Asian Journal of Environment & Ecology

Volume 22, Issue 1, Page 52-62, 2023; Article no.AJEE.103566
ISSN: 2456-690X

Phytosociology of the Herbaceous Flora of University of Ibadan Oil Palm Plantation, University of Ibadan, Ibadan, Southwest, Nigeria

Oluseun S. Olubode [a*]

[a] *Department of Crop Protection and Environmental Biology, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria.*

Author's contribution

The sole author designed, analysed, inteprted and prepared the manuscript.

Article Information

DOI: 10.9734/AJEE/2023/v22i1475

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103566

Original Research Article

Received: 21/05/2023
Accepted: 24/07/2023
Published: 27/07/2023

ABSTRACT

Plantation agriculture perturbs native flora of ecosystems. This impacts vegetation biodiversity, through species invasion and shift in weeds population dynamics. Oil palm plantations are common in tropical landscapes, and can cause long-term floristic changes. There is paucity of knowledge on inventory and potential impacts of the plantation on community structure of plants. This study investigated herbaceous flora diversity and phytosociology as indicators of appropriateness of management strategy in the University of Ibadan oil palm plantation. The study site is located in a lowland rainforest at the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria on 07°27`253`N latitude and longitude 03°53`427`E. A systematic sampling was employed to enumerate herbaceous flora of a hectare mega plot. The hectare was laid along 100 m transects at 10 m intervals, with 10 m separating each transect. Each transect was laid to cut across middle of 9 m x 9 m x 9 m plant spacing for oil palm. Data were collected on species composition, frequency and density for determination of relative importance value (RIV), species diversity, ordination and

---

**Corresponding author: E-mail: bodethanks@yahoo.com;*

classification. The plantation consisted of 32 herbaceous species in 15 plant families. *Commelina erecta* had the highest RIV (12.621) while *Alchornea cordifolia* had the least (RIV=0.288). Diversity indices indicated high species richness (Simpson Index = 0.909) among enumerated species and species co-dominance (D = 0.091) Ordination biplots indicated three distinct vegetation structures (Secondary, wetland, dryland/fallow). Classification model showed *Commelina erecta* had widest coverage of 92% in distribution at the site followed by *Commelina benghalensis* at 88%. The Oil palm plantation is heterogeneous in species composition, and was not detrimentally invaded. Weeding regimes and other agronomic practices in the plantation should be ecologically integrated to conserve its native vegetation.

Keywords: Oil palm plantation; native plant species; biodiversity conservation; phytosociology, community structure.

1. INTRODUCTION

Agriculture viz a viz conversion of forest land to cropland is one of the major contributor to land use change. This involves the agro-forestry practices including Teak, Oil palm, Gmelina as the case may be in Nigeria. Gibbs et al. [1] reported that early palm plantations were thought to be replacing existing croplands and utilizing degraded land while it is evident that intact tropical forests have been, and will continue to be, a major source of new land for palm plantations [2,1]. They are known to improve living standards and human capital through increase in income, nutrition, connectedness [3,4]. However, since natural forests are being lost at alarming rates, with grave consequences for carbon sequestration, sustainable development and biodiversity conservation, there is need for an integrated forest management strategy under which various forest-based land-uses are planned and sustained with the objectives of preserving primary forest, intensifying the use of non- timber resources, agroforestry [5], and selective establishment and use of plantation forestry (such as Teak, Oil palm and Gmelina plantations).

Oil palm plantations lack forest trees, lianas (woody climbing vines), epiphytic orchids and indigenous palms [6]. The oil palm (*Elaeis guineensis*) is one of the important economic crops in the tropics (Anyanwu and Anyanwu, 1982) belonging to the family Palmae *and* subfamily *Cociodeae.* The oil palm is a versatile tree crop with almost all parts of the tree being useful and of economic value. The fruit is edible and is usually harvested for its kernel in palm oil processing and industrial process. Palm oil has global production which has risen from 13.5 million tonnes in 1990 to 155.8 million tonnes in 2014 [7]. The success of this great production is attributable to its low cost, and stability of the oil makes it the most attractive. Progressively, the worldwide average oil yield per harvested hectare oil palm is 2.5 t and national averages in Malaysia and Indonesia are close to 4 t [8]. Palm oil has many important uses including food, cosmetics, detergents, plastics, industrial chemicals, biofuels and medicinal purpose. Prescott et al*.* [9] found 58 epiphytic species recolonizing palm plantations after deforestation, which are then typically removed in order to protect the intended crop. The impacts of oil palm plantations include species invasion, plant population dynamics, changes in the forest structure, and increasing habitat fragmentation and destruction emanating from use of dangerous chemicals, frequent anthropogenic pertubation. It is known that oil palm plantation also undermines the ecosystem services and functions (Nutrient cycling and Geo-chemicals, carbon sequestration [10] and recreation etc). Similarly, in a monoculture of teak (*Tectona grandis*), the environmental challenges that might propounds from its expansion might include reduced biodiversity emanating from the clearing of undergrowth vegetation; soil erosion by fire treatment and litter raking; nutrient losses during harvesting; the spread of pests such as defoliators, the bee hole borer, skeletonizer; and the effects of water cycling [11,12,13]. Fitzherbert et al. [14] found that oil palm supports fewer species than rubber, cocoa, or coffee plantations, although all plantation types decrease species richness when compared to intact forest.

