Research in Plant Sciences, 2015, Vol. 3, No. 1, 4-11
Available online at http://pubs.sciepub.com/plant/3/1/2

DOI:10.12691/plant-3-1-2

Correlation of Oil Palm (*Elaeis Guineensis* Jacq.) Age, Leaflet Parameters, and Incidence of Its Major Pest *Coelaenomenodera Minuta* Uhmann

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Received March 02, 2015; Revised March 22, 2015; Accepted April 09, 2015

Abstract The oil palm (*Elaeis guineensis* Jacq.) is an oleaginous plant cultivated in the humid inter tropical zone. Its economic importance is significant as it represents the world's leading source of fats of vegetable origin. Its yield is higher per hectare than any other oilseed in the world, but this yield may be limited by *Coelaenomenodera minuta* Uhmann, one of the most damaging pests of oil palm. Because of the damage of this pest, palms can lose up to 50% of their production within two successive years. This study aims at putting in place a method of control of *C. minuta*. For this reason, 14 samples and three repetitions were defined; 11 doses of insecticides and 3 replications were tested. After statistical analysis, the results showed that 25% of the trees had at least 2 adults, 50% had at least 4 adults, 75% of the trees had 9 larvae, 4 nymphs and 7 adults. These results are sufficient to trigger an intervention to reduce the population. The threshold is the same as in older tress, were we had 8 larvae, 4 nymphs and 2 adults. Also, it was found that treatment with evisect's at a dose of 300 g / ha is the best treatment that can significantly reduce the population of larvae, nymphs and adults of *C. minuta* in three weeks. It is recommended that more research work on the seasonality of *C. minuta* be undertaken. This can help identify the period of the year, the moment when the larvae, the nymphs and the adults of *C. minuta* are abundant, allowing proper orientation in decision making. This study can improve on integrated pest management strategies against this major oil palm pest.

Keywords: *Coelaenomenodera minuta Uhmann, Elaeis guineensis Jacq., leaflet parameters, oil palm, integrated pest management*

Cite This Article: Nlend Alain Nicaise, Kosma Philippe, Tabe Taku Robert, Tamfuh Eric, and Ntsomboh Ntsefong Godswill, "Correlation of Oil Palm (*Elaeis Guineensis* Jacq.) Age, Leaflet Parameters, and Incidence of Its Major Pest *Coelaenomenodera Minuta* Uhmann." *Research in Plant Sciences*, vol. 3, no. 1 (2015): 4-11. doi: 10.12691/plant-3-1-2.

1. Introduction

The oil palm (*Elaeis guineensis* Jacq.) is a perennial crop cultivated in the intertropical zone. Its economic importance is considerable since it represents the greatest source of vegetable oils worldwide (Jacquemard, 2011). Oil palm yields more oil per surface area than any other oil producing crop in the world. However, these yields could be limited by *Coelaenomenodera minuta* Uhmann (Coleoptera - Chrysomelidae - Hispinae) which is one of the most damaging insect pest of the oil palm capable of causing up to 50% production losses during at least two successive production seasons (Lecoustre *et al.*, 1980). In the recent years, the incidence of *Coelaenomenodera minuta* has been remarkable in the *Soci*é*t*é *Camerounaises de Palmeraies* (SOCAPALM), plantations at Mbongo situated in the Littoral Region of Cameroon. Young palms have been noted to be their major target even though previous studies undertaken in these same plantations have shown that *C. minuta* attacks mostly palms aged 5 years and above. Since 2001, it was concluded that all plantations in this zone excepting those with young palms should be monitored for the pest. Therefore, the current monitoring system put in place against this pest in the plantations exempts younger palms below 4. Meanwhile for some time now, field observations in SOCAPALM plantations at Mbongo reveal that younger palms of 4 years of age and below which were formerly not a cause for concern have become sensitive to *C. minuta*. The expertise that recommended this monitoring strategy postulated the following hypothesis:

There are more natural enemies of *Coelaenomenodera minuta* in younger plantations;

The leaflets of younger palms have lesser thickness;

Palms of these younger plantings do not overlap, making it difficult for the insects to move from one palm to another.

The objective of this study was to measure leaflet parameters (mass, surface area and thickness) of young palms in comparison with those of adult palms in order to establish the correlation between these parameters and the incidence of *C. minuta* in young and adult palm plantations.

2. Materials and Methods

2.1. Measurement of Leaflet Parameters

Oil palm leaflets were harvested from point B with table knives and carried in bags to the laboratory. *C. minuta* were collected from oil palm (*Elaeis guineensis*) fronds. Tap water was used for washing of the leaflets while alcohol (70°) was used to conserve the insects collected during the experimentation. Analytical balance was used to weigh the leaflets while a graduated ruler, vernier calipers and meter tape were used to measure their dimensions.

