VOL. 6, NO. 1, JANUARY 2011 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science


www.arpnjournals.com

FLORISTIC COMPOSITION AND ABUNDANCE OF WEEDS IN AN OIL PALM PLANTATION IN GHANA

Paul K. Essandoh[1], Frederick A. Armah[1], Justice O. Odoi[2], David O. Yawson[3] and Ernest K.A. Afrifa[1]
[1]Department of Environmental Science, School of Biological Sciences, University of Cape Coast, Ghana
[2]Ghana Nature Today, a Standard Estates, Sakumono, Osu, Accra, Ghana
[3]School of Agriculture, University of Cape Coast, Cape Coast, Ghana
E-Mail: parosepa@yahoo.com

ABSTRACT

The weed flora in an oil palm plantation situated in a semi-deciduous forest zone in Central Region of Ghana was assessed to identify the weeds and evaluate their abundance. The comprehensive stock of weeds obtained was analysed to determine the relative abundance of taxa and life forms. One hundred and thirty six weed species belonging to 33 dicot families, 3 monocot families and 8 families of Pteridophyta were identified. The weed families derived from seven subclasses; the most diverse of the dicots were the Rosidae and Asteridae. The monocots present were from the Commelinidae. Eight plant life forms were identified; the most diverse were the herbs, which consisted of 79 species and 56 genera; and the shrubs which consisted of 32 species and 26 genera. In terms of abundance and distribution, weeds of Poaceae and Asteraceae were found to be far more invasive. *Chromolaena odorata*, *Aspillia africana* and *Melanthera scandens* of the Asteraceae, *Panicum maximum* and *Imperata cylindrica* of the Poaceae and *Mallotus oppositifolius* of the Euphorbiaceae were widespread and problematic. The diversity of weed species was high in the oil palm plantation.

Keywords: floristic composition, weeds abundance, oil palm, Ghana.

1. INTRODUCTION

In order to meet both domestic and industrial needs of palm produce in Ghana as well as for export, various organizations have been encouraged to cultivate oil palm plantations. The support for oil palm promotion was operationalised as part of the Presidential Special Initiative (PSI) on oil palm through which out-grower support units were established. The PSI proposed to plant about 100,000 hectares of oil palm over a five-year period (2006-2007). Again, 12 nurseries across Ghana consisting of about 1.2 million seedlings were set up. However, weeds and weed problems continue to be important factors reducing yields. Improved oil palm varieties start production within three years after planting and have average economic life of about thirty years. However, growth, development and yield of the crop are adversely affected by weeds (Corley and Tinker, 2003).

In established oil palm plantation, noxious weeds such as *Chromolaena odorata*, *Mikania cordata* and *Mikania micrantha* compete with the oil palm for nutrients, moisture and sunlight and eventually cause yield depression (Pride, 2010; Lam, Lim and Badrulison, 1993). Palms that grow where there is *Imperata cylindrica* are generally stunted and retarded in growth. Other noxious grasses include *Chloris barbata*, *Pennisetum purpureum* and *Panicum maximum* (Pride, 2010). Generally, *Axonopus* sp., *Digitaria* sp. and *Palspalum* sp. are classified as soft weeds which maintain the balance of the weed flora and prevent weed succession by noxious species simply because base land for the noxious weeds to colonise is less available (Lam, Lim and Badrulison, 1993; Quah, Kim and Badrulison, 2000).

Studies on weeds in perennial crops have been conducted for various species including forest species (Toledo, 2000), fruit trees (Senerathne, Samarajeewa and Perera, 2003) and other crops (Aquilar, Staver and Milberg, 2003). Some of these studies have evaluated the floristic composition of weeds (Yanagizawa and Maimoni-Rodella, 1999) and their effect on crop yield (Defrank and Clement, 1995).

The out-growers concept in Ghana which involves the attachment of small scale oil palm farmers to well established large plantations like Twifo and National oil palm plantations has gained enormous patronage as a result of the improved yield returns. This concept was developed largely to address the poor management of oil palm plantations by small-scale farmers especially in the area of weed control.

To plan any efficient measures of controlling weeds, it is necessary to identify the weeds, know their distribution and understand the factors which affect their distribution.

The present study was conducted to

- Compile an inventory of weeds associated with an oil palm plantation and
- Ecologically evaluate the abundance of the weeds.

2. MATERIAL AND METHODS

2.1. Study area

The study was carried out on a 50 hectare oil palm plantation located near Assin Edubiase in the Assin South District of the Central Region of Ghana. The climate of the area is characterized by two distinct seasons: a humid and wet season from April through October and a dry season which runs from November through March. Mean annual rainfall during the last three years was 1300 mm. Temperature ranged from 20.8^{o}C to 31.5^{o}C and a mean sunshine of 7 hours per day.

