Floristic Composition of Weeds planted with Theobroma cacao L. A case study of Ago-Yeye, Supare and Oke – Igbo in Ondo North Senatorial District, Ondo State, Nigeria

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BY

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Abstract

The quest for more agricultural produce has constantly tried to modify the environment thereby threatening its integrity, food supply and the existence of other organisms which has enhanced inter and intra specific competition by plants leading to increased reduction in yield quantity or quality. To assess the inventory of weeds towards its adjoining areas, the present study reports the floristic survey of weeds planted with *Theobroma cacao* L. in Ago-Yeye, Supare and Oke-Igbo in Ondo North Senatorial District, Ondo State, Nigeria. Floral composition of the vegetation was investigated using a systematic sampling design in collecting vegetation data in Cocoa plantations. Forty (40) quadrats measuring 1m ×1m were randomly laid within each of the three different age groups of *Theobroma cacao* plantations at each location; young (<3years), mature (5-16 years) and old (>16 years). A total number of 92 plant species, belonging to 82 genera and 40 plant families were documented across the cocoa plantations. Of the three locations studied, Supare had 61 plant species, 51 genera and 32 families, Oke-Igbo had 70 plant species, 61 genera and 32 families while Ago-Yeye had 61 plant species, 54 genera and 27plant families. The families were distributed in different life forms. The three (3) most dominant plant families were Asteraceae, Euphorbiaceae and Fabaceae with 11 and 6 plant species each, distributed in 11 and 6 genera each respectively. Broad leaved weeds such as *Asystasia gagentica, Ageratum connyzoides, Chromolaenaodorata, Aspilia africana, Oplismenus burmannii, Sida acuta, Talinum triangulare, Xanthosomas agitifolia, Cnestis ferruginea and grasses* such as *Axonopus compressus* were dominant in both young and old plantations. In comparison of the similarity among the cocoa plantations using the Jaccard system, 50 plant species were documented to be similar between Supare and Oke-Igbo plantations, 45 plant species were similar to both Ago-Yeye and Oke-Igbo plantations and 39 plant species similar to Supare and Ago-Yeye plantations. Supare and Oke-Igbo were more similar with Jaccard similarity index of 61.73% while Ago-Yeye and Oke-Igbo had similarity index of 52.33% followed by Supare and Ago-Yeye plantations with similarity index of 46.99%. The diversity of weed species in the three Cocoa plantations at different growth stage was generally high. This study suggest that the adjoining areas could deploy slashing and the use of little amount of eco-friendly chemicals as weed management control measures in the plantations.

Keywords: Floristic survey, weeds, Cocoa, diversity, plantations.

INTRODUCTION

Theobroma L. is a genus that falls within the malvaceae family with 22 species (Daba & Sharma, 2018). Of the 22 species, the most economically important species amongst them is *Theobroma cacao* L. (Menarid et al*.,* 2021). *Theobroma cacao* originated from the Amazon basin in South America that is a tropical under storey tree that grows as a commercial crop in plantations in Asia, America and Africa, as it is an important source of income and livelihood for most farmers in those regions, particularly Nigeria, (Obaid et al., 2023). Despite this crops huge importance to the people, productivity of it has reduced compared to global production. This decline in yield can be associated with several reasons, which includes improper agricultural methods such as weed control.

Weed could be referred to as any plant growing in cultivated ground to the injury of the crop or desired vegetation, or to the disfigurement of the place; an unsightly, useless, or injurious plant at a Specific time in a particular space. At least 10% of the world's vascular plants have the potential to invade other ecosystems and affect native biota in direct or indirect ways (Gomaa et al. 2020). Weeds impede agricultural systems compete with crop plants for resources, contribute to insect and plant pathogens infestation, slow harvesting operations, increase cost of production, reduce market value of crops and decrease yield, (Mouillonet et al. 2020; Asif et al. 2020). In agriculture as a general rule, for every unit of weed growth, there will be one less unit of crop growth. Based on the above that this study aims to assess the potential of carrying out a floristic survey of weeds planted with *Theobroma cacao* L. in the adjoining areas of an underexplored cocoa plantations with Ago-Yeye, Supare, and Oke-Igbo as a case study.

MATERIALS AND METHODS

DESCRIPTION OF STUDY AREA: Three (3) well cultivated cocoa plantations were selected in Ondo North Senatorial district of Ondo state namely; Supare farm location in Akoko South West Local Government Area, Oke-Igbo farm location in Akoko South West Local Government Area and Ago-Yeye farm location in Ose-Owo Local Government Areas respectively with each covering approximately a hectare of land. Supare farm location lies between Latitude $07^{0}25'.931''$N and Longitude $005^{0}37.355^{1}$E, Oke-Igbo farm location lies between Latitude $07^{0}25.531^{1}$Nand longitude $005^{0}45.076^{1}$E while Ago-Yeye farm location lies between Latitude $07^{0}17.449^{1}$N and longitude $005^{0}39.045^{1}$E. The climatic conditions are characterized by two distinct conditions of wet and dry seasons. High humidity and rainfall are often experienced from May to October period of the year with an annual average of 500-2000 mm. The vegetation of northern Ondo State is mostly sub-tropical rainforest with characteristics of a derived savannah and dominated by tree such as *Milicia excels, mahogany and obeche,* grasses (*Banbusa vulgare, Imperata cylindrical and Axonopuscompressus*) and weeds (*Chromolaenaodorata and Sidaacuta*). The average temperature varies between 20^{0}C to 34^{0}C every year.

KEY:Ago-Yeye ▲ Supare Oke-Igbo ◇

Fig. 1 Map of Ondo state showing the study locations.

SAMPLING DESIGN

A systematic sampling design was used in collecting data on the weeds in the cocoa plantations. A quadrat measuring 1m x 1m were randomly laid in three 12 times in each of the 3 different age groups of *T. cacao plantations;* very young (≤< 3 years), mature (≥5-16 years) and old (8-17 years) with the following tags: A, B and C for each group. Weeds within each quadrat were uprooted, sorted into species, identified, counted and recorded. The presence or absence of each weed species at the different sections of the cocoa plantation were also used to produce an additional data matrix. The weed specimens collected were pressed and kept for confirmation of identity and some farmers were also asked to document problematic weeds in their farms. Proportion of taxa and life forms of weed species were also compiled. Before analysis, the presence of a plant on the data matrix was denoted by (+) and absence by (-). Wooden pegs were used in demarcation of the area of the square for proper identification of the location with a long rope tied round the 4 pegs as indicator and sign for visitor and to remind the farmers that experiment is going on and to ensure that they will not cut the weeds till after the study.

IDENTIFICATION OF WEED FLORA

The weed species found in each of the quadrats were identified, classified and catalogued according to their taxonomic names, growth habits and chorological status (native or exotic) with the aid of appropriate literatures, manual, and checklist (Aigbokhan 2014). A checklist of all the plant taxa grouped by family and indicating presence or absence at each of the 3 sections of the cocoa plantations was also generated.

DATA ANALYSIS

Species abundance, diversity and distribution of the plant species were determined using the following: species richness, diversity indices; Shannon –Wiener index, and species evenness (E). Shannon-Wiener diversity index (H') was used to compare the diversity in species composition of 3 different age group in 3 different location of cocoa plantations. The Simpson index of similarity (Qs) was used to compare the species composition in all the ages. Species evenness in each age group at different location was calculated using Shannon’s index. Analytic vegetation characters (Community indices (Jaccard similarity index and Importance value index (IVI) = summation of relative frequency, relative abundance and relative density) were assessed from sections of the quadrats.

FREQUENCY: It is expressed as number of quadrats where species is/are found.

DENSITY: It is expressed as number of species per unit area. (Quadrat area = $1m^2$)

$$\text{Density} = \frac{\text{number of species}}{\text{Area of quadrats}}$$

RELATIVE FREQUENCY

This is expressed in terms of percentage occurrence. It is the degree of dispersion of individual species in an area in relation to the number of all the species that occurred.

$$\text{Relative frequency} = \frac{\text{Frequency of species}}{\text{Total frequencies of all species}} \times 100$$

RELATIVE DENSITY

Relative density: Is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Relative density} = \frac{\text{Density of species}}{\text{Total density of all species}} \times 100$$

IMPORTANCE VALUE INDEX

This index is used to determine the overall importance of each species in the community structure.
Importance Value (IVI) = Relative Frequency + Relative Density + Relative abundance
ABUNDANCE: It is the study of the number of individuals of different species in the community per unit area. It is represented by the equation:

$$\text{Abundance} = \frac{\text{Relative frequency} + \text{Relative density}}{2}$$

DOMINANCE: Dominance of a species is determined by the value of the basal cover. It is expressed as:

$$\text{Dominance} = \frac{\text{Absolute density of species}}{\text{Number of quadrats where species is found}} \times 100$$

RELATIVE DOMINANCE: This is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area. It is expressed as:

$$\text{Relative dominance} = \frac{\text{Abundant of species}}{\text{Total abundance of all species}} \times 100$$

SIMPSON'S INDEX (D): It measures the probability that two individual weed species randomly selected from a sample will belong to the same species (or category other than species).

$$\text{Simpson diversity index (D)} = \Sigma \frac{n(n-1)}{\text{N}-1}$$

Where n = the total number of weeds of particular species; N = the total number of weed of all species.

RESULTS

Composition of Different Plant Families, Genera and Species in Cocoa Plantations

Plants found in the adjoining cocoa plantations had a total number of 92 plant species distributed across 40 plant families and 82 genera. The family Asteraceae, Euphorbiaceae and Fabaceae had the highest genera and species richness as shown in table 1, figure 1 and figure 2. Supare had 61 plant species and 51 genera, Oke-Igbo had 70 plant species and 61 genera and Ago-Yeye had 61plant species and 54 genera distributed in 32, 34 and 27 plant families respectively as shown in figure 3.For the young (< 3 years old) cocoa plantation, Supare and Oke-Igbo had 25 and 30 weed species belonging to 13 families, while Ago-Yeye had 25 weed species belonging to 10families (Figure 4). For the mature (5-16 years old) cocoa plantations, Supare had 20 weed species belonging to 11 families, Oke-Igbo and Ago-Yeye had 23 and 19 weed species belonging to 12 and 9 families respectively (figure 5). In the old (>16 years) cocoa plantations, Supare had 16 weed species belonging to 8 families, Oke-Igbo and Ago-Yeye had 17 weed species each belonging to 9 and 8 families respectively as presented in (Figure 6).

Table 1 Inventory of weed flora in cocoa plantations surveyed at three different locations in Ondo North Senatorial district of Ondo State

S/N	PLANT NAME	FAMILY	LIFE FORM	PHYTOGEOGRAPHY ORIGIN (NATIVITY)	SUPARE	OKE-IGBO	AGO-YEYE
1	*Acalyphaciliata*L.	Euphorbiaceae	Herb	Africa	+	+	_
2	*Acanthospermum hispidum* DC	Asteraceae	Herb	Brazil	_	_	+
3	*Acanthus montanus* T. Anderson	Acanthaceae	Shrub	Africa	+	+	+
4	*Achyranthes aspera* L.	Amaranthaceae	Herb	Africa	+	+	_
5	*Ageratum conyzoides* L.	Asteraceae	Herb	South America	+	+	+
6	*Alternanthera brasiliana* (L.) Kuntze	Amaranthaceae	Herb	Central America	+	+	+
7	*Alchornea laxiflora* (Benth) Pa x and Hoffm.	Euphorbiaceae	Shrub	Tropical Africa	+	_	_
8	*Amaranthus spinosus* L	Amaranthaceae	Herb	Tropical America	_	_	+
9	*Anacardium occidentale* L	Anacardiaceae	Tree	Brazil	_	_	+
10	*Anchomanes difformis* (Blume) Engl.	Araceae	Herb	Tropical Africa	_	+	+
11	*Anelienna beniniensis* (Beauv.) Kunth	Commelinaceae	Herb	Tropical Africa	_	+	+
12	*Anthocleista vogelii* Planch.	Gentianaceae	Tree	Africa	+	+	_
13	*Aspilia Africana* (Pers) C.D. Adams	Asteraceae	Herb	Africa	+	+	_
14	*Asystasia gangetica* (L) T. Anders	Acanthaceae	Herb	Tropical Africa	_	+	+
15	*Axonopus compressus* (Sw) P. Beauv.	Poaceae	Grass	Tropical America	-	+	+
16	*Biden spilosa* L.	Asteraceae	Herb	North America	+	+	+
17	*Brillantaisia patula* T. Anders	Acanthaceae	Shrub	Africa	_	_	+
18	*Boerhavia diffusa* L.	Ncytaginaceae	Herb	Tropical Africa	+	+	-
19	*Calopogonium mucunoides* Desv.	Fabaceae	Vine	Tropical America	+	-	+
20	*Carpolobia lutea* G. Don	Polygalaceae	Shrub	Tropical Africa	+	+	+
21	*Cassia fistula* L.	Fabaceae	Tree	India	_	+	+
22	*Centrosema mole* Benth.	Fabaceae	Vine	Central America	+	+	+
23	*Chassalia kolly* (Schumach) Hepper	Rubiaceae	Shrub	Africa	+	+	_
24	*Chromolaena odorata* R.M. Kings & Robinson	Asteraceae	Herb	America	+	+	+
25	*Cissusar alioides* (Welw.) Planch.	Vitaceae	Liane	Africa	+	+	+
26	*Cissus populnea* Guil. & Perr.	Vitaceae	Liane	Africa	+	-	+
27	*Clenodendron capitatum* L.	Verbenaceae	Herb	Tropical Africa	_	+	_
28	*Cnestis ferruginea* VahlexDC	Connaraceae	Shrub	Africa	+	+	-

29	*Commelina diffusa* Burm. F.	Commelinaceae	Herb	Asia	-	+	-
30	*Colocassia esculenta* (L.) Schott	Araceae	Herb	India	+	+	+
31	*Commelina errecta* L.	Commelinaceae	Herb	Africa	+	-	-
32	*Crinum jagus* (Thomps.) Dandy	Amaryllidaceae	Bulb	Tropical Africa	+	+	_
33	*Cyathula prostrata*(L) Blume	Amaranthaceae	Herb	Africa	+	+	-
34	*Daniella oliveri*(Rolfe) Hutch.&Dalz	Leguminosae	Tree	Africa	+	+	+
35	*Desmodium scorpiurus*(Sw.) Desv.	Fabaceae	Herb	Tropical America	+	_	_
36	*Dioscorea alata L.*	Dioscoreaceae	Vine	Asia	+	+	-
37	*Dioscorea bulbifera* L.	Dioscoreaceae	Vine	Africa	+	+	+
38	*Dioscorea prehensilis* Benth.	Dioscoreaceae	Vine	Africa	-	+	-
39	*Dracaena mannii*Bak.	Dracaenaceae	Tree	Africa	_	+	+
40	*Dracaena surculosa*Linl.	Dracaenaceae	Herb	Tropical Africa	+	+	+
41	*Emilia practermissa* Milne-Redhead	Asteraceae	Herb	Africa	+	+	+
42	*Eragostis tenella* (L.)	Poaceae	Grass	Africa	-	_	+
43	*Erigeron floribundus* (H. B. & K.)	Asteraceae	Herb	Tropical America	+	+	-
44	*Euphorbia heterophylla* L.	Euphorbiaceae	Herb	Central America	+	+	+
45	*Euphorbia hirta* L.	Euphorbiaceae	Herb	Central America	+	+	+
46	*Euphorbia hyssopifolia* L.	Euphorbiaceae	Herb	Tropical Africa	+	_	-
47	*Geophila obvallata* (Schumach.) Didr**.**	Rubiaceae	Herb	Africa	+	+	+
48	*Heterotis rotundifolia* (Sm.) Jacq.	Melastomatacea e	Herb	Africa	_	_	+
49	*Hibiscus suranttensis*L.	Malvaceae	Shrub	Africa	_	+	-
50	*Hypoestes cancellate* Nees	Acanthaceae	Herb	Tropical Africa	+	+	+
51	*Icacina trichantha* Oliv.	Icacinaceae	Liane	Africa	+	-	+
52	*Imperata cylindrica*	Poaceae	Grass	Tropical America	_	_	+
53	*Ipomoea triloba* L.	Convolvulaceae	Vine	Tropical America	_	+	+
54	*Ipomoea involucrata* (L.) Beauv.	Convolvulaceae	Vine	West Africa	_	-	+
55	*Manihot esculenta* Crantz.	Euphobiaceae	Shrub	Brazil	+	+	+
56	*Melanthera scandens* (Shcum and Thonn)	Asteraceae	Herb	South America	+	_	+
57	*Mikannia cordata*	Asteraceae	Vine	South America	_	+	+
58	*Milicia excelsa* (Welw.) C. C. Berg	Moraceae	Tree	West Africa	+	+	_
59	*Mitracarpus villosus* (Sw.) Cham & Schltdl. ex DC.	Rubiaceae	Herb	North America	+	+	+
60	*Momordica charantia* L.	Cucurbitaceae	Herb	India	+	+	+
61	*Mucuna pruriens* (L.) DC.	Fabaceae	Vine	West Africa	+	+	+
62	*Nephthytis afzelii* Schott.	Araceae	Herb	Africa	+	+	+
63	*Ocimum gratissimum*L.	Lamiaceae	Herb	Africa	+	+	+
64	*Oplismenus burmannii* (Retz.) P. Beauv	Poaceae	Grass	Africa	+	+	_