Leaflet samples were collected from palm fronds affected by *C. minuta.* Plantings of 3, 4 and 5 years (N3, N4 and N5) were considered for the study in three repetitions each with the notion that leaflets from each year have the same age. Sixty leaflets were collected from each palm tree making 180 leaflets per palm age and a total of 540 samples harvested. After washing and dry-cleaning the leaflets they were weighed in groups of 30. Then the central vein of the leaflet was removed and the two separate flaps in the same groups of 30 were again weighed for each year of planting. The width of the leaflet was measured at the median position. This plus the measured length were used to calculate the surface area of the leaflet.

To measure the thickness of leaflets, 18 lots of 30 leaflets each were constituted, six from 3 years old plantings, six from 4 years and six from 5 years old plantings (control). A vernier calipers was used to measure the thickness of each lot and the averages calculated.

2.2. Sampling of C. minuta

Oil palm trees were randomly sampled and identified per block for observations and verification of the critical threshold of *C. minuta.* The following formula (Balajas et al., 2008; Krid and Messati, 2013) was used to calculate the tree sampling rate:

$$X = \frac{\text{Number of trees visited per hectare}}{\text{Total number of palm trees per hetare}} \times 100$$

where X = Sampling rate

Oil palm trees were identified one day before data collection. Sample size was 30% i.e. 43 trees per experimental unit. The 43 palm trees were selected randomly from each plot. The number of larvae, nymph and adult *C. minuta* were recorded from leaflets of each tree.

2.3. Statistical Analysis

Microsoft Excel software was used for data entry and arrangement. Statistical analysis (ANOVA) and correlation test was done with the help of R Version 2. 13. 1 (2011-07-08) software.

3. Results

Results generated by R software show information on minimum, first quartile, median, third quartile and maximum values for each leaflet of a given age.

3.1. Distribution of Leaflet Parameters

3.1.1. Mass of Leaflets

Figure 1 presents the distribution of leaflet masses with respect to tree ages. Leaflets N5 have minimum mass slightly above 8 g and a maximal value above 12 g, 50% of individuals have masses between 10 g and maximum mass, On the contrary, the minimum mass of leaflets N4 are greater than for N5 though their maximum mass is less than or equal to the average mass of leaflets N5. The median of N5 is slightly greater than 7 g.

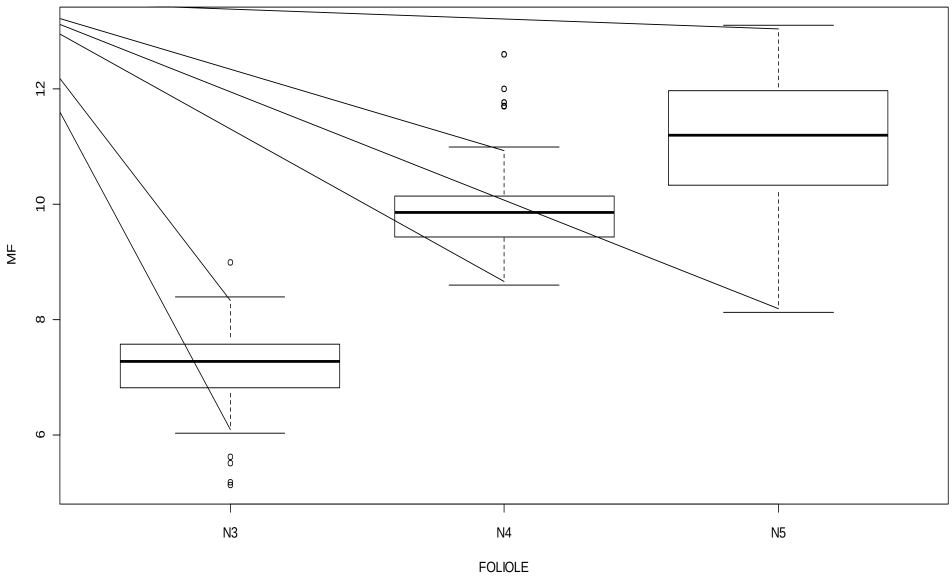

Figure 1. Distribution of leaflet (foliole) mass (MF) with respect to age of palm

3.1.2. Mass of Leaflet Vein

Figure 2 presents the distribution of leaflet veins with respect to the age of leaflets. It can be observed that the mass of leaflet veins is half that of the whole leaflet. The dots on the figures represent isolated values which could be due to reading or typing errors.

