SURVEY OF POLLINATORS ON SOME VEGETATION COVER AT AHMADU BELLO UNIVERSITY, SAMARU, ZARIA

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ABSTRACT
Decline in biodiversity and population of pollinators have similar declining effect on the corresponding pollinated plant species, therefore efforts at conservation, perpetuation and establishment of the pollinators are necessary. Hence the survey of pollinators of some selected vegetation cover within Global Positioning System coordinates of 11˚09' 30" N, 007˚38' 0" E & 11˚10' 00" N, 007˚38' 30" E, at Area F, Ahmadu Bello University, Staff Quarters, Zaria. The vegetation was luxuriant, diverse and comprised more than nine species of flowering plants. In a six months' survey, aimed at conservation of the pollinators and conducted at four days interval between 6:00am and 8:00am or 16:00 and 18:00pm GMT, from January to June, 2016. The flowering plants and their pollinator visitors were identified, the dangers and threats, and the advantages and opportunities for the pollinators were determined. More than twenty-seven species within seven insect orders and two bird species of the Order Passeriformes were the observed pollinator visitors. Birds and insects made up 6.37% and 85.39% respectively of the pollinators while bees alone constituted 31% of the bulk of 91.76% of observed pollinators. The flowering plants provided rewards as nutrients, habitats and breeding sites for the animal pollinators. Loss of habitat and fragmentation due to agricultural activities and construction were among the dangers and threats to the pollinators.

Keywords: Pollinators, Flowering plants, Insects, Ahmadu Bello University, Neem.

Introduction

Sexual reproduction is a very important phenomenon in plants as well as in animals. It is responsible for genetic diversity. Unlike in animals; plants rely on pollen vectors to transport pollens from one individual to another to bring about cross-pollination (Berenbaum, 1995). It has been common knowledge over the years that pollinators are of great importance in reproduction. About 75% are portrayed as significantly contributing in the production of most important world crops and 80% of all flowering plant species rely on animal pollinators to actualize reproduction (Nabhan and Buchmann, 1997; Kevan *et al.*, 2002; Dirzo *et al*., 2014). The basic pollinators include insects, gravity, wind, water, birds,

bats and even humans (Abrol, 2012; Partap & Ya, 2012). It is estimated that out of the numerous animal-pollinated crops of the global food supply 15% are pollinated by domestic bees, while at least 80% are pollinated by wild bee species and other wildlife (Prescott-Allen and Prescott-Allen, 1990; Ingram *et al.,* 1996). Approximately 73-75% of the worlds cultivated crops, such as cashews, squash, mangoes, cocoa, cranberries and blueberries, are pollinated by some variety of bees, 19% by flies, 6.5% by bats, 5% by wasps, 5% by beetles, 4% by birds, and 4% by butterflies and moths (Fact Sheet: Pollinator Diversity, 2004: Dirzo *et al*., 2014).

Notable pollinator decline in recent years has roused the concern of many workers (Feldman, 2012; Gosden, 2014). Many researchers consider habitat destruction, pesticide, parasitism, diseases, and climate change or their synergistic effects, which are ultimately detrimental to pollinator populations as relevant explanations for the observed decline (Feldman, 2012; Lebuhn *et al*., 2013; Gosden, 2014). Decline of pollinators in the world poses shortage of food to humans and animals which depend on them for food production. Dangers consequent to this decline are loss of essential ecosystem services and functions that pollinators provide (Breno *et al.* 2004). A logical approach to alleviating these problems, with a view to their conservation, lies in systematic identification of the pollinators of an ecosystem, and determining the strength, weaknesses, opportunities and threats to the pollinators within their ecosystem.

The aim of this study therefore was to survey the pollinators on some vegetation cover at Ahmadu Bello University (A.B.U.), Zaria. The objectives of this study were to identify the flowering plants of the vegetation cover of the selected study site; observe and collect pollinator visitors of the flowering plants in the vegetation cover, if possible; and determine the dangers and threats, advantages and opportunities for the pollinators within the study site.

Materials and Methods

Study site for the survey was selected from Ahmadu Bello University, Sabon Gari, Local Government Area, Samaru, Zaria, Kaduna State, Nigeria (Fig 1). The site selection was the based on the occurrence of wide diversity of flowering plants and accessibility. To select the site, the entire A.B.U. was visited. The study duration was 6 months (January-June, 2016). During the study, frequently conducted investigation procedures such as, observation and collection of flowering plants or their parts and flower visitors of the flowering plant species

were carried out at intervals of four days, between 6:00-8:00am or 16:00-18:00pm GMT.

