrubs had no leaves at all during the long dry season.



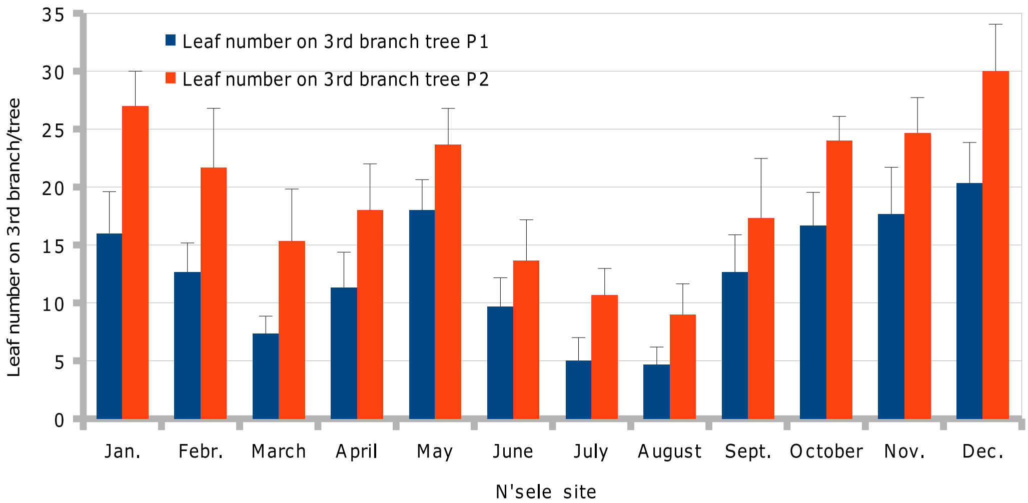


Figure 7: Impact of attacks by insect pests on *J. curcas* foliage.

Table 1

Vegetative development of *J. curcas.*

Plots	January 2011			January 2013		
	Diameter (cm)	Height (m)	Ramification Number	Diameter (cm)	Height (m)	Ramification Number
P1 N'sele	11.0±2.1	1.8±0.2	35.6±4.3	15.1±2.6	2.2±0.3	44.8±5.1
P2 N'sele	12.1±1.8	1.7±0.3	34.2±2.6	18.4±4.5	2.5±0.5	57.3±6.3
	NS	*NS*	*NS*	*P<0.05*	*P<0.05*	*P<0.05*
P1 Mbankana	5.5±0.5	1.3±0.1	15.4±3.4	7.2±4.1	1.4±0.7	23.4±4.5
P2 Mbankana	5.9±0.7	1.3±0.1	16.1±2.1	9.1±3.4	1.6±0.8	37.9±5.6
	N.S	*N.S*	*N.S*	*P<0.05*	*P<0.05*	*P<0.05*

N.S: non significant; P1= plot not treated with insecticide, P2= plot treated three times year^{-1} with dimethoate

Table 2

Impact of attacks by insect pests on *J. curcas* seed yields.

Plots	Yield (kg/ha)					
	Year: 2011			Year: 2012		
	1st peak production	2nd peak production	Total	1st peak production	2nd peak production	Total
P1 N'sele	159	207	366	324	473	797
P2 N'sele	385	563	948	792	1082	1878
P1 Mbankana	9	12	21	16	23	39
P2 Mbankana	77	129	206	167	245	412

1st production peak: April-July. 2nd production peak: September-December

P1= plot not treated with insecticide, P2= plot treated 3 times yea^{r-1} with dimethoate

If the plant is fully defoliated and there is no fruit on the shrub, *Aphthona* sp. become established on the ends of the branches and devour the leaf buds, by forming a blackish coating, which prevents any new leaves from developing.

The presence of leaves from late April until early June, at the N'sele and Mbankana sites, does not result in an increased number of individual *S. thraustica* and *Aphthona* sp. shrub^{-1} (Figure 5 and Figure 6). A major reduction in the number of leaves shrub^{-1} caused by flea beetles and leaf miners was also observed by Nyst (25) in another trial conducted close to Mbankana on plants that had not been treated with an insecticide. If insecticide is not applied, some plants can remain fully defoliated for several months. Both at Mbankana and N'sele, plants that were given insecticide treatments showed a significant increase in root collar diameter, height and the number of branches (Table 1). The presence of a blackish crust at the ends of the branches, following major attacks by flea beetles, also explains the low ramification observed on plants that had not been protected by an insecticide.

