

Potential Weed Species as Alternate Hosts of Insect Vectors of the Lethal Yellowing Disease (LYD) of Coconut Palms (*Cocos nucifera* L.) in Nigeria

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Abstract

Weed species examined as alternate hosts implicated *Panicum maximum* Jacq as the most abundant host of vector insects of the lethal yellowing disease (LYD) of coconut palms. Ten weed species out of the 19 examined hosted leaf hoppers *Cicadellidae* and plant hoppers *Flugoroidea*. They were found in inner leaf sheaths and leaflets. The weed species in coconut LYD areas recorded abundance of *Cicadellidae* and *Flugoroidea* species with *Panicum maximum* 32.7%, *Andropogon gayanus* 23.6%, *Sorghum arundinaceum* 13.4%, *Cyperus difformis* 12.4% and *Oryza barthii* 11.2%. Weed species in coconut non-LYD areas recorded relatively low abundance with *P. maximum* 9.1%, *A. gayanus* 8.4%, *Leptochloa filiformis* 6.8%, and *S. arundinaceun* 2.8%. Eggs, nymphs and adult *Cicadellidae* and *Flugoroidea* species were excised from these weeds mainly grasses. The under-story canopies of coconut palms LYD temperature at 26 ± 2 °C made the vegetation cool, conducive and environmentally friendly for mass breeding when compared with non LYD areas at 32 ± 2 °C. The insects were found on the canopies of LYD coconut palms up to late in the evening (7:00 p.m.) and early in the morning (6:30 a.m.). Some of the *Flugoroidea* species were observed with the proboscis pointed down to the leaf surface with streak damages, an indication of feeding and nesting. Frequencies occurrence of *Cicadellidae* and *Flugoroidea* species proved that abundance of decaying palm logs, pruned fronds, spathes and inflorescence were reservoir for mass breeding. This development could predispose coconuts to series of infections and possible transmission of LYD to healthy coconut palms.

Key words: LYD, Weed, Coconut, Alternate host, Vector insect

Introduction

Lethal yellowing is the most damaging coconut disease in West Africa (Dery et al., 1997). In Nigeria the disease is called Awka wilt and was first reported in 1917 in the Awka district in the former Eastern region (Johnson, 1918). In Nigeria, the coconut grove populations are estimated at 13,615 hectare with over 2 million coconut trees of mainly the West African Tall cultivars, providing livelihood for over 30,000 rural families for whom coconut is the source of food, wood-fuel, building material, drink etc (Osagie et al., 2008). The LYD was detected in a ten hectare coconut plantation in 1995 when a general disease survey was conducted. By the eleventh year (2006), 98.8% of the West African tall (WAT) palms in the same field had died, while averages of 72% of the dwarfs were lost (Odewale et al., 2010).

Survey of insect populations established that *Myndus crudus* van Duzee was by far the most abundant potential vector on coconut palms. Populations of this plant hopper species were as much as 40 times higher in areas of high lethal yellowing (LY) incidence than disease free areas (Howard 1980). When coconut and other palms in insect proof cages were exposed to *M. crudus* adults gathered from palms in LY affected areas, transmission of LY to most test palms occurred within 34 months, whereas similar palms protected from *M. crudus* remained healthy (Howard et al., 1982).

The LYD are caused by phytoplasma which are essentially cell wall-less prokaryotes belonging to the class Mollicutes. Plant to plant transmission of these pathogens are carried out by insect vectors (plant hoppers and leaf hoppers), through vegetative propagation of infected plant materials or by graft inoculation (Kirkpatrick, 1992). Phytoplasma cannot be cultured in vitro, a phenomenon due probably to the lack of essential genes and functions (Razin, 2007). Phytoplasma diseases are invariably transmitted by insects of the order *Homoptera*, suborder *Auchenorrhyncha*, particularly the

families, *Cicadellidae* (leafhoppers) and *Flugoroidea* (Planthoppers) (Nelson, 1979). Approximately 20,000 leafhopper species have been described (Dietrich 2005). Aisagbonhi (2008), also presented the list and numbers of insects encountered per 100 coconut palms surveyed, insect vectors *Meenoplus proximus* (M.R. Wilson) and *Proutista fritillaries* were reported.

Some plant species such as *Emelia forbergii* and *Synedrella nodiflora* have been reported as hosts of the coconut lethal yellowing disease. (Brown et al., 2007). In related studies, pepper, tomato, potato, cassava, sugar cane, *Solanum* spp. and *Euphorbia* spp. have been reported to host phytoplasmas (Nasir et al., 2007).