Purposive sampling method was used to study plant species of the site due to the uneven distribution of flowering plants in the site. Sampling type was heterogeneous or maximum variation sampling to ensure the presence of maximum variability within the primary data (Black, 2010). The plants were identified by collection of morphologically intact flowers, leaves and pictorial representation of the plants, where possible. Standard identification guides, manuals, handbooks, monographs and revisions (University of North Carolina, 1974) were used to classify the plants according to their orders. Prominent among the guides was "A Handbook of West African weeds" (Akobundu and Agyakwa, 1987). Besides, the plants were also identified by consultation with renowned plant taxonomists and authenticated in the Herbarium, Department of Botany, Ahmadu Bello University.

The flowering seasons of plants of the study site also referred to as their bloom's period were determined by observation and literature consultation on their phenology. Investigations for flower visitors of each plant species were carried out at the regular survey intervals during flower bloom periods of the plants. Visual capture, sound recordings of flying animals, collection with traps and sweep nets (Mississippi Entomological Museum, 2015) were carried out. Identification of the flower visitors were conducted using keys of standard identification guides, manual, guide, handbook, monograph and revision of fauna. Some of the keys used were "Some African Birds" (Ben, 2006), "Wildlife of West Africa". Confirmatory identification of insects was conducted by comparison with samples at the museum of Crop Protection Department of Ahmadu Bello University, while confirmatory identification of birds was conducted with the assistance of renowned ornithologists and zoologists.

To determine existing opportunities for pollinators within the study site indicators for benefits/opportunities to the pollinators were investigated at each survey period. The indicators considered were observation for pollinator rewards as availability of breeding habitats for the pollinators and determination of bloom periods of the plants in order to provide of pollens or nectar as pollinator nutrients (Breno *et al.,* 2004). The determination of existing dangers and threats to the pollinators were similarly investigated at each survey period. The indicators considered for observation were habitat destruction, detrimental factors to pollinator habitats such as usage of pesticides, bird hunters, parasitism, diseases,

coupled with synergy in their effects, all of which were factors listed as dangers/threats to the pollinators in any environment (Feldman, 2012; Lebuhn *et al*., 2013; Gosden, 2014).

Data was analysed using Microsoft Office Excel 2007 and descriptive statistics, such as frequency counts, percentages and a chart.

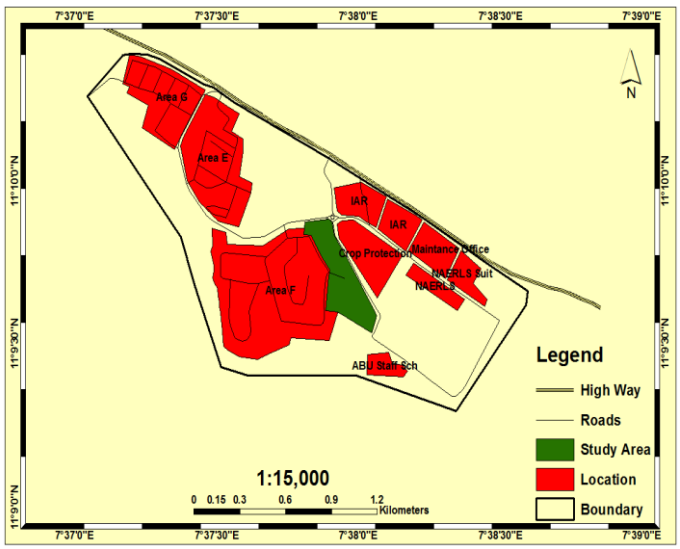

Fig 1: The Study Area (A Section of Ahmadu Bello University Staff Quarters)

RESULTS

The selected study site, Area F, Ahmadu Bello University Staff quarters, is represented by the green coloured area in the map, Fig.1. The study site lies within the Global Positioning System (GPS) coordinates 11˚ 09' 30" N, 007˚ 38' 0" E & 11˚ 10' 00" N, 007˚ 38' 30" E of Area F, A.B.U., Staff Quarters, Samaru, Zaria.

