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Estimation of Yield Loss of *Jatropha curcas L.* Due to *Calidea spp.* (Heteroptera: Scutelleridae), in the Sub-Sudanian Zone of Burkina Faso

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***Abstract* – *Jatropha curcas* L. is a biofuel plant that belongs to the Euphorbiaceae family. The production of this plant can improve the livelihood of smallholder farmers in rural areas. Meanwhile, several insect pests including *Calidea* spp. feed on *J. curcas* L. *Calidea* spp. is a Heteropteran that feeds on the flowers and the fruit of *J. curcas*. No yield loss assessment of *J. curcas* due to this pest has been conducted. Therefore, the objective of this study was to assess the yield loss associated with this insect pest. This study was conducted in Léo, South Burkina Faso during the 2013 rainy season, from August to October. A randomized complete bloc design was used. The experimental design consisted of 5 treatments and 5 replicates. The treatments consisted of various numbers of adults of *Calidea* spp. caged with a 4-year old single *J. curcas* plant:T0 (control = no insect pest), T1 (4 couples) T2 (8 couples), T3 (16 couples) and T4 (20 couples). The monitored variables included the number and weight of fruit, the number and weight of undamaged and damaged seeds and the damage due to the insect pest. The results showed that the control (T0) and T1 (10.5% damage) showed the lowest damage while T3 and T4 (36.83%) were the most damaged. There was 7% yield gain in T1 while there was 59% yield loss in T4.**

***Keywords* – Burkina Faso, Biofuel, *Jatropha curcas*, *Calidea* spp., Yield Loss.**

I. Introduction

J. curcas Linnaeus 1753 is a perennial non edible and biofuel plant belonging to the family Euphorbiaceae. Its height varies from 3 to 5 m ([1]). *J. curcas* originates from Mexico or Central America. The plant was probably introduced into Africa in the 16th century by Portugese navigators through Cabo Verde, then brought to Guinea Bissau and the rest of Sub-Saharan Africa([2]).The genus *Jatropha* contains approximately 170 known species ([3]).

In Burkina Faso, four species of jatropha are known: *J. curcas* L., *J. gossypiifolia* L., *J. podagrica* H. and *J. integerrima* J. ([4]). But *J. curcas* L. remains the most abundant and most planted species.

J. curcas seeds produce an oil that is used as biofuel. This species has potential to diversify agricultural production and increase small scale farmers' incomes and thus fight rural poverty through the development of crude oil production ([5]). In addition to biofuel production, many other uses are associated with the *J. curcas'* plant. These include the production of soap and organic manure from the cake. The plantation of *J. curcas* reduces soil and wind erosion, and increases carbon sequestration that reduces the emission of CO2. Despite the toxicity of its oil, which is insecticidal, *J. curcas* is subject to attack by several insect pests ([6]; [7]; [8]; [9]).

In Africa, several insect pests feed on *J. curcas*. These include crickets, coccinellid beetles, mealybugs, true bugs and lepidopterous larvae([10]; [8];[9]).The major insect pests of *J. curcas* in Nicaragua are Heteroptera that feed on the flower and fruit, causing premature abortion of the flowers or the malformation of the seeds ([11]). The associated yield loss was estimated at 18.5% of the potential seed production ([12]).

Calidea spp. is a polyphagous insect pest from the Scutelleridae family in the Heteroptera order. It has been reported as a cotton feeding insect in Tanzania and as a pest of sorghum and sunflower in South Africa ([13]). According to the same author, this insect pest is a severe constraint to the commercial production of *J. curcas* in Malaysia. *Calidea* spp.is also reported in Guinea Bissau where it apparently causes damage to the seed and the quality of oil ([13]). Another species, *C. panaethiopica* occurs on *J.* curcas in Sénégal ([14]) and Niger ([15]).