65	*Panicum laxum* Sw.	Poaceae	Grass	Tropical America	_	+	_
66	*Palisota hirsuta*(Thunb.) K.Schum. ex Englee	Commelinaceae	Herb	Africa	+	_	+
67	*Parquetina nigrescens (*Afzel.) Bullock	Asclepiadaceae	Shrub	Africa	+	+	_
68	*Paulinia pinnata* L.	Sapinadaceae	Liane	South America	+	+	+
69	*Piper quineense Schum. & Thonn.*	Piperraceae	Herb	West Africa	+	+	_
70	*Phyllantus amarus* Schum et Thonn	Phyllanthaceae	Herb	America	-	-	+
71	*Physalis sp* L.	Solanaceae	Herb	South America	+	+	+
72	*Platostoma africanum* P. Beauv	Lamiaceae	Herb	Tropical Africa	_	+	_
73	*Rauvolfia vomitoria* A.	Apocynaceae	Shrub	Africa	-	+	+
74	*Richardia brasiliensis* Gomes	Rubiaceae	Herb	South America	-	+	+
75	*Rinorea yaundensis* Engl.	Violaceae	Shrub	Tropical Africa	-	+	-
76	*Secamone afzelli* (Schulfes) Schum	Apocynaceae	Vine	West Africa	+	+	_
77	*Senna occidentalis* (L.	Fabaceae	Shrub	South America	_	_	+
78	*Setaria barbata* (Lam) Kunth	Poaceae	Grass	Asia	-	+	-
79	*Sida acuta Burm* F.	Malvaceae	Shrub	Tropical America	+	+	+
80	*Sida garckeana* Polak.	Malvaceae	Shrub	West Africa	_	+	_
81	*Smilax anceps* Willd.	Smilacaceae	Vine	Tropical Africa	+	+	+
82	*Solanecio biafrae* L	Solanaceae	Herb	Africa	+	+	+
83	*Solanum nigrum* L.	Solanaceae	Herb	Tropical America	+	+	+
84	*Spigelia anthelmia* Linn.	Loganiaceae	Herb	Tropical America	+	+	+
85	*Synedrella nodiflora* Gaertn.	Asteraceae	Herb	Tropical America	+	+	+
86	*Stachytarphyta cayennensis* L. C. Rich) Schau.	Verbenaceae	Shrub	India	+	_	_
87	*Talinum triangulare* (Jacq.) Willd	Portulacaceae	Herb	Tropical Africa	+	+	+
88	*Triclisia coriacea* Oliv	Menispermacea e	Vine	Tropical Africa	+	_	_
89	*Tridax procumbens*L.	Asteraceae	Herb	Tropical America	+	+	+
90	*Triumpheta cordifolia* A. Rich.	Tiliaceae	Shrub	Tropical Africa	_	+	+
91	*Urena lobate* Linn.	Malvaceae	Shrub	Tropical Africa	_	_	+
92	*Xanthosoma sagitifolia* (L.) Schott	Araceae	Herb	Tropical America	+	+	+
				Total 92	**61**	**70**	**61**

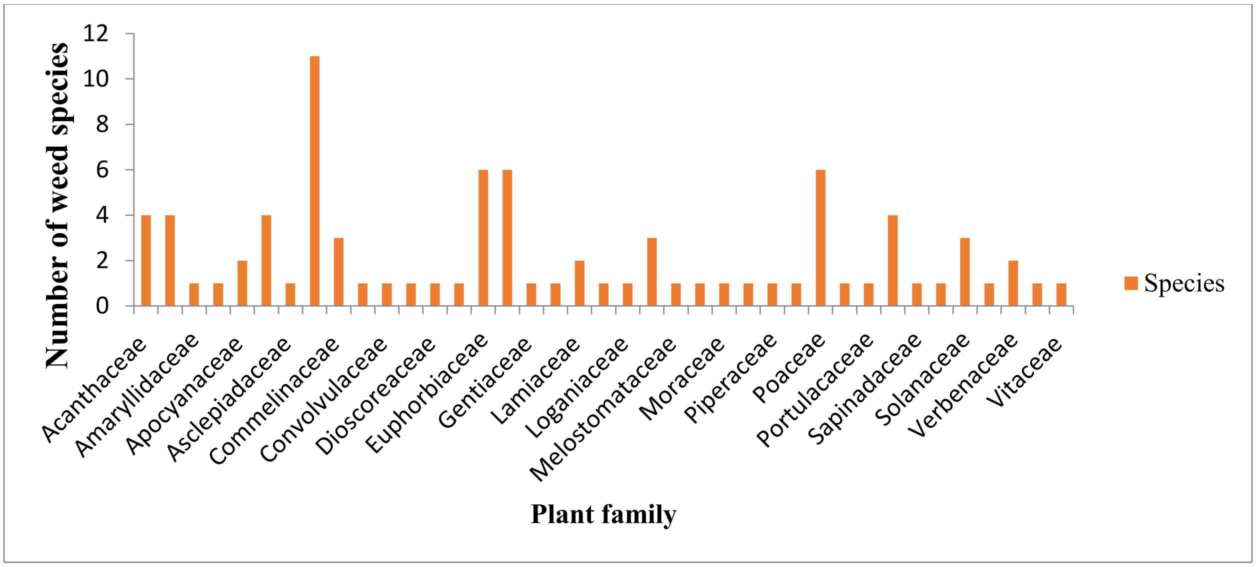


Fig. 1 Total number of weed species distributed in different plant families of the three cocoa plantations in Ondo state.

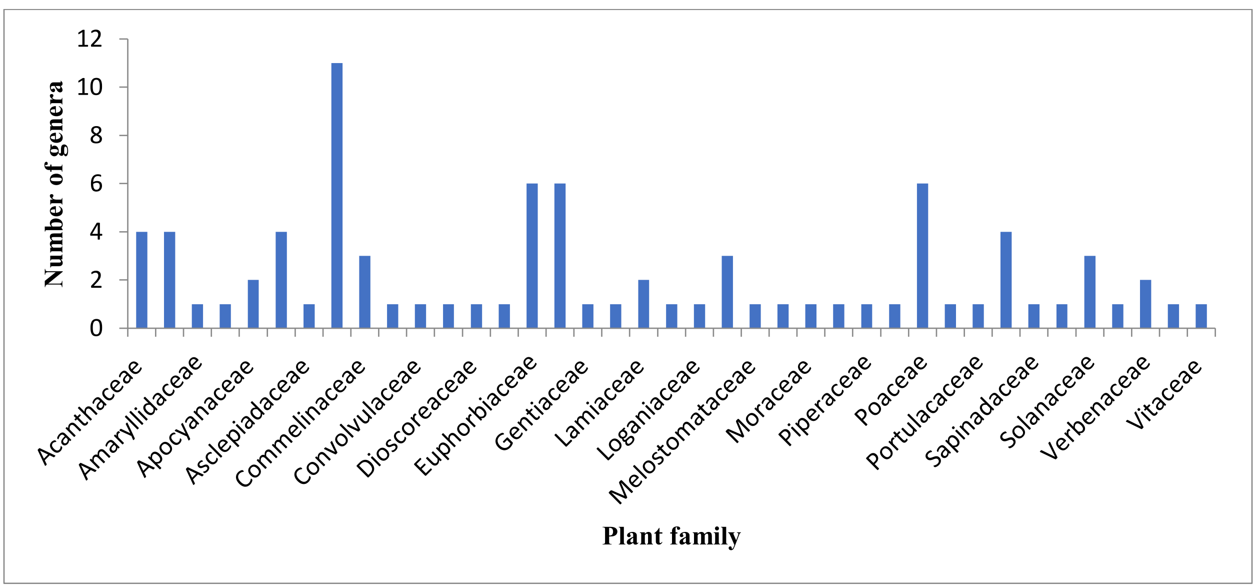


Fig. 2 Total number of plant genera distributed in different plant families of the three cocoa plantations in Ondo state.

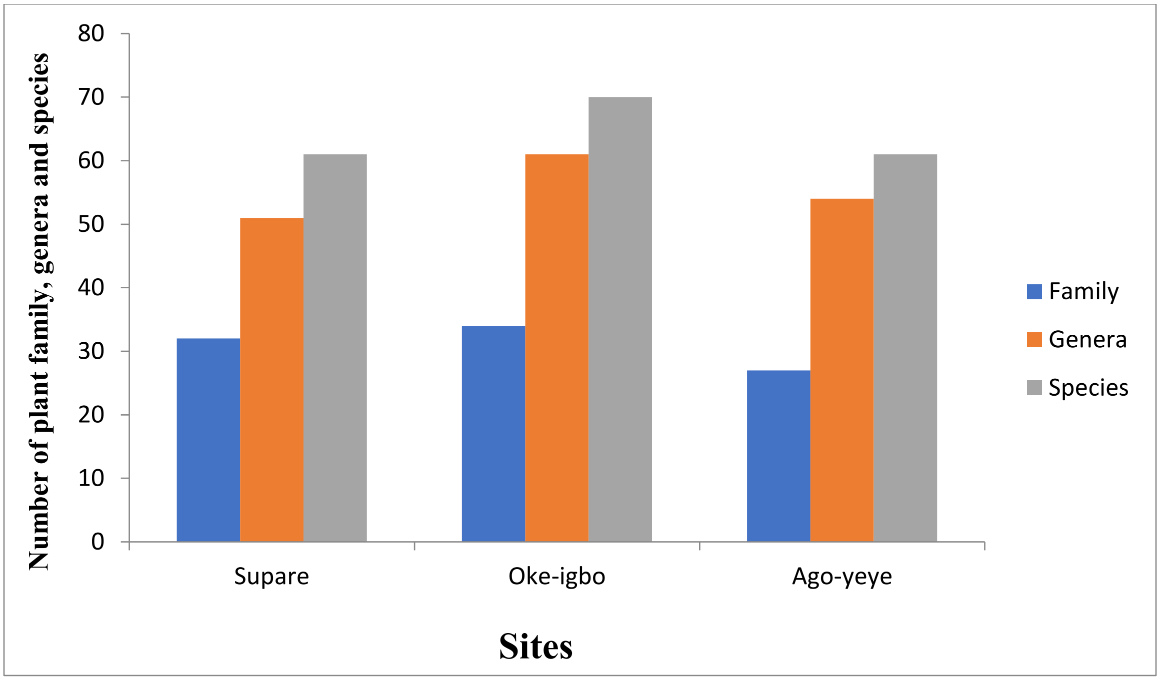


Fig. 3 Number of plant family, genera and species distributed in the different cocoa plantations in Ondo state.

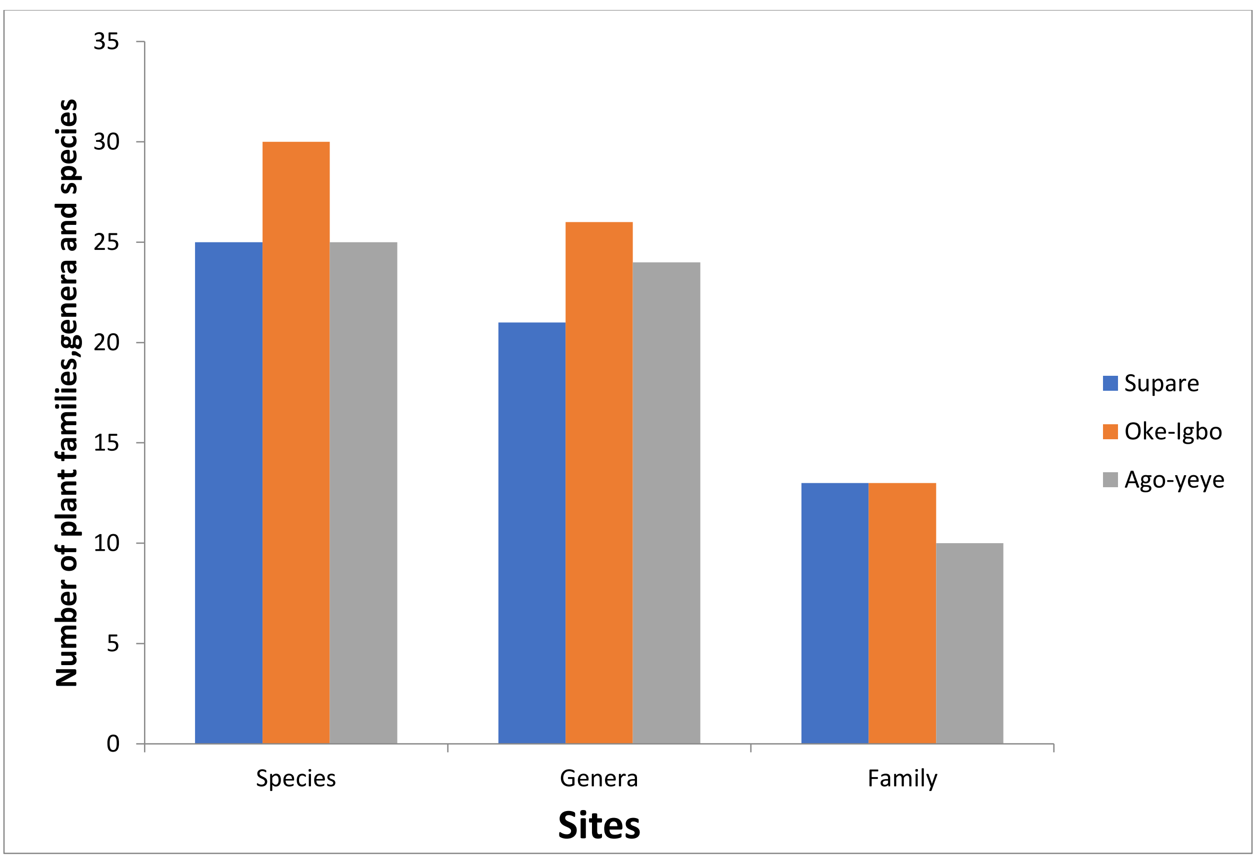


Fig. 4 Number of plant family, genera and species of plant distribution in <3 years old cocoa plantation