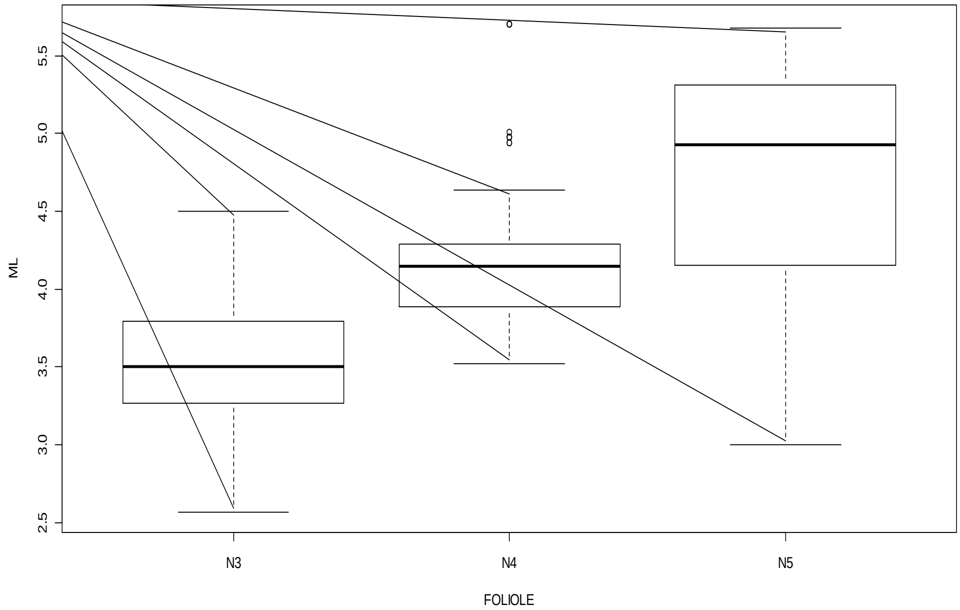

Figure 2. Distribution of the mass of leaflet veins (ML) with respect to the age of leaflets (foliole)

3.1.3. Relationship between Surfaces Area of Leaflet and its Mass

Figure 3 presents the distribution of mass and leaflet surfaces with several values overlapping. Correlation test indicates a p-value < 2.2e-16 and a correlation r = 0.7037503 with a confidence threshold of 95% and confidence interval between: 0.6030765 and 0.7823563. This shows that mass of leaflet varies as a function of leaflet surface.

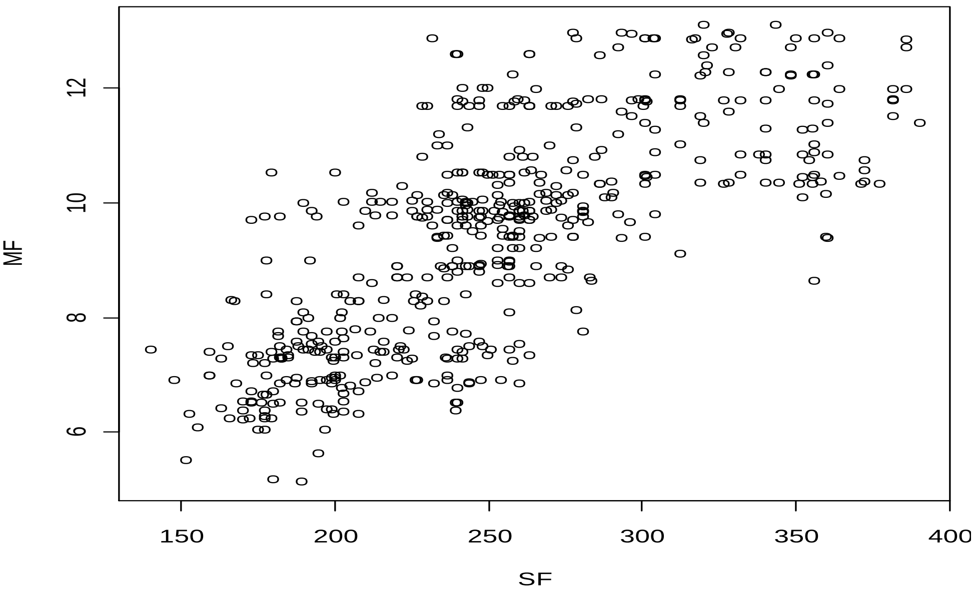

Figure 3. Relationship between mass (MF) and leaflet surface (SF)

3.1.4. Thickness of Leaflet Veins

Figure 4 represents the distribution of leaflet thickness with respect to tree age. It can be observed that leaflet thickness varies between 0.014 and 0.017 cm. ANOVA done with P-value < 0.05 revealed that there is no significant difference between leaflet vein thickness of young plantings (3 and 4 years) and adult (5 years) ones.

3.1.5. Surface Areas of Leaflets vs. vein Surface Areas

Figure 5 and Figure 6 present the distribution of surfaces with respect to leaflet ages. These figures show that the surface area of a leaflet or vein vary as a function of age of palm tree. Analysis of variance (P>0.05) for 3 and 4 years old leaflets show no significant difference between them. On the contrary, the difference is highly significant (P<0.05) between the leaflets of young plantings (3 and 4 years) and those of adult (5 years) plantings.