The selected site was a typical urban settlement, remarkable for its lustrous vegetation. The site was supplied by small streams running through the vegetation and there was access to adequate sunlight for growth. The vegetation was replete with diverse flowering plants. Table 1 presents the identified flowering plants and their frequencies of occurrence, expressed as percentages of observed flowering plants in the site. Their frequency of occurrence in a decreasing order was Neem (*Azadirachta indica*) 26.52% > rattleweed *(Crotolaria retusa)* 18.94% > *Acacia* spp (comprising *Acacia redolens* 15.15%; *Acacia fleckii,* 04.55%) > African

mahogany (*Khaya senegalensis* 11.36% > *Parkia biglobosa*, 05.68% > *Delonix regia* 03.41%.

Table 1: Frequency of Flowering Plants in Study Site

S/N	Plant Family-Scientific Name/ Common Name	Voucher Number	Frequency of Species Distribution	Percentage (%)
1.	Anacardiaceae-*Mangifera indica* (L.)/Mango	1944	18	06.82
2.	Fabaceae- *Parkia biglobosa*(Jacq.)/locust bean	7064	15	05.68
3.	Meliaceae-*Azadirachta indica* (A.Juss) / Neem	0900151	70	26.52
4.	Meliaceae-*Khaya senegalensis* (A.Juss)/African mahogany	090081	30	11.36
5.	Fabaceae-*Delonix regia* (B. ex Hook)/ flamboyant	1971	9	03.41
6.	Fabaceae - *Acacia redolens*(Mas.)/ Gardener	2417	40	15.15
7.	Fabaceae - Acacia fleckii	0880	12	04.55
8.	Fabaceae - *Crotolaria retusa* /Rattleweed	1229	50	18.94
9.	Verbenaceae- *Lantana camara*(L.)	0595	20	07.57

The abundance of flowering plants pollinated by the three major pollinating agents in the site, in an increasing order, was birds (6%) < wind (8%) < insects (Fig.2). Investigation of the plant species for their flowering periods and their pollinators revealed agents and animal pollinators of various sizes and shapes which put the pollinators in various taxa (Table 2).

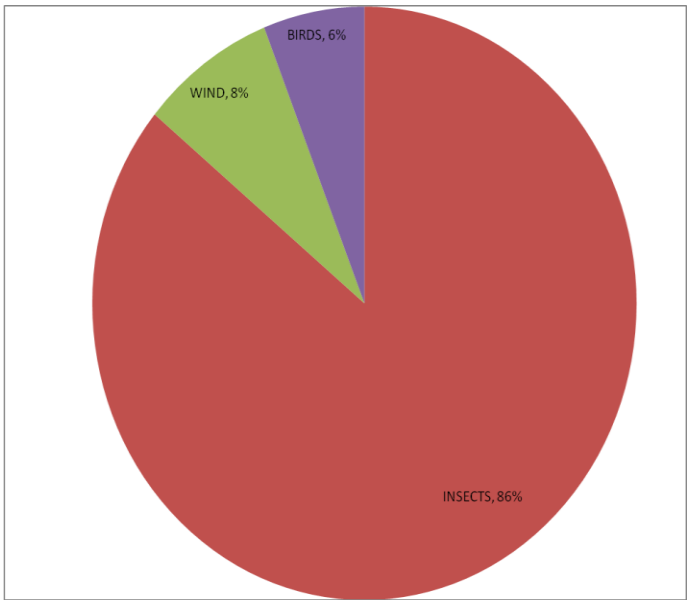

Fig 2: Percentages of Groups of Pollinators

Table 2: Flowering Plants, Flowering Periods, their Pollinators and Pollinator Rewards