In Burkina Faso, *Calidea* spp. has been reported as one of the most frequent insect pests in *J. curcas'* plantations. Indeed, the reference [16] reported that the insect was present in 59.6% of *J. curcas* plantations. Nymphs and adults of *Calidea* spp. apparently feed on flowers and fruits of *J. curcas*. However, there is no reliable data on the effect of the feeding of the insect pest on seed production. Therefore, the objective of this study was to assess the potential yield loss due to *Calidea* spp.

II. Material and Methods

2.1 Material

2.1.1. Experimentation site

The study was conducted from August 13th to October 15th in the village of Mouna, Burkina Faso(11° 8' N; 2° 4' W, 370.95m). Mouna is located 4 km north-west Léo, the capital city of the Sissili province. The *J. curcas* plantation used for this study had an area of 10,000 m^2. *J. curcas* was planted in 2009 on 12 rows with 8 m between rows and 2 m between plants. Each line comprised 41 plants.

The commune of Léo is located in the south-sudanian zone of Burkina Faso. The climate is characterised by a unimodal rainfall pattern, with the rainy season starting in

May and ending in October. Mean annual precipitation varies between 900 mm and 1200 mm. The 2013 annual precipitation was1,042 mm ([17]).

'The vegetation in the area is predominately savannah type with most prominent tree species being: *Butyrospermum parkii*, *Parkia biglobosa*, *Afzelia africana*, *Anogeissus leiocarpus*, *Pterocarpus erinaceus*, *Burkea africana*, *Asoberlinia doka*, *Tamarindus indica*, *Crossopteryxfebrifuga*, *Adansonia digitata*, and *Combretum* spp. There are also diverse types of grasses and sedges in the wetlands' ([18]).

2.2 Field Methods

We used 25,4-year old *J. curcas* plants intercropped with sweet potato. On the rows, plants were chosen haphazardly. The 25 plants were individually caged with muslin with tight mesh. Each cage was 2.6 m in high and 5.6 m in diameter. The muslin was attached to the tree.

Two entry sleeves were placed at different heights of the muslin (1.4 m and 2.1 m from the soil level) to facilitate observations inside the net. Each cage plant contained one *J. curcas* plant bearing flowers and fruit at different developmental stages. Before placing the net, each selected plant was carefully inspected to make sure that there were no *Calidea* spp.(eggs, nymphs or adults) on the plant. The plants were infested by *Calidea* spp. during 10 weeks (from August, 13 to October, 15 2013).

The experimental design was a randomized complete block with 5 treatments and 5 replicates. The treatments consisted of couples of *Calidea* spp. adults of caged with a 4-year old single *J. curcas* plant. The treatments included T0 (control = no insect pest), T1 (4 couples) T2 (8 couples), T3 (16 couples) and T4 (20 couples). All treatments were caged and infested the same day in the same conditions. Entomological evaluations were performed weekly, on Monday, starting a week after the plants were infested until all fruit have reached maturity.

The yellow or brownish mature fruits, on the ground or harvested from each tree were counted and their number recorded. They were then put into plastic bags and taken to the laboratory where they were weighed and shelled. Damaged seeds were malformed and often empty. Undamaged seeds were full and hard when touched with fingers. Damaged and undamaged seeds harvested from each plant were counted and their numbers recorded. They were then placed in large plastic bags and allowed to dry under the cover of a shed for one week. After this operation, the seeds were weighed and kept separately in labelled plastic bags.

From data collected in the field, the following computations were conducted:

- the percentage of damaged seeds

$$= \frac{\text{Number of damaged seeds}}{\text{Number of damaged} + \text{undamaged seeds}} \text{ X } 100$$

- number of dead *Calidea* spp. adults
- number of fruit
- weight of the fruit
- weight of undamaged seeds
- weight of damaged seeds

The loss in seeds due to *Calidea* spp. damage was estimated using the formula of [19]:

$$P\ (\%) = \frac{Rm - Yi}{Rm} X100$$

Where:

P = seeds loss due to the attack of *Calidea* spp.

Rm = maximum yield in the absence of *Calidea* spp.