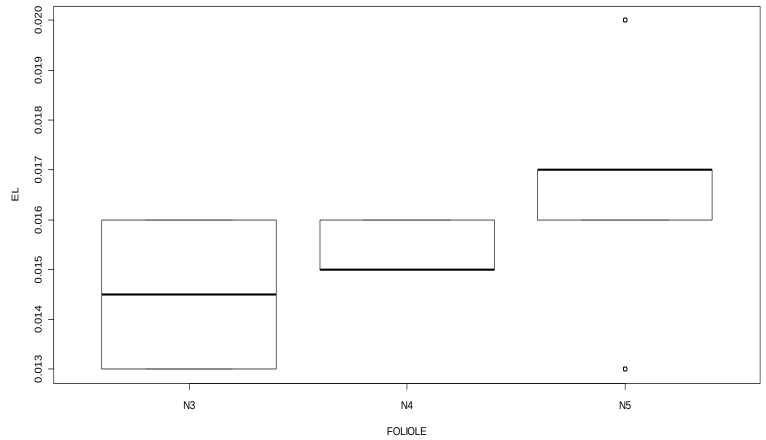

Figure 4. Distribution of leaflet vein thickness (EL) with respect to age of leaflets (folioles)

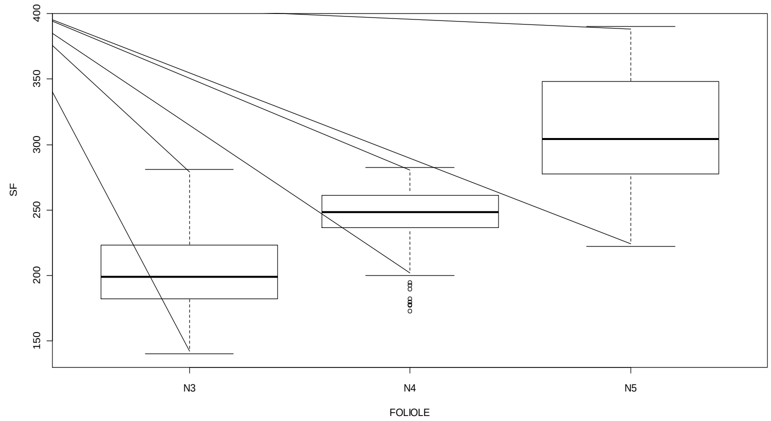

Figure 5. Distribution of surface areas of leaflets (SF) with respect to leaflet (foliole) age

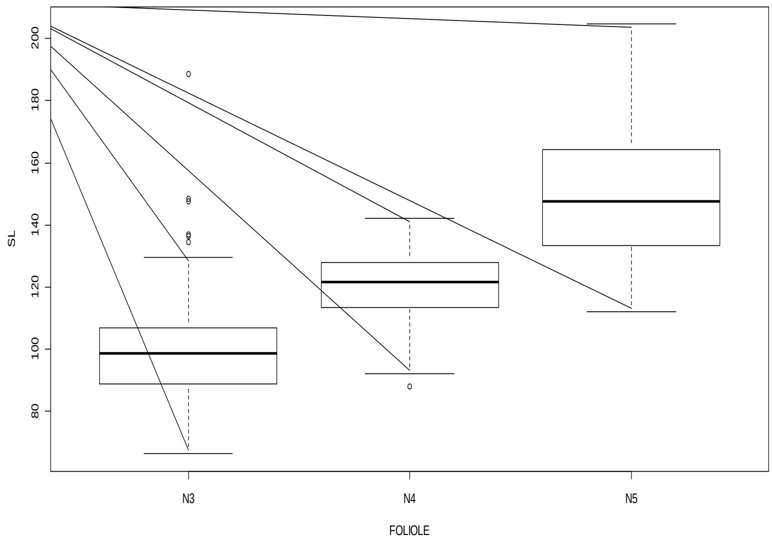

Figure 6. Distribution of the surface area of leaflet veins (SL) with respect to leaflet (foliole) age

3.2. Incidence of *C. minuta* and Correlation with oil Palm Leaflet Parameters

3.2.1. Incidence of *C. minuta* Larvae and Correlation with Mass of Leaflets

Figure 7 presents the distribution of *C. minuta* larvae with respect to age of host plant. This result shows that at the larval stage, young palm trees (3 and 4 years of age) are as susceptible as adult (5 years) palm trees. Analysis of variance at 5% significance level shows a value equal to 0.9323 > 5%. This confirms that the difference in infestation between young and adult oil palm trees by *C. minuta* is not significant. The Pearson's product-moment correlation test between the larvae of *C. minuta* and the mass of leaflets shows a student value (t) = -1.076, p-value = 0.2868 at 5% significance threshold. The confidence interval at 95% had values between -0.3961463 and 0.1238869, with estimated correlation value r = -0.1462159. Figure 8 presents the dispersion of larvae as a function of mass of leaflets. This dispersion confirms that the population of *C. minuta* larvae does not vary as a function of the mass of leaflet.

