

Research Article

Weed Diversity and Infestation in *Elaeis Guineensis* Agroecosystems of Industrial Plantations in the Grands Ponts Region, Southern Ivory Coast

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Abstract

In oil palm cultivation, weeds are a major obstacle due to their negative effects on crop growth, soil fertility, and agricultural management systems. They compete with crops for the elements necessary for crop development and growth. Therefore, weed control is essential for maintaining yields. However, effective weed control requires knowledge of the weeds specific to palm oil groves and their potential harmfulness to the crop. This study aims to assess the floristic diversity and weed infestation in oil palm plantations within the Integrated Agricultural Unit (IAU) in Irobo, southern part of Côte d'Ivoire. A total of 250 floristic inventories were conducted across 5 localities, based on 2 ecological variables: age groups and toposequence, each with 3 options. Walk-through surveys using the "field walk" method were conducted within each 2500 m² plot to identify the weed species, genera, families, and biological types present, and to assess their frequencies, abundance-dominance, and potential harmfulness. As a result, a total of 657 species were identified, comprising 373 genera distributed across 98 botanical families. The most represented families are Fabaceae (65), Poaceae (61), Cyperaceae (37), Rubiaceae (36), Asteraceae (33), Apocynaceae (32), and Malvaceae (25). Dicotyledons and hemicryptophytes were the most common, accounting for 74.58% and 20%, respectively. The infestation diagram highlighted five of the nine groups and showed their infestation levels. *Nephrolepis biserrata*, *Pueraria phaseoloides*, and *Heterotis rotundifolia* are the species in group G1, that could be considered the major general weeds and the most harmful in the study area. In addition, *Steinchisma laxum* and *Croton hirtus* are identified as potential general weeds belonging to group G2. This study identified the main classes, families, species, and biological types of weeds present, as well as their potential to be harmful in industrial oil palm plantations. It could help guide the development of sustainable weed management practices in industrial oil palm plantations.

Keywords

Weed Diversity and Infestation, *Elaeis Guineensis*, Industrial Plantations, Southern Côte D'Ivoire

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1. Introduction

The oil palm (*Elaeis guineensis*) has become the world's leading source of vegetable fats thanks to its oil yields, which are 4 to 10 times higher than those of other oilseeds. These yields can reach 15 tonnes of bunches or 3 tonnes of oil per hectare [1-3]. The oil palm accounts for 39% of global vegetable oil production on a much smaller agricultural area than that devoted to other oilseed crops [4]. Like any crop, the date palm faces numerous challenges, compounded by climate change-induced rainfall deficits that disrupt its growth cycle and reduce productivity. Fungal diseases (such as *Fusarium* wilt) and pests (such as the date palm moth) also attack the date palm and contribute to yield losses. Weeds are one of the main agronomic and biological constraints [5] affecting global agricultural production, particularly in developing countries [6]. Controlling competing weeds in an agroecosystem allows for better crop development from the earliest stages, followed by optimal fruiting, and facilitates harvesting and collection of detached fruit thanks to the exposed fruit rings [7].

In oil palm cultivation, weed control relies primarily on manual weeding and chemical control [8, 9]. However, the repeated use of synthetic herbicides not only promotes the selection of resistant species, which are harmful to the crop, but also that of species harmful to the environment and human health in the absence of preventive measures [10, 11]. Faced with a growing labor shortage and the high costs of herbicide treatments in oil palm cultivation, exacerbated by the vast planted areas, particularly in industrial plantations, and the need to protect the environment and biodiversity, it is crucial to implement a truly integrated weed management strategy. However, such an approach requires a preliminary study of the diversity and harmfulness of weeds present in palm groves.

In Côte d'Ivoire, several recent studies have focused on weeds in commercial crops such as dessert bananas [12], cashews [13], and cotton [14], but those conducted in commercial oil palm plantations date back more than ten years [15]. Therefore, the objective of this study is to assess the floristic diversity of weeds and their level of infestation in industrial oil palm plantations.

2. Materials and Methods

2.1. Study Site

This study was carried out in the industrial oil palm plantations of the Integrated Agricultural Unit (IAU) of Irobo, in the Grands-Ponts region, in southern Côte d'Ivoire (5° 20' N; 4° 20' W; 5 - 20 m), on the Dabou-Grand Lahou axis (Figure 1).

The administrative division of this region is characterized by a subequatorial climate [16]. It has two distinct seasons: a long rainy season and a short dry season [17]. The rainy season extends from April to November. The wettest months are May, June, and July. The dry season lasts from December to March [18, 19]. Average annual rainfall is 1,650 mm, with an average temperature of 26 °C and relative humidity reaching approximately 85% [18, 20, 21]. The ombrothermic diagram (Figure 2) shows average temperatures and rainfall. The vegetation of this region is characterized by dense evergreen forest (tropical rainforest) and savanna. The soils are primarily ferrallitic and hydromorphic, very deep and fertile, supporting large trees as well as food and perennial crops.