Yi = yield of i treatment.

2.3 Statistical analysis

Data were analysed with the software Stat view version. 5.0.0.0. Means were compared with Analysis of Variance and post-hoc tests were performed using the Protected Least Significant Difference of Fischer at the 5% probability level. Figures were prepared using Excel software Microsoft Office 2010.

III. Results

3.1 Percentage of Damaged Seeds

The percentage of damaged seeds significantly varied between treatments (df = 4; S^2= 6052.1; F = 6.52; P < 0.001), with treatments T3 and T4 resulting in higher damage than treatments T0 and T1 (Fig. 1).

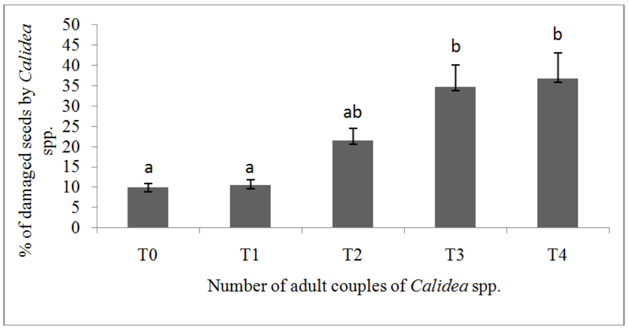

Fig.1.Percentage of damage seeds of *J. curcas* L. for each of the five treatments

Equal letters above bars indicate homogenous groups at 5% level (Protected Least Significant Difference of Fischer).

There was a high and positive correlation(R^2= 0.959) between the number of insect pests and the percent of damaged seeds as indicated in Fig. 2. This correlation indicates that the higher the number of insect pests, the higher the associated damage level.

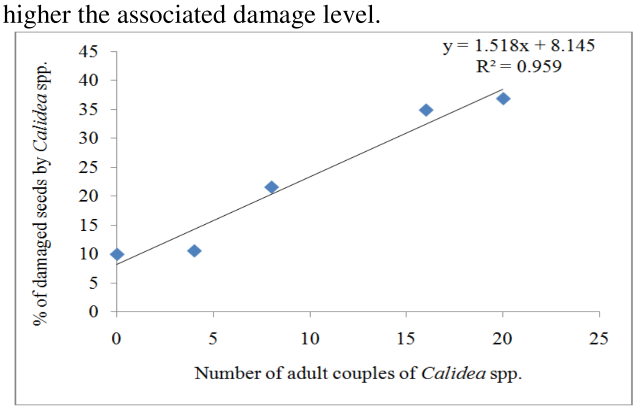

Fig.2. Linear regression between the % of damaged seeds and the number of adults of *Calidea* spp.

3.2 Average number of fruit

The analysis of variance of this variable did not reveal any significant difference (P < 0.3) between treatments (Fig.3).

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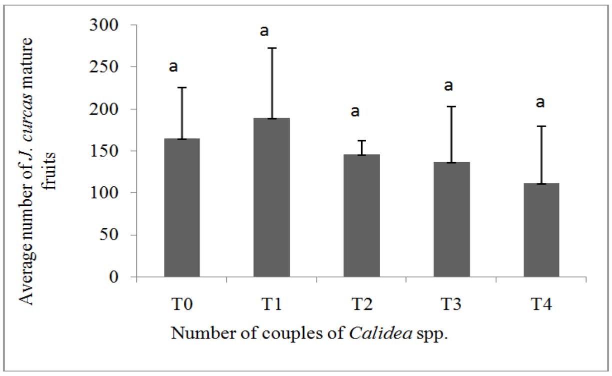

Fig.3. Average number of *J. curcas* mature fruits for each of the five treatments

Equal letters above bars indicate homogenous groups at 5% level(Protected Least Significant Difference of Fischer).

3.3 Average weight of harvested fruit

The analysis of variance of the average weight of the harvested fruits revealed highly significant differences ($P < 0.01$) between the treatments (df = 4; $S^2 = 1066459.3$; F = 3.94), with T1 and T2 providing heavier fruit than T3 and T4 (Fig. 4).