Control of the spread of LYD insect vectors has been difficult due to paucity of information in the literature on weed species as alternate hosts. In Nigeria, there are areas where the disease outbreak occurred in coconut fields and twelve years after the disease was still spreading to adjoining replanted coconut fields. The objective of this study was to search for alternate hosts of insect vectors of the LYD. It is hoped that knowledge gathered from this study would be utilized in devising effective and practical methods to control the spread of insect vectors of the LYD.

Materials and Methods

Sampling Locations

Sampling of weed species were carried out in four locations of LYD and non-LYD (field not planted with coconuts) areas in Edo State (NIFOR sub station Ubiaja Edo State), South East (Igborim Anambra State), South West (NIFOR sub station, Badagry Lagos State) and central (Aloma-Ofu, Kogi State) of Nigeria. The insects collected were preserved in sample bottles containing 80% alcohol, buffer solution and agarose gel granules for future use.

Sampling Period

Sampling was done during the dry and rainy seasons between the periods of October 2010 till September 2011. This was necessary in order to observe the various taxonomic group and population dynamics of different weed species. During the field study the mean maximum temperature was 33 °C and the mean minimum temperature was 28 °C.

Sampling methodology of weed species

The sampled weed species were mainly grasses and a few aquatic species. Weed leaflets/leafsheaths with streaks or damages were collected and examined. A total of 19 weed species were sampled during the period. The weeds were sampled within coconut LYD endemic tracts and non-LYD areas. For the sampling, rectangular quadrat was laid in different locations. For each location the percentage occurrence was calculated as the percentage of infected weeds (insect collected) in the total weed population sampled in a particular location of every 100 weeds observed. Counting is done 3-monthly when the larval index is below 10 and the adult index below 1; monthly when the indices are 10-20 and 1-3; and weekly when more 20 and 3. (Hartley, 1988). Four blocks (I, II, III, IV), each block contained 12 plots of rectangular quadrat of 1m x 1m x 1m. Five replicates of these were conducted making 20 blocks by 12 making 240 plots per location. Weeds that could not be identified directly in the field using a field handbook of West African weeds by Akobundu and Agyakwa (1987), were taken to the Herbarium Unit of Botany Department, University of Lagos, Nigeria for identification.

Examining other alternate hosts for vector insects

We collected eggs, nymphs and adult insects using sweep nets twelve times each from decaying palm logs, fronds and canopy of LYD (spathes and inflorescences). Some of the collected samples were excised, viewed with the aid of magnifying lens. Eggs, nymphs and adult insects were also recovered and kept in cages for observation. They were viewed with the aid of Motic 230 digital

camera lens connected to Motic microscope and computer. The vector insects were identified while the eggs were transferred to millet seedling inside insect cage (Plate 2A) for rearing at the screen house. The other eggs and nymphs were reared in an artificial diet (composition of artificial diet in 1 litre: H₂O 1000ml, KOH 4ml, Soy flour 15gm, Wheat flour 15gm, Fresh grass leaf 2gm, Sucrose 30gm, Methyl paraben 1.0gm, Yeast 15gm, Agar 15gm, Leaf powder 1.2gm, Acetic acid 4ml, Formaldehyde 2ml and Vitamins capsule 1) at 27 ± 2°C for 6 weeks, for the emergence of adult insects. The insect rearing from the egg till the emergence of the adult was carried out to confirm and compare with the existing adults excised from weeds and coconut palm canopies of the LYD. Examining weed species as alternate hosts of vector insects, priority was given to common species with insect streaks and damages caused by proboscis. The uncommon species without streaks and damages were excluded. The LYD areas were fields with mixture of dwarfs, hybrids, West African tall coconut palms including decapitated coconut stems (Plate 1D). The unidentified vector insects were taken to Entomology Division of the Nigerian Institute for Oil Palm Research (NIFOR) for identification or sent to Natural History Museum in United Kingdom.

Statistical analysis

The sampling procedure was rectangular quadrat. Data were analyzed as % occurrence and student test analysis (t-test).