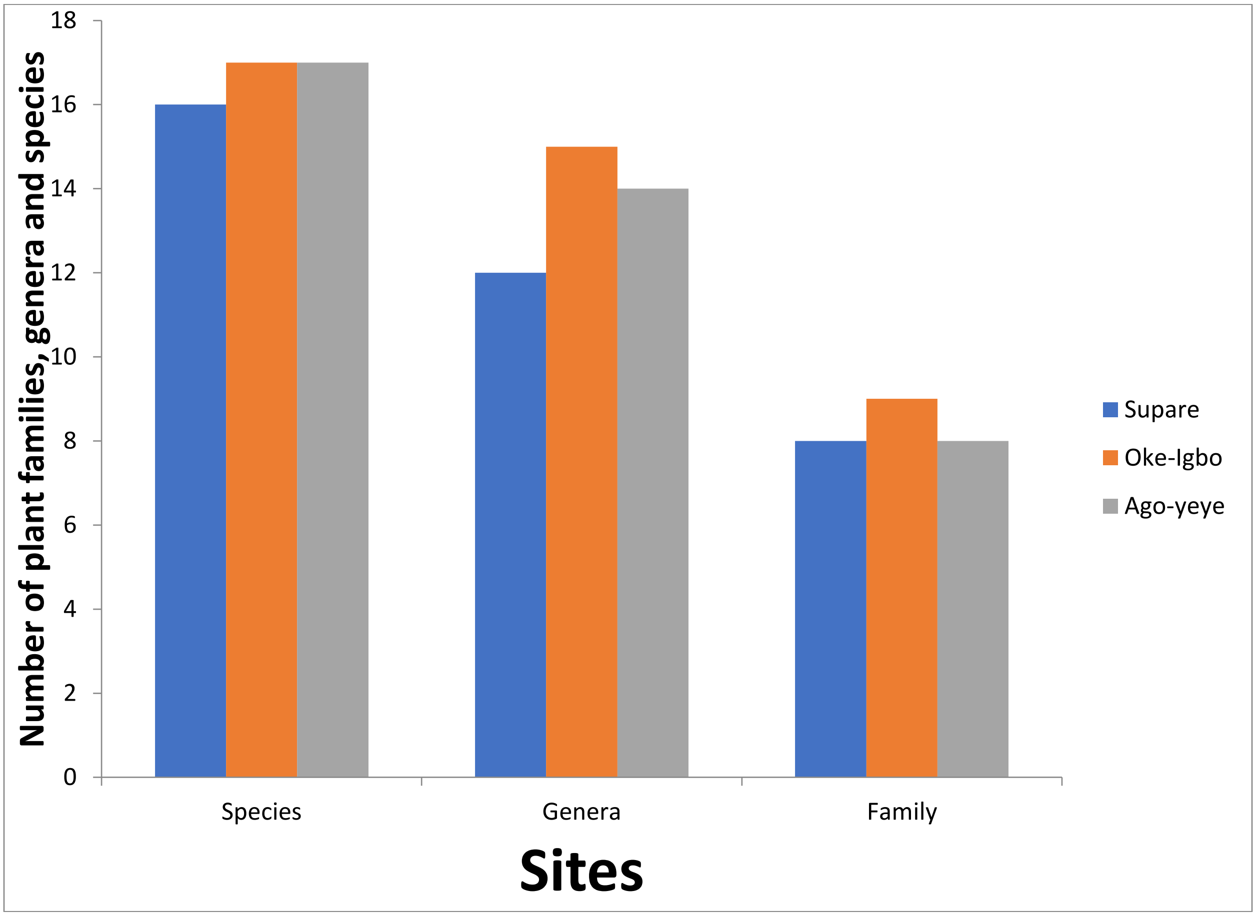


Fig. 5 Number of plant family, genera and species of plant distribution in > 16 years old cocoa plantation.

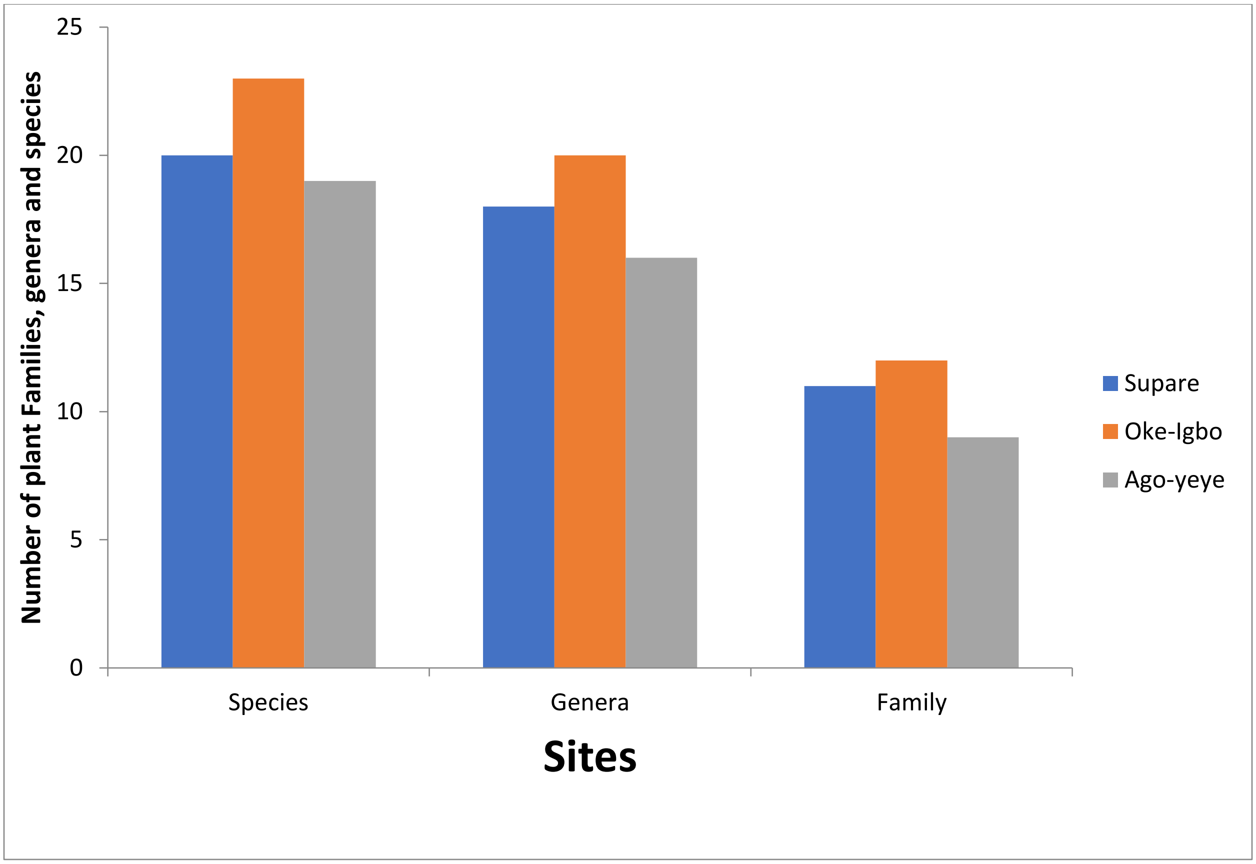


Fig. 6 Number of plant family, genera and species of plant distribution in 5-16 years old cocoa plantation.

Growth Form Distribution

Life form analysis shows that 50% of the weed species are herbs, 18% are shrubs, 6% are trees, 12% are vines, 6% are grasses, 1% is bulb and 4% are lianas species as represented in figure 7. Supare had 35 herbs, 7 shrubs, 1 grass, 8 vines, 3 trees and 1 liana species which were distributed across the different age groups, Oke-Igbo had 37 herbs, 12 shrubs, 5 trees, 9 vines, 4 grasses, 1 bulb and 2 liana species and Ago-Yeye had 33 herbs, 9 shrubs, 4 trees, 8 vines, 3 grasses, and 4 liana which were distributed across the different age groups as shown in (Figure 8). The herb, shrub, grass, tree, vine, bulb and liana species had 42, 15, 6, 6, 9, 1 and 3 genera respectively distributed in 18, 11, 1, 6, 7, 1 and 3 plant families respectively as shown in (Figure 9).

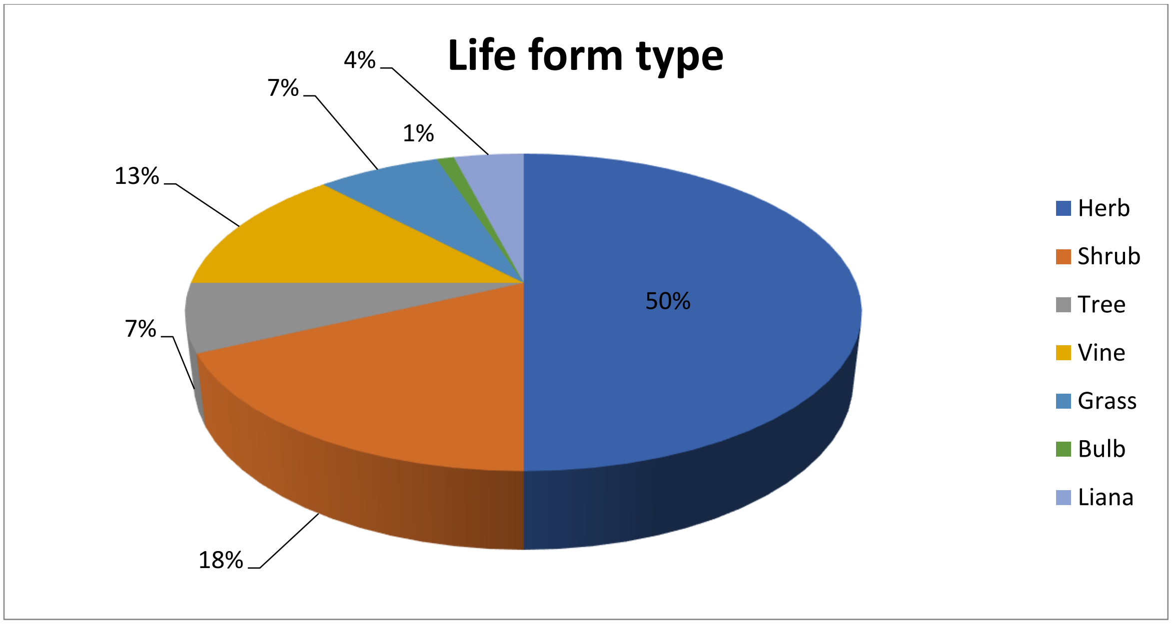


Fig. 7 General life form type of weed flora in the cocoa plantations surveyed.

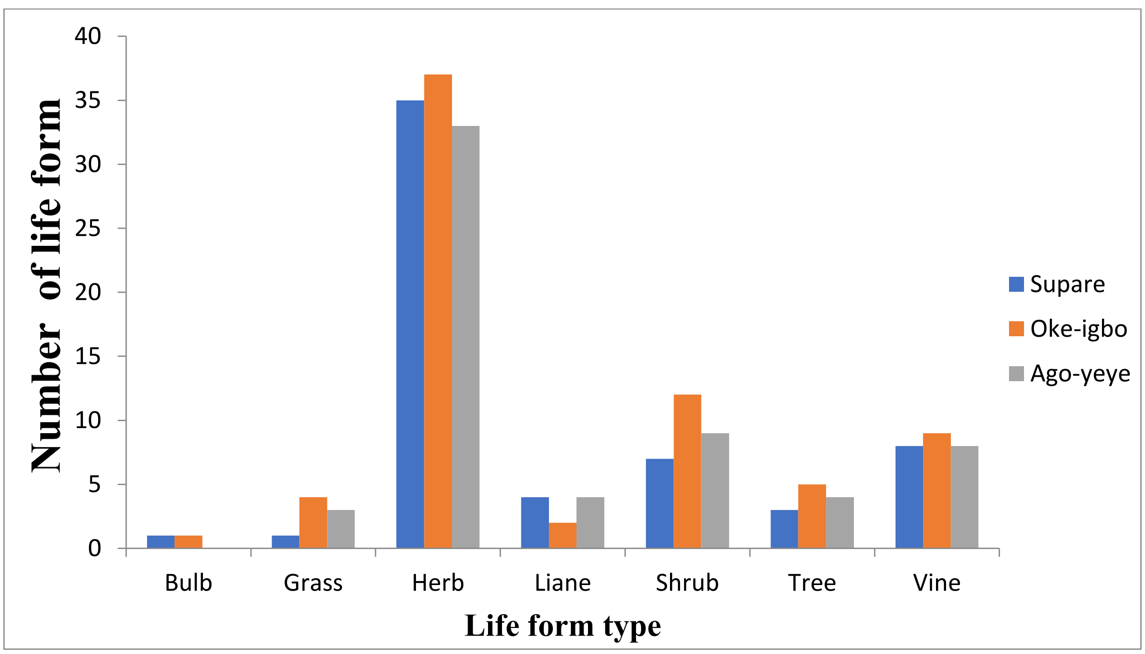


Fig. 8 Life form profile in the three different cocoa plantations of 3 different age groups.

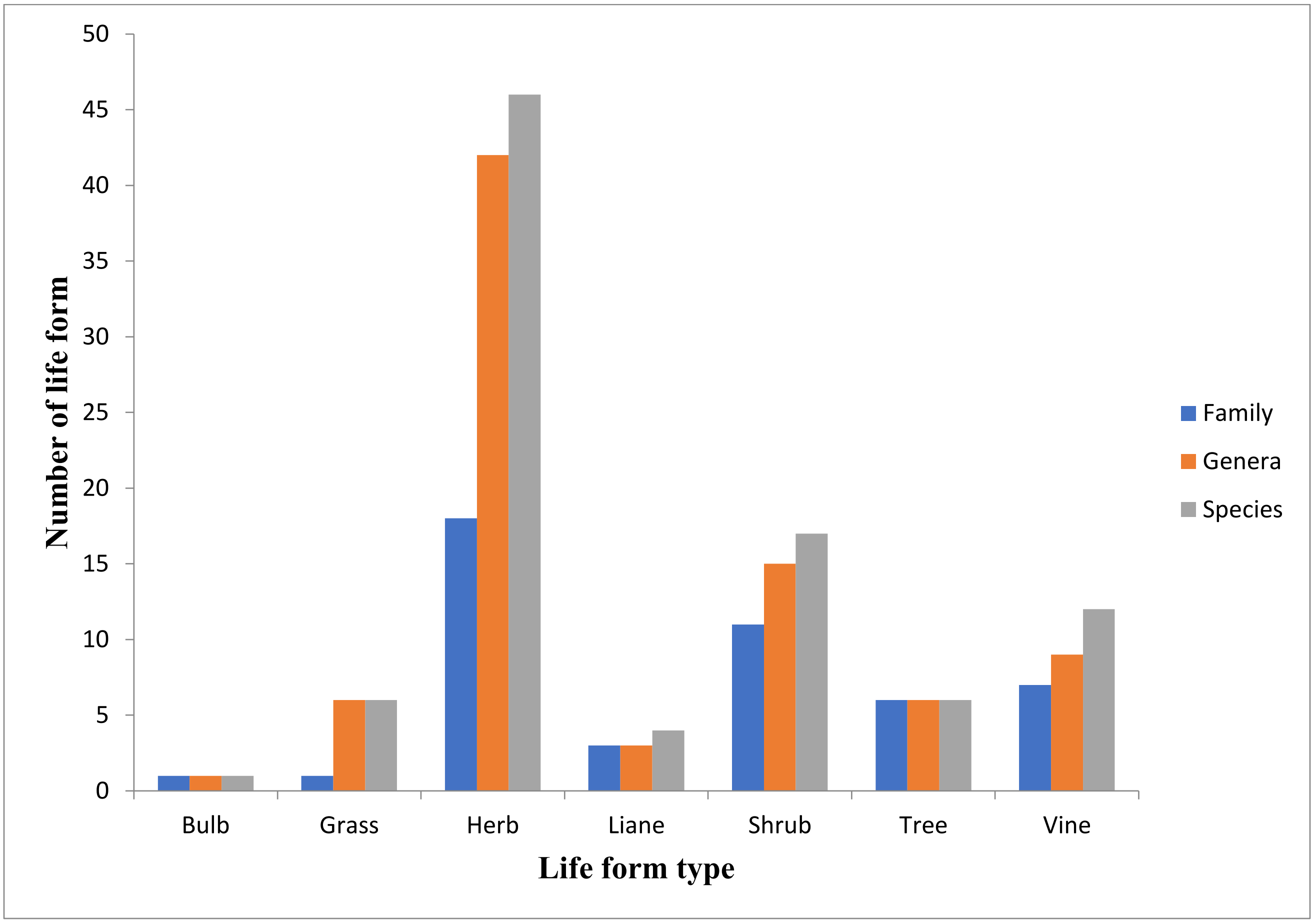


Fig. 9 Life form profile per number of plant family, genera and species across age groups of the plantations.