Weeds are key components of agroecosystems because they support biological diversity within crop fields. Biodiversity in weedy population results from taxonomic diversity, as well as diversity in those weedy traits that affect the survival mortality and reproduction of the individual weeds [15]. Since most of the output of oil palm plantation is targeted at palm oil production all over the globe, many factors has impeded the production yield, among which are age of palms [16], labour shortage and low level of mechanization [17], poor crop management related to fallen palm oil prices and increased production costs [18,19,17]. Other constraints identified include drought and fires in South East Asia (Casson, 2000), erosion and growing pest pressure. The acquisition and understanding of ecological information on any ecosystem is very essential for sustainable utilization and management of such ecosystem. Ecological indicators of weed diversity are usually assessed on a field scale, but weeds are distributed unevenly within fields. In Nigeria, many plant biologists had enumerated the weed flora of cultivated fields.

Komolafe [20] surveyed cashew, cocoa and coffee plantations in the old Western Region of Nigeria and documented the weeds associated with them. Agbaka [21] provided the checklist of weeds found in rubber plantations in Bendel state, now Edo and Delta states. There is however paucity of information on the weeds composition, diversity and the potential impacts on the ecosystem of oil palm plantation of University of Ibadan. This study therefore aimed at providing baseline information on the flora composition, vegetation structure of the oil palm plantation.

2. MATERIALS AND METHODS

2.1 Study Site

The floristic survey was carried out in the the Oil Palm Plantation of the University of Ibadan located on longitude 07°27`253``N and latitude 03°53`427``E with a mean elevation of 180 metres above sea level. The plantation is located in Ibadan Oyo State, Nigeria in the rainforest-savanna transition ecological zone of Nigeria. The wet and dry seasons of the study area are determined by prevalence of maritime southwesterly monsoon from the Atlantic ocean and the dry continental northeasterly Harmattan from the Sahara desert [22].

2.2 Flora Sampling Procedure

A 100-meter tape measure was used to lay the plots in meters, one square meter ($1m^{2)}$ wooden quadrat was used for the sampling of herbaceous flora in individual plots. Garmin™ *ertrex 12* H model Global Positioning System (GPS) was used for geo referencing.

A systematic sampling was used to carrying out the enumeration of the herbaceous flora with the total area studied being 100 m × 100 m (10,000 m^2). The sample area was sampled with 1 square meter quadrats systematically laid at 9 m interval along transects, and with 9 m separating the transects. The layout corresponded to the area of triangular planting configuration of 9x9x9 m for oil palm, with each transect passing though the centre of the triangles. Data were collected on herbaceous flora composition, density and frequency of occurrence.

2.3 Data Collection and Species Identification

Each of the herbaceous flora encountered was identified using published flora of Akobundu and Agyakwa [23] and Johnson [24]. Plants that were difficult to identify were coded and preserved in a plant press, and identified at the herbarium located at botany department of University of Ibadan. Data that were collected include; Species types by visual and use of standard flora, Count of individuals in quadrats and plots for abundance, frequency, density, species diversity using diversity indices calculations and Percentage cover using cluster analysis.

2.4 Data Analyses

Data collected were arranged and analyzed for species abundance, Relative Importance Values (RIV) [25]. Diversity indices were computed Shannon-Wiener diversity, Simpson's index for species richness, Dominance index, Evenness and Equitability indices Paleontological statistics Software (PAST 2.14) [26]. Multivariate relationship of the flora was determined by ordination and classification procedures in Hammer et al*.,* [26]. They were presented as detrended correspondence and cluster analyses.

3. RESULTS

3.1 Herbaceous flora composition and Relative Importance Value of the Oil Palm Plantation of the University of Ibadan, Ibadan, Nigeria

The herbaceous flora enumeration conducted at the Oil palm plantation of University of Ibadan revealed presence of 32 herbaceous species (Table 1) variously distributed in 15 families (Table 2). Among the species encountered and their family groupings, four different families had the highest number of species composition; Fabaceae, Amaranthaceae, Asteraceae and Poaceae and followed by only the family Euphorbiaceae containing three species. Commelinaceae, Urticaceae and Acanthaceae families had two species each while the remaining seven (7) families (Cyperaceae, Convolvulaceae, Cucurbitaceae, Arecoideae, Malvaceae, Combretaceae and Araceae) compose of one species each (Table 2).