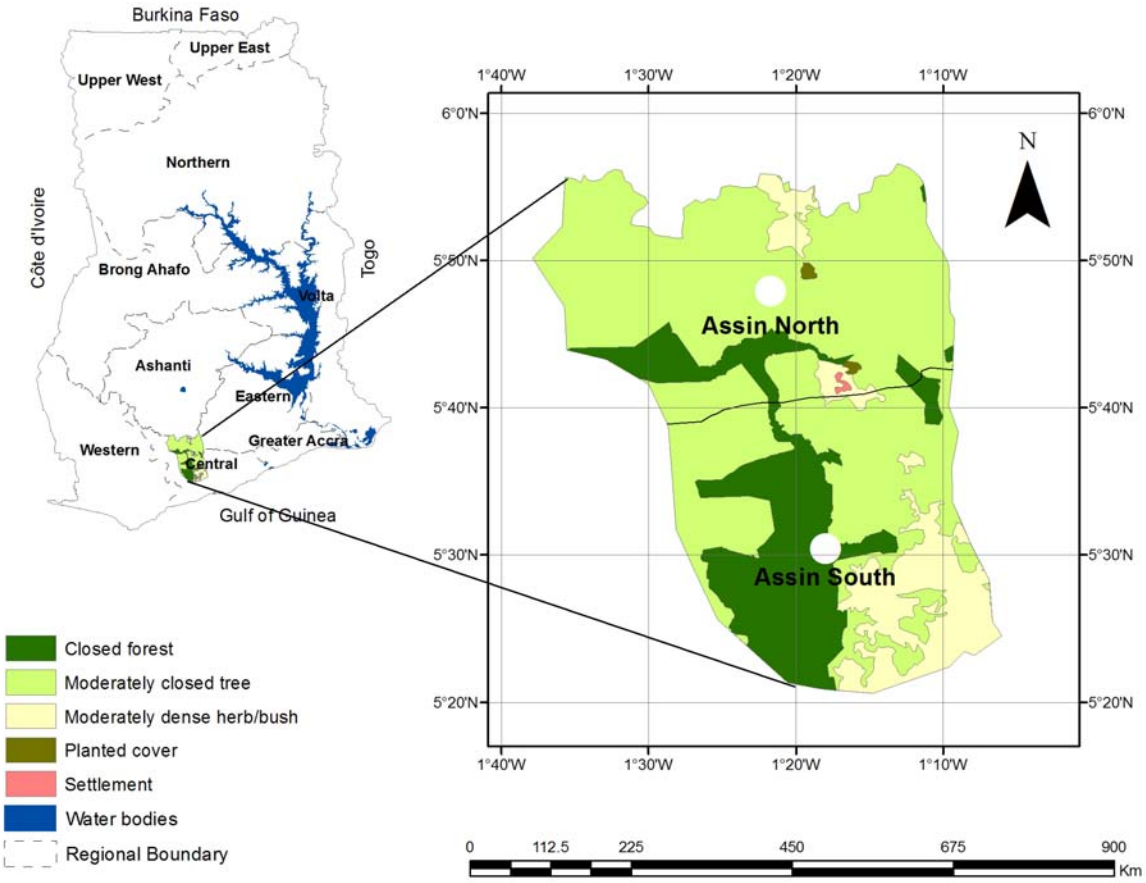

Figure-1. Map of Ghana showing the Assin south district where the study was conducted.

2.2 Sampling method

Two belts transects, each measuring 250 m x 50 m were constructed across different age groups of palms viz. young (<5 years) and mature (5 to 15 years). Each belt transect was divided into five quadrats measuring 50 m x50 m. Quadrats of 1.0m^2 and 1.0 m^2 grid quadrats were placed at random in each constructed quadrat (50 m x 50 m) to facilitate identification and recording of weed species and to determine percentage cover of weed species respectively. Weed specimens were collected for confirmation of identity and some farmers were interviewed and questioned about problematic weeds in their farms. The comprehensive list of weeds obtained was used in the determination of the proportion of taxa and life forms.

Analytical characters were determined by the census quadrat method where weed species were listed and the number of individuals of each species counted.

The vegetation parameters determined were absolute frequency (F), relative frequency (Rf) (%), absolute density (D), relative density (Rd) (%), Percentage Cover (Co), relative percentage cover (RCo) and Important Value $(IV = Rf + Rd + RCo)$ [10].

Plant vegetation analysis was done using Shannon's Index, $H = -\sum Pi\ In\ Pi$ where $Pi = ni/N$ (proportional abundance of *i*th species [11], $ni =$ number of individuals of the *i*th species and N = total number of individuals; Simpson's index, D = 1- C where C= $\sum ni\ (ni-1) / N\ (N-1)$ and Species Evenness, E = $H'/In\ S$ where $H' =$ Shannon -Weaver Index and $S =$ number of species [12].

3. RESULTS AND DISCUSSIONS

One hundred and thirty six weed species belonging to 101 genera and 44 families were identified in the flora of the oil palm plantation (Table-1). Thirteen of the 136 weed species were found only in the matured oil palm plantation (Table-4). Eight plant life forms were recognized amongst the weeds. These were herbs, herbaceous climbers, shrubs, climbing shrubs, trees, small trees, ground and epiphytic ferns.

Table-1. Plant groups of weed flora in the oil palm plantation.

	Number of families	Number of Genera	Number of species
Liliopsida	3	20	33
Magnoliopsida	33	73	95
Pteridophyta	8	8	8
Total	44	101	136

Table-2. Plant life forms of weed species in the oil palm plantation.

Plant group	Families	Genera	Species
Herbs	22	56	79
Shrubs	17	26	32
Small trees	5	5	5
Large trees	4	4	4
Herbaceous climbers	3	4	5
Climbing shrub	3	3	3
Pteridophyta	8	8	8

The group with the highest diversity of species, genera and families was the herbs which accounted for 58.1% of all the species growing in the study area (Table-2). These were followed by the shrubs (23.5%), ground fern (4.4%), herbaceous climbers (3.7%) and small trees (3.7%). The remaining life forms; trees, climbing shrubs and epiphytic ferns showed up as 2.9%, 2.2% and 1.5% of the species respectively. The weed families derived from seven subclasses. The most diverse of the dicots were the Asteridae followed by the Rosidae. In order of decreasing diversity, the rest were Dilleniidae, Caryophyllidae, Hamamelidae and Magnoliidae. The monocots were from the subclass Commelinidae.

3.1 Ecological status of weed species

The important value indices (IVI) of the species were generally low (Table-4). In the young plantation, Chromolaena odorata was the most dominant species with IVI value of 17.13 followed by Aspillia africana (13.19). Other species of importance were Melanthera scandens (11.17), Mallotus oppositifolius (7.08) and Digitaria horizontalis (5.52). Chromolaena odorata (14.19), Aspillia africana (8.71) and Melanthera scandens (8.11) were dominant in the mature plantation. Other notable species were Imperata cylindrica (7.76), Panicum maximum (7.52) and Cyperus rotundus (7.11). The low IVI values could be due to the sharing of resource spaces to minimize interactions among the species and to facilitate access to resources (Tsingalia, 1990). Also, the low IVI values could be due to many different species with few individuals represented in each weed species (Tsingalia, 1990). The findings from this study showed that there were many different weed species with few individuals in each species (Table-4).

The high diversity of weed species represented by Simpson's (0.98) and Shannon's (3.68) for young plantation and Simpson's (0.98) and Shannon's (0.80) for the mature plantation (Table-3), could be due to operation of moderate environmental conditions in the oil palm plantation. The high diversity of weed species could also be due to the differences in seed production, dispersal, germination and seedling establishment (Newman, 1994), which promote high levels of co-existence among the weed species.

The distribution of individuals among the species is given by evenness index (E) (Sarada, Sreekandan and Reghunath, 2002) which was relatively higher in the matured plantation (0.78). Evenness is highest when all species have the same number of individuals or are equally abundant (Pascal and Pellissier, 1996). Hence weed species were more equally abundant in the matured plantation than the young plantation.

3.2 Weed association with the oil palm plantation

In zones opened up for plantation cropping, a wide range of broad leaved weeds are found on newly opened land, a mixture of grassy and broad leaved weeds in young plantations and a predominance of grasses in well established plantations (Chee, *et al.*, 1991). This study showed that broad leaved weeds such as *Chromolaena odorata, Aspillia africana* and *Melanthera scandens* and grasses such as *Panicum maximum, Imperata cylindrica* and *Digitaria horizontalis* were dominant in both young and old plantations (Table-4). The two most dominant weed families were Poaceae and Asteraceae. Poaceae turned up the largest number of species, made up of 26 species distributed in 15 genera. This conforms to findings of (Sunitha, 1995) that grass weeds dominate new oil palm plantation. Asteraceae emerged with 15 species distributed in 11 genera. The dominance of Asteraceae may be due to their efficient mechanism of seed dispersal. Another notable weed family was Euphorbiaceae with *Mallotus oppositifolius* and *Maniophyton fulvrum* as the dominant species.