Chronological Profile

In terms of phytogeography origin, 33% of the weed species are originated from Africa, 17% from Tropical Africa, 16% are invasive species from Tropical America, 8% from south America, 5% are invasive species from Central America, 4%, 3%, 3%, 2% and 2% from India, Asia, Brazil, America and North America respectively. Supare had 36% of the species originated from Africa, 16% from tropical Africa, 15% were invasive species from tropical America, 7% of the species were from central America, 6% from south America, 5%, 3% and 2% from India, North America, Brazil and Asia respectively. Oke-Igbo had 30% of the species originated from Africa, 20% from tropical Africa, 14% were invasive species from tropical America, 6% of the species were from central America, 7% from south America, 4%, 3% and 4% from India, North America, Brazil and Asia respectively. However, Ago-Yeye had 28% of the species originated from Africa, 16% from tropical Africa, 18% were invasive species from tropical America, 7% of the species were from central America, 12% from south America, 5%, 3% and 5% from India, North America and Brazil respectively as presented in (Figure 11).

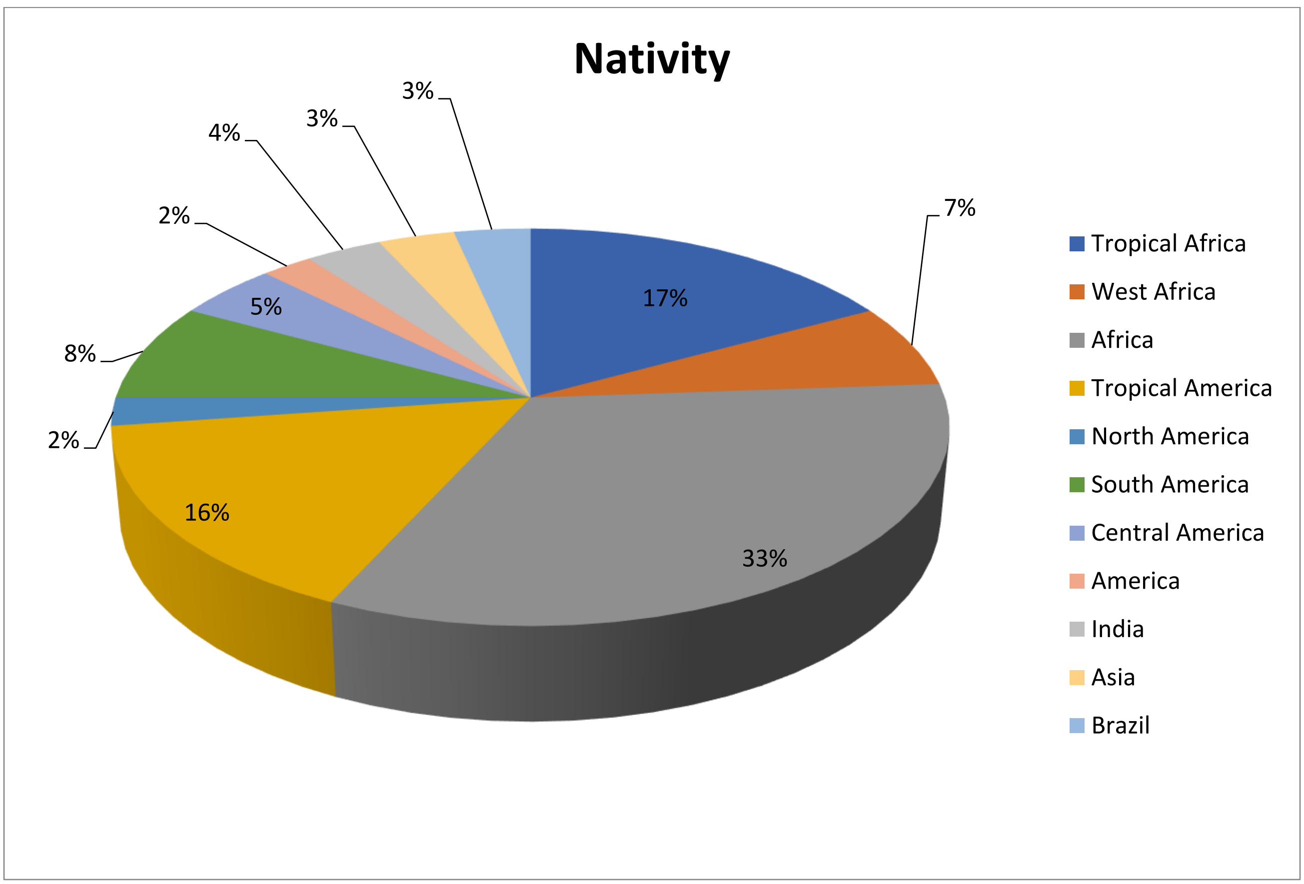


Fig. 10 General phytogeography origin of weed flora in the three cocoa plantations with different age groups surveyed.

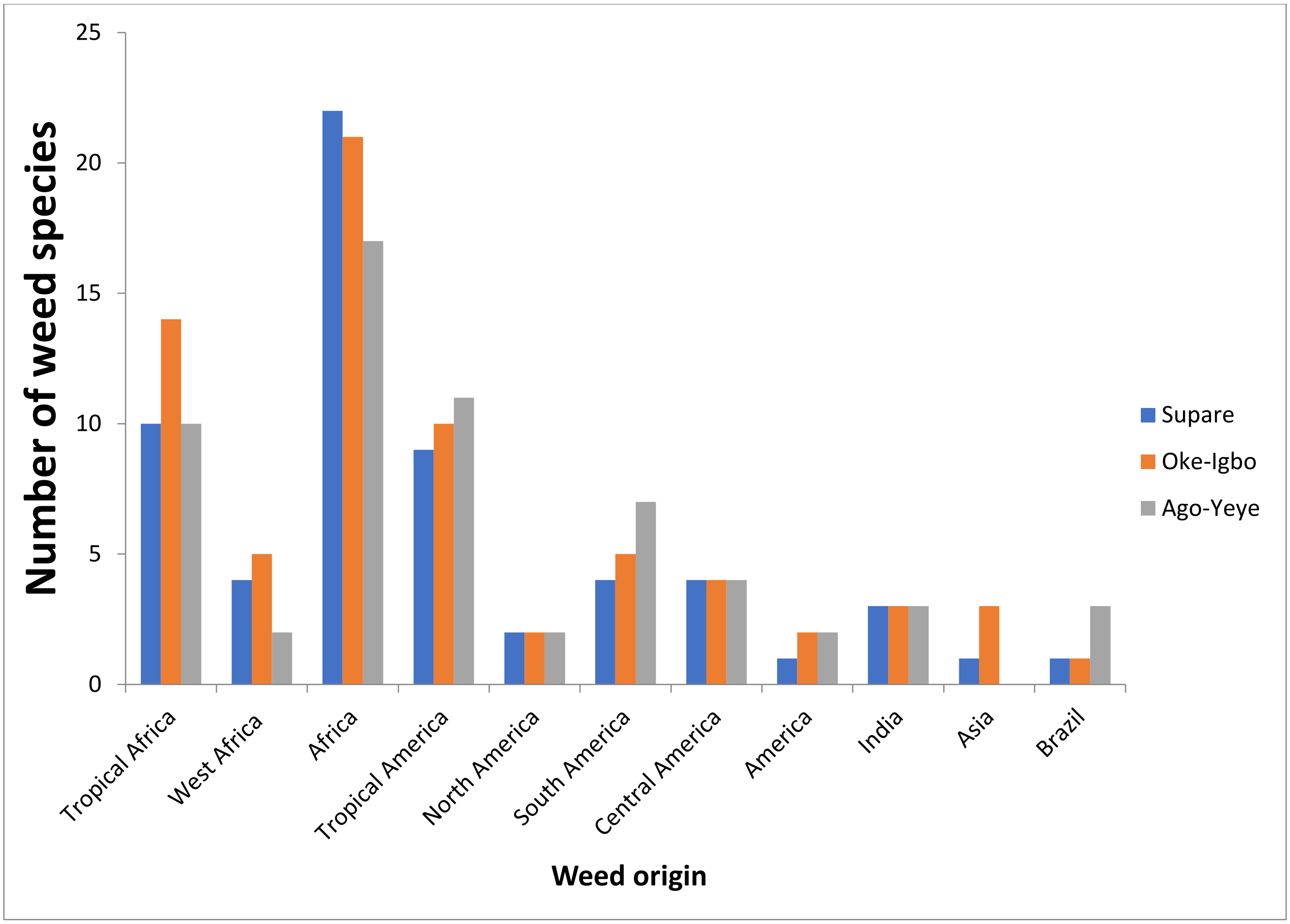


Fig. 11 Phytogeography origin of weed flora in the different location of cocoa plantations in Ondo state.

Weed Community Indices of the three Different Cocoa Plantations across 3 Different age Groups

Jaccard Similarity Index: In comparing the similarity among the cocoa plantations using the Jaccard system, 50 plant species was observed to be similar between Supare/Oke-Igbo plantations, 45 plant species similar to both Ago-Yeye/Oke-Igbo plantations and 39 plant species similar to Supare/Ago-Yeyeplantation as shown in figure 12. According to the Jaccard index, Supare/Oke-Igbo is more similar with 0.6173 (61.73%) followed by Ago-Yeye/Oke-Igbo with 0.5233 (52.33%) and Supare/Ago-Yeye plantations with 0.4699 (46.99%) as shown in (Figure 13).

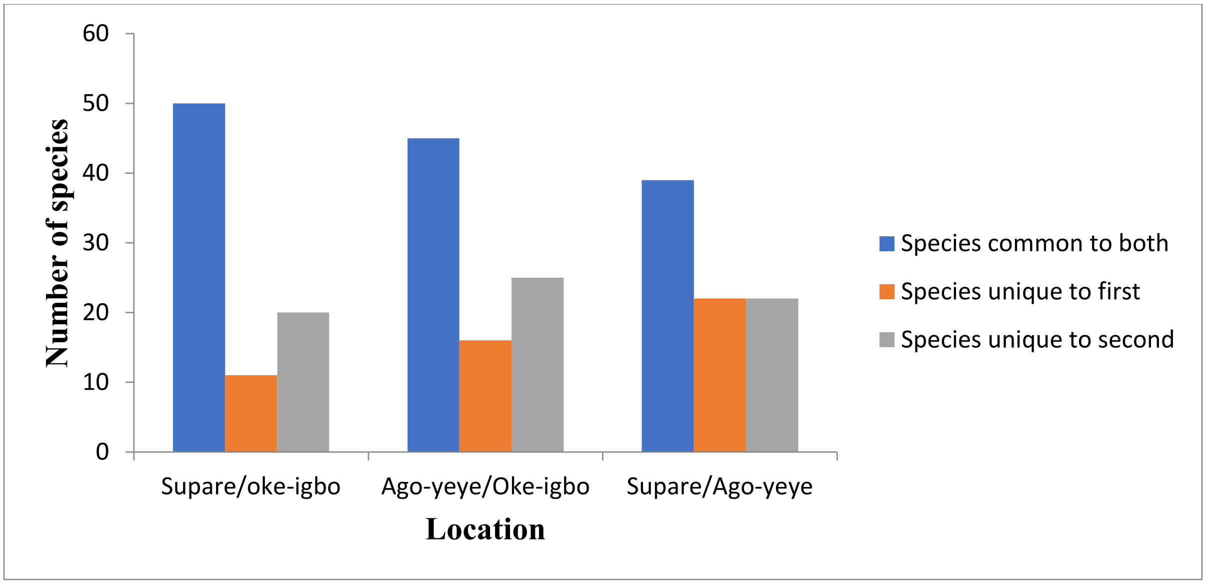


Fig. 12 Number of species common and unique between the three cocoa plantations.

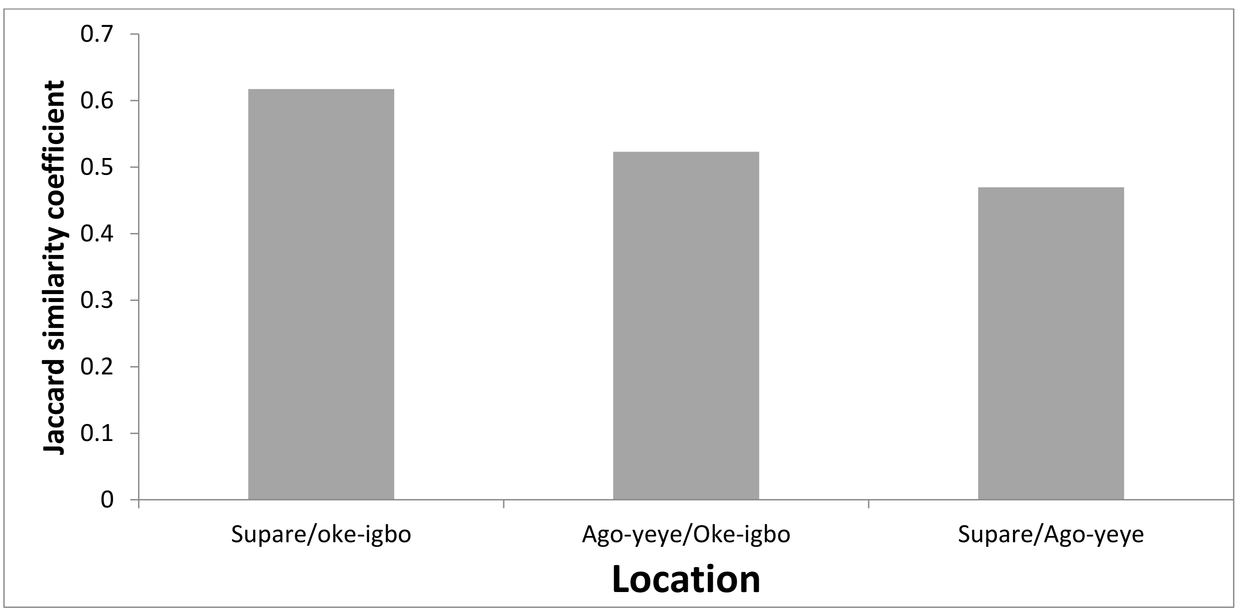


Fig. 13 Jaccard similarity coefficient between 3 different cocoa plantations.

Diversity Indices

Species Dominance: In terms of species dominance, the result in figure 14 shows that in the 3years old cocoa plantations studied, Oke-Igbo had the highest dominance of weed with value 12.29 and Ago-Yeye had the least dominance of weed with value 7.96 and in the mature 5-16years old cocoa plantations, Supare had the highest dominance value of 13.21 and Oke-Igbo had the least of value of 9.57 while in the 10years old (mature) cocoa plantations, Oke-Igbo had the highest value of 17.01 and Supare had the least value of 11.07.