S/N	Pollinator species	Flowering Period	Pollinator Rewards	Flower Visitors
1.	*Mangifera indica*	Dec - Feb	Pollen, Nectar, Nesting site	INSECTS Apidae -Apis melifera Calliphoridae- Chrysomya chloropyga (Rob. D) Formicidae- *Camponotus* sp. (Mayr.). BIRD Turdidae- *Turdus pelios.* (B.) WIND
2.	*Parkia biglobosa*	Feb-April	Pollen, Nectar	INSECTS Apidae -Apis melifera Alydidae- *Tenosius* sp. (A.&S.) BIRDS Turdidae- Turdus pelios Pycnonotidae- *Pycnonotus barbatus* (Des.)
3.	*Azadirachta indica*	Feb-April		WIND
4.	*Khaya senegalensis*	March-May	Pollen Nectar	INSECTS Apidae -Apis melifera. Vespoidae- Eumenes maxillosus (De G.) Arctiidae- *Metarctia* sp. Megachilidae- *Megachile sp.* (Lat.) Apidae- *Trigona* sp. Tarachodidae- Tarachodes sanctus kibwezianus (Gig.-T) Calliphoridae- *Chrysomya chloropyga* Cicadellidae-*Coloborrhis corticina* (Ger.) Miridae- *Campylomma* sp.
6.	*Acacia redolens*	April-Date	Pollen Nectar	INSECTS Apidae -*Apis melifera* Alydidae- *Tenosius* sp. Cicadellidae- *Empoasca sp*. Miridae- *Lygocoris* sp Nymphalidae- *Speyeria Cybele* (Fab.)
8.	*Crotolaria retusa*	April- Date	Pollen Nectar	INSECTS Arctiidae- *Utetheisa lotrix.* (Cra.) Nymphalidae- *Vanessa cardui* (Lin.)
9.	*Lantana camara*	April- date	Pollen Nectar	INSECTS Formicidae- *Camponotus* sp. Apidae -*Apis melifera* Acrididae-*Trilophidia repleta.* (Wal.) Nymphalidae- *Euphaedra* sp. (Hub.) Tabanidae- *Philoliche sp*.(Hard.) Sphingidae-*Macroglossum stellatarum* (Lin.) Pieridae- *Aphrissa statira* Arctiidae- *Utetheisa lotrix* Nymphalidae- *Speyeria cybele* BIRD Pycnonotus- *Pycnonotus barbatus*

Neither insect nor bird visitors of the flowers of *Azadirachta indica* was observed. Their inflorescence comprised copiously produced tiny florets that dried up and were windblown. There was similar observation of the inflorescence of *Mangifera indica* however, insect visitors were observed. The animal pollinating agents are presented according to their percentage distribution on the plant species of the study site (Table 3). Two bird species were observed pollinating *Parkia biglobosa*.

Table 3: Percentage distribution of pollinators in relation to plant species

S/N	Pollinator Order	Pollinator	Plants	Frequency of Occurrence of Pollination	%age Plant Species Pollinated
1.	HYMENOPTERA	*Apis melifera*	*Mangifera indica*	18	
			Parkia biglobosa	15	
			Khaya senegalensis	30	
			Delonix regia	09	
			Acacia redolens	40	
			Acacia fleckii	12	
			Lantana camara	20	
					13.48
		Eumenes maxillosus	*Khaya senegalensis*	30	02.81
		Megachile sp.	*Khaya senegalensis*	30	02.81
		Trigona sp.	*Khaya senegalensis*	30	02.81
		Auplopus sp.	*Acacia fleckii*	12	01.12
		Camponotus sp.	*Mangifera indica*	18	
			Acacia fleckii	12	
			Lantana camara	20	
					04.68
		Megachile sp.	*Khaya senegalensis*	30	02.81
2.	DIPTERA	*Chrysomya chloropyga*	*Mangifera indica*	18	
			Delonix regia	09	
			Acacia fleckii	12	
					03.65
		Philoliche sp.	*Lantana camara*	20	01.87
		Musca domestica	*Acacia fleckii*	12	01.12
		Chetogena sp.	*Acacia fleckii*	12	01.12
		Zaprionus sp.	*Delonix regia*	09	00.84

3.	LEPIDOPTERA	*Metarctia sp*	*Khaya senegalensis*	30	02.81
		Utetheisa lotrix	*Crotolaria retusa*	50	
			Lantana camara	20	
					06.55
		Euphaedra sp.	*Lantana camara*	20	01.87
		Macroglossum stellatarum	*Lantana camara*	20	01.87
		Aphrissa statira	*Lantana camara*	20	01.87
		Vanessa cardui	*Crotolaria retusa*	50	04.68
		Speyeria cybele	*Lantana camara*	20	
			Acacia redolens	40	
			Acacia fleckii	12	06.74
4.	MANTODAE	*Tarachodes sanctus kibwezianus*	*Khaya senegalensis*	30	02.81
5.	HEMIPTERA	*Tenosius* sp.	*Parkia biglobosa*	15	
			Acacia redolens	40	05.14
		Lygocoris sp.	*Acacia redolens*	40	03.74
		Empoasca sp.	*Delonix regia*	09	
			Acacia redolens	40	04.59
		Coloborrhis corticina	*Delonix regia*	09	00.84
6.	ORTHOPTERA	*Trilophidia replete*	*Lantana camara*	20	01.87
9.	WIND		*angifera indica*	18	08.24
			adirachta indica	70	