However, the relative frequencies and relative densities of the species encountered defined by their relative importance values (RIVs) projected *Commelina erecta* with the highest RIV of 12.641 and closely followed by *Fluerya ovalifolia* (RIV=12.147). *Fimbrystylis ferrugenia* (RIV=9.848*)* and *Commelina benghalensis* (RIV=7.200) had high RIV. *Pueraria phasioloides*, (RIV=6.703), *Alternanthera brasiliana* (RIV=6.402) and *Calopogonium mucunoides* (RIV=5.698) were of intermediate RIV; while *Hypoestes verticilata*, *Synedrella nodiflora*, *Ischaemum nigosum*, *Pennisetum purpureum* and *Achyranthes aspera* with RIVs of 4.532, 3.987, 3.784, 3.244, and 2.144 respectively had moderate RIV. The Low RIV-ranked species at the study site were *Desmodium scorpiurus* (RIV=1.680), *Andropogon tectorum* (RIV=1.022), *Cyathula prostrata* (RIV= 0.896), *Jatropha curcas* (RIV=0.864), *Colocasia esculenta* (0.608), *Larpotea austeans* (RIV=0.576), *Mallotus oppositifolius* (RIV=0.513), *Combretum hispidum* (RIV=0.351) and *Alchornea cordifolia* (Table 1). These species were rare in the plantation.

Table 1. Species composition and relative importance value (RIV) of the herbaceous flora of oil palm plantation of university of ibadan, ibadan, nigeria in 2016

S/No.	Species	Family	RIV
1	*Commelina erecta*	Commelinaceae	12.621
2	*Fluerya ovalifolia*	Urticaceae	12.147
3	*Fimbristylis ferruginea*	Cyperaceae	9.848
4	*Commelina benghalensis*	Commelinaceae	7.200
5	*Pueraria phasioloides*	Fabaceae	6.703
6	*Alternanthera brasilliana*	Amaranthaceae	6.402
7	*Calopogonium mucunoides*	Fabaceae	5.698
8	*Hypoestes verticilata*	Acanthaceae	4.532
9	*Synedrella nodiflora*	Asteraceae	3.987
10	*Ischaemum nigosum*	Poaceae	3.784
11	*Pennisetum purpureum*	Poaceae	3.244
12	*Achyranthes aspera*	Amaranthaceae	2.144
13	*Desmodium scorpiurus*	Fabaceae	1.680
14	*Alternanthera sessilis*	Amaranthaceae	1.617
15	*Melanthera scadens*	Asteraceae	1.599
16	*Tithonia diversifolia*	Asteraceae	1.441
17	*Evolvulus alsinoides*	Convolvulaceae	1.428
18	*Cynodon dactylon*	Poaceae	1.374
19	*Asystasia gangetica*	Acanthaceae	1.365
20	*Luffa cylindrical*	Cucurbitaceae	1.283
21	*Elaeis guinensis*	Arecoideae	1.216
22	*Chromolaena odorata*	Asteraceae	1.216
23	*Sida acuta*	Malvaceae	1.184
24	*Centrosema pubesens*	Fabaceae	1.153
25	*Andropogon tectorum*	Poaceae	1.022
26	*Cyathula prostrate*	Amaranthaceae	0.896
27	*Jathropha curcas*	Euphorbiaceae	0.864
28	*Colocasia esculenta*	Araceae	0.608
29	*Laportea aestuans*	Urticaceae	0.576
30	*Mallotus oppositifolius*	Euphorbiaceae	0.513
31	*Combretum hispidium*	Combretaceae	0.351
32	*Alchornea cordifolia*	Euphorbiaceae	0.288

Table 2. Summary of family categorization of the herbaceous flora of the Oil palm plantation of University of Ibadan, Ibadan, Nigeria

S/No	Family	Number of species present
1	Fabaceae	4
2	Amaranthaceae	4
3	Asteraceae	4
4	Poaceae	4
5	Euphorbiaceae	3
6	Commelinaceae	2
7	Urticaceae	2
8	Acanthaceae	2
9	Cyperaceae	1
10	Convolvulaceae	1
11	Cucurbitaceae	1
12	Arecoideae	1
13	Malvaceae	1
14	Combretaceae	1
15	Araceae	1

3.2 Multivariate Analysis (Detrended Correspondence Analysis) of the Herbaceous Floral of University of Ibadan Oil Palm Plantation in 2016