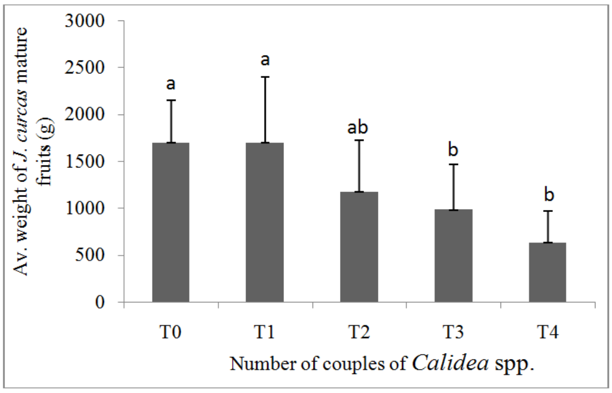

Fig.4. Average weight of harvested fruit for each of the five treatments.

Equal letters above bars indicate homogenous groups at 5% level (Protected Least Significant Difference of Fisher).

3.4 Average number of undamaged seeds

As illustrated by Fig. 5, there was a significant difference in the average number of undamaged seeds (df = 4; $S^2 = 56065.9$; F = 3.5; $P < 0.02$) with T0 and T1 producing more seeds than T3 and T4.

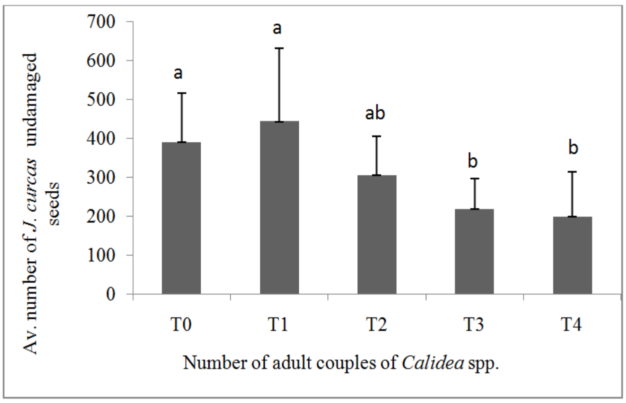

Fig.5. Average number of undamaged seeds for each of the five treatments

Equal letters above bars indicate homogenous groups at 5% level (Protected Least Significant Difference of Fisher).

3.5 Average weight of undamaged seeds

These data represent the average weight of seeds harvested from each tree (treatment). Significant differences were found in the average weight of undamaged seeds (df = 4; $S^2 = 41803.8$; F = 3.5; $P < 0.02$).There were significant differences between T0 and T3, T0 and T4, T1 and T3, T1 and T4 (Fig. 6).

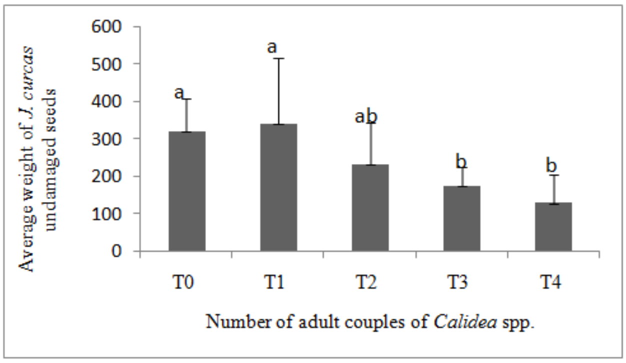

Fig.6. Average weight of undamaged seeds of *J. curcas* for each of the five treatments

Equal letters above bars indicate homogenous groups at 5% level (Protected Least Significant Difference of Fischer).