Insects of the order Lepidoptera listed in association with *Lantana camara* (Fig 3.) *Acacia* spp and *Delonix regia* in Table 3 were collected from their colourful inflorescence. Nests of birds and bee hives were observed on *Mangifera indica*. Bee hives were also observed on the trunk of *Khaya senegalensis*. *Utetheisa lotrix* and *Vanessa cardui* were the observed pollinating the flowers of *Crotolaria retusa* plant which had typical floral morphology of the leguminous plants with encapsulated sexual structures comprising stamen and carpel, concealed within the boat shaped enclosure of the petals (Fig.4).

Fig. 3: *Aphrissa statira* as pollinator visitor of *Lantana camara*

Fig 4: Flowers of *Crotolaria retusa*

Nests of bird and bee hives observed on *Mangifera indica* and *Khaya senegalensis* were part of the existing benefits and opportunities for the pollinators in the study site (Table 2.). *Azadirachta indica, Mangifera indica*, and *Acacia fleckii* produced abundant flowers that dehisced and poured to the ground where they also provided habitat and forage for ants and some other observed pollinators. Existing threats to the pollinators were also observed at the study site. The sources of threats were from alteration in the environment due to agricultural activities which were land preparation and plant cultivation which affected the dynamics of the vegetation and pesticides sprays by farmers. Construction works involving buildings and water pipe construction project were also on going at the

study site. Low *Mangifera indica* fruit production relative to previous years was common observation by all within in the study area.

DISCUSSION

Although the study site was in Zaria, within the Northern Guinea Savannah (Ibrahim *et al*., 2016) the rich vegetation cover was not typical of the Northern Guinea Savannah. The selected study site had water supplied by running streams and adequate sunlight for effective plant growth had vegetation cover that is specific to Northern Guinea Savannah. Consequently, this report of the study conducted at A.B.U. Staff Quarters, Samaru, Zaria may not be limited to the vegetation only but can be adapted to more humid areas of the Southern Guinea Savannah, with slight modification to accommodate the peculiarity of areas for adoption.

Acacia spp, African mahogany, *Crotolaria retusa* and Neem, with relatively high frequencies of occurrence in the study site were introductions of afforestation programme (Oyenuga, 1967). Whereas the abundance of the observed originally indigenous flowering plant, *Parkia biglobosa*, relative to the flowering plants of the study area was not appreciable, only a menial 05.68%. The exotic plants have become so indigenised and of common occurrence all through the Northern Guinea Savannah (Oyenuga, 1967). There was similar report on vegetation modification and distribution of indigenous plants relative to exotic plants (Valette and Ibanga, 1984).

Azadirachta indica and *Mangifera indica* produced abundant florets and pollens during the dry season which dried the pollens and facilitated their being windblown with ease, which are typical of inflorescence that display anemophily. The observation from both *Azadirachta indica* and *Mangifera indica* exhibit anemophily agrees with the works of Puri (2003), who in his book, "Neem: The Divine Tree *Azadirachta indica",* reported that the neem is usually wind pollination, although he acknowledged entomophily to be a lesser pollination procedure. The observation that pollination in *Mangifera indica* was observed to be both anemophilous and entomophilous agrees with the reports of Bally (2006), and Aliakbarour and Che-Salama (2010). Legumes of the Family Fabacae are generally known to be one bulk of plant species majorly pollinated by insects with few plant species pollinated by birds. In the course of this survey two bird species were observed pollinating *Parkia biglobosa*. Although, the works of Goodwillie *et al.* (2005) and CABI (2019) reported self-compatibility in the cleistogamous of *Crotalaria retusa* due to the floral morphology. The common scientific knowledge on the physiological asynchrony in pollen production and

maturity of the stigma of *Crotolaria retusa* limits the scope of self pollination and enhances the option of pollination by pollinators. In this study a few insect visitors of the Order Lepidoptera mainly, *Utetheisa lotrix* and *Vanessa cardui* were observed pollinating the flower of *Crotolaria retusa*.