The detrended correspondence analysis of the herbaceous floral of University of Ibadan oil palm plantation shows varying degrees of relatedness in the distribution of the various species encountered at defining plantation ecosystem under study. The variation in the relatedness of the species in relevance to the sampling area accounted for 59.32% variability on axis 2, the strongest axis; and 51.07% variability on axis 3, following axis 2 in order of strength, and generally indicating close relatedness between the flora and habitat (Fig. 1). Furthermore, distinct vegetation structures were identified based on the habitat characteristic of the oil palm plantation. The habitat/vegetation components of the ecosystems include; secondary/regenerating forest vegetation, wetland vegetation, fallow and dryland vegetation. It was widely shown that the species belonging to the fallow vegetation with species of *Desmodium scorpiurus, Tithonia diversifolia*, *Pennisetum purpureum*, *Peureria phasioloides, Hypoestes verticilata, Andropogon tectorum, Commelina benghalensis, Fluerya ovalifolia, Ischaemum nigosum, among others.* The secondary/regenerating forest vegetation comprises of *Melenthera scandens*, *Mallotus oppositifolius, Luffa cylindrica, Alchornea cordifolia and Combretum hispidum.* The species of wetland vegetation category (Fig. 1) found were *Cynodon dactylo*n, *Elaeis guinensis and Calopogonium mucunoides*. However, among the dryland/fallow vegetation found were *Cyathula prostrata*, *Synedrella nodiflora, Centrosema pubescens, Larpotea austeans and Evolvolus alsinoides* (Table 1).

3.3 Species Diversity of the Herbaceous Flora of the Oil Palm Plantation of University of Ibadan in 2016

The diversity indices of the herbaceous flora of Oil Palm Plantation of the University of Ibadan indicates that thirty two (32) species of herbaceous flora were encountered (Taxa = 32) and with the cumulative population (total density) of all the species encountered being two hundred thousand, eight hundred and thirty (2,830) based on counts across the sampled area (Individuals = 2,830) (Table 3). The Simpson index (0.933) was very high and tends to 1 suggesting that the site had high species richness and widely spread across each of the sampling point at the study site hence interspecific association among the species. This was buttressed by the low dominance index value (0.091) indicating that there was no particular species prevalence at the study. The high evenness index (0.496) corroborated high incidence of spread of the different species encountered at the study site. The oil palm plantation was high in herbaceous species diversity with occurrence and presence of high number of species co-dominance as indicated by high Shannon-weiner index of 2.764 (Table 3). There was randomness of occurrence of any species among the herbaceous flora at the site as indicated in the equitability index value being very high 0.867 (Table 3) and tends to 1 thus showed that the families (Table 2) contained a high level of different species (Table 1).

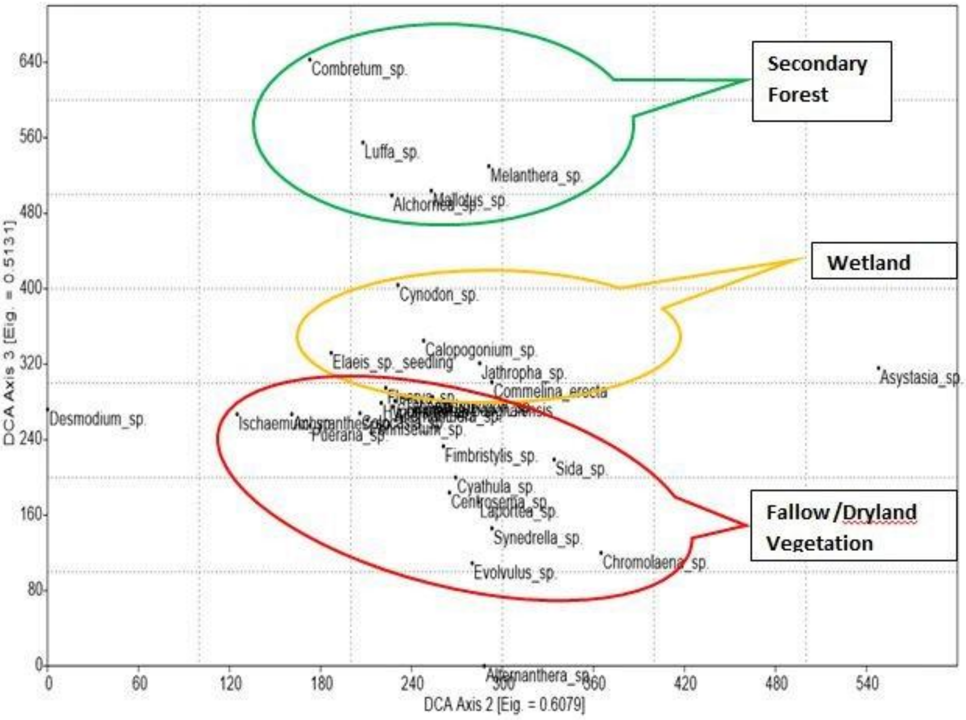

Fig. 1. Detrended correspondence analysis defining the herbaceous flora composition and habitat preferences of Oil Palm Plantation of University of Ibadan, Ibadan, Nigeria

Table 3. Species diversity of the herbaceous floral component of Oil palm plantation of University of Ibadan in 2016