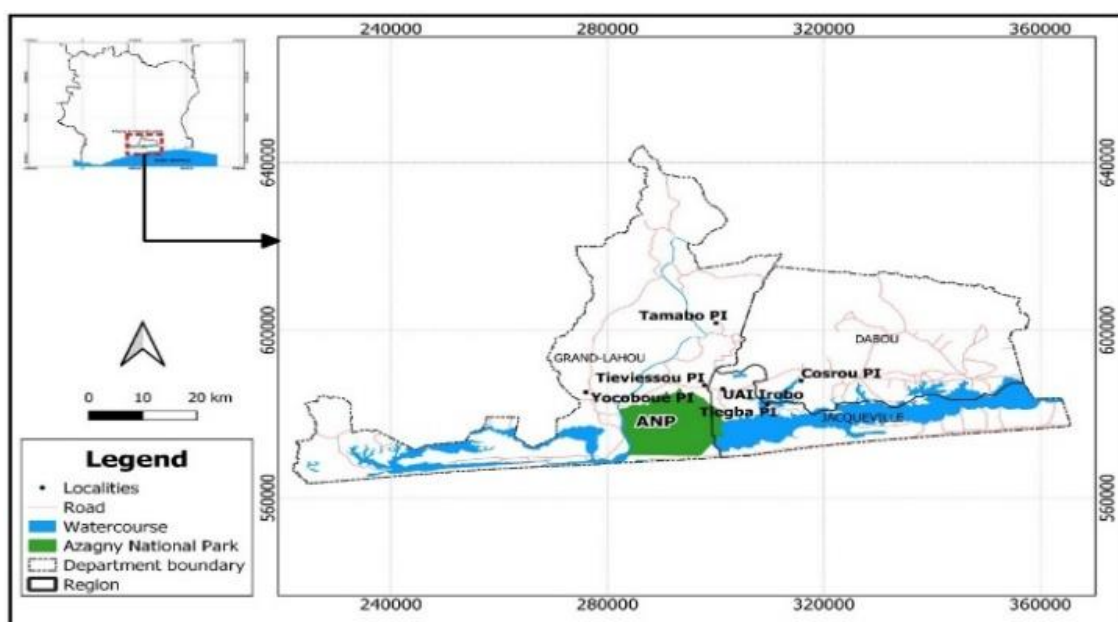


Figure 1. Presentation of the study area and location of the inventoried sites in the region of the main bridges.

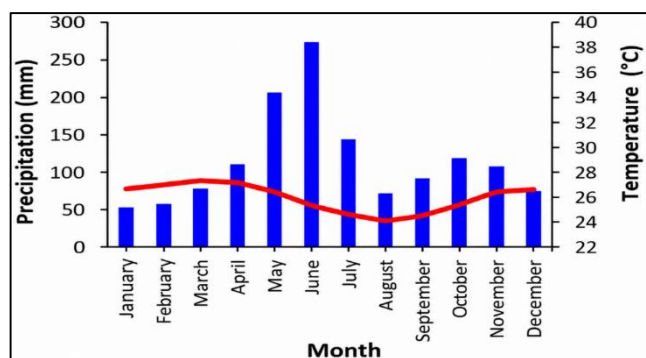


Figure 2. Ombro-thermal diagram of the main area of the bridge from 1991 to 2021 Source: <https://www.climatsetvoyages.com/climat/cote-d-ivoire/Dabou> [22].

2.2. Material

2.2.1. Biological Material

The biological material includes various types of adventitious plants (weeds) found in oil palm (*Elaeis guineensis*) plantations, belonging to the Arecaceae family.

2.2.2. Technical Equipment

The technical equipment consisted mainly of a smartphone used as a camera; newspapers for creating a herbarium; a GPS to locate the different plots studied; plant identification sheets; 1.5-meter-high wooden stakes; and a tape measure to delimit the plots. Data entry and analysis were performed using Excel 2021.

2.3. Methods

2.3.1. Data Collection

The floristic composition of agroecosystems varies with the crop, ecological conditions, and the spatial structure of the plots. The sampling area is adapted to the vegetation type to ensure the representativeness of the floristic inventories [23]. In this study, stratified sampling was used to account for the ecological and agronomic heterogeneity of the palm groves [17, 24, 25]. Three stratification criteria were considered: the age class of the palm groves, the topographic position according to toposequence, and the locality. The floristic inventory was carried out on 2,500 m² (¼ ha) plots, deemed appropriate for representing the weed flora of the studied agroecosystems [23, 26]. It is considered a weed or an unwanted plant, covering all spontaneous species found in oil palm plantations. This

includes herbaceous plants, tree shoots, and regrowth from abandoned oil palm fruits, all of which can damage the crops in place. In each plot, a comprehensive inventory of plant species was conducted by systematically traversing the area in several directions, using the pedestrian survey method, until no new species were detected. This process aimed to maximize the recording of all species present in each sampling unit. In total, 250 floristic surveys were carried out across the five industrial plantations of the Irobo Integrated Agricultural Unit (UAI), distributed according to the 2 ecological variables studied (Tables 1-3). For each inventory, all observed plant species were recorded and, where possible, identified on site. The relative importance of each species in the plot was estimated using an abundance-dominance coefficient based on the Lebourgeois scale [27]. When field identification was impossible, photographs of the individuals were taken. Specimens were also collected to create a reference herbarium, which was then used to confirm or supplement the taxonomic identification. The Guide to Adventitious Plants of West Africa by Akobundu and Gyakwa [28], the Guide to the Spontaneous Flora of the Agrosystems of Mayotte by Nagy *et al.* [29], and the herbarium of the National Floristic Center of the Felix Houphouët-Boigny University enabled the identification of these species.