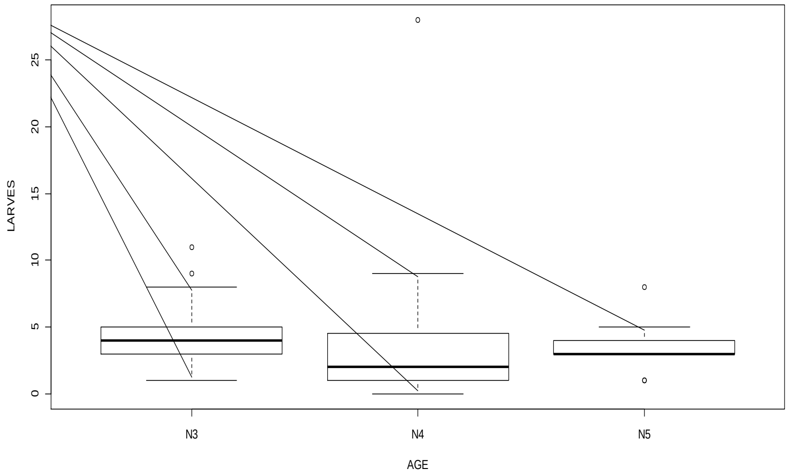

Figure 7. Distribution of C. minuta larvae with respect to oil palm age

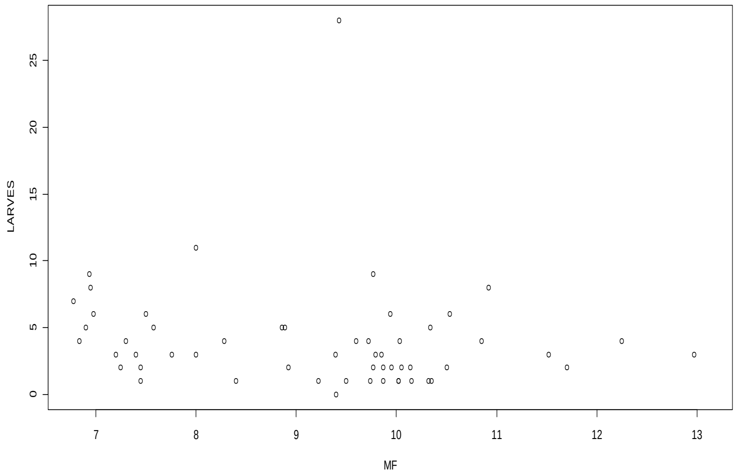

Figure 8. Dispersion of C. minuta larvae as a function of leaflet mass (MF)

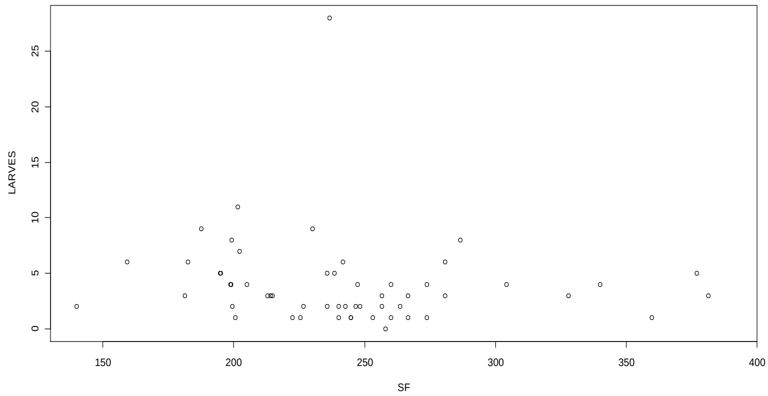

Figure 9. Dispersion of C. minuta larvae as a function of leaflet surface area

3.2.2. Incidence of *C. minuta* Larvae and Correlation with Surface Area and Thickness of Leaflets

Figure 9 shows the dispersion of *C. minuta* larvae as a function of leaflet surface area. This result showing a wide dispersion entails that the incidence of *C. minuta* larvae is not proportionate to the surface area of oil palm leaflet. Correlation test gave p-value = 0.3497 at the threshold of 5%. A value of this correlation was estimated at r = -0.1285287, with a confidence interval between -0.3808399 and 0.1415967 at 95%. The correlation test showed that t_{cal} (-0.9761) < $t_{5\%}$, meaning that infestation of leaflets by *C. minuta* is not a function of leaflet thickness.