Tree crops usually produce shade which influences light intensity, temperature and humidity thereby restricting the species of weeds that can grow under them. The closer the crops are, the more weed

growth is suppressed; but as the crop closes its canopy, shade-tolerant weeds become common (Chee, *et al.*, 1991 and Akobundu, 1987). The oil palm does not close up its canopy early enough and can accommodate weeds with or without preference for shade for relatively longer period. This probably accounted for the presence of a wider diversity of weeds. Different crops (Souza, Silva and Souza, 2003) and different cultivars of the same crop (Seavers and Wright, 1999) are capable of influencing the composition and growth of weeds.

Weed flora of the study area showed that 13 weed species grew only in the matured plantation. They include *Eclipta prostrata*, *Cyathula prostrata*, *Acalypha ciliata*, *Mollugo verticilliata* and *Peperomia pellucida* and ferns such as *Pteris burtoni* and *Ctenitis protensa* (Table-4). This probably derived from their preference for shade. The suppressive effect of perennial plants on weeds is frequently attributed to shading by trees (Souza, Silva and Souza, 2003) and there are evidences that shading reduced growth in grasses (Souza, Silva and Souza, 2003).

On most oil palm plantations in the far East, the cover that establishes itself is a mixture of the fern *Nephrolepsis bisserata* with varying components of grasses such *Paspalum conjugatum* and *Axonopus compressus* (Subtropen 2003, and Hartley, 1988) *Nephrolepis bisserata* provides herbage which rots rapidly to give a complex of decaying vegetation suitable for the growth of oil palm. Moreover, *Nephrolepis bisserata* provides a substantial cover for the soil and rarely grows to height that needs constant slashing. In this study, *Nephrolepis bisserata* had a mean frequency of 60.27% and density value of 6.90/m^2 in the mature plantation and could be exploited as an input for cover in the oil palm plantation. Figure-2, Figure-3, Figure-4 and Figure-5 show the distribution of dicot species, monocot and pteridophyta species, herbaceous species, and shrub species in the oil palm plantation, respectively.

3.3 Pest weeds

In the natural flora of the oil palm plantation, some weeds are considered as pests since they compete with the oil palm to the extent that yield is reduced and some weeds also grow rapidly to shade out young palms requiring high expense for their control (Corley and Tinker, 2003; Quah,Kim and Badrulison, 2000). Perennial grasses with relatively high IVI values (Table-4) such as Panicum maximum, Imperata cylindrica, Pennisetum polystachion and Paspalum conjugatum were very invasive and aggressive. Annual grassy weeds with relatively higher IVI values growing in the study area include Digitaria horizontalis and Bracharia lata. They were serious pests because of their luxuriant growth and habit of regrowing after slashing.

Cyperus rotundus with density values of 8.88/m^2 and 8.19/m^2 and frequency values of 65.80% and 59.15% for young and matured plantations respectively, was found to be a serious pest. Cyperus rotundus needed constant slashing especially in the young plantation due to its numerous underground nuts which produce fast and dense infestation. Annual broad leaved weeds of importance include Spigelmia anthelmia, Ageratum conyzoides, Euphorbia heterophylla and Synedrella nodiflora (Table-4). These were serious pests mainly in the newly established plantation due to their fast rate of growth and prolific production of seeds. The most invasive and aggressive perennial broad leaved weeds with relatively higher IVI's include Chromolaena odorata, Aspillia africana, Melanthera scandens and Mallotus oppositifolius. Chromolaena odorata with mean density and frequency values of 14.2/m^2 and 81.59% respectively, was of importance in the oil palm plantation. Chromolaena odorata grows rapidly to about 3.6 m tall and aggressively competes with the young palms for nutrient and light to cause yield depression and requires higher expense for its control (Pride, 2010; Corley and Tinker, 2003).

4. CONCLUSIONS

The floristic studies carried out on weeds in an oil palm plantation near Assin Edubiase in the Central Region of Ghana showed that there were many different weed species with few individuals in each weed species. One hundred and thirty six weed species belonging to 33 dicot families, 3 monocot families and 8 families of Pteridophyta were identified. The weed families derived from seven subclasses; the most diverse of the dicots were the Rosidae and Asteridae. The monocots present were from the Commelinidae. Eight plant life forms were identified; the most diverse were the herbs, which consisted of 79 species and 56 genera; and the shrubs which consisted of 32 species and 26 genera. In terms of abundance and distribution, weeds of Poaceae and Asteraceae were found to be far more invasive. Chromolaena odorata, Aspillia africana and Melanthera scandens of the Asteraceae, Panicum maximum and Imperata cylindrical of the Poaceae and Mallotus oppositifolius of the Euphorbiaceae were widespread and problematic. The diversity of weed species was high in the oil palm plantation.

However, the spread of Chromolaena odorata is of great concern because of its competitive nature. The findings in this investigation demonstrate that Nephrolepis bisserata could be exploited for cover in the plantation. This probably could be more effective than the use of any herbicide because of the high diversity of the weed flora. The farmer interviews though not presented in this paper, pointed to lack of knowledge about weeds and weed control techniques. It is recommended that weed control should form an integral part of the out-growers concept and should be emphasized when dealing with small-scale oil palm plantation farmers.

Table-4. Floristic composition of weeds in the oil palm plantation near Assin Edubiase.