The result that animal pollinators, comprising birds (6.37%) and insects (85.39%), sum up 91.76% of the pollinators of various pollinated flowering plant species agrees with the report that 75% of world crops and 80% of angiosperms are animal pollinated (Nabhan & Buchmann, 1997; Kevan *et al.* 2002) and that of Ollerton *et al.* (2011) indicated that insects are the predominant animal pollinators. Reports of the Science Daily (2015) stated that bees, wasps and occasionally Hymenoptera (ants), Coleoptera (beetles), Lepidoptera (moths and butterflies), and Diptera (flies) are the orders of insect pollinators also corroborated the findings of this survey in which insects pollinators were of the Orders Hymenoptera, Lepidoptera, Hemiptera and Diptera.

Investigations on flowering periods, pollinators and pollinator rewards of plants at the study site revealed that bees, observed to be associated with all the flowering plant species, were the pollinators of almost all them. This is in accord with the common parlance that bees are universal pollinators. This also agrees with the assertion that 73% of the globally cultivated crops are pollinated by bees (Fact Sheet, 2004) while Samuel (2017) recorded a higher percentage of about 90%. For these result, it can be said without reserve, that the bee is a generalist with little or no specificity to pollination of flowering trees and shrubs. Given the wide array of pollinator groups and the bulk of pollinators associated with the flowering plants in this study, the bee family still constituted 31%. Besides the broad distribution and high relative abundance of bees in the site, the efficiency of bees as pollinator was further enhanced by its natural equipping with small hairs that pollen grains can stick to, which gave it an upper edge over other pollinator vectors (Daphne, 2011).

There were existing benefits and opportunities and notable threats for the pollinators of the study site. The potential of flowers to attract pollen visitors is dependent on the morphology and physiology of their inflorescence through advertisements and providing rewards were highlighted by Filella *et al*. (2013) and Tölke *et al*. (2019). Thus the colourful floral inflorescence of *Acacia* spp and *Delonix regia* provided habitat for the insects. *Mangifera indica* and on *Khaya senegalensis* provided habitats and breeding sites for birds and insect species as bird's nests and bee hives observed on the trees. The abundant dehisced flowers of *Azadirachta indica, Mangifera indica*, and *Acacia fleckii* were nutrient sources

and habitat for the pollinating bird species, bees and ants. Other evidences of interactions between pollinators and visited plants were mainly associations in which pollen or another part of the visited plant was the direct or indirect pollinator food. Bees in association with plants directly feed on pollens and indirectly used pollens in the production of honey for storage (Lau *et al*., 2019).

Notable threats to pollinators in the site were habitat loss, degradation and fragmentation which resulted from the observed agricultural activities of farmers and development projects which included the water pipe construction project that was also on going at the study site and resulted in the removal of some plant species and disruption of soil which served as nesting sites and foraging resources. These habitat losses, degradation and fragmentation could have their effect on pollen vectors that foraged for pollen and nectar, and their nesting sites (Lebuhn *et al*. 2013). Possible explanations for the low fruit production by *Mangifera indica* observed *during* the study period are the increasing clamour on problems that are detrimentally consequent to plant-pollinator diversity, interactions such as climate change, may be invisible reaction advanced the to be the reason for reduction or loss of species (Hughes, 2000; Walther *et al*., 2002;Parmesan, 2006).

CONCLUSION

The survey indicated that the luxuriant vegetation ascribed to the study site, Area F, Ahmadu Bello University Sfaff Quarters, Zaria is typical of a tropical climate. The predominant pollinators identified were bees, belonging to class Insecta and significant as generalists and most abundant of pollinators. *Azadirachta indica*, the most predominant flowering plant at the study site, had no pollinator visitor and was ascribed to be only anemophilous, although *Mangifera indica* had the most predominant diversity of pollinators was entomophilous, anemophilous and bird pollinated. The peculiarity of the study site makes the findings applicable beyond the Northern Guinea Savannah, Sudan Savannah and the more humid Southern Guinea Savannah.

ACKNOWLEDGEMENT

We thank the staff of Biology and Botany Department, Institute of Agricultural Research (IAR) and National Agricultural Extension Research and Liaison Services (NAERLS) Ahmadu Bello University. Specifically, Prof. A. Oparake, Mr. P.K. Keku, Dr. A. Ibrahim, Mr. I.P. Musa, Zadok, Professor and Dr (Mrs) Uyovbisere whose advise and contributions were vital to the completion of this work.

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