The identified taxa were coded to facilitate the processing, analysis, and interpretation of the collected data. The international 5-letter mnemonic code [30], also known as the BAYER code, approved by the Weed Science Society of America (WSSA) and the Weed Science Society of Japan (WSSJ), was chosen. This code consists of the first three letters of the genus and the first two letters of the species name.

Table 1. Ecological sampling variables (or descriptors) and their respective strata.

Ecological variables	
Age group	Topo-sequence
Age 1	Hillside
Age 2	Slope
Age 3	Plateau

Age 1: plots from 0 to 10 years; Age 2: plots from 11 to 20 years; Age 3: plots from 20 to 30 years

Table 2. Plant surveys carried out at each site along the topo-sequences.

Localities	Strata related to the topo-sequence			Total of floristic survey
	Slope	Plateau	Hillside	
Cosrou PI	8	40	12	60
Tamabo PI	4	38	3	45
Tiegba PI	9	23	8	40
Tieviessou PI	8	45	7	60
Yocoboue PI	2	41	2	45
Total of floristic survey	31	187	32	250

Table 3. Plant surveys carried out in each site according to the age class of the palm oil plantation.

Localities	Age groups of palm oil plantations			Total of floristic survey
	Age 1	Age 2	Age 3	
Cosrou PI	20	20	20	60
Tamabo PI	20	25	0	45
Tiegba PI	20	0	20	40
Tieviessou PI	20	20	20	60
Yocoboue PI	0	0	45	45
Total of floristic survey	31	187	32	250

Age 1: plots from 0 to 10 years; Age 2: plots from 11 to 20 years; Age 3: plots from 20 to 30 years

2.3.2. Data Analysis

Data collected on weed growth in industrial (IP) oil palm plantations of PALMCI Irobo IAI were subjected to qualitative and quantitative analyses.

(i). Qualitative Analysis

A qualitative analysis was conducted to determine the composition and floristic richness of the weed flora in PALMCI's industrial plantations in Irobo, in the Grands-Ponts region. The floristic composition was obtained by cross-referencing lists of species recorded in the different plantation plots. This allowed for the determination of the floristic richness of the oil palm agroecosystem. This richness was determined using a diagram showing the number of species as a function of the number of surveys conducted across the different plots. The floristic richness and composition of the oil palm agroecosystems were assessed by considering several parameters, includ-

ing the number of species, their distribution by genus and family, and their biological type.

(ii). Quantitative Analysis

For the spectrum of biological types, the adopted classification model is Raunkiaer's [31], as adapted by Ake Assi [32]. Calculating the percentage of each biological type allowed us to establish this spectrum, highlighting the floristic importance of the plant formations [33]. The calculation follows formula (1) below:

$$pc = \frac{\sum \text{ADavg species of the same (TB)}}{\sum \text{ADavg of all species}} \times 100 \quad (1)$$

pc - percentage; TB - biological type; ADavg - average abundance-dominance.

The meaning of the abbreviations used to designate the biological types and the height limits of the vegetative buds of each type are given in Table 4.

Table 4. Meaning of the abbreviations for biological types and limits of vegetative bud height for each biological type [31].

Biological types	Meanings
Megaphanerophyte (MP)	Tree over 30 m tall
Mesophanerophyte (Mp)	Tree 8 to 30 m tall
Microphanerophyte (mp)	Tree 2 to 8 m tall
Nanophanerophyte (np)	Shrub from 25 cm to 2 m tall
Therophyte (Th)	An annual species that survives the unfavorable season as dormant embryos, protected inside the seeds.
Chamaephyte (Ch)	A species whose perennial buds are located less than 25 cm from the ground
Hemicryptophyte (H)	A species whose buds are located at or very close to ground level.
Geophyte (G)	A species whose buds are hidden in the soil

The absolute frequency (Fa) of a species, or specific frequency, is the number of times (n) a species (e) has been observed in (N) surveys during sampling: $Fa = n/N$. It allows us to assess the regularity of a species within an agroecosystem [31] and to classify species by frequency.

The relative frequency (Fr) of the species is the ratio between the absolute frequency (Fa) and the total number (N) of records; formula (2) is as follows:

$$Fr = \frac{Fa(e)}{N} \quad (2)$$

The centesimal frequency (Fc) is the expression of the relative frequency (Fr) as a percentage; the formula (3) used is:

$$Fc = \frac{Fa(e)}{N} \times 100 \quad (3)$$

The abundance-dominance index assesses the degree of weed infestation by visual observation of the number (density) and coverage rate of weeds. All abundance-dominance measurements (Table 5) were conducted using Le Bourgeois's weed infestation quantification scale [27]. The average abundance-dominance of a species (e) is the sum of the abundance-dominance scores divided by the total number of surveys (N) in which the species was present. This index is calculated according to the following formula (4):

$$I - ADavg = \frac{\sum I - ADavg \text{ of species } (e)}{N} \quad (4)$$

The Bourgeois scale [27] was used to classify the nuisance potential in different groups of species (Table 6).

Table 5. Scale adopted to quantify weed cover [27].

Clues	Meanings
1	Individuals are rare, scattered, or abundant, but with low coverage.
2	Individuals that are very abundant or that cover 1/20 of the sampled area
3	Individuals covering ¼ to ½ of the surface area, regardless of their abundance
4	Individuals covering half to three-quarters of the surface area, regardless of their abundance
5	Individuals covering more than ¾ of the surface area, regardless of their abundance

Table 6. Groups of weed plants according to their relative frequency and average abundance/dominance [27].