Name of plant		Strata of Plantation								
				Young a						Mature b
		Rf (%)	**Rd** (%)	**Rco** (%)	**IVI**	**Rf** (%)	**Rd** (%)	**Rco** (%)	**IVI**	**LF**
1	*Acalypha ciliata* Forsk	-	-	-	-	0.57	0.54	0.26	1.37	H
2	*Ageratum conyzoides* L	1.44	2.34	0.84	4.62	1.24	0.95	0.61	2.80	H
3	*Alafia lucida* Stapf.	0.41	0.24	0.01	0.66	0.29	0.16	0.01	0.46	CS
4	*Albizia adianthifolia* (Schumach) Wright	0.43	0.15	0.01	0.59	0.34	0.17	0.17	0.68	S
5	*Alchornea laxiflora* (Benth) Pax and Hoffm.	0.41	0.64	0.31	1.36	0.38	0.48	0.35	1.21	S
6	*Amaranthus Spinosus L*	1.19	1.73	0.87	3.79	0.94	0.55	0.80	2.29	H
7	*Aneilema beniniens* (Beauv.) Kunth	1.30	1.43	0.93	3.66	1.09	1.02	0.87	2.98	H
8	*Anthropogon fastigiatus* SW.	0.76	0.25	0.18	1.19	0.53	0.44	0.26	1.23	G
9	*Anthonotha macrophylla* P. Beauv.	0.43	0.11	0.07	0.61	0.19	0.14	0.06	0.39	S
10	*Aspillia africana* (Pers) Adams	1.76	3.93	7.50	13.19	1.38	2.77	4.56	8.71	H
11	*Aspillia latifolia* Oliv and Hiern	1.44	1.80	1.24	4.48	1.12	1.56	1.04	3.72	H
12	*Asystasia coromandeliana* Nees	1.07	1.06	0.34	2.47	0.75	0.39	0.50	1.64	H
13	*Asystasia gangetica* (L) T. Anders	0.68	0.95	0.36	1.99	0.86	0.81	0.43	2.10	H
14	*Asystasia macrophylla* (T. Anders) Lindau	0.79	0.73	0.36	1.88	0.74	0.68	0.33	1.75	H
15	*Axonopus compressus* (SW) Beauv.	1.24	0.76	0.49	2.49	0.94	0.64	0.57	2.15	G
16	*Azadiractha indica* Juss.	0.28	0.15	0.04	0.47	0.19	0.08	0.06	0.33	T
17	*Baphia nitida* Lodd	0.44	0.21	0.09	0.74	0.28	0.09	0.09	0.46	T
18	*Boerhaavia diffusa* L.	1.07	1.09	0.69	2.85	0.75	0.92	0.74	2.41	H
19	*Bolbitis* sp.	-	-	-	-	-	-	-	-	F
20	*Bracharia deflexa* (Schumach) Hubbard	0.34	0.27	0.01	0.62	0.34	0.13	0.01	0.37	G
21	*Bracharia lata* (Schumach) Hubbard	1.10	0.82	0.84	2.76	1.08	1.18	0.92	3.18	G
22	*Bridelia micrantha* Bail	0.43	0.24	0.01	0.68	0.19	0.14	0.13	0.46	T
23	*Bryophyllum pinnatum* (Lam.) Oken	1.51	1.04	0.87	3.42	1.20	0.71	0.85	2.76	S
24	*Chassalia laxiflora* Benth	0.79	0.43	0.27	1.49	0.72	0.19	0.35	1.26	S
25	*Chloris pilosa* Schumach	1.28	1.81	0.89	3.98	1.05	1.25	0.09	3.20	G
26	*Chromolaena odorata* (L.) King and Robinson	1.82	4.80	10.51	17.13	1.50	4.21	8.78	14.49	S
27	*Cnestis ferruginea* DC.	0.34	0.26	0.11	0.71	0.38	0.10	0.04	0.52	T
28	*Combretum hispidium* Laws	0.18	0.21	0.01	0.40	0.19	0.11	0.01	0.31	CS
29	*Commelina benghalensis* L.	1.45	1.85	3.33	6.63	1.27	1.97	2.39	5.63	H
30	Commelina diffusa Burm. F.	1.11	1.52	1.38	4.01	0.94	1.31	1.59	3.84	H
31	Crassocephalum biafrae (Oliv and Hiern) Moore	-	-	-	-	0.23	0.17	0.09	0.49	HC
32	*Ctenitis protensa* (Afzel ex SW) Ching	-	-	-	-	0.57	1.00	0.48	2.05	F
33	*Cyclosorus afer* (Christ) Ching	1.24	0.80	0.52	2.56	1.08	1.03	0.54	2.65	F

34	*Cynodon dactylum* (L.) Pers.	1.30	1.23	0.93	3.46	1.05	0.92	0.89	2.86	G
35	*Cyperus compressus* L.	1.16	0.99	0.53	2.68	0.94	0.58	0.47	1.99	SE
36	*Cyperus rotundus* L.	1.31	2.17	3.11	6.59	1.22	2.39	3.50	7.11	SE
37	*Cyathula prostrata* (L) Blume	-	-	-	-	0.89	1.45	1.72	4.06	H
38	*Dactyloctenium aegyptium* (L.) Beauv.	0.44	0.23	0.27	0.94	0.65	0.50	0.35	1.50	G
39	*Desmodium adscendes* (SW) DC.	0.44	0.26	0.09	0.79	0.38	0.10	0.07	0.55	S
40	*Desmodium triflorum* (L.) DC.	0.88	0.57	0.49	1.94	0.94	0.77	0.42	2.13	H
41	*Digitaria horizontalis* Willd	1.45	2.34	1.73	5.52	1.13	1.35	1.70	4.18	G
42	*Digitaria longiflora* (Retz.) Pers.	1.12	2.23	1.64	4.99	1.06	1.12	1.61	3.79	G
43	*Diplazium sammatti* (Kuhn) C. Chr.	0.44	0.22	0.23	0.94	0.75	0.50	0.74	1.99	F
44	*Dissotis erecta* (Guill and Perr) Dandy	0.89	0.64	0.44	1.97	0.66	0.79	0.35	1.80	S
45	*Dissotis rotundifolia* (SM.) Triana	1.31	1.02	0.71	3.04	1.08	0.85	0.87	2.80	H
46	*Eclipta prostrata* L.	-	-	-	-	0.91	0.71	0.42	2.04	H
47	*Eleusine indica* (L.) Gaertn.	1.18	1.31	0.65	3.14	0.93	0.75	0.52	2.20	G
48	*Emilia practermissa* Milne-Redhead	0.89	1.02	0.53	2.44	1.05	0.85	0.50	2.40	H
49	*Euphorbia heterophylla* L.	1.29	1.88	0.81	3.98	1.12	1.68	0.61	3.41	H
50	*Euphorbia hirta* L.	0.89	0.75	0.29	1.93	0.93	0.65	0.37	1.95	H
51	*Euphorbia hyssopifolia* L.	0.89	1.00	0.46	2.35	1.02	0.84	0.50	2.36	H
52	*Euphorbia ovalifolia* L.	0.86	1.37	0.35	2.58	0.72	0.69	0.30	1.71	H
53	*Euphorbia prostrata* Ait	-	-	-	-	0.89	0.57	0.36	1.82	H
54	*Fagara pubescens* A. Chev.	0.37	0.25	0.13	0.75	0.37	0.27	0.17	0.81	S
55	*Fleurya aestuans* (L.) ex Miq.	0.89	0.70	0.80	2.39	1.12	1.02	1.04	3.18	H
56	*Fleurya ovalifolia* (Shum and Thonn) Dandy	1.31	1.06	1.77	4.14	1.29	1.20	1.78	4.27	H
57	*Ficus asperifolia* Miq.	0.41	0.14	0.04	0.59	0.32	0.13	0.06	0.51	S
58	*Griffornia simplicifolia* Baill	0.45	0.10	0.01	0.56	0.36	0.13	0.02	0.51	CS
59	*Hilleria latifolia* (Lam) Watt.	-	-	-	-	1.06	0.89	0.74	2.69	H
60	*Hibiscus suranttensis* L.	-	-	-	-	0.94	0.58	0.69	2.21	H
61	*Icacina mannii* Oliv.	0.41	0.23	0.04	0.68	0.34	0.22	0.06	0.62	S
62	*Icacina trichantia* Oliv.	0.22	0.20	0.04	0.46	0.23	0.22	0.07	0.52	H
63	*Indigofera hirsuta* L.	0.34	0.27	0.02	0.63	0.23	0.13	0.04	0.40	S
64	*Imperata cylindrica* (L.) Beauv	0.89	2.16	4.80	7.85	1.20	2.22	4.34	7.76	G
65	*Ipomoea heredifolia* L.	0.89	0.59	0.53	2.01	0.75	0.48	0.35	1.58	HC
66	*Ipomoea involucrata* (L.) Beauv.	0.88	0.57	0.43	1.88	0.94	0.28	0.26	1.48	HC
67	*Jatropha curcus* L.	0.41	0.22	0.13	0.76	0.36	0.08	0.04	0.48	t
68	*Jussiaea linearis* Willd.	0.43	0.26	0.18	0.87	0.53	0.28	0.26	1.07	H
69	*Kyllinga erecta* Schumacher	0.45	0.26	0.31	1.02	0.34	0.27	0.26	0.87	SE
70	*Lantana camara* L.	0.45	0.31	0.40	1.16	0.38	0.86	0.45	1.69	S
71	*Lygodium* sp.	-	-	-	-	-	-	-	-	F
72	*Macrophylla longistyla* (DC) Hiern	0.46	0.20	0.22	0.88	0.35	0.05	0.01	0.41	S