3.2.3. Incidence of *C. minuta* Nymphs and Correlation with Leaflet Parameters

Figure 10 shows the distribution of *C. minuta* nymph population as a function of oil palm age. Analysis of variance shows that the difference in incidence of nymphs on oil palm trees is less significant (p-value = 0.2542 * > 0.05).

Figure 11 presents the distribution of *C. minuta* nymphs as a function of leaflet mass (MF). This result shows a relatively high dispersion, r = -0.32, and confirms that there is no correlation between the incidence of *C. minuta* nymphs and the mass of leaflets.

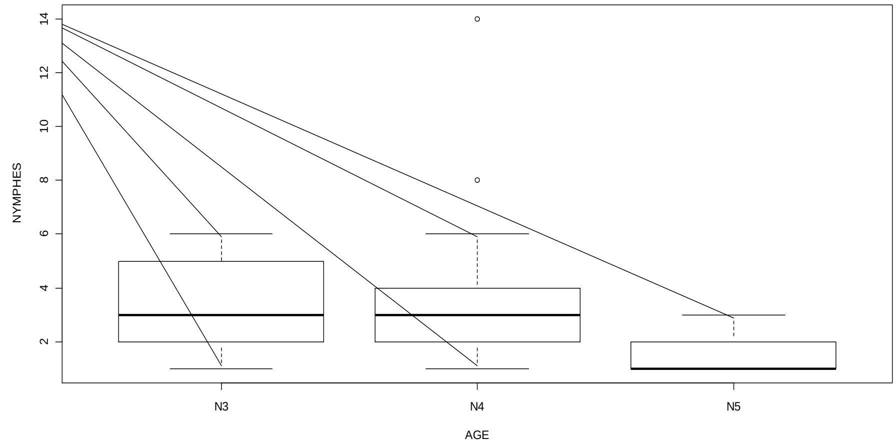

Figure 10. Distribution of C. minuta nymphs as a function of oil palm age

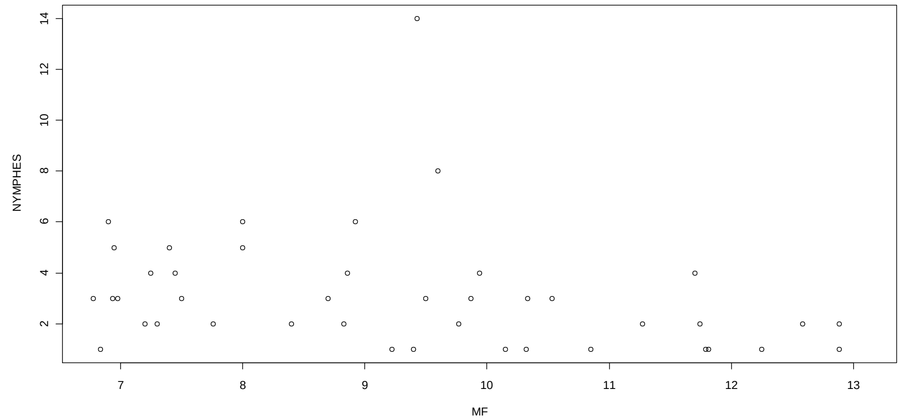

Figure 11. Distribution of C. minuta nymphs with respect to mass of oil palm leaflets

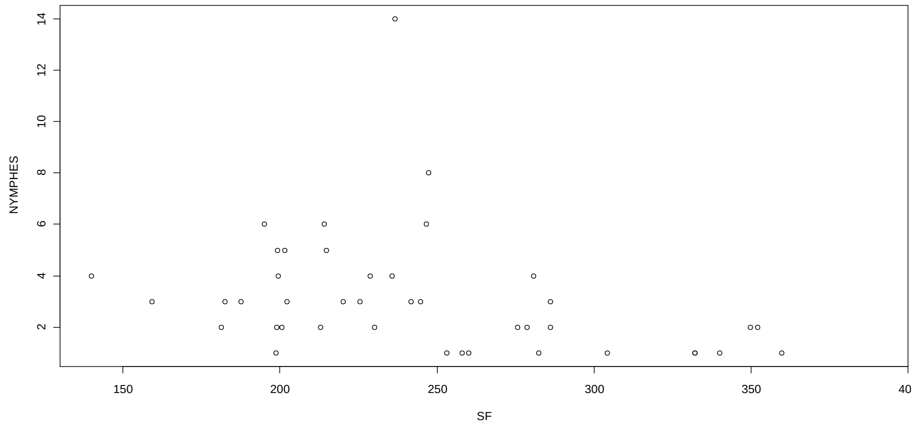

Figure 12. Distribution of nymphs as a function of leaflet surface area (SF)

Figure 12 presents the distribution of nymphs with respect to leaflet surface area (SF). This result shows a relatively great dispersion, r = -0.31. This confirms the non significant correlation between the incidence of C. minuta nymphs and leaflet surface area. The correlation test revealed a wide dispersion around nymphs and leaflet surface area. But the test showed no correlation between incidence of nymphs and leaflet thickness.