Codes	Groups of weeds	Relative frequency (Fr)	Average Abundance/Dominance (Y)
G1	Major General Weeds	Fr > 50%	ADavg > 1.5
G2	General potential weed	Fr > 50%	1.25 < ADavg < 1.5

Codes	Groups of weeds	Relative frequency (Fr)	Average Abundance/Dominance (Y)
G3	Weeds in general	Fr > 50%	< 1.25
G4	Main regional weeds	20% < Fr < 50%	> 1.5
G5	Potential regional weeds	20% < Fr < 50%	1.25 < ADavg < 1.5
G6	Regional weeds	20% < Fr < 50%	ADavg < 1.25
G7	Main local weeds	Fr < 20%	ADavg > 1.5
G8	Potential local weeds	Fr < 20%	1.25 < ADavg < 1.5
G9	Minor weeds	Fr < 20%	ADavg < 1.25

3. Results

3.1. Floral Arrangement

The floristic inventory revealed a significant diversity of weed plants, totaling 657 species, the most frequent of which are listed in Table 7. These species are distributed among 373 genera and belong to 98 botanical families. The most dominant of which are the Fabaceae (65), the Poaceae (61), the Cyperaceae (37), the Rubiaceae (36), the Asteraceae (33), the

Apocynaceae (32), and the Malvaceae (25) (Figure 3). The recorded species belong to three classes: Dicotyledons (74.58%), Monocotyledons (23.14%), and Pteridophytes (2.28%) (Figure 4). Eight (8) different biological types have been identified. The most dominant are hemicryptophytes (20%), microphanerophytes (19%), nanophanerophytes (18%), therophytes (17%), and mesophanerophytes (11%), followed by the least dominant: geophytes (7%), megaphanerophytes (4%), and chamaephytes (4%), as illustrated in Figure 5.

Table 7. Diversity of weed species with a frequency greater than 20%.

Nº	Species	Families	Class	Fa	Fr (%)
1	<i>Achyranthes aspera</i> L. (1753)	Amaranthaceae	Dicotyledons	103	41.2
2	<i>Adenia lobata</i> (Jacq.) Engl. (1891)	Passifloraceae	Dicotyledons	133	53.2
3	<i>Ageratum conyzoides</i> L. (1753)	Asteraceae	Dicotyledons	170	68
4	<i>Albizia adianthifolia</i> (Schumach.) W. Wight (1909)	Fabaceae	Dicotyledons	105	42
5	<i>Alchornea cordifolia</i> (Schumach. & Thonn.) Müll. Arg.	Euphorbiaceae	Dicotyledons	111	44.4
6	<i>Alstonia Boonei</i> De Wild. (1914)	Apocynaceae	Dicotyledons	90	36
7	<i>Anthocleista djalensis</i> A. Chiv. (1908)	Gentianaceae	Dicotyledons	69	27.6
8	<i>Anthocleista schweinfurthii</i> Gilg (1893)	Gentianaceae	Dicotyledons	91	36.4
9	<i>Antiaris toxicaria</i> (Pers.) Lesch. (1810)	Moraceae	Dicotyledons	69	27.6
10	<i>Gangetic asystasis</i> (L.) T. Anderson (1860)	Acanthaceae	Dicotyledons	157	62.8
11	<i>Axonopus compressus</i> (Swedish) P. Beauv. (1812)	Poaceae	Monocotyledons	128	51.2
12	<i>Cecropia peltata</i> L. (1759)	Urticaceae	Dicotyledons	77	30.8
13	<i>Centrosema pubescens</i> Benth. (1837)	Fabaceae	Dicotyledons	145	58
14	<i>Chromolaena odorata</i> (L.) R. M King & H. Rob. (1970)	Asteraceae	Dicotyledons	188	75.2
15	<i>Clerodendrum splendens</i> G. Don (1824)	Lamiaceae	Dicotyledons	55	22
16	<i>Commelina benghalensis</i> L. (1753)	Commelinaceae	Monocotyledons	130	52
17	<i>Commelina diffusa</i> Burm. f. (1768)	Commelinaceae	Monocotyledons	136	54.4