73	*Mallotus opositifolius* (Giesel) Mull. Arg.	1.28	2.31	3.49	7.08	1.27	1.99	3.04	6.30	S
74	*Mallotus subulantus* Mull Arg.	0.40	0.12	0.13	0.65	0.35	0.09	0.01	0.43	S
75	*Malvastrum coromandelianum* (L.) Garcke	0.45	0.24	0.18	0.87	0.37	0.32	0.26	0.95	H
76	*Maniophyton fulvrum* Mull. Arg.	1.08	0.38	0.76	2.22	0.32	0.59	0.47	1.38	S
77	*Mariscus alternifolius* Vahl.	1.33	1.31	0.38	3.02	1.10	0.58	0.78	2.46	SE
78	*Melanthera scandens* (Shcum and Thonn) Roberty	1.67	3.04	6.46	11.17	1.31	3.24	3.56	8.11	H
79	*Mikania cordata* (Burm) Robinson	0.85	0.97	0.46	2.28	0.75	0.87	0.40	2.02	HC
80	*Mikania scandens* Willd.	0.56	0.94	0.35	1.85	0.57	0.34	0.30	1.21	H
81	*Milletia zechiana* Harms.	0.45	0.20	0.03	0.68	0.37	0.14	0.05	0.56	S
82	*Mimosa pigra* L.	0.28	0.15	0.02	0.45	0.19	0.20	0.03	0.42	H
83	*Mollugo verticillata* L.	-	-	-	-	0.94	1.06	0.55	2.55	H
84	*Momordica charantia* L.	0.78	0.95	0.76	2.49	0.90	0.13	1.30	3.33	H
85	*Musaenda elegans* Schum. and Thornn.	0.62	0.10	0.04	0.76	0.36	0.16	0.06	0.58	CS
86	*Nelsonia canescens* (Lam.) Spreng	0.68	0.26	0.18	1.12	0.56	0.41	0.20	1.17	H
87	*Nephrolepis bisserata* (SW) Schott.	1.11	1.14	2.49	4.74	1.12	1.86	2.60	5.58	F
88	*Nuclea diderrichi* (De Wild and Th. Dur) Merill	0.24	0.05	0.03	0.32	0.28	0.13	0.02	0.43	T
89	*Ocimum basilicum* L.	0.25	0.09	0.02	0.36	0.35	0.11	0.03	0.49	H
90	*Panicum brevifolium* L.	0.79	0.65	0.49	1.93	1.00	0.59	0.35	1.94	G
91	*Panicum laxum* SW.	0.89	0.75	0.62	2.26	0.75	0.85	0.52	1.95	G
92	*Panicum maximum* Jacq.	1.54	3.10	5.29	9.93	1.28	2.89	3.38	7.52	G
93	*Panicum repens* L.	1.11	0.76	0.62	2.49	0.87	1.06	0.57	2.50	G
94	*Paspalum conjugatum* Berg.	1.33	1.58	1.78	4.69	1.08	1.19	1.80	4.07	G
95	*Pauzolzia guineensis* Benth.	1.11	1.63	1.38	4.12	0.86	1.52	1.55	3.93	H
96	*Pennisetum polystachoin* (L) Schultz	1.18	1.55	0.89	3.62	0.92	0.40	1.70	4.02	G
97	*Pennisetum purpureum* Schumach	1.19	0.81	0.83	2.83	1.09	0.74	0.62	2.45	G
98	*Peperomia pellucida* (L.) H. B. and K.	-	-	-	-	1.04	0.85	0.42	2.31	H
99	*Pergularia daemia* (Forsk) Chiov.	0.42	0.14	0.13	0.69	0.53	0.27	0.26	1.06	HC
100	*Phyllantus amarus* Schum et Thonn	0.45	0.17	0.38	1.00	0.94	1.12	2.29	4.35	H
101	*Physalis angulata* L.	0.40	0.15	0.36	0.91	0.48	0.54	0.43	1.45	H
102	*Physalis micrantha* Link.	0.43	0.08	0.36	0.87	1.03	0.47	0.30	1.80	H
103	*Portulaca oleraca* L.	1.40	0.87	0.85	3.12	1.12	0.54	0.35	3.81	H
104	*Pteridium aquilinum* (L.) Kuhn	-	-	-	-	0.37	0.53	0.26	1.16	F
105	*Pteris burtoni* Bak.	-	-	-	-	0.37	0.27	0.17	0.81	F
106	Rauvolfia vomitoria Afz.	0.43	0.11	0.36	0.90	0.37	0.09	0.01	0.47	t
107	*Rottboellia cochinchinensis* (Lour) Clayton	0.85	0.26	0.37	1.48	0.93	0.42	0.54	1.89	G
108	*Scoparia dulcis* L.	0.41	0.08	0.01	0.50	0.37	0.13	0.01	0.57	S
109	*Schwenkia americana* L.	1.17	0.40	0.44	2.01	0.94	0.54	0.48	1.96	H
110	Secamone afezelii (Roem and Schult) Schum	0.45	0.15	0.01	0.61	0.34	0.13	0.01	0.52	S