Diversity indices	Values
Taxa	32
Individuals	2,830
Dominance index	0.091
Simpson index	0.909
Shannon weiner index	2.764
Evenness index	0.496
Equitabiltiy index	0.867

3.4 Cluster Analysis of the Phytosociology of Herbaceous floral of Oil Palm Plantation of the University of Ibadan, Ibadan, Nigeria in 2016

The similarities among the herbaceous flora species occurrence and distribution of the oil palm plantation of University of Ibadan was revealed by the dendrogram output of cluster analysis (Fig. 2). The species, *Commelina erecta* had the widest coverage of about 92% in distribution at the site followed by *Commelina benghalensis* at 88%. It was clear that the two species markedly had distinct vegetation structure and formation. Associated closely with *Commelina erecta* at the study site were *Fluerya ovalifolia* (69%) and the co-associated species of *Pennisetum purpureum* and *synedrella nodiflora* both at 28% coverage. However, the species of *Fimbrystlis ferruginea (40%), Alternanthera brassiliana* (37%) and co-associated species of *Desmodium scorpiurus and Ischaeum nigosum (27%)* are closely distributed with *Commelina benghalensis* (Fig. 2). At a higher level of agglomeration, *Pennisetum purpureum* was similar in occurrence and distribution and co-associates with *Fimbrystlis feruginea* and *Alternanthera brasiliana.*

Futhermore, there were association among *Mallotus oppositifolius, Alchornea cordifolia* and *comretum hispidum* indicating the shrub-like and secondary forest nature of the vegetation (Fig. 1) with a coverage of about 10% distribution. There were co-association between *Cyathula prostrata and Luffa cylindrica,* as well as *Chromolaena odorata* and *Andropogon tectorum* at less than 10% coverage and typical of fallow vegetation (Fig. 1).

4. DISCUSSION

From the result obtained from the floristic enumeration of the oil palm plantation of University of Ibadan, it was observed that the herbaceous flora composition and diversity of the oil palm plantation were high. Fitzherbert et al. [14] observed that Oil palm plantations support much fewer species than do forests and often also fewer than other tree crops. The high number of plant species and the high diversity observed in the University of Ibadan Oil palm plantation could be attributed to the specific planting configuration of 9 m x 9 m x 9 m which offered large spaces for low-growing plants to inhabit. It could also indicate that the weeding in the plantation was not carried out on regular basis, thus preventing colonization of plants hardy enough to withstand continuous weeding.

The wetland-biased flora of *Commelina erecta* and *Fluerya ovalifolia* were abundant and frequently occurred in many of the plots enumerated as showed by the relative importance values of the species (12.694 and 12.213 respectively) and they are most likely becoming resilient weeds based on trans-habitat spread. It has been reported that well-established plantation undergrowth can limit both, erosion [27,28,29,30] and the insect pressure [31,32,33]. Therefore, while the herbaceous plants prevent soil and nutrient losses associated with erosion, they can also help facilitate development of insect communities and ecosystem services they offer. Marselle et al*.* [34] further considers conservation of urban biodiversity as public health investment because of health and social functions that biodiversity offer.