Results and Discussion

Out of a total of 19 weed species sampled, only 10 were found hosting leaf hoppers of *Cicadellidae* and plant hoppers of *Fulgoroidea* species. They were found in the inner leafsheets/leafsurface of *Panicum maximum* with 32.7%, *Andropogon gayanus* 23.6%, *Sorghum arundinaceum* 13.4%, *Cyperus difformis* 12.4% and *Oryza barthii* 11.2%. The weed species in non-LYD areas recorded relatively low level of vector insects with *P. maximum* 9.1%, *A. gayanus* 8.4%, *Leptochloa filiformis* 6.8%, and *S. arundinaceun* 2.8% respectively (Table 1). Some of the *Fulgoroidea* species were

observed in a typical feeding position with the proboscis pointed down to the leaf surface with streak damages. It was obvious that they were feeding from the inner leafsheets of the weeds mainly grasses (Plate 1B and C).

The excission of eggs, nymphs and adult plant hoppers from these grasses (Plates 2B, C and D) were not only for their nesting and resting but also for mass breeding. The emerged adult plant hoppers from eggs reared in artificial diet were the same species with the adults excised from weeds and LYD coconut palms. Decaying coconut palm logs, pruned fronds, spathes and inflorescence were also found to host the vector insects in large numbers with frequencies occurrence of *Flugoroidea* species 20.5% and *Cicadellidae* species 13.5% (Table 2). The understory canopies of the LYD coconut palms at 26 ± 2 °C made the vegetation cool, conducive and environmentally friendly for mass breeding of vector insects when compared with non-LYD areas at 32 ± 2 °C due to absence of cooling canopies. On close observation, *Fulgoroidea* species were found on the canopies of LYD coconut palms up to late in the evening when observation was stopped (7:00 p.m.) and early in the morning (6:30 a.m.) when observation commenced (Plate 1C), with the proboscis pointed down to the leaf surface with streak damages.

Evidence in this study indicates that *Panicum maximum* Jacq Guinea grass (Plate 1A) was by far the most abundant potential host of insect vectors. Population of these leaf hoppers and plant hoppers were as much as three to eight times higher in areas of LYD incidence when compared to non-LYD areas. The implication of ten weed species as alternate hosts of LYD in this study confirmed that the weed species could be the major source of mass breeding of vector insects. This agreed with Wilson (2005), who reported that plant hopper species were of major importance because of their high fecundity thereby damaging crops and are also known vectors of bacterial or viral pathogens.

The resting and nesting of the insect vectors on LYD coconut canopies till late in the evening (7:00 p.m.) and early in the morning (6:30 a.m.) at $26 \pm 2^{\circ}\text{C}$ proved that the coconut vegetation was a cool and conducive environment for mass breeding when compared with non-LYD areas at $32 \pm 2^{\circ}\text{C}$.

The frequencies occurrence of decaying palm logs, pruned fronds, spathes and inflorescence encouraged mass breeding of insect vectors *Cicadellidae* and *Flugoroidea* species. These alternate hosts facilitated the complete life cycles, reservoir of pathogens and this could predispose coconuts to more attacks. This was supported by Oropeza et al., (2008) who reported that the rate of infection was found to increase with time and was associated with greater availability of inoculum.

This study disagreed with Nkasah-Poku et al., (2008), who reported that to reduce the rate of spread of the disease, infected palms must be felled with a chain saw machine, fronds pruned off and trunk cut into pieces of meters to facilitate quick drying. The duration of leaving the felled diseased palms, pruned fronds and trunk cut into pieces for quick drying is enough to promote mass breeding of vector insects since these substrata are alternate hosts for the vector insects. Rather they should be eliminated by burning soon after felling. Adequate weed management technique should also be practiced.

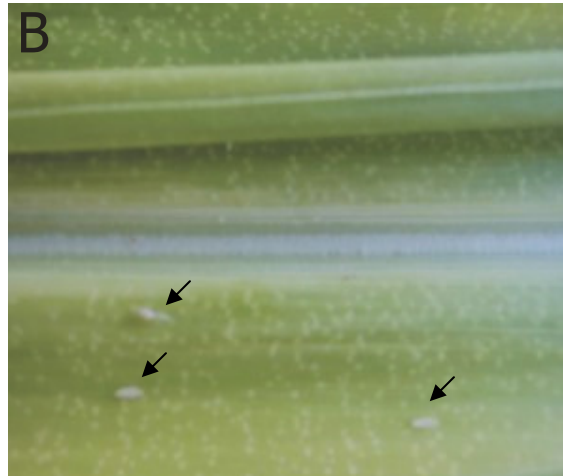
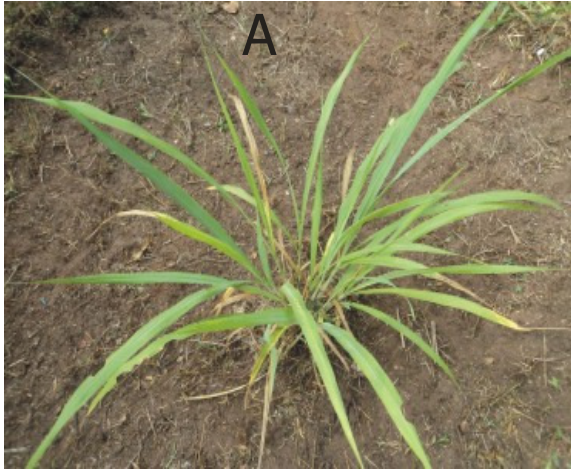
Conclusion