3.2.4. Incidence of Adults of *C. minuta* and Correlation with Leaflet Parameters

Figure 13 presents the distribution of adult C. minuta as a function of oil palm age. The analysis of variance (ANOVA) showed a p-value (0.4024) > 0.05. This led to the conclusion that the incidence of C. minuta adults is not a function of the age of oil palm trees.

Correlation tests between distribution of C. minuta adult and leaflet parameters showed a great dispersion with r = ±0.11. The p-values and Student (t) test values were compared at 0.05 significance threshold. Results obtained helped to show that the correlation between the incidence of adult C. minuta population and leaflet parameters was not significant. Figure 13, Figure 14 and Figure 15 show the dispersion of adult C. minuta as a function of age, mass and surface area of leaflets respectively. Test results of Pearson's product-moment correlation showed non-significant correlations for the leaflet parameters and the incidence of adult C. minuta.

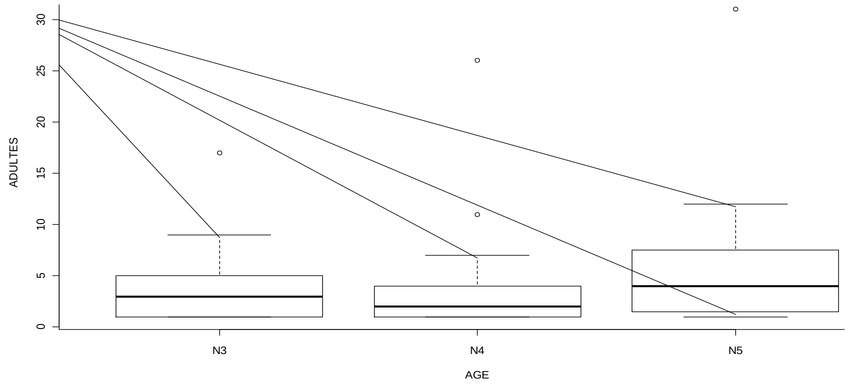

Figure 13. Distribution of adult C. minuta with respect to oil palm age

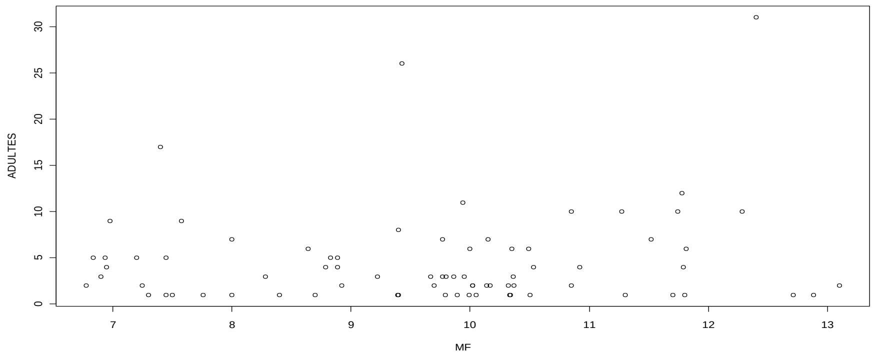

Figure 14. Dispersion of adults of C. minuta with respect to leaflet mass (MF)

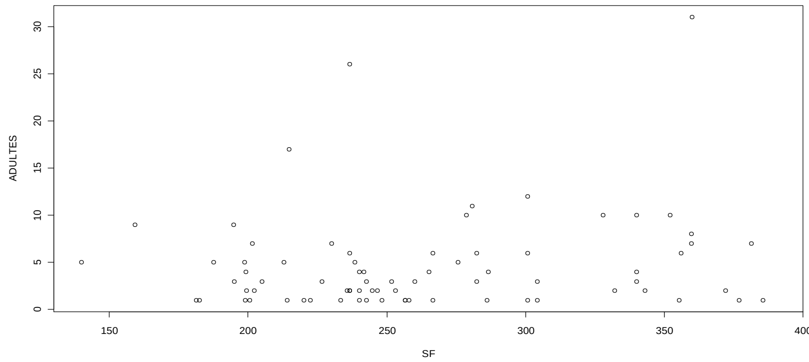

Figure 15. Dispersion of adults of C. minuta with respect to leaflet surface area (SF)