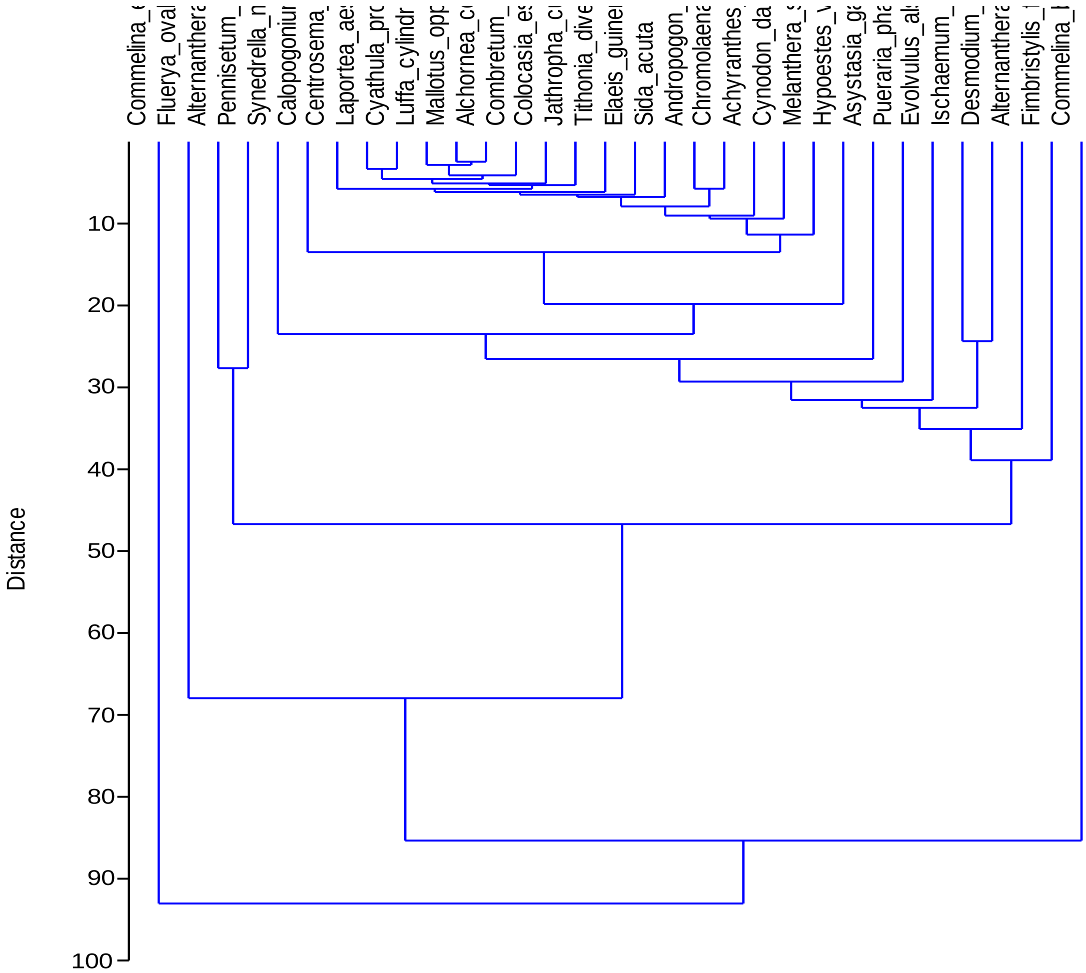

Fig. 2. Hierarchical cluster analysis

The abundance of *Commelina erecta* and *Fluerya ovalifolia* might be further attributed to ecological integrity of the plantation agroecosystem and to interplay of other ecological processes, such as pollination, ambient factor relations at the study site, and genetic constitution of the plants. Mavraganis and Christopher [35] have shown that genetic and ecological processes, many of which are dependent on size of the populations and degree of association between them, influence the demography of a natural populations.

The detrended correspondence analysis depicts three different vegetation structures (secondary, wetand and fallow/dryland) at the study site. Vegetation communities including weeds evolve in response to dynamics, presence/absence of different agronomic practices and environmental factors. Among the vegetation communities, there was high presence of fallow vegetation with many other flora (*Mallotus oppositifolius, Combretum hispidum, Luffa cylindrica and Alchonea cordiflora*) in secondary and regenerating forest vegetation hence indicative of ecological succession in the oil palm plantation. The various vegetation communities encountered in the plantation might have arisen as a result of deficiencies in the management; just like Gul et al*.* [36] discovered in urban forestry in Turkey.

The species diversity at the oil plantation was very high (Shannon weiner index= 2.764). According to clement et al. [37] potential benefits of increased weed species diversity include more competition between the weeds, more niche for natural enemies of weeds, more weeds interactions, greater diversity of weed life histories including aggressive weeds species, greater community stability and reduced incidence of herbicide resistance. The high species diversity recorded is consistent with the findings of Olubode and Ighodalo [38] in Oil palm plantation at the Nigerian Institute for Oil Palm Researrch (NIFOR), Edo State, Nigeria; but not in the varied community structure discovered in the University of Ibadan. This could be due to differences in management practices, anthropogenic land use types and in the prevalence of fern species at NIFOR. Likewise, the possibility of the influence of climate change in the study area cannot be under underestimated [39].

In the long run, there was low species dominance (D = 0.091) and a proportionate richness 0.909 at the study site. The number of species composition in the study site is an indication of quality health of the ecosystem. The high diversity could be due to reduced anthropogenic activities which calls management practices to question on one hand, but desirable for conservation of native flora and fauna on the other hand. Other advantages of plantation undergrowth are nitrogen fixation [40,41], buffering of leaching losses [42], amelioration of physical soil properties [43,30] and reduction of diurnal soil temperature fluctuations [30].

The dendrogram from the cluster analysis revealed that the distribution of the weed flora at the plantation depicts that *Commelina erecta* was dense at many plots and had the highest coverage of 92% among the species enumerated in close similarity to *Fluerya ovalifolia* at 69% as the positive preferential while *Commelina benghalensis* had a coverage of 88% closed in similarity with *Fimbrystylis ferruginea* had a coverage of 40%. The species of *Cyathula prostrata and Luffa cylindrica,* as well as *Chromolaena odorata* and *Andropogon tectorum* belonging to the fallow vegetation had the lowest density and coverage at less than 10%.