111	*Setaria barbata* (Lam) Kunth	1.24	1.49	1.23	3.96	1.13	1.20	1.50	3.83	G
112	*Setaria longiseta* Beauv.	0.89	0.97	0.84	2.70	1.08	0.78	0.35	2.21	G
113	*Setaria megaphylla* (Steud.) Dur. and Schinz	0.86	0.67	0.27	1.80	0.86	0.75	0.33	1.94	G
114	*Setaria pallide-fusca* (Schum.) Stapf. and Hubbard	0.68	0.70	0.27	1.65	0.67	0.52	0.30	1.49	G
115	*Setaria verticillata* L.	0.65	0.25	0.40	1.30	0.72	0.49	0.30	1.51	G
116	*Sida acuta* Burm F.	1.30	1.41	0.98	3.69	1.10	1.28	1.77	4.15	S
117	*Sida cordifolia* L.	1.33	1.28	1.17	3.78	0.93	0.85	0.78	2.56	S
118	*Sida corymbosa* R. E. Frees	1.18	1.35	0.93	3.46	0.93	1.30	1.70	3.39	S
119	*Sida rhombifolia* L.	0.68	0.65	0.19	1.52	0.71	0.52	0.27	1.50	S
120	*Solanum nigrum* L.	-	-	-	-	0.73	0.21	0.08	1.02	H
121	*Solanum torvum* Swartz.	0.79	0.66	0.40	1.85	0.75	0.83	0.55	2.13	H
122	*Spigelia anthelmia* L.	1.30	1.69	0.73	3.72	1.13	0.95	0.61	2.69	H
123	*Sporobolus poirettii* L.	0.40	0.13	0.08	0.61	0.37	0.07	0.01	0.45	G
124	*Sporobolus pyramidalis* Beauv.	0.85	1.00	0.87	2.72	0.75	0.72	0.43	1.90	G
125	*Stachytarpheta cayenensis* (Rich) Schau	0.45	0.10	0.35	0.90	0.61	0.40	0.24	1.25	S
126	*Stachytarpheta indica* (L) Vahl	0.45	0.12	0.52	1.09	0.93	0.59	0.35	1.87	H
127	*Strophantus gratus* (Hook) Franch	0.24	0.05	0.07	0.36	0.34	0.11	0.01	0.46	CS
128	*Synedrella nodiflora* Gaertn.	0.77	0.57	0.93	2.27	1.29	1.92	1.83	5.04	H
129	*Talinum triangulare* (Jacq.) Willd	1.43	0.80	0.96	3.19	1.12	1.08	1.39	3.59	H
130	*Thumbergia erecta* (Benth) T. Anders	0.23	0.08	0.03	0.34	0.19	0.07	0.01	0.27	S
131	*Tridax procumbens* L.	1.46	1.56	0.89	3.91	1.28	1.69	1.72	4.69	H
132	*Urera lobata* L.	0.45	0.11	0.03	0.59	0.36	0.13	0.02	0.51	S
133	*Urera mannii* (Wedd.) Benth.	0.35	0.08	0.02	0.45	0.37	0.19	0.02	0.58	S
134	Vernonia amygdalina Del.	0.45	0.09	0.02	0.56	0.32	0.14	0.01	0.47	S
135	*Vernonia biafrae* Oliv and Hiern	0.63	0.14	0.09	0.86	0.34	0.13	0.01	0.48	S
136	*Vernonia colorata* (Willd) Drake	0.65	0.19	0.40	1.24	0.36	0.13	0.01	0.50	t

Key:

Rf =Relative frequency
Rd = Relative density
RCo = Relative cover
IVI = Important value index

LF = Life form
H = Herb
F = Fern

t = small tree
CS = climbing shrub
S = shrub
T = Tree

HC = Herbaceous climber
SE = Sedge
F* = epiphytic fern
G = Grass

Table-3. Vegetation analysis indices of the two strata of plantation sites.

Strata	**Simpson's index** (D)	**Shannon's index** (H^1)	**Evenness index** (E)
Young (< 5 years)	0.97	3.68	0.77
mature (5-15 years)	0.98	3.80	0.78

Table-5. Weeds encountered in the oil palm plantation in descending order of abundance with regard to genus and species.

Family	Number of genera	Number of species	Family	Number of genera	Number of species
Poaceae	15	26	Mimosaceae	2	2
Asteraceae	11	15	Portulacaceae	2	2
Euphorbiaceae	8	13	Convolvulaceae	1	2
Malvaceae	4	7	Icacinaceae	1	2
Fabaceae	4	5	Melastomataceae	1	2
Rubiaceae	4	4	Crassulaceae	1	1
Acanthaceae	3	5	Combretaceae	1	1
Solanaceae	3	5	Moraceae	1	1
Cyperaceae	3	4	Nyctaginaceae	1	1
Urticaceae	3	4	Onagraceae	1	1
Apocynaceae	3	3	Piperaceae	1	1
Commelinaceae	2	3	Phytolacaceae	1	1
Verbenaceae	2	3	Scrophulariaceae	1	1
Amaranthaceae	2	2	Rutaceae	1	1
Ascelpiadaceae	2	2	Adianthaceae	1	1
Caesalpinaceae	2	2	Aspidiaceae	1	1
Connaraceae	1	1	Athyriaceae	1	1
Cucurbitaceae	1	1	Davalliaceae	1	1
Lamiaceae	1	1	Dennstaedtiaceae	1	1
Loganiaceae	1	1	Lomariopsidaceae	1	1
Meliaceae	1	1	Schizaeceae	1	1
Molluginaceae	1	1	Thelypteridaceae	1	1