3.6 Estimation of yield loss of *J. curcas* L.

The average seed yield of *J. curcas* varied from 322 g (T0) to 130.98 g (T4). There was a high, positive and linear correlation ($R^2 = 0.912$) between the average seeds weight and the number of couples of *Calidea* spp.(Fig.7).Yield gained in T1 was 7 %, while there was 59 %loss in T4. This correlation clearly shows that the level of yield loss is proportional to the number of couples of *Calidea* spp. used in the experimentation except for T1.

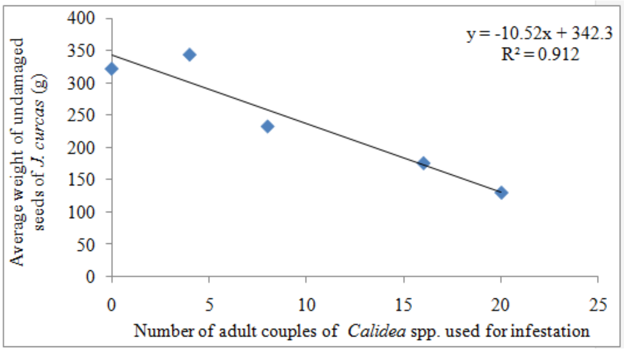

Fig.7. Linear regression between the average weight of *J. curcas* seeds and the number of *Calidea* spp. used for infestation.

IV. Discussion

Our study clearly showed that a sufficient amount of *Calidea* spp. adults is sufficient to damage a significantly high number of seeds and to lower yield by nearly 59%. The 9.9% of damaged *J. curcas* seeds observed in the control (T0) could be explained by the fact that the experiment was implemented and plants caged in August

2013 when some plants were bearing flowers and were already damaged prior to caging. However, all treatments were exposed to the same conditions.

Yield loss was proportional to the number of adult couples of *Calidea* spp. used for infestation except for T1. Our results are consistent with those of reference [13] in studies conducted in Guinea Bissau. This author reported up to 20% of yield loss due to *Calidea* spp. in this West African country. Reference [20]reported that *C. panaethiopica* a closely related species to *Calidea* spp. was associated with 33% of damage in Sénégal. Reference [21]also reported on the economic importance of *Calidea* spp. in Kenya. He stressed that this insect pest is the most frequent pest in *J. curcas* plantations in Kenya. Reference [3] stated that bugs like *Calidea* spp. and *Nezara viridula*, severely damage the fruits of *J. curcas.* Reference [15]observed, in South-East Niger, grain suckers like *Dysdercus*sp. *Calidea* sp., *N.viridula* and two other species of the genus *Leptoglossus (L.zonatus* and *L.gonagra* of the families Pentatomidae, Coreidae, Pyrrhocoridae and Scutelleridae) causing damage to the flowers and the fruit of *J. curcas*. Reference [12] estimated seed yield loss up to 18.5% associated with several Heteropteran species in *J. curcas*' plantations in Nicaragua. Reference [22] observed that in Nicaragua, Heteropterans e.g. *Leptoglossus zonatus* and *Pachycoris Klugii*, are insect pests of *J. curcas* fruit causing the abortion of the flowers resulting in the reduction of yield. Reference [11] reported that the flower bug, *Hypselonotus intermedius* Distant (Heteroptera : Coreidae) is a pollinator of *J. curcas* but at high population, the insect attacks the fruit of the plant. References [23]and [24]reported on *Agonosoma trilinearum* (Heteroptera : Scutellaridea) causing heavy damage to *J. curcas'* plantations in Australia and Madagascar. In India, reference [25]reported on *Scutellera nobilis* (Heteroptera : Scutelleridae) as one of the major insect pests damaging *J. curcas*. At heavy populations, the insect causes the abortion of the flowers, reduces the size and the weight of the seeds resulting often in empty seeds. The gain in yield with T1 suggests that the presence of a low number of the insect pest stimulates seed production rather than reducing the yield. In fact, the determination of yield loss is complex as it involves several factors including the 'physiological state of the plant, its phenological stage at time of attack, the part of the plant attacked, soil fertility, the presence of other biotic and abiotic stresses [26]. Working on rice yield loss assessment, [27] showed that the 'rice plant could compensate for the tiller removal to a certain extent during vegetative growth phase of the plant'.