4. Discussion

This study involved measurement of the parameters of oil palm leaflets in order to determine the correlation between these parameters and the incidence of Coelaenomenodera minuta, a major insect pest of the oil palm. The study focused on leaflets because the action of Coelaenomenodera minuta is limited to the leaflets of the host plant on which it causes serious damages while feeding. Another reason is that formerly, C. minuta was alleged to attack only adult palm trees from 5 years of age and above in SOCAPALM Mbongo plantations; but since 2013 the pest is observed to attack younger palm trees between 3 and 4 years of age. It has been reported that the spread of pests is less frequent in old palm plantations during the first 10 years (Mariau, 2001a). Mariau (2001a) found that the spatio-temporal distribution of Coelaenomenodera minuta is independent of palm age. However, the highest infestations of C. minuta were found by Mondjeli et al. (2013) to be mainly concentrated on mature oil palm trees and relatively null in the young plantation. In a similar study on the variation of sex-ratio and identification of natural enemies of C. minuta, plots of the adult palms hosted the highest number of different development stages of C. minuta as well as the infestation of leaflets (Mondjeli et al., 2014). Larvae at the stages 1, 2, 3 and 4 are most responsible for the damages caused in plantations.

Concerning monitoring of the critical threshold, SOCAPALM uses a method recommended by E.G.P.S. Consultancy but this method does not take into account palm trees less than 5 years of age. The method considers 4 years and less as young palms which should not be considered for phytosanitary monitoring of C. minuta. Our observations in these same plantations revealed a normal distribution of the pest at all its stages of developmental cycle in both adult (5 and above) and young (4 and below) plantings. These plantations included 2010, 2011, and 2009 plantings respectively.

Results showed that there is no correlation between the infestation of C. minuta and leaflet parameters measured.

Our results are in line with those obtained by Philippe et al. (2004) on the monitoring and action threshold of C. minuta. According to them, in all oil palm plantations, a regular and periodic monitoring of C. minuta is recommended for earliest detection of any sudden increase of the pest population in any part of the plantation since C. minuta usually starts spreading on palm trees close to fruiting or in the course of production. This pest can attack young plantings of less than four years by contamination from older plantations. However, a previous study of the leaf miner pest C. minuta in oil palm plantations of Tiko Benoe palm estate in Cameroon revealed that the mature oil palm plantation (nine years old) was strongly more infested than the young oil palm plantation (one year old), suggesting that the age of the host plant (oil palm), a biological factor, influenced the attraction of C. minuta individual insects (Mondjeli et al., 2013).

The pest population of C. minuta can increase exponentially at the borders of oil palm plantations especially in marshy areas. At SOCAPALM, third cycle hybrid palms start production after 30 months (2.5 years). A pest control that intervenes 5 years after planting is therefore not timely; the spread of C. minuta could have been more important. An interesting pest control measure is the exploitation of natural enemies. In SOCAPALM plantations, some red and black ants have been identified as natural enemies that feed on eggs and larvae of C. minuta. They are thought to have contributed to the control of the pest in the absence of pesticide control.

Our results also showed that there is no significant difference between leaflet thickness of young palms and adults above 5 years. Studies conducted in the oil palm research station at Pobé in Benin revealed that Coelaenomenodera spp infestation seems to be favoured by the thickness of epidermis and cuticle of the lower surface of leaflets (Coffi et al., 2003). In fact, the greatest infestation was recorded on palm trees with least leaflet thickness while the least affected were those with thick epidermis and cuticle. Coffi et al. (2012) through a study in Benin hypothesized that infestation can also be a function of the genetic origin of palms. Elaeis oleifera is generally les attacked by C. minuta than E. guineensis. There are also differences in susceptibility among E. guineensis populations; high contents of polyphenols (especially in Elaeis oleifera) is toxic to the leaf miner. Assessment of leaflet surface area with respect to age revealed significant differences between young and adult palms. Leaflet surface area varied between 130 and 390 cm^2. These observations corroborate with the results of other worker (Anonymous, 2009) who showed that leaflet surface area of the oil palm varies with respect to age and is between 133 and 480 cm^2; central leaflets are longer and larger measuring up to about 1.2 m, and 4 to 5 cm respectively. Slight differences observed were the effect of environmental influence with border effect.

5. Conclusion

The objective of this study was to assess the variation of leaflet size with respect to palm age and in relation to C. minuta infestation. Measurements were taken on the mass, surface area and thickness of leaflets. Results show that there is obvious variation of leaflet parameters with respect to palm age. Statistical analysis showed that there is no significant difference between leaflet thickness of young and adult palms which probably is the reason why palms of all ages are attacked by C. minuta. It is important to lay emphasis on monitoring of critical threshold of pest populations in plantations of all ages rather than focusing on palm age alone. A study should be carried out to determine the correlation between plant age, leaflet thickness and the incidence of C. minuta on the oil palm.

Acknowledgement

The authors are grateful to Jean François Pajot, the then Mbongo SOCAPALM Plantations Manager who provided the enabling administrative and technical environment as well as support towards the realization of the field work. We also thank the anonymous peer reviewers whose critical observations helped to improve on the quality of this paper.

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