5. CONCLUSION

Oil palm plantation has potentials to encourage high biodiversity of flora and fauna because of planting configuration. Old and irregularly weeded oil palm plantations can further facilitate ecological succession, the progress and magnitude of which would depend on an interplay of environmental factors. The University of Ibadan Oil Palm plantation was undergoing the natural process of succession which was being facilitated by subtle/minimal anthropogenic impact occasioned by suspected irregular weeding as a management practice. Therefore, it is recommended that the authorities of the Teaching and Research Farm of University of Ibadan should adopt the sustainable management practices at the oil palm plantation especially to prevent ecological succession and impairment of objective(s) for the establishment of the oil palm plantation.

ACKNOWLEDGEMENTS

The permission of the management of the University of Ibadan Teaching and Research Farm to conduct this study at the Oil Palm Plantation is appreciated.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Gibbs HK, Ruesch AS, Achard F, Clayton MK, Holmgren P, Ramankutty N, Foley JA. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. Proceedings. of the National Academy of Sciences of the United States of America. 2010;107(38):16732-16737.
2. Koh LP, Wilcove DS. Is oil palm agriculture really destroying tropical biodiversity? Conservation Letters. 2008;1(2):60-64.
3. Mehraban N, Kubitza C, Alamsyah Z, Qaim M. Oil palm cultivation, household welfare, and exposure to economic risk in the Indonesian small farm sector. Journal of Agricultural Economics. 2021;72:901-915.
   Available:https://doi.org/10.1111/1477-9552.12433.11
4. Chrisendo D, Siregar H, Qaim M. Oil palm cultivation improves living standards and human capital formation in smallholder farm households. World Development. 2022;159:1-9.
   Available:https://doi.org/10.1016/j.worlddev.2022.106034
5. Adesina FA, Siyanbola WO, Oketola FA, Pelemo DA, Momodu SA, Adegbulugbe AO, Ojo LO. Potential of agroforestry techniques in mitigating CO_2 emissions in Nigeria: Some preliminary estimates. Global Ecology and Biogeography. 1999; 8(2):163-173.
6. Danielsen F, Beukema H, Burgess ND, Parish Z, Bruhl CA, Donald PF, et al.. Biofuel plantations on forested lands: Double jeopardy for biodiversity and climate. Conservation Biology. 2009;23(2): 348-358.
7. FAO - Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT). Crops; Indonesia; Oil, palm and Oil, palm fruit; Average production of commodity. 1990-2014; 2016.
   Accessed: 16 March 2020.
   Available:http://faostat3.fao.org/browse/Q/QC/E.
8. FAO - Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT).FAOSTAT. 2002.
   Accessed: 16 March, 2020.
   Available:http://www.apps.fao.org.
9. Prescott GW, Edwards DP, Foster, WA. Retaining biodiversity in intensive farmland: Epiphyte removal in oil palm plantations does not affect yield. Ecology and Evolution. 2015;5(10):1944-1955.
10. Koh LP, Miettinen J, Liew SC, Ghazoul J. Remotely sensed evidence of tropical peatland conversion to oil palm. Proceedings of the National Academy of Sciences of the United States of America. 2011;108(12):5127-5132.
11. Niskanen A. Value of external environmental impacts of reforestation in Thailand. Ecological Economics. 1998;26: 287–297.
    ISSN 0921-8009.
12. Pandey D, Brown C. Teak: a global overview. An overview of global teak resources and issues affecting their future outlook. Unasylva. 2000;201(51):3–13.
    ISSN 0041-6436.
13. Hallett JT, Diaz-Calvo J, Villa-Castillo J, Wagner MR. Teak plantations: Economic bonanza or environmental disaster? Journal of Forestry. 2011;288–292.
    ISSN 0022-1201.
14. Fitzherbert, EB, Struebig M J, Morel A, Danielsen F, Brühl CA, Donald PF, Phalan, B. How will oil palm expansion affect biodiversity? Trends in Ecology & Evolution. 2008;23(10):538-545.
15. Harper JL, Hawksworth DL. Preface. In: Hawksworth, D.L. editor. Biodiversity measurement and estimation. Chapman and Hall, and the Royal Society, London. 1995;5-12.
16. Kui YT. Surviving the low prices of palm oil. New Straits Times of 08 April 2001, Kuala Lumpur, Malaysia; 2001.
17. Jaafar M, and Sukaimi J. The future of palm oil in the new millennium in Malaysia. Burotrop Bulletin. 2001;16:10-13.
18. Anonymous. Palm oil production will plateau; 2002.
    Accessed 02 May, 2022.
    Available:www.agjournal.com
19. Casson A. The hesitant boom: Indonesia's oil palm sub-sector in an era of economic crisis and political change. Occasional Paper 29, CIFOR, Bogor, Indonesia; 2000.
20. Komolafe DA. Weed in tree crops in Nigeria. PANS. 1976;22:250-256.
21. Agbaka AC. Some weeds of rubber plantations in Nigeria. A preliminary survey. Rubber Research, Benin City. Mimeographed. 1997;9.