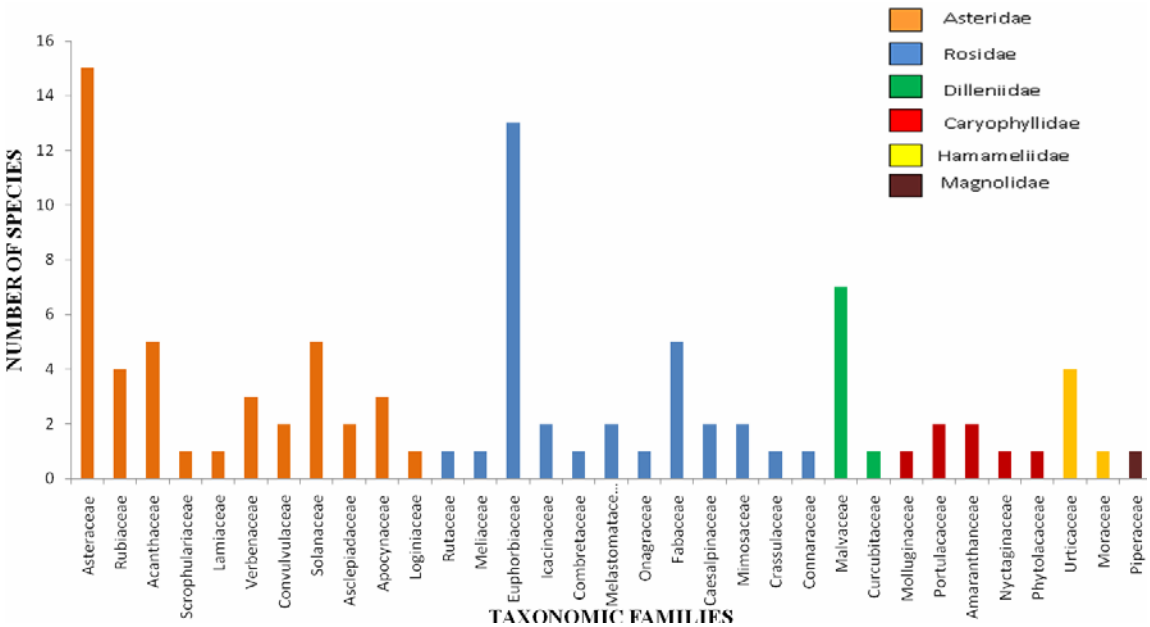

Figure-2. Distribution of dicot species in the oil palm plantation.

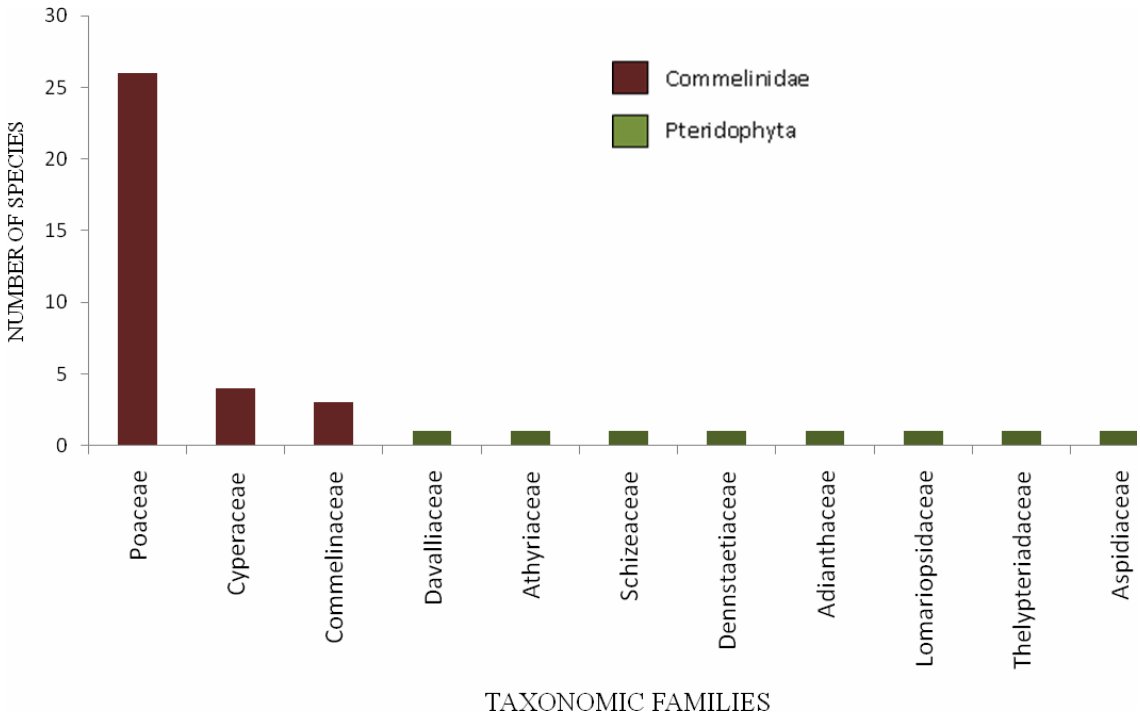

Figure-3. Distribution of monocot and pteridophyta species in the oil palm plantation.

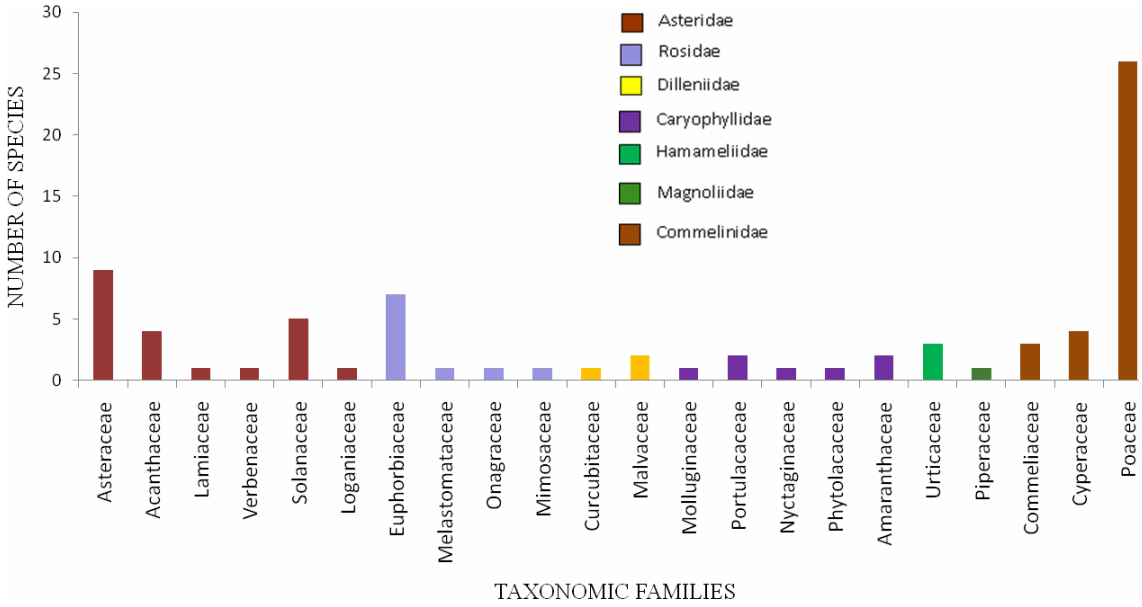

Figure-4. Distribution of herbaceous species in the oil palm plantation.