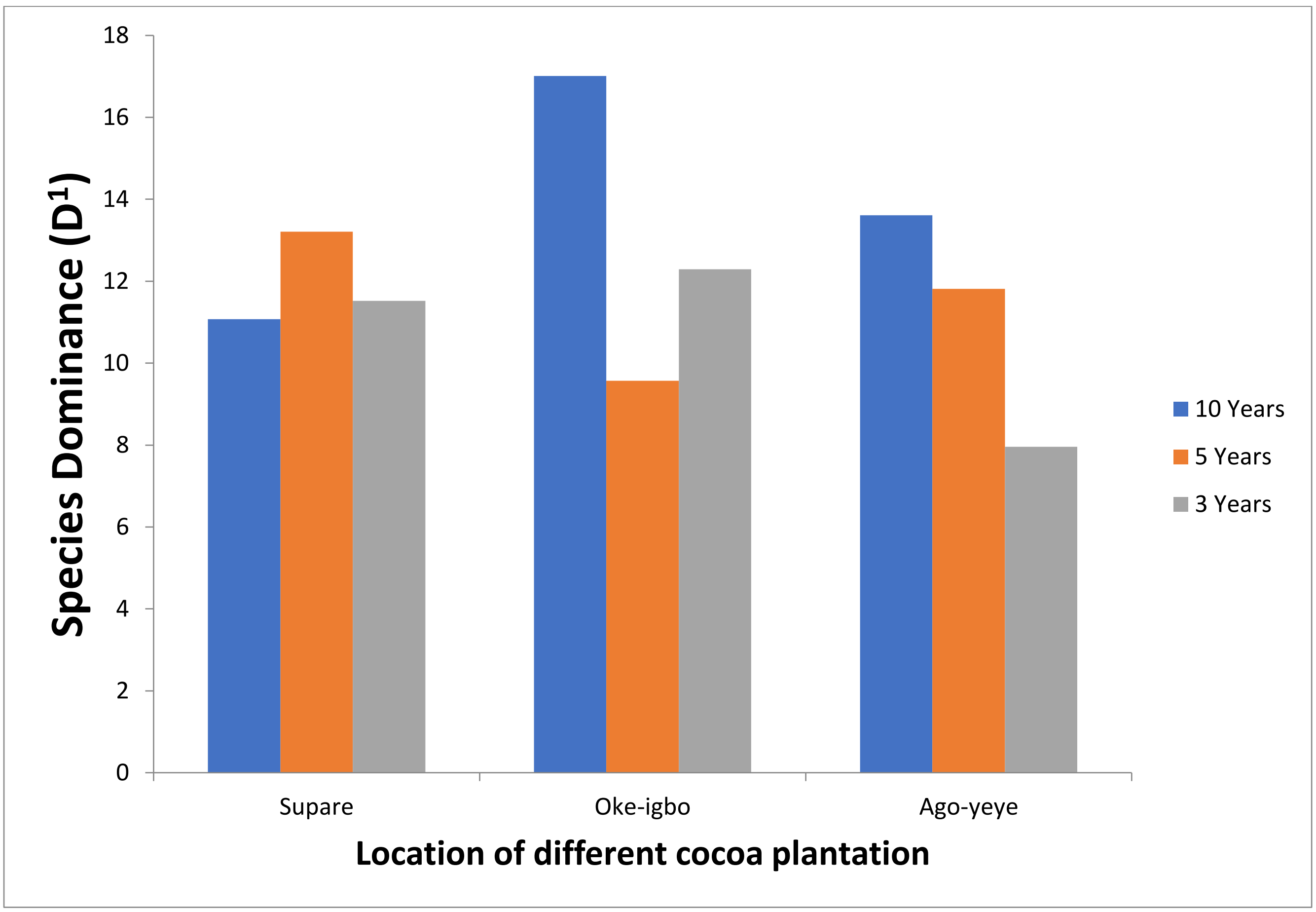


Fig. 14 Species dominance across the different age group of the three (3) different cocoa plantations.

Simpson Index (1-D)

In terms of Simpson index, in the < 3 years old cocoa plantation, Oke-Igbo had the highest value of 0.9186 while Ago-Yeye had the least value of 0.8744. In the the mature (5-16years) old cocoa plantation, Supare had the highest value of 0.9243 and Oke-Igbo had the least of value 0.8955 while in the old (>16years) cocoa plantations, Oke-Igbo had the highest value of 0.9412 and Supare had the least value of 0.9097 as shown in (figure 15).

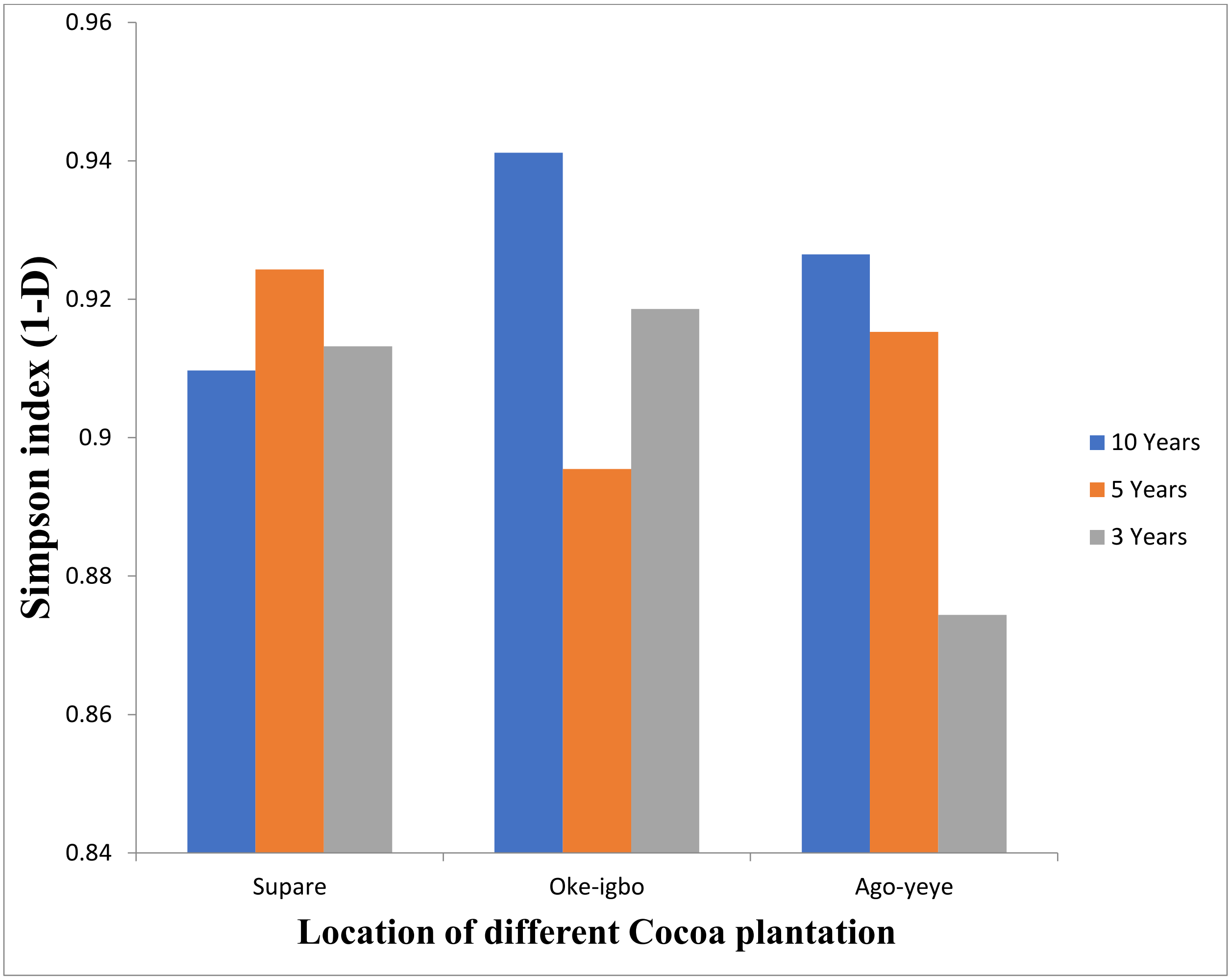


Fig 15: Simpson index (1-D) across the different age group of the three (3) different cocoa plantations.

Shannon Index

In the < 3 years old cocoa plantations surveyed in terms of Shannon index, Oke-Igbo had the highest diversity of 2.7572 while Ago-Yeye had the least value of 2.3459. In the mature(5-16years) old cocoa plantations, Supare had the highest diversity with value 2.7555 and Oke-Igbo had the least value 2.3647 while in the old (>16years) old cocoa (mature) plantation, Oke-Igbo had the highest diversity of 2.9464 and Supare had the least value of 2.5876 as shown (Figure 16).

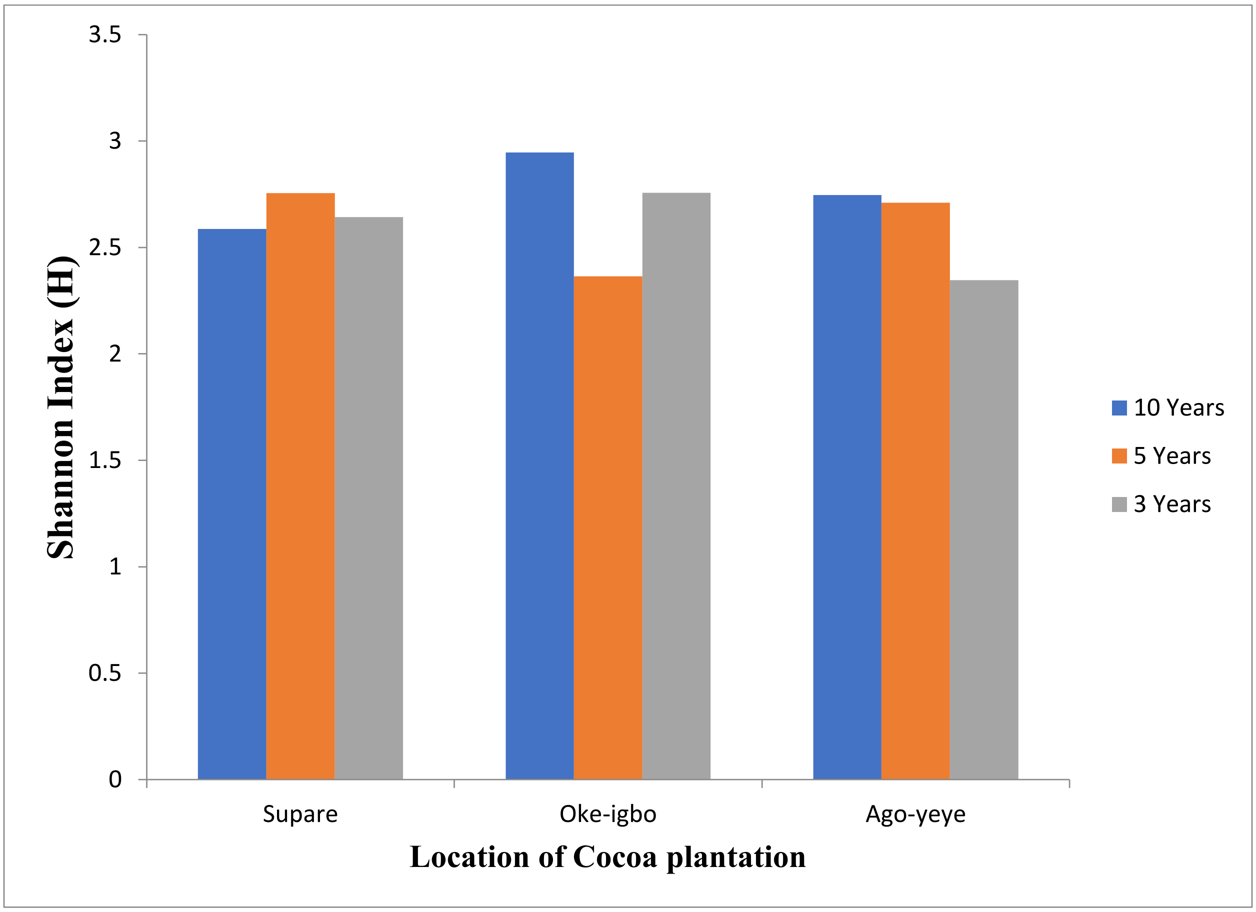


Fig 16: Shannon index across the different age group of the three (3) different cocoa plantations.

Species Evenness: In terms of species evenness, for the 3years old (young) plantation, Supare had the highest species evenness of 1.915 while Ago-Yeye had the least value of 1.851. In the mature (5-16years) old cocoa plantations, Supare had the highest diversity with value 1.998 and Oke-Igbo had the least value 1.749 and for the old (>16years) plantation, Ago-Yeye had the highest species evenness of 2.078 while Supare had the least value of 1.723 as shown in (Figure 17).

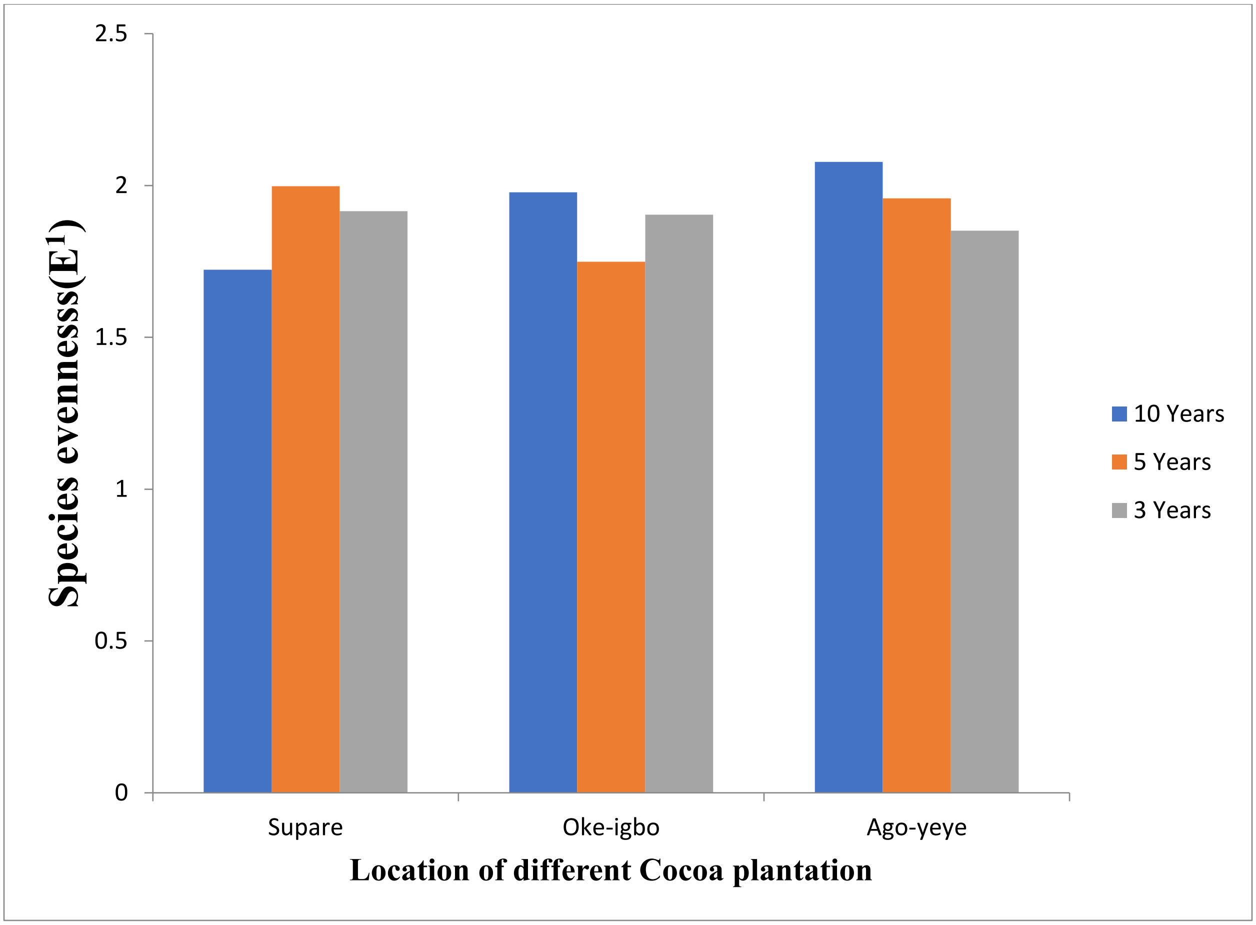
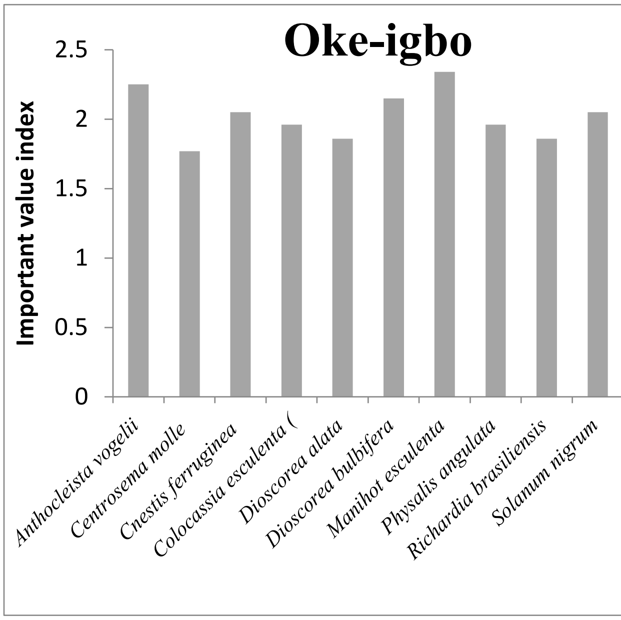
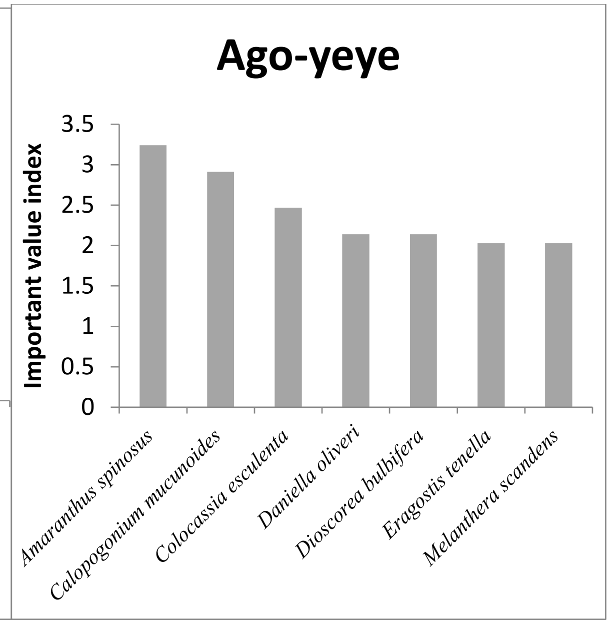