This study has clearly evidenced the economic importance of *Calidea* spp. in South Burkina Faso *J. curcas* plantations. Our results were obtained in semi-artificial conditions but can be extrapolated into natural conditions. Further research on the biology and the ecology of this insect pest is necessary to develop control methods.

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AUTHOR'S PROFILE

Wakaï Younous Djimmy

was born in Faya Largeau, Chad in 1973. He earned a B.Sc. in agronomical sciences and environment in 1999 in the Academic Institute of Agronomical Sciences and Environment of Sarh, Chad. He graduated from in 2002 from the Institute of Agronomical Sciences and Environment of Sarh, Chad. Lastly, Mr. Djimmy earned a MSc. degree in Plant Protection and Breeding in 2012 at the University of Ouagadougou, Burkina Faso. Mr Djimmy received several training including Monographic survey of the Lake Iro, in 2002, at the National Office of Farming Development of Kyabe, Chad; Management of Industrial Waste and the monitoring of socioeconomics aspects in oil production area producer of oil, in 2003, in Doba, Chad, training on the Communal Ecosystem Management in 2006 in Lake Chad and Chari Baguirmi, Chad. He was also trained on Environmental Impact in 2007 at the International Institute for Environment and Water Engineering, Ouagadougou, Burkina Faso. Mr Djimmy's MSc. research was done on the Inventory of natural enemies associated with rice insect pests in the Sourou Valley, Burkina Faso in 2011.

Mr Djimmy served as an officer of the Ministry of the Environment and Water of Chad, from 2004 to 2006. He was Regional Director of the Environment and Water of N'djamena, Hadjer lamis and Chari Baguirmi area in Chad from 2006 to 2008. Since December 2012, he is a PhD. student at the University Polytechnique de Bobo-Dioulasso, Burkina Faso with research work in the Entomology Laboratory of of Fondation Fasobiocarburant in Léo, Burkina Faso.

Souleymane Nacro

was born in 1959 in Abidjan, Côte d'Ivoire. He earned a diploma in Mathematics, Physics, Chemistry and Biology in 1981 at the University of Niamey, Niger. In 1984, he graduated from the University of Ouagadougou with a MSc. in agronomy. He earned a PhD in biology at the University of Rennes 1, France. In 2012, he received a MSc. in integrated water resources management from the International Institute of Water and Environment Engineering, in Ouagadougou Burkina Faso.

He was a research assistant from 1985 to 1994 in Bobo-Dioulasso, Burkina Faso at the Institute of Environment and Agricultural Research (INERA). He was recruited by the West Africa Rice Development Association (WARDA) as an Integrated Pest Management (IPM) consultant from 1995 to 1997. From 1998 to 2000, he was an IPM consultant for the Food and Agriculture Organization of the United Nations (FAO). He was the national coordinator of the IPM program for Burkina Faso from 2001 to 2009. Since 2010, he teaches Entomology and IPM in a Master course at the University of Ouagadougou. From 2009 to 2013 he was the Director of both Fasobiocarburant SARL and Fondation Fasobiocarburant respectivelly a biofuel company and an organization that promotes sustainable biofuel production in Léo, South Burkina Faso. He resumed his senior entomologist position at INERA, Kamboinsé, Ouagadougou in August 2013.

Dr. Nacro authors about 50 publications including paper published in peer-review international journals, extension journals, books or book chapters. He supervided the research work of about 30 Master and 3 PhD students. Here is a list of selected publications:

Souleymane Nacro and Jean-Pierre Nénon, 2006: Anatomy of the female Reproductive System and the Ultrastructure of the Egg's Envelopes of *Orseolia oryzivora* (Diptera: Cecidomyiidae). *Journal of Entomology* 3 (1): 16-22.

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