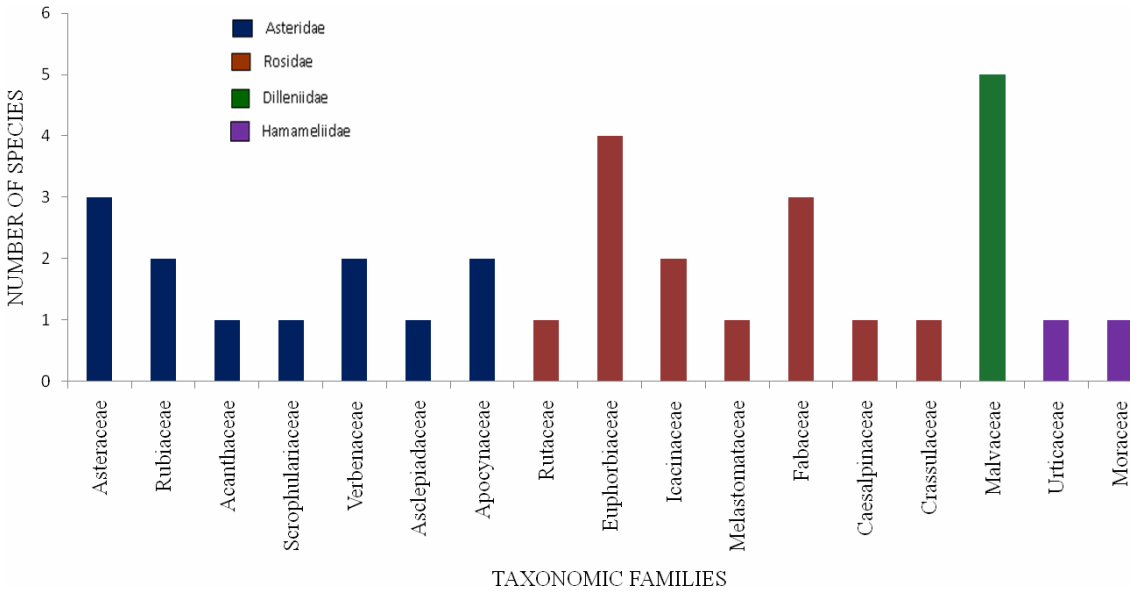

Figure-5. Distribution of shrub species in the oil palm plantation.

REFERENCES

Corley R.H.V., Tinker P.B. 2003. The Oil Palm, 4th Ed. Blackwell Science Ltd: Oxford, UK. pp. 592-593.

Pride D. 2010. Environmentally friendly weed control in Oil Palm Plantations. Available at http:/www. Palm Oil Truth Foundation.com. Accessed on 15th April.

Lam C. H., Lim J. K., Badrulisan J. 1993. Comparative studies of Paraquat mixtures and glyphosate and or its mixtures on weed succession in plantation crops. The Planter. 69: 525-535.

Quah K. B., Lim J. K., Badrulisan J. 1997. Alternating herbicide to minimize weed succession in the plantation. In Extended Abstract Proceedings of 2nd International Pesticides Conference -'Crop Protection towards 2000', MACA, Kuala Lumpur. pp. 110-113

Toledo R. E. B. 2000. Efeitos de periodeos de controle de plantas daninhas sobre o desenvolvimento inicial de plantas de eucalypto. *Planta Daninha*. 18: 395-400.

Senarathne S. H. S., Samarajeewa A. D., Perera K. C. P. 2003. Comparison of different weed management systems and their effects on yield of coconut plantations in Sri Lanka. Weed Biol. Manag. 3: 319-328.

Aquilar V., Staver C. and Milberg P. 2003. Weed vegetation response to chemical and manual selective group cover management in a shaded coffee plantation. Weed Res. 43: 68-75.

Yanagizawa Y. A. N. P., Maimoni-Rodella R. C. S. 1999. Composicao floristica e estrutura da communidade de plantas do estrato herbaceo em areas de cultivo de arvores frutiferas. Planta Daninha. 17: 459-468.

Defrank J., Clement C. R. 1995. Weed control in pejibaye heart of palm plantations in Hawaii. Hort. Sciences. 30: 1215-1216.

Hiyat A.S.M., Kudus K.A. 2010. Assessment of plant species diversity at Pasir Tengkorak forest reserve, Langkawi Island, Malaysia. J. Agric. Sci. 2: 31-38.

Magurran A. E. 2004. Ecological Diversity and Its Measurement. Princeton University Press: New Jersey, USA. pp. 40-45.

Magurran A.E. 2004. Measuring Biological Diversity. Blackwell Science Ltd: New York, USA. pp. 256-257.

Tsingalia M.T. 1990. Habitat disturbances severity and patterns of abundance in Kakamega forest, Western Kenya. African J. Ecol. 28: 213-226.

Newman E. I. 1994. Applied Ecology. Blackwell Scientific Publications: London, UK. pp. 50-55.

Sarada S., Sreekandan N. G., Reghunath B.R. 2002. Quantification of medicinally valuable weeds in oil palm plantation of Kerala. J. Trop. Agric. 40: 19-26.

Pascal L.P., Pellissier R. 1996. Structure and Floristic Composition of a Tropical evergreen forest in South -West India. J. Trop. Ecol. 12: 191-210.

Chee Y. K., Lee S.A., Ahmed A. I., Teo L., Chung G.F., Khairudin H. 1991. Crop loss by weeds in Malaysia. Lee, S. A.; Kon, K. F. Eds. Malaysian Plant Protection Society, Kuala Lumpur. Proceedings of the 3rd Tropical Weed Science Conference. pp. 1-21.

Sunitha S., Suja G., Varghese P. T., Nampoothiri K. U. K. 1995. Weed menace in oil palm plantation of Kerala. Indian Oil J. 5:169-171.

Akobundu I. O. 1987. Weeds Science in the Tropics: Principles and Practices. John Wiley and Sons: New York, USA. pp. 522-523.

Souza L. S. A., Silva J. F. and Souza M. D. B. 2003. Composicao floristica de plantas daninhas em agrossistemas de cupuazeiro (*Theobroma grandiflorum*) e pupunheiro (*Bactris gasipaes*). Planta Daninha. 21: 249-255.

Seavers G. P., Wright K. J. 1999. Crop canopy development and structure influence weed suppression. Weed Res. 39: 319-328.

Kumar B. M., George S. J., Suresh T. K. 2001. Fodder grass productivity and soil fertility changes under four grass + tree associations in Kerala, India. Agrofor. Syst. 52: 91-106.

Subtropen T. 2003. Spatial undergrowth species composition in oil palm plantation in West Sumatra. Palm Oil Institute of Malaysia (PORIM), Kuala Lumpur, Malaysia. pp. 17-30.

Hartley C.W.S. 1988. The Oil Palm. John Wiley and Sons Inc: New York, USA.