Fig 17: Species evenness (E^1) across the different age group of the three (3) different cocoa plantations.

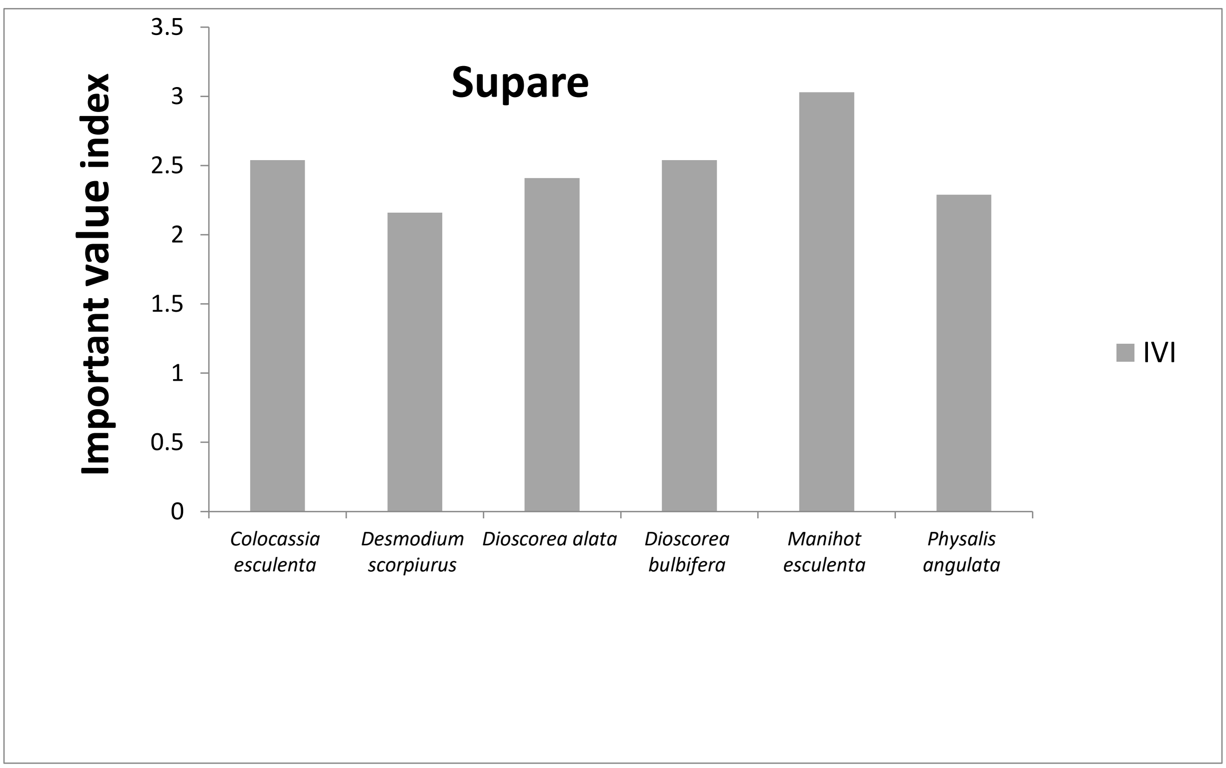
Important value index: The importance value indices (IVI) for the species with lower relative dominance were presented in figure 18, 19 and 20 for 3years, 5-16years and >16years old cocoa plantation for the different locations respectively. However, the important value indices for species with higher relative dominance were represented in figure 21, 22 and 23 for 3years, 5-16years and >16years old cocoa plantation respectively.


Oke-igbo
Important value index
0
0.5
1
1.5
2
2.5
Anthocleista vogelii
Centrosema molle
Cnestis ferruginea
Colocassia esculenta (
Dioscorea alata
Dioscorea bulbifera
Manihot esculenta
Physalis angulata
Richardia brasiliensis
Solanum nigrum


Ago-yeye
Important value index
0
0.5
1
1.5
2
2.5
3
3.5
Amaranthus spinosus
Calopogonium mucunoides
Colocassia esculenta
Daniella oliveri
Dioscorea bulbifera
Eragostis tenella
Melanthera scandens

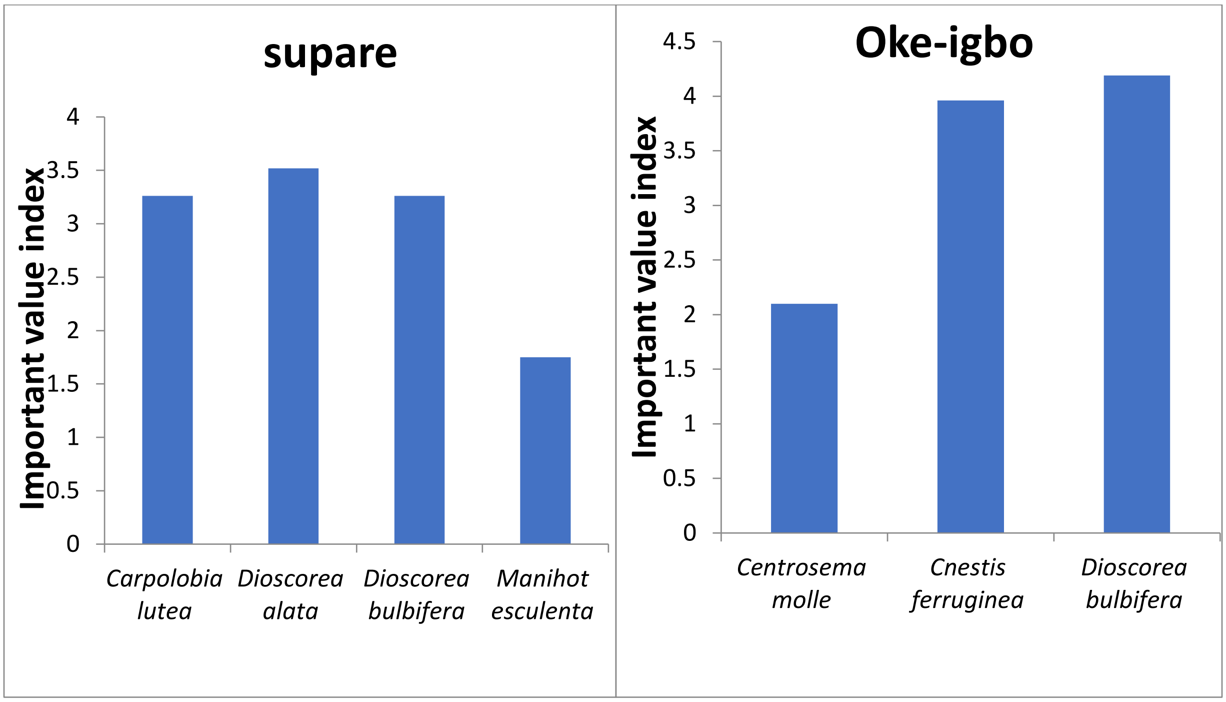
A

B

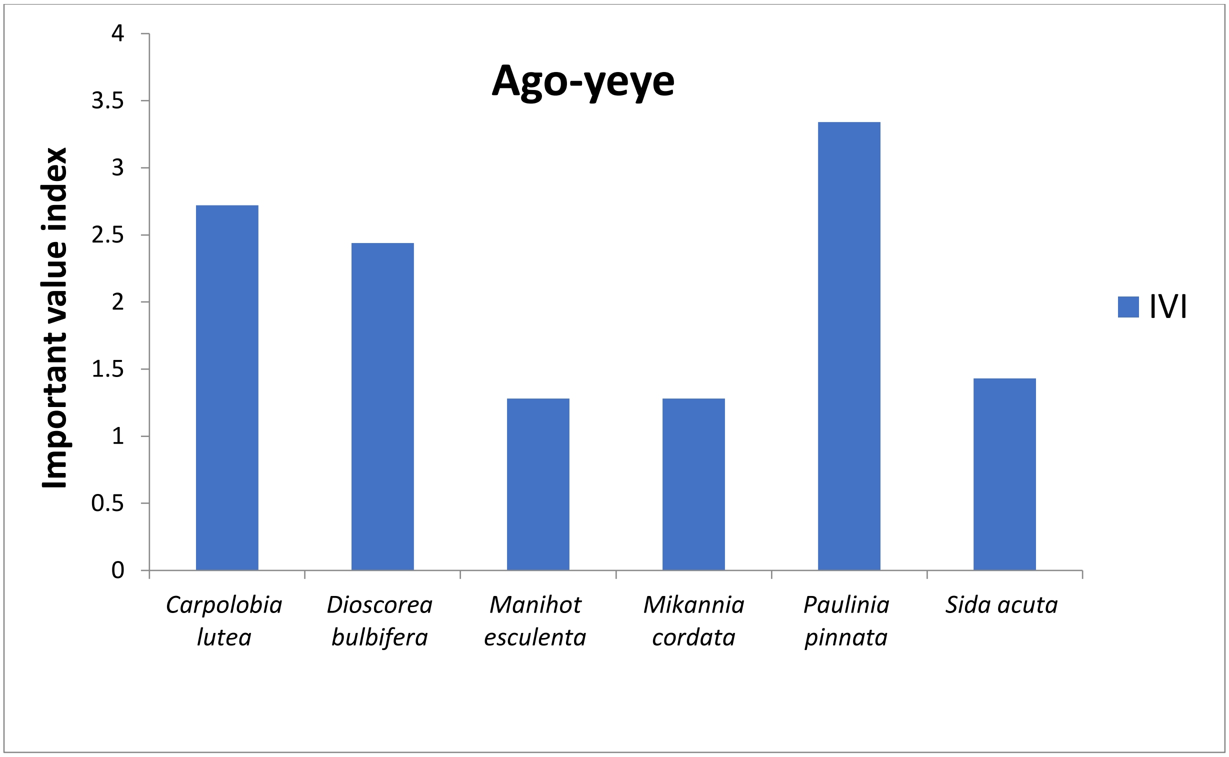

Supare
Important value index
0
0.5
1
1.5
2
2.5
3
3.5
Colocassia esculenta
Desmodium scorpiurus
Dioscorea alata
Dioscorea bulbifera
Manihot esculenta
Physalis angulata
IVI

C

Fig. 18 A, B and C: weed species of < 3 years old cocoa plantation with low important value index for three (3) different locations.

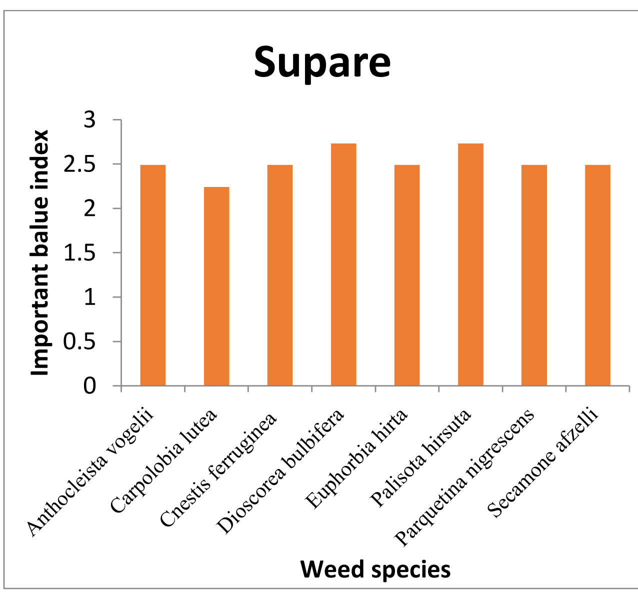


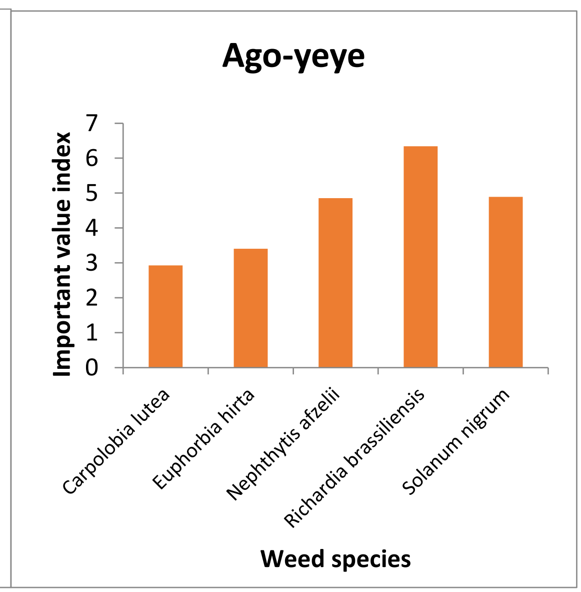
A B



C

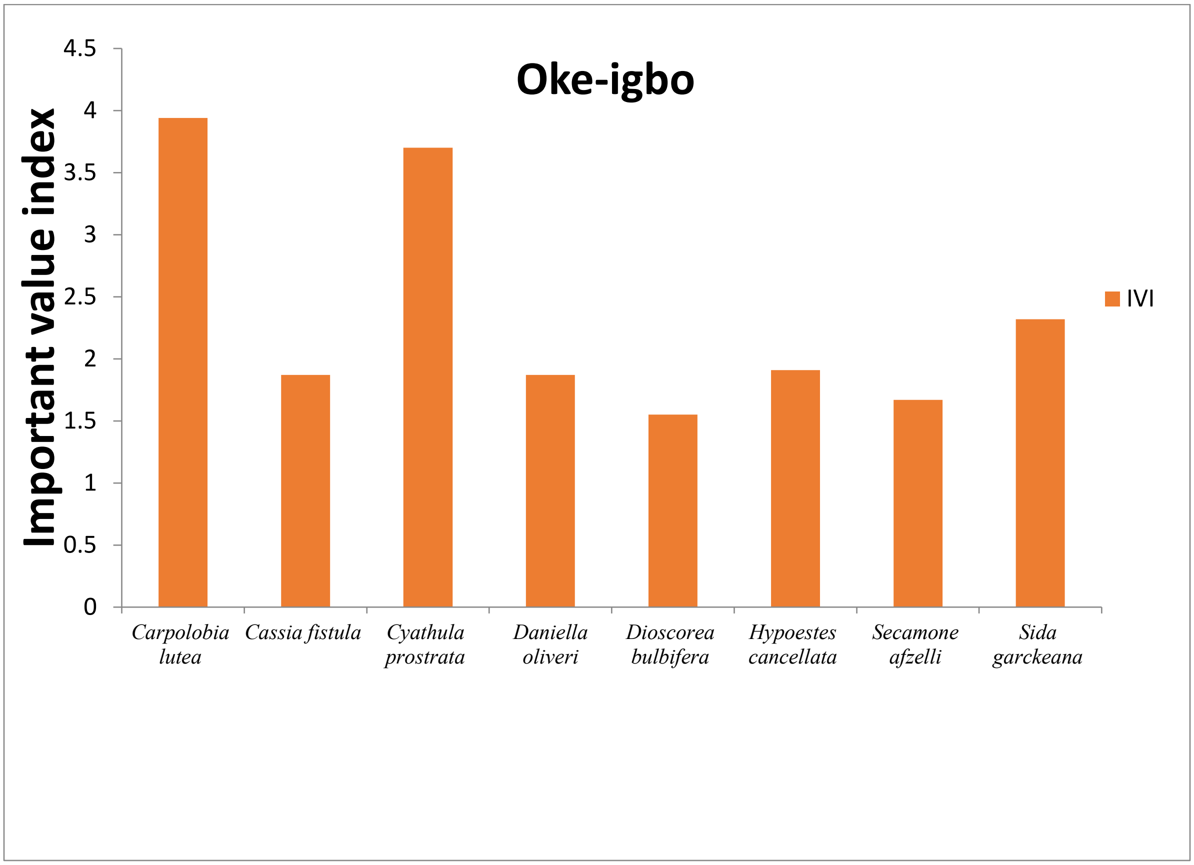
Fig. 19 A, B and C: Weed species of 5-16 years old cocoa plantation with low important value index for three (3) different locations.