N°	Species	Families	Class	Fa	Fr (%)
18	<i>Commelina erecta</i> L. (1753)	Commelinaceae	Monocotyledons	80	32
19	<i>Croton hirtus</i> The Herald (1785)	Euphorbiaceae	Dicotyledons	177	70.8
20	<i>Cyathula prostrata</i> (L.) Blume	Amaranthaceae	Dicotyledons	98	39.2
21	<i>Elaeis guineensis</i> Jacques (1763)	Arecaceae	Monocotyledons	104	41.6
22	<i>Emilia fosbergii</i> Nicolson (1975)	Asteraceae	Dicotyledons	65	26
23	<i>Ficus exasperata</i> Vahl (1805)	Moraceae	Dicotyledons	125	50
24	<i>Grona trifloral</i> (L.) H. Ohashi and K. Ohashi (2018)	Fabaceae	Dicotyledons	146	58.4
25	<i>Heterotis rotundifolia</i> (Sm.) Jacq.-Fel. (1981)	Melastomataceae	Dicotyledons	184	73.6
26	<i>Laportea aestuans</i> (L.) Chew (1965)	Urticaceae	Dicotyledons	54	21.6
27	<i>Milicia excelsa</i> (Welcome) CC Berg (1982)	Moraceae	Dicotyledons	109	43.6
28	<i>Mimosa pudica</i> L. (1753)	Fabaceae	Dicotyledons	84	33.6
29	<i>Momordica charantia</i> L. (1753)	Cucurbitaceae	Dicotyledons	137	54.8
30	<i>Nephrolepis biserrate</i> (Swedish) Desv. (1834)	Nephrolepidaceae	Pteridophyte	166	66.4
31	<i>Neustanthus phaseoloides</i> (Roxb.) Benth. (1852)	Fabaceae	Dicotyledons	62	24.8
32	<i>Oplismenus burmanni</i> (Retz.) P. Beauv. (1812)	Poaceae	Monocotyledons	54	21.6
33	<i>Passiflora lutea</i> L. (1753)	Passifloraceae	Dicotyledons	153	61.2
34	<i>Phyllanthus amarus</i> Schumacher & Thonn (1827)	Phyllanthaceae	Dicotyledons	91	36.4
35	<i>Phyllanthus urinaria</i> L. (1753)	phyllanthusaceae	Dicotyledons	125	50
36	<i>Psidium guajava</i> L. (1753)	Myrtaceae	Dicotyledons	97	38.8
37	<i>Pueraria phaseoloides</i> (Roxb.) Benth. (1867)	Fabaceae	Dicotyledons	180	72
38	<i>Richardia scabra</i> L. (1753)	Rubiaceae	Dicotyledons	80	32
39	<i>Scleria gaertneri</i> Raddi (1823)	Cyperaceae	Monocotyledons	73	29.2
40	<i>Sida acuta</i> Burm. fil. (1768)	Malvaceae	Dicotyledons	128	51.2
41	<i>Smilax anceps</i> Willd. (1806)	Smilacaceae	Monocotyledons	152	60.8
42	<i>Spermacoce latifolia</i> Aubl. (1775)	Rubiaceae	Dicotyledons	130	52
43	<i>Steinchisma laxum</i> (Swedish) Zuloaga (2003)	Poaceae	Monocotyledons	152	60.8
44	<i>Talinum paniculatum</i> (Jacq. to Gaertn (1791))	Talinaceae	Dicotyledons	58	23.2
45	<i>Urena lobata</i> L. (1753)	Malvaceae	Dicotyledons	150	60

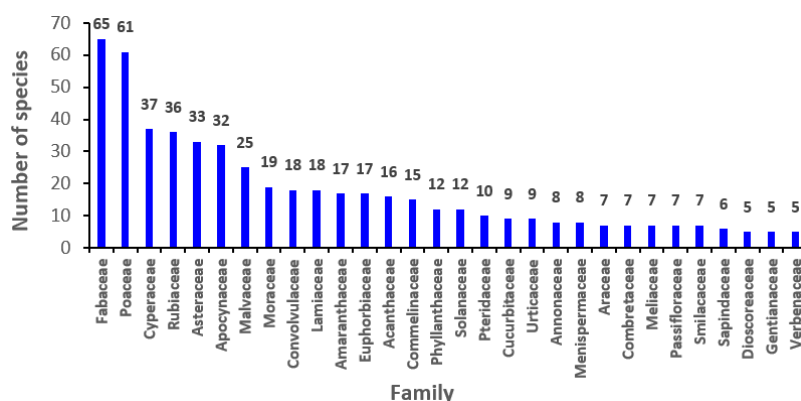


Figure 3. Dominant weed family in PALMCI industrial plantations in Irobo.

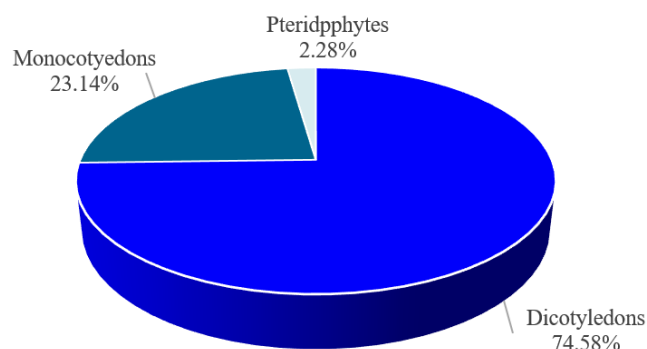


Figure 4. Spectrum of weed classes in PALMCI industrial plantations in Irobo.

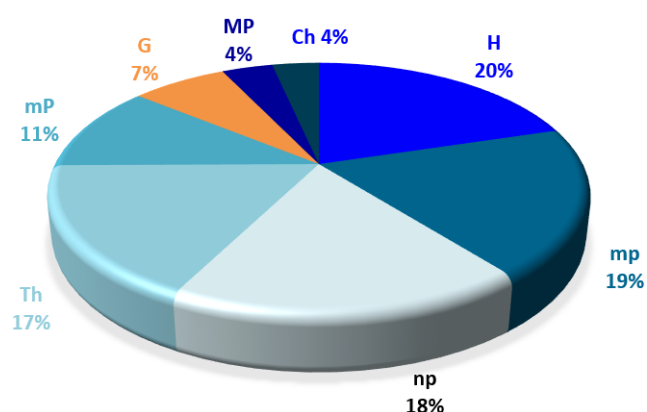


Figure 5. Spectrum of biological types of weed flora in PALMCI industrial plantations in Irobo.