Ramification is a major factor for *J. curcas* yields, as the flowers form at the ends of the branches (9). The defoliation caused by pests reduces photosynthetic activity in the plant and results in low vegetative development.

Impact of attacks by insect pests on *J. curcas* yields

The application of insecticide treatments makes it possible to increase seed yields during the two annual production peaks, both at Mbankana and N'sele (Table 2). At Mbankana, in the absence of insecticide treatments, the yield losses caused in the 2nd and 3rd years reached 90% (21 kg ha^{-1} without spraying and 206 kg ha^{-1} with spraying in the 2nd year; 39 kg ha^{-1} without spraying and 412 kg ha^{-1} with spraying in the 3rd year). At N'sele, on the other hand, the percentage of yield losses on untreated plots is approximately 60%: 366 kg ha^{-1} without spraying and 948 kg ha^{-1} with spraying in the 3rd year; 797 kg ha^{-1} without spraying and 1878 kg ha^{-1} with spraying in the 4th year.

The lower yield losses recorded at N'sele is probably due to large inputs of organic and mineral fertilisers and irrigation, which have a positive effect on the development of the plants, as well as the effect of associated crops, which could contribute to the prevention of attacks by insects. At Mbankana, where *J. curcas* is cultivated as a sole crop, the very low yields obtained are probably due to the poor quality of the soil in terms of nutrients and major role played by phytosanitary problems.

Pure cropping systems established on a large scale can encourage outbreaks of pest populations (24, 28). According to Grimm (12), economic damage caused by bugs on *J. curcas* in Nicaragua is estimated at 18.5% of the total seed yield. In reality, leaf miners alone do not pose a threat to crop yields (11), but when they are combined with other pests, the damage can become of economic importance. The development of phytosanitary programmes adapted to the local context is therefore vital for the sustainable cultivation of *J. curcas*.

Other insects present on *J. curcas* in the Kinshasa area

Several insects are occasionally present on *J. curcas* plants. Among these insects, the mealy bug *Phenacoccus* sp. (*Hemiptera, Pseudococcidae*) has been observed, which attacks leaves and developing fruits, as well as migratory locusts *Locusta migratoria* Linné (Orthoptera, Acridoidea) that devour *J. curcas* leaves. The damage caused by these insects was insignificant on the plots observed. However, this does not mean that it will not reach critical thresholds one day. The presence of useful insects has also been observed, such as the praying mantis *Mantis religiosa* Linné (Mantodea, Mantidea) on the plants included in our tests.

In a study conducted by Srinophakun *et al.* (32) in Thailand, mealy bugs were identified as pests on a *J. curcas* plantation. Sahito *et al.* (29) have also found populations of mealy bugs on *J. curcas* on an Indian ecotype and the maximum average number of individual bugs plant^{-1} was 3.5. Planting *J. curcas* adjacent to cassava fields (*Manihot esculenta* Crantz) must be avoided due to the risk of mealy bugs being transferred from the cassava to the *J. curcas*.

Conclusion

In the Kinshasa region, *J. curcas* crops are subject to pressure from four major insect pests (*B. membranaceus, Aphthona* sp., *S. thraustica* and *Calidea* sp.), which belong to the following orders: *Orthoptera, Coleoptera, Lepidoptera and Heteroptera*. Attacks by these pests represent a very important constraint for production.

On the Batéké Plateau, the period when *J. curcas* is planted coincides with cricket outbreaks. Between mid-November and mid-December, 30-40% of plants are destroyed by cricket attacks after being planted.

This percentage is approx. 10% during the first two weeks of October and second two weeks of December. The seed yield losses on plantations cultivated as a sole crop on marginal land on the Batéké Plateau reach approx. 90% if an insecticide does not protect them. These losses amount to 60% in the agroforestry system practised under irrigation at N'selé. The highest average numbers of the main pests (leaf miners, flea beetles, bugs) were observed between October and January, with a peak in December, and the lowest numbers were observed between February and September with the lowest numbers in July. Rainfall has an indirect effect on the fluctuating populations of the main pests affecting *J. curcas* due to its availability as a food source.

The implementation of integrated management methods for these pests must take into account their dynamic throughout the year. The application of bio-pesticides and use of potential natural predators are possible ways forward, which should be explored for the sustainable cultivation of *J. curcas* in the Kinshasa region. Information on the biological parameters of the insect pests and their host plants, in terms of when they feed and lay their eggs, is important for the development of effective alternative strategies aimed at controlling these pests.

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