The study conforms to the general epidemiology of disease epidemics such as climate, surrounding flora, susceptible host and vector insects. To reduce the spread of the insect vectors, coconut plantation must be weed and debris free. There must be burning of eradicated weeds, coconut palm logs, diseased coconut palms and pruned coconut fronds in plantations. This management approach will reduce avenues for mass breeding of alternate hosts of the LYD.

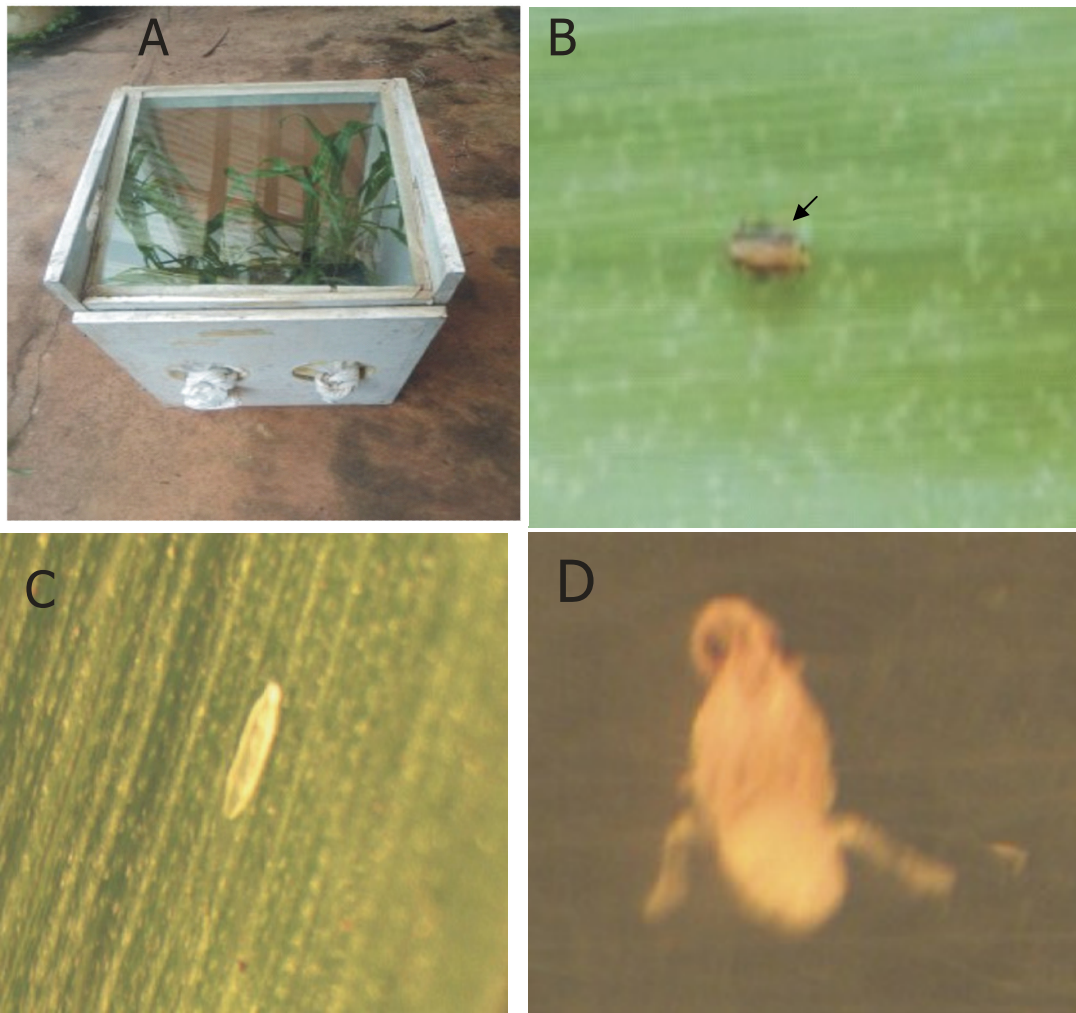
Molecular transmission study is required to confirm the insect vectors status and the LYD coconut palms.