MP: Megaphanerophyte; Mp: Mesophanerophyte; np: Nanophanerophyte; mp: Microphanerophyte; Th: Therophyte; Ch: Chamaephyte; H: Hemicryptophyte; G: Geophyte.

3.2. Weed Infestation Degree

Analysis of the relationship between relative frequency and average abundance-dominance (ADavg) of weed flora identified five species groups (G1, G2, G3, G6 et G9) among the nine theoretical groups in the infestation diagram (Figure 6). These groups reflect the level of damage and agronomic importance of the weeds identified in the PALMCI industrial oil palm plantations in Irobo. The first three groups require close

monitoring (Table 8).

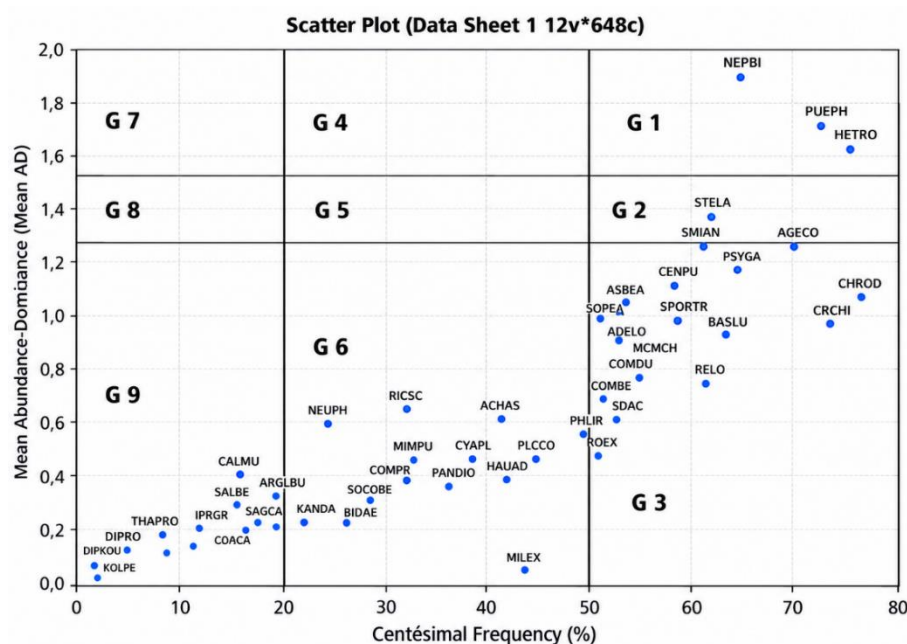
Group G1, corresponding to the main weeds, comprises the most harmful species in the study area. It consists of three species: *Nephrolepis biserrata* (NEPBI), *Pueraria phaseoloides* (PUEPH), and *Heterotis rotundifolia* (HETRO). These species are characterized by a strong presence and dense plant cover, demonstrating their high colonization capacity and strong competition with the oil palm.

Group G2 comprises potentially invasive species. It includes two species, *Steinchisma laxum* (STELA) and *Croton hirtus* (CROHI). These species have a high potential for infestation and are likely to become major weeds if ecological conditions become favorable.

Group G3, designated general weeds, includes species with relatively high frequency but generally low coverage. It includes seventeen species: *Ageratum conyzoides* (AGECO), *Smilax anceps* (SMIAN), *Asystasia gangetica* (ASYGA), *Axonopus compressus* (AXOCO), *Commelina benghalensis* (COMBE), *Commelina diffusa* (COMDI), *Chromolaena odorata* (CHROD), *Centrosema pubescens* (CENPU), *Adenia lobata* (ADELO), *Ficus exasperata* (FICEX), *Grona trifloral* (GROTR), *Passiflora lutea* (PASLU), *Momordica charantia* (MOMCH), *Phyllanthus urinaria* (PHYUR), *Sida acuta* (SIDAC), *Urena lobata* (URELO) and *Spermacoce latifolia* (SPERLA). These species exert moderate competition.

Group G6, composed of regional weed species, includes species with an average abundance-to-dominance ratio less than 1.25 and a relative frequency greater than 20% and greater than 50%. This group includes several species, among them: *Achyranthes aspera* (ACHAS), *Milicia excelsa* (MILEX), *Neustanthus phaseoloides* (NEUPH), *Mimosa pudica* (MIMPU), and *Richardia scabra* (RICSC). Their relatively wide distribution reflects their good adaptation to local ecological conditions.

Group G9, corresponding to minor weeds, comprises the least harmful species to the crop. These species represent more than half of the recorded species. They are characterized by an average abundance/dominance below 1.25 and a relative frequency below 20%. Their low ground cover and weak competitiveness limit their impact on oil palm development. *Calopogonium mucunoides* (CALMU) is a representative species of this group.



G1: Group 1; G2: Group 2; G3: Group 3; G4: Group 4; G5: Group 5; G6: Group 6; G7: Group 7; G8: Group 8; G9: Group 9

Figure 6. Weed infestation diagram of PALMCI industrial plantations in Irobo.

Table 8. Main weeds of the first three groups.