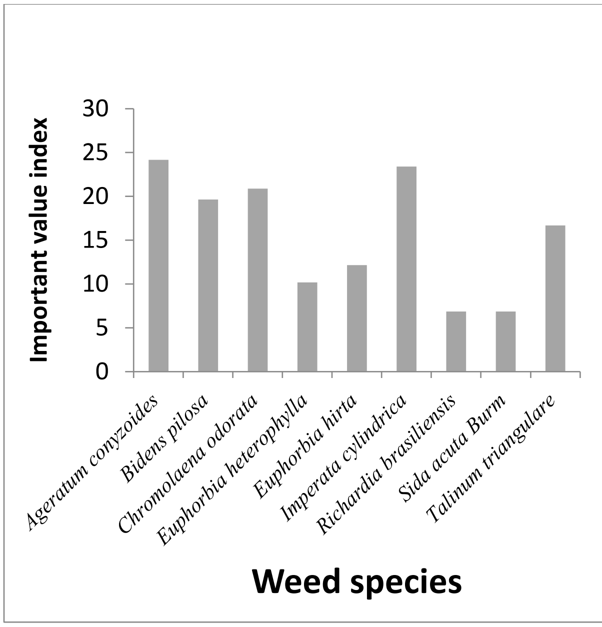
A

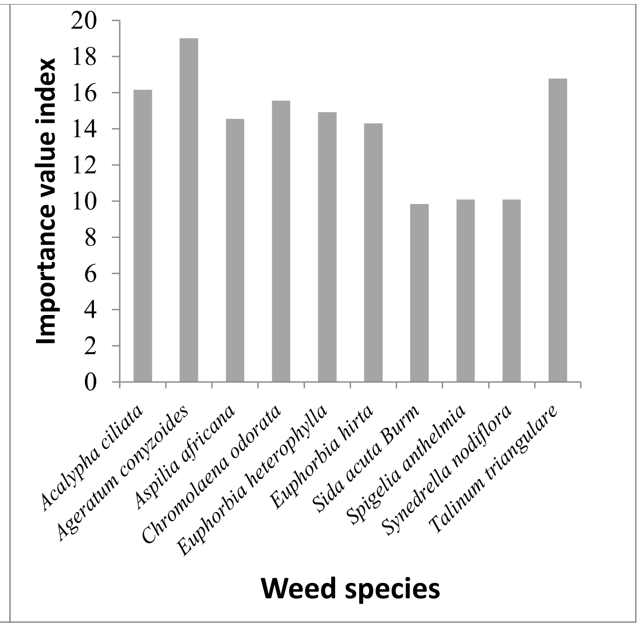
B



C

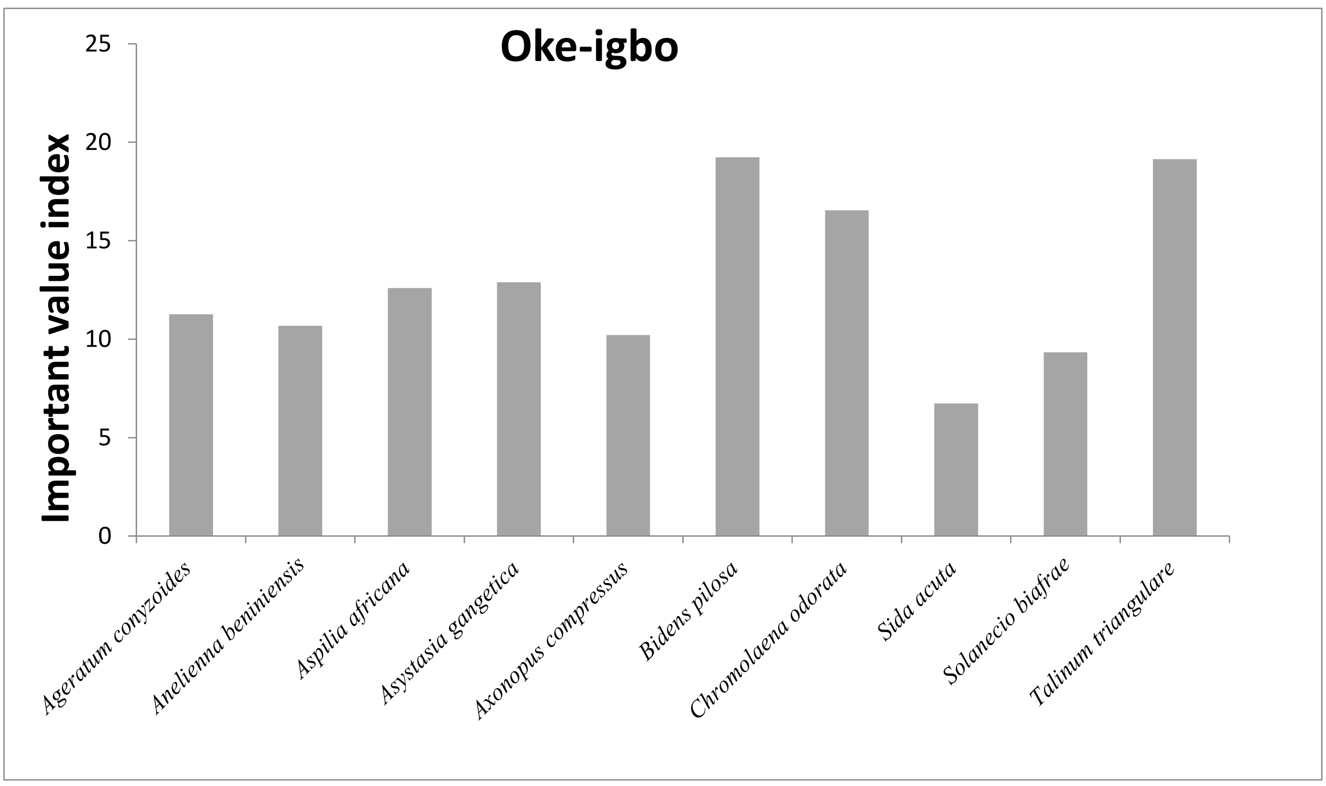
Fig. 20 A, B and C: Weed species of >16years old cocoa plantation with low important value index for three (3) different locations.





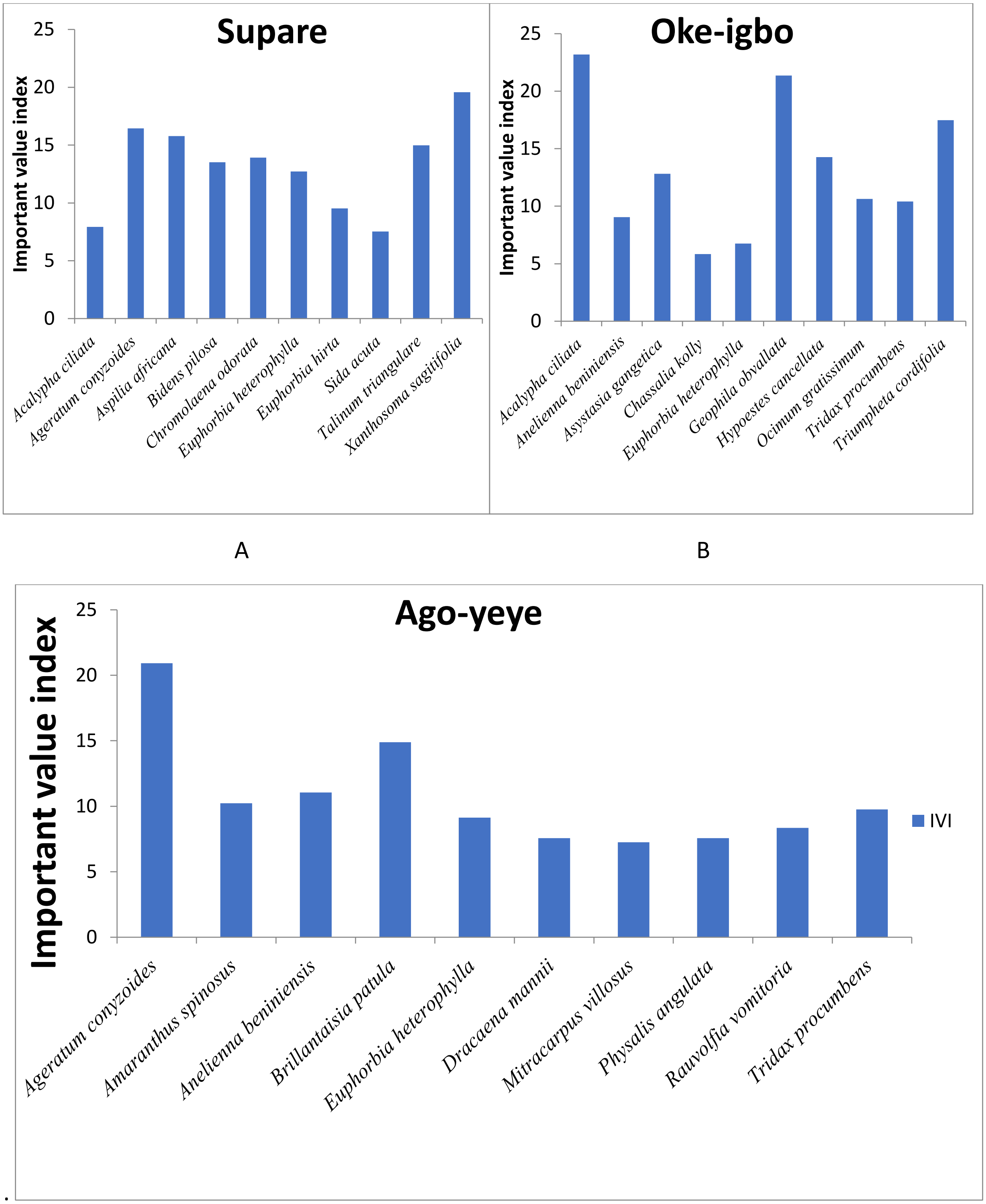
A

B



C

Fig. 21 A, B and C: Weed species of < 3 years old cocoa plantation with high important value index for three (3) different locations.

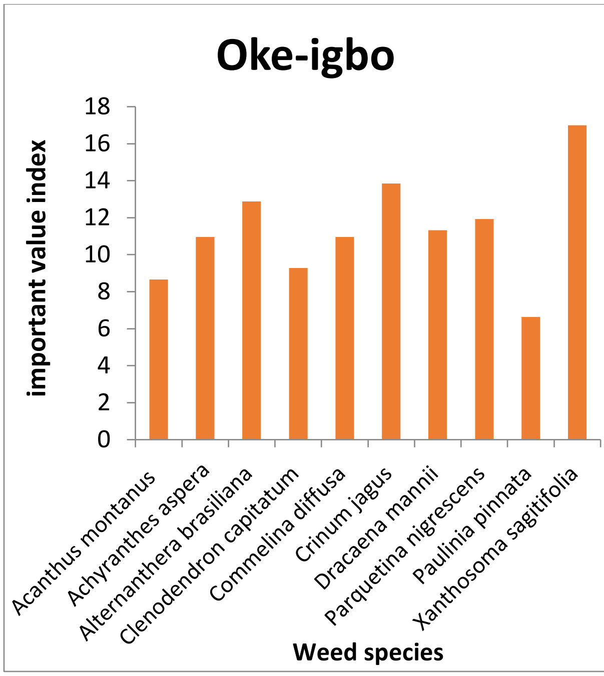


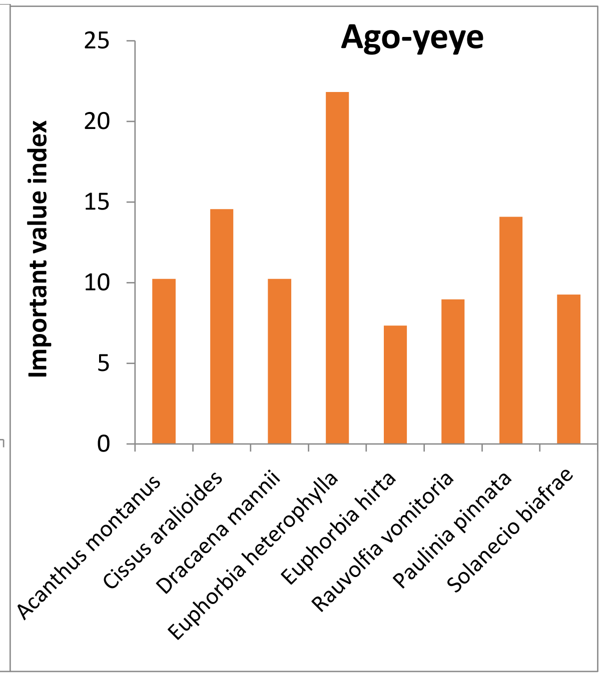
A

B

C

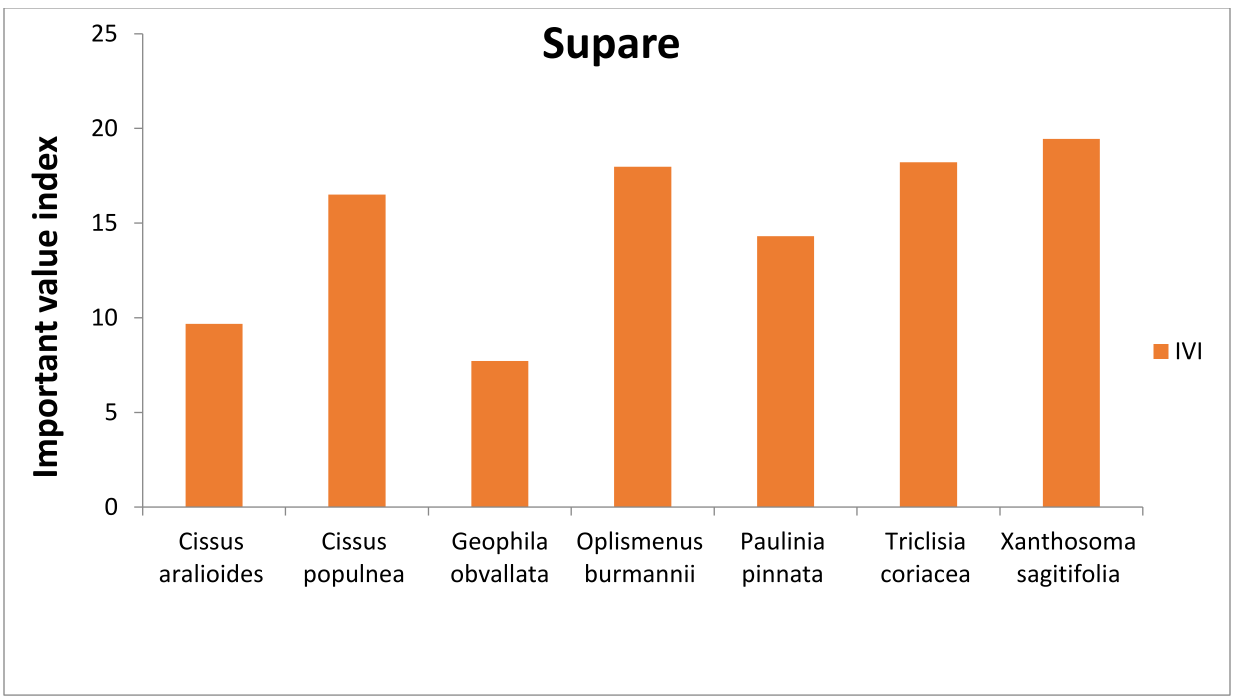
Fig. 22 A, B and C: Weed species of 5-16years old cocoa plantation with high important value index for three (3) different locations.