22. Ayeni OD, Adediran A, Ofordu CS, Amoo-Onindundu ON, Arabomen O, Okumodi BO. Analysing the characteristic-sequence of rainfall amounts in Ibadan, Nigeria. Journal of Meteorology and Climate Science. 2020;18(1):89-98.
23. Akobundu O, Agyakwa C. A Handbook of West African Weeds. Publisher, IITA; 1998.
ISBN 97 8131 1290.
24. Johnson DE. Weeds of Rice in West Africa. Technical centre for agriculture and rural cooperation; 1997.
ISBN 92 91113 1105.
25. Kent M, Coker P. Vegetational Description and Analysis: A practical approach. John Wiley and Sons, Chichester. 1992; 363.
26. Hammer O, Harper DAT, Ryan P. PAST: Paleontological Statistics Software Package for education and data analysis; 2001.
27. Beaufoy G. The olive oil regime. In: Brouwer F, Lowe P, editors. CAP Regimes and the European countryside prospects for integration between agriculture, regional and environmental policies), pp. 155-178. CAB International, Wallingford, UK; 2000.
28. Hashim GM, Yussoff WA, Ciesiolka C. Overland flow and soil erosion in sloping agricultural land. Malaysian Journal of Soil Science. 1997;1:35-49.
29. Ross M. Auswirkungen verschiedener Rodeverfahren und des Unterbewuchses auf Bodenfruchtbarkeit, Bodenwasserhaushalt, Erosion, und Bestandsentwicklung eines Ölpalmenbestandes. Berichte aus der Agrarwissenschaft, Shaker Verlag, Aachen, Germany; 1999.
30. Fairhurst, T. Management of nutrients for efficient use in smallholder oil palm plantations. PhD Thesis, University of London, Wye, Ashford, Kent, UK; 1996.
31. Wahid MB, Siburat S, Ravigadevi S, Arshad O. Beneficial plants for natural enemies of bagworm in oil palm plantations. In: 1999 PORIM International Palm Oil Congress, 1-6 February 1999, PORIM, Kuala Lumpur, Malaysia. 1999; 165-179.
32. Mexzón RG, Chinchilla CM. Natural enemies of harmful arthropods in oil palm (*Elaeis guineensis* Jacq.) in tropical America. ASD Oil Palm Papers. 1996;13:9-33.
33. Ho CT, Teh CL. The use of Euphorbia heterophylla L. for natural reduction of leaf pests damage to oil palm. In: Proceedings of the 1999 PORIM International Palm Oil Congress - Agriculture. Emerging Technologies and Opportunities in the Next Millennium, Palm Oil Research Institute of Malaysia (PORIM), Kuala Lumpur, Malaysia. 1-6 February 1999;139-164.
34. Marselle MR, Lindley SJ, Cook PA, Bonn A. Biodiversity and health in the Urban environment. Current Environmental Reports. 2021;8(2):146-156.
DOI: 10.1007/s40572-021-00313-9
35. Mavraganis K, Christopher GE. Effects of population size and isolation on reproductive output in aquilegia Canadensis (Ranunculaceae). Oikos. 2001;95:300-310.
36. Gul A, Yazici N, Sahin CK. Opinions, tendencies and preferences about urban residents: A case study on the Isparta City-Turkey. Energy, Education Science and Technology Part A: Energy Science and Research. 2013;30(2);933-944.
37. Clements DR, Swanton CJ. Integrated weed management and weed species diversity. Phytoprotection. 1994;75:1-18.
38. Olubode OS, Ighodalo DJ. Diversity and Ecological Importance of Ferns in Nigerian Institute for Oil Palm Research (NIFOR) Oil Palm (*Elaeis guineensis* Jacq.) Plantation in Edo State, Nigeria. In: Agbeja BO, Adetogun AC, Adejoba OR, Ogunsina IOO, editors. Proceedings of the 2nd Commonwealth Forestry Association (CFA), Nigeria Chapter held on 5-7 June 2018 at Federal University of Agriculture Abeokuta, Ogun State, Nigeria. 2018;253-263.
39. Egbinola CN, Amobichukwu AC. Climate variation assessment based on rainfall and temperature in Ibadan, South-Western Nigeria. Journal of Environment and Earth Science. 2013;3(11):32-46.
40. Hartley CWS. The oil palm. Agricultural Series, 3rd edition., Longman, Harlow, UK; 1988.
41. Turner PD, Gillbanks RA. Oil palm cultivation and management. The Incorporated Society of Planters, Kuala Lumpur, Malaysia; 1974.
42. Parrotta JA. The role of plantation forests in rehabilitating degraded tropical ecosystems. Agriculture, Ecosystems and Environment. 1992;41:115-133.

43. Pini R, Paris P, Benetti AV, Guidi G, Pisanelli, A. Soil physical characteristics and understory management in a walnut (*Juglans regia* L.) plantation in central Italy. Agroforestry Systems. 1999;46:95-105.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103566