Groups of weeds	Bayer Code	Species	Families	Classes	Fa	FC (%)	ADavg
G1	HETRO	<i>Heterotis rotundifolia</i> (Sm.) Jacq.-Fel. (1981)	Melastomataceae	Dicotyledons	184	73.6	1.604
	NEPBI	<i>Nephrolepis biserrata</i> (Swedish) Desv. (1834)	Nephrolepidaceae	Pteridophytes	166	66.4	1.896
	PUEPH	<i>Pueraria phaseoloides</i> (Roxb.) Benth. (1867)	Fabaceae	Dicotyledons	180	72	1.64
G2	STELA	<i>Steinchisma laxum</i> (Swedish) Zuloaga (2003)	Poaceae	Monocotyledons	152	60.8	1.312
	CROHI	<i>Croton hirtus</i> The Herald (1785)	Euphorbiaceae	Dicotyledons	177	70.8	1.32
	SMIAN	<i>Smilax anceps</i> Will. (1806)	Smilacaceae	Monocotyledons	152	60.8	1.204
G3	ADELO	<i>Adenia lobata</i> (Jacq.) Engl. (1891)	Passifloraceae	Dicotyledons	133	53.2	1.132
	AGECO	<i>Ageratum conyzoides</i> L. (1753)	Asteraceae	Dicotyledons	170	68	1.168
	ASYGA	<i>Gangetic asystasis</i> (L.) T. Anderson (1860)	Acanthaceae	Dicotyledons	157	62.8	1.112
	AXOCO	<i>Axonopus compressus</i> (Swedish) P. Beauv. (1812)	Poaceae	Monocotyledons	128	51.2	1.136
	CENPU	<i>Centrosema pubescens</i> Benth. (1837)	Fabaceae	Dicotyledons	145	58	1.136
	CHROD	<i>Chromolaena odorata</i> (L) R. M. King & H. Rob. (1970)	Asteraceae	Dicotyledons	188	75.2	1.144
	COMBE	<i>Commelina benghalensis</i> L. (1753)	Commelinaceae	Monocotyledons	130	52	1.140

Groups of weeds	Bayer Code	Species	Families	Classes	Fa	FC (%)	ADavg
	COMDI	<i>Commelina diffusa</i> Burm. f. (1768)	Commelinaceae	Monocotyledons	136	54.4	1.124
	GROTR	<i>Grona triflora</i> (L.) H. Ohashi and K. Ohashi (2018)	Fabaceae	Dicotyledons	146	58.4	1.116
	MOMCH	<i>Momordica charantia</i> L. (1753)	Cucurbitaceae	Dicotyledons	137	54.8	1.12
	PASLU	<i>Passiflora lutea</i> L. (1753)	Passifloraceae	Dicotyledons	153	61.2	1.108
	SIDAC	<i>Sida acuta</i> Burm. fil. (1768)	Malvaceae	Dicotyledons	128	51.2	1.120
	RICSC	<i>Richardia scabra</i> L. (1753)	Rubiaceae	Dicotyledons	129	51.6	1.104
	SPELA	<i>Spermacoce latifolia</i> Aubl. (1775)	Rubiaceae	Dicotyledons	130	52	1.112
	URELO	<i>Urena lobata</i> L. (1753)	Malvaceae	Dicotyledons	150	60	1.104

Fa: absolute frequency; Fc: centesimal frequency; ADavg (e): average abundance-dominance; G1: group 1; G2: group 2; G3: group 3.

4. Discussion

The floristic inventory identified 657 weed species, belonging to 373 genera distributed across 98 botanical families. Seven botanical families are of relative importance for these species. Among them, six families (Fabaceae, Poaceae, Cyperaceae, Rubiaceae, Asteraceae, and Malvaceae) are among the ten families considered to be "major weeds globally" [34].

Dicotyledons account for 74.58% of weeds, compared with 23.14% for monocotyledons and 2.28% for pteridophytes. They constitute the majority of weeds in intertropical Africa. This study corroborates the studies of Boraud [35] on sugarcane cultivation, Mangara *et al.* [36] on pineapple cultivation, Kouakou [37] on maize cultivation, and Traore *et al.* [38] on oil palm cultivation.

The high proportion of hemicryptophytes observed in weed flora is attributable to their ability to withstand recurring disturbances in agroecosystems. Their regeneration buds, located at ground level, offer them better protection against the effects of weeding, tillage, and climatic variations. This biological strategy promotes their rapid regeneration and persistence in cultivated environments [39, 40]. According to Boraud [35], the dominance of hemicryptophytes in crops often reflects their adaptation to anthropogenic disturbances and the permanent opening of the plant canopy.

The abundance of microphanerophytes, nanophanerophytes, and mesophanerophytes could be explained by the subequatorial climate of the Great Ponts region, characterized by high rainfall and the absence of tilling after oil palm planting. Palm groves are perennial crops that promote the development of local vegetation. Therophytes are plants generally adapted to cultivated environments [41-43].