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- Plates 1A. Shows Guinea grass *Panicum maximum* as alternate host of Planthoppers (vector insects).
- B. Arrows show planthoppers emerging from the inner leaf sheet of Guinea grass
- C. Planthopper (*Flugoridea*) found feeding on the canopy of LYD coconut palm
- D. LYD crownless coconut palms caused by insect vectors known to transmit phytoplasma disease.



- Plates 2A. Shows insect cage with millet seedlings for rearing planthoppers
- B. Arrow shows planthopper emerging from the inner leaf sheet of Guinea grass
- C. Egg of a Planthopper *Flugoroidea* found in the inner leaf sheet of Guinea grass
- D. Nymph of a Planthopper *Flugoroidea* found in the inner leaf sheet of Guinea grass

Table 1. Abundance of vector insects in weed species in LYD and non LYD areas

Weed species	Mean % of leafhoppers & planthoppers	
	LYD areas	non-LYD areas
<i>Acanthus montanus</i>	0.0 ± 0.0	0.0 ± 0.0
<i>Acroceras zizanioides</i> Dandy	0.0 ± 0.0	0.0±0.0
<i>Andropogon gayanus</i> Kunth Var.	23.6 ± 1.30 a	8.4 ± 0.06 a
<i>Cyperus rotundus</i> Linn	0.0 ± 0.0	0.0 ± 0.0
<i>Cyperus difformis</i> Zinn	12.4 ± 0.04 b	5.2 ± 0.21 b
<i>Conyza sumatrensis</i> Retz Walker	0.0 ± 0.0	0.0 ± 0.0
<i>Diplazium sammatti</i> Kuhn	0.0 ± 0.0	0.0 ± 0.0
<i>Heteranthera callifolia</i> Rchb. ex Kunth	3.5 ± 0.02 d	0.0 ± 0.0
<i>Heterotis rotundifolia</i> (SM) Triana	0.0 ± 0.0	0.0 ± 0.0
<i>Hyphis suaveolous</i> Poit	0.0 ± 0.0	0.0 ± 0.0
<i>Kyllinga squamulaoa</i> Thorn	0.0 ± 0.0	0.0 ± 0.0
<i>Leptochloa filiformis</i> (Lam.) P. Beauv Feathergrass	0.0 ± 0.0	6.8 ± 0.14 b
<i>Oryza barthii</i> A. Chev	11.2 ± 0.31 b	2.7 ± 0.20 d
<i>Panicum maximum</i> Jacq Guinea grass	32.7 ± 0.41a	9.1 ± 0.03 a
<i>Paspalum scrobiculatum</i> linn (Ricegrass paspalum)	6.5 ± 0.02 c	1.3 ± 0.04 e
<i>Rottboellia cochinchinensis</i> (Lour) Clayton (Itchgrass)	0.0 ± 0.0	2.4 ± 0.13 d
<i>Setaria barbarata</i> (Linn)	2.7 ± 0.08 e	0.0 ± 0.0
<i>Sorghum arundinaceum</i> (Desv.) Stapf	13.4 ± 0.11 b	2.8 ± 0.08 c
<i>Sporobolus pyramidalis</i> P. Beauv.	0.0 ± 0.0	0.0 ± 0.0

Mean with the same letters indicate non-significant differences while different letters in the same column indicate significant differences in regard to abundance at $p = 0.05$ using student test (t-test), to test for standard error of mean (SEM).

Table 2. Excision and collection in sweep nets insect vectors from LYD materials and their frequencies.

Species	Decay LYD materials			
	Palm logs	Fronds	Spathes & inflorescence	%
	mean No. spp.	mean No. spp.	mean No. spp.	frequencies
<i>Flugoroidea</i> large (3.4μ)	3	6	0	20.5
<i>Flugoroidea</i> small (2.3μ)	2	3	1	13.6
<i>Flugoroidea</i> egg (0.4μ)	3	8	2	29.5
<i>Cicadellidae</i> large (3.1)	4	2	0	13.5
<i>Cicadellidae</i> small (2.4μ)	3	2	0	11.4
<i>Cicadellidae</i> egg (0.3μ)	2	3	0	11.4

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