The infestation diagram highlights a clear hierarchical structure of the weed flora within the oil palm plantation, with

highly competitive species alongside a variety of less dominant secondary species. This observation is corroborated by several studies conducted in various tropical agroecosystems, where the weed flora is generally dominated by a limited number of major species, accompanied by a wide diversity of minor species [33, 44, 45]. In our case, *Nephrolepis biserrata*, *Pueraria phaseoloides*, and *Heterotis rotundifolia* belong to the group of major generalist weeds most harmful to oil palm cultivation. These species are very abundant and constitute cover crops when present. Indeed, *Pueraria phaseoloides* is an introduced species used as a cover crop in industrial plantations, and its seeds can remain viable in the soil for extended periods. The other two species thrive particularly well in humid and semi-shaded areas. Mature palm groves create a humid microclimate under their canopy, conducive to their growth. Our study confirms the findings of Traore *et al.* [42] and Traore and Pene [15], conducted in the inclusive savanna zone of Dabou and in the oil palm agroecosystems of the Me region, which also showed the dominance of *Nephrolepis biserrata* and *Heterotis rotundifolia*. These species could be considered companions of the oil palm. These authors also reported a strong dominance of *Chromolaena odorata* (Asteraceae), *Panicum laxum* (Poaceae), *Oplismenus burmannii* (Poaceae), *Clerodendrum splendens* (Verbenaceae), *Phaulopsis falcisepala* (Acanthaceae), *Emilia praetermissa* (Asteraceae), *Desmodium adscendens* (Fabaceae), *Mariscus alternifolius* (Cyperaceae), *Secamone afzelii* (Asclepiadaceae), *Phyllanthus amarus* (Euphorbiaceae), *Thaumatococcus daniellii* (Marantaceae), *Ipomoea involucreata* (Convolvulaceae), *Mariscus flabelliformis* (Cyperaceae), and *Lantana camara* (Verbenaceae) in the undergrowth of oil palm plantations.

The work of Traore and Maillet [46] showed that these harmful weeds strongly compete with cotton and are distinguished from other weeds by their high frequency (> 50%) and an abundance-dominance index greater than 1.5. Their harm-

fulness is thought to stem from high seed production. *Steinichisma laxum* and *Smilax anceps* belong to the group of general potential weeds, whose relative frequency exceeds 50%, with an AD average of 1.25 (< 1.5). They are not dominant. Their intermediate position in the diagram suggests a potential dynamic of expansion in response to changes in agricultural practices or environmental conditions. This situation confirms the evolutionary nature of weed communities, strongly influenced by anthropogenic disturbances and ecological gradients [47]. These species should therefore be considered early indicators of changes in weed community structure.

The species in group G3 are generalist weeds. Their relative frequency exceeds 50%, and their average A/D ratio is less than 1.25; in other words, they exhibit low abundance and low dominance. They constitute a group of widespread generalist weeds with a low direct agronomic impact. This type of structure is frequently observed in tropical agroecosystems, where many species maintain a diffuse presence without achieving high dominance. Their ecological role is nevertheless important, as they contribute to floristic diversity and can influence the overall dynamics of plant communities.

Group G6 comprises species widely distributed in oil palm plantations, demonstrating good adaptation to local soil and climatic conditions. The presence of *Mimosa pudica*, *Achyranthes aspera*, and *Richardia scabra* is characteristic of cultivated systems subjected to regular disturbances. According to Boraud [35], this type of species is often favored by repeated cultivation practices, particularly mechanical and chemical weeding, which modify the plant canopy structure and create available ecological niches. Finally, group G9, composed of minor weeds, represents more than half of the recorded species. Despite their high species richness, their low cover indicates weak competitiveness against oil palm. This distribution, characterized by high diversity but low dominance, is typical of plant communities stabilized by agricultural constraints and confirms Le Bourgeois's observations [27] on the structure of weed flora in cultivated environments.

5. Conclusions

This study identified 657 weed species belonging to 373 genera and 98 botanical families. Seven families predominate in the surveyed flora: Fabaceae (65 species), Poaceae (61 species), Cyperaceae (37 species), Rubiaceae (36 species), Asteraceae (33 species), Apocynaceae (32 species), and Malvaceae (25 species). Dicotyledons constitute the largest class, representing 74.58% of all surveyed species. Analysis of biological types reveals a predominance of Hemicryptophytes (20%), Microphanerophytes (19%), Nanophanerophytes (18%), Therophytes (17%), and Mesophanerophytes (11%). The infestation diagram highlights a limited number of highly competitive species (*Heterotis rotundifolia*, *Nephrolepis biserrate*, *Pueraria phaseoloides*), while most inventoried species play a secondary role in the infestation of palm oil plots. A weed

management strategy must be implemented to improve the effectiveness of weed control.

Abbreviations

MP	Megaphanerophyte
Mp	Mesophanerophyte
np	Nanophanerophyte
mp	Microphanerophyte
Th	Therophyte
Ch	Chamaephyte
H	Hemicryptophyte
G	Geophyte
Dicot	Dicotyledons
Mono	Monocotyledons
Pterido	Pteridophytes
G1	Group 1
G2	Group 2
G3	Group 3
G4	Group 4
G5	Group 5
G6	Group 6
G7	Group 7
G8	Group 8
G9	Group 9
Fa	Absolute Frequency
Fc	Percentage Frequency
ADavg (e)	Average Abundance-dominance
Fc	Centesimal Frequency
Fr	Relative Frequency
N	Total Number of Surveys
Age 1	Plots from 0 to 10 Years
Age 2	Plots from 11 to 20 Years
Age 3	Plots from 21 to 30 Years
PI	Industrial Plantation

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Conflicts of Interest

The authors declare no conflicts of interest.

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