A

B



C

Fig. 23 Weed species of >16years old cocoa plantation with high important value index for three (3) different locations.

DISCUSSION

An inventory of weed species across three different cocoa plantations were documented with total number of 92 weed species distributed across 40 plant families and 82 genera. Supare had 61 weed species and 51 genera, Oke-Igbo had 70 plant species and 61 genera and Ago-Yeye had 61 plant species and 54 genera distributed in 32, 34 and 27 plant families respectively as shown in figure 3. For the young (< 3 years old) cocoa plantation, Supare and Oke-Igbo had 25and 30 weed species belonging to 13 families each respectively, while Ago-Yeye had 25 weed species belonging to 10families (figure 4). For the mature (5-16 years old) cocoa plantations, Supare had 20 weed species belonging to 11 families, Oke-Igbo and Ago-Yeye had 23 and 19 weed species belonging to 12 and 9 families respectively (figure 5). In the old (>16 years) cocoa plantations, Supare had 16 weed species belonging to 8 families, Oke-Igbo and Ago-Yeye had 17 weed species each belonging to 9 and 8 families respectively.

Life form analysis shows that 50% of the weed species documented was broad leaved herbs as well as the highest genera and family distributed across all the cocoa plantations (figures 7 and 8) which is similar with the studies of (Essandoh et al. 2011; Singh et al. 2010). The greater viability and tolerance to harsh conditions could result in the preponderance of herbs across the area. This may be due to their short life cycle, well established dispersal system and the potential to capture light at low and partly shaded environment. Broad leaved weeds such as *Ageratum conyzoides, Asystasia gangetica, Aspilia africana*, *Axonopus compressus, Chromolaena odorata, Secamone afzelli, Commelina diffusa, Cnestisfer ruginea,Oplismenus burmannii*, *Sida acuta*, *Talinum triangulare* and *Xanthosoma sagitifolia* were dominant in the different plantations.

The family Asteraceae, Euphorbiaceae, Fabaceae and Poaceae were the four (4) dominant families with 11 species and 11 genera in Asteraceae and with 6 species consist of 6 genera each for Euphorbiaceae, Fabaceae and Poaceae families as shown in figure 1 and figure 2. Dominance of Asteraceae may be due to its ability to produce achene fruit which may bear one or two seeds, tap root system, perennial underground stem which can be fleshy or woody depending on the species; this gives them capacity to re-grow after slashing by farmers. (Singh et al. 2010; Sekar 2012) also reported the dominance of Asteraceae among invasive alien species in their studies in Uttar Pradesh and Indian Himalaya respectively. In concordance with the alien floras of Europe (Lambdon et al. 2008) and China (Wu et al. 2010), Asteraceae is the most species-rich family in the alien flora of India (Khuroo et al. 2012). The quality to produce many seeds which may be distributed through explosion of fruits when dried, the potential to produce phytoxins and ability to sprout easily within a short period of time after cuttings makes Euphorbiaceae family to dominate according to (Sharma et al. 2005). Poaceae may be able to colonize variable environmental conditions while that of Fabaceae may be as a result of their characteristics to fix nitrogen making it available for growth and survival.

In terms of phytogeographical origin, 33% of the weed species originated from Africa, 17% from Tropical Africa, 16% are invasive species from Tropical America, 8% from south America, 5% are invasive species from Central America while 4%, 3%, 3%, 2% and 2% from India, Asia, Brazil, America and North America. Supare had 36% of the species originated from Africa, 16% from tropical Africa, 15% were invasive species from tropical America, 7% of the species were from central America, 6% from south America while 5%, 3% and 2% from India, North America, Brazil and Asia respectively. (Khuroo et al. 2012) reported that more than one-third (35%) of the alien flora in India has its native ranges in South America, followed by Asia (21%), Africa (20%), Europe (11%), Australia (8%), North America (4%); and cryptogenic (1%).Oke-Igbo had 30% of the species originated from Africa, 20% from tropical Africa, 14% were invasive species from tropical America, 6% of the species were from central America, 7% from south America while 4%, 3% and 4% from India, North America, Brazil and Asia respectively. However, Ago-Yeye had 28% of the species originated from Africa, 16% from tropical Africa, 18% were invasive species from tropical America, 7% of the species were from central America, 12% from south America while 5%, 3% and 5% from India, North America and Brazil respectively as presented in figure 11. This is similar to the study of (Singh et al. 2010) who reported that invasive weeds have faster rates of growth and biomass production compared to the native species.

In comparing the similarity among the cocoa plantations using the Jaccard system, 50 plant species was documented to be similar between Supare/Oke-Igbo plantations, 45 plant species was similar to both Ago-Yeye/Oke-Igbo plantations and 39 plant species similar to Supare/Ago-Yeye plantations as shown in figure 9. According to the Jaccard index, Supare/Oke-Igbo is more similar with 0.6173 (61.73%) followed by Ago-Yeye/Oke-Igbo with 0.5233 (52.33%) and Supare/Ago-Yeye plantations with 0.4699 (46.99%) as shown in figure 10. The high similarity index between Supare/Oke-Igbo may be attributed to probable similarity in the soil type, ecological succession, weather condition, weed seed bank and cultural practices in these plantations (Davis et al. 2005; Gulden et al. 2003; Roxana et al. 2007).

The diversity of weed species were presented based on Dominance (1/D) or Simpson's reciprocal index: the value of this index starts with 1 as the lowest possible figure. The figure would represent a community containing only one species. The higher its value, the greater the diversity, Simpson's (D), Evenness and Shannon indices as shown in figure 11, 12, 13 and 14. Increase in value of D causes decrease in species diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give Simpson's index of diversity. Simpson's index of diversity (1–D): The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the diversity. In this case, the index represents the probability that two individual weed species randomly selected from a sample will belong to different species.

For the 3years old (young) plantation, Supare had (11.52, 0.9132 1.9155 and 2.6468), Oke-Igbo had (12.29, 0.9186, 1.904 and 2.7572) and Ago-Yeye had (7.96, 0.8744, 1.851 and 2.3459) respectively while for 5years old *T. cacao* plantation, Supare had (13.21, 0.9423, 1.998 and 2.7555), Oke-Igbo had (9.57, 0.8955, 1.749 and 2.3647) and Ago-Yeye had (11.81, 0.9153, 1.957 and 2.7106) respectively and finally for10years old (mature) *T. cacao* plantation, Supare had (11.07, 0.9097, 1.723 and 2.5876), Oke-Igbo had (17.01, 0.9412, 1.978 and 2.9464) and Ago-Yeye had (13.61, 0.9265, 2.078 and 2.7464) respectively. The diversity of weed species in the different *T. cacao* plantations at different growth stages was generally high and this could be due to variable environmental conditions in the *T. cacao* plantations as well as adaptive characteristics of the weed species to different control methods used in these cocoa plantations (Simberloff et al. 2005).

It is also observed in this study that intercropping system of farming is also common in *T. cacao* plantations at the three different locations studied. This has a great effect on the species diversity of weeds species. (Noba et al. 2017) reported that Intercropping increase crop diversity, biological stability of the ecosystem and labour efficiency. Intercropping is a predominant cropping system in developing countries which involves the practice of growing two or more crops at the same time, during the same season in the same piece of land (Gill and onyibe 1988). Many tree crops notably oil palm, cocoa, coffee have been successfully intercropped with other trees and food crops (Huang et al. 2009). Intercropping of compatible plants also encourages biodiversity, by providing a habitat for a variety of insects and soil organisms that would not be present in a single-crop environment.

(Nunez and Pauchard 2010) reported that the differences in the requirement for seed production, dispersal, germination and seedling establishment may account for the high diversity of weed species observed, as a result high level of co-existence among weed species are promoted. (Weber and Li 2008) stated that the distribution of individuals among the species is given by evenness index (E). This evenness index was observed to be relatively higher in the matured (5-15years old) *T. cacao* plantation (Essandoh et al. 2011). Evenness is highest when all species are equally abundant (Pascal and Pellissier 1996) thus the matured *T. cacao* plantation had the highest evenness index than the young plantation (Essandoh et al. 2011).

The Important Value Indices (IVI) of the species as shown in figure 15-20; *Ageratum conyzoides* was the most dominant species in Supare *T. cacao* plantation with IVI of 19.01 for the 3years old (young) plantation while *Xanthosoma sagitifolia* was the most dominant species in both 5years and 10years old (mature) *T. cacao* plantation with IVI of 19.57 and 19.45 respectively. Other dominant species in Supare *T. cacao* plantation with high IVI includes *Acalypha ciliata, Aspilia africana, Biden spilosa, Chromolaena odorata, Cissus araloides, Cissus populnea, Geophila obvalata, Oplismenus burmanii, Paulinia pinnata, Triclisia coriaceae, Euphorbia heterophylla, Euphorbia hirta, Sida acuta. Spigelia anthelmia, Synedrellano diflora* and *Talinum triangulare.*

(Lowe et al., 2000) also reported that the present inventory of alien vascular plant species in India includes 17 species. Of these, the present study characterized 11 species as invasive which include Chromolaena odorata and *Ageratum conyzoides.*

Xanthosoma sagitifolia was the most dominant species in Oke-Igbo *T. cacao* plantation with IVI value of 19.15, 23.18 and 16.99 for the 3years, 5years and 10years old *T. cacao* plantation respectively. Other dominant species with high IVI includes *Ageratum conyzoides, Alternanthera brasiliana, Aspilia africana, Asystasia gagentica, Axonopus compressus, Achyranthes aspera, Chromolaena odorata, Commelina benghalensis, Crinum jagus, Euphorbia heterophylla, Geophila obvalata, Hypoestes cancellata, Ocimum grattisimum, Tridax procumbens, Triumpheta cordifolia, Solanum biafrae and Talinum triangulare.*

Ageratum conyzoides was the most dominant species in Ago-Yeye *T. cacao* plantation with IVI of 24.18 and 20.92 for 3years and 5years old *T. cacao* plantation respectively while *Euphorbia heterophylla* was the most dominant species in 10years old (mature) *T. cacao* This observation was also in agreement with an earlier report by Mallen-Cooper and Pickering (2008) who recorded high concentration of broad leaf weeds under the canopies of mature citrus trees. Other dominant species present in Ago-Yeye with high IVI includes *Acanthus montanus, Amaranthus spinosus, Aneilemabeniniensis, Bidenspilosa, Brillantassiapatula, Dracaena mannii, Chromolaenaodorata, Cissusaraloides, Calopogoniummucunoides, Centrosemapubescens, Imperatacylindrica, Pauliniapinnata and Talinum triangulare*. Other such studies vary slightly in percent share of tropical American nativity.

All these high IVI values could be as a result of high resource allocation and space to minimize interactions among other species and to facilitate access to these allocated resources. The results obtained from this study in terms of the dominant flora are in agreement with the studies of (Raghubanshi 2005). They also identified *Ageratum conyzoides*, *Chromolaena odorata, Axonopus compressus* and *Asystasia gagentica* as key weed flora that compete with the crop for resources such as nutrients, moisture and sunlight and eventually cause yield depression. Plant species with low IVI was also represented in figure 18, 19 and 20. These are the weed species that are of little management implications. The high IVI value of legumes present in cocoa plantations demonstrates the intentional introduction of these species by the farmers to improve the quality of nitrogenous nutrients in the plantation. The most commonly used legume cover crop (LCC) comprises *Pueraria phaseoloides* Benth, *Centrosema pubescens* Benth. *Calopogonium mucunoides* Desv and *Desmodium sp.* (Essandoh et al., 2011). It has been reported in studies that exotic aggressive weeds pose threat to *T. cacao* plantation because of their ability to tolerate a wide range of environmental conditions (Chytryet al. 2008) and in line with this, phytogeographic status of weed species is very important. Across the entire *T. cacao* plantation studied, native species was highest followed by exotic species as shown in figure 7. This reveals the contributive effort of exotic species as weed species in *T. cacao* plantation. Exotic aggressive species of notable important value indices and relative abundance encountered in this study are *Alternanthera brassiliana, Bidenspilosa, Euphorbia heterophylla, Chromolaena odorata and Axonopus compressus, Synedrella nodiflora, Tridax procumbens and Talinum triangulare*.

Chromolaena odorata grows rapidly to about 3.6 m tall and aggressively competes with the *T. cacao* for nutrient and light to cause yield depression and requires higher expense for its control (Richardson et al. 2000). Perennial weed species with relatively high IVI values and abundance such as *Axonopus compressus, chromolaena odorata, Imperata* cylindrica*, Ageratum conyzoides, Aspilia Africana, Acalypha ciliata, Euphorbia heterophylla, Talinum triangulare* and *Xanthosoma sagitifolia* were very aggressive and they are regarded as serious pest weeds because of their luxuriant growth and habit of re-growing after slashing, this confirms earlier report of (Mallen-Cooper and Pickering 2008) who reported high relative weed density of *Euphorbia heterophylla*in juvenile citrus plot in National Horticultural Research Institute (NIHORT) Ibadan, Oyo state, Nigeria. High light requirement, aggressive growth, short life cycle, large seed production with potent explosive seed dispersal mechanisms were identified as attributes that may be responsible for the high relative weed density they observed.

Oke-Igbo and Ago-Yeye had the highest exotic species of 16 and 19 species (as shown in figure 8) this may be as a result of frequent applications of chemicals in these plantations. Exotic weed species have often been reported to evolve in new forms that are tolerant to herbicides application thus a probable reason for the high population of exotic species despite the chemical control. The information gathered from the Farmers (owners) of some of the *T. cacao* also revealed that similar exotic and aggressive weeds; *Ageratum conyzoides, Acalypha ciliata, Aspilia africana, Acalypha ciliata, Chromolaena odorata, Axonopus compressus, Euphorbia heterophylla, Imperata cylindrica, Talinum triangulare* and *Xanthosoma sagitifolia* are problematic plants to them.

This study reveals that exotic species are weed species of management implication and serious attention should be given to their control or possible prevention of introduction. Three (3) methods namely; hand/slash, chemical and mechanized can be efficiently used. They may be used in combination with each other with varying degree. This may be due to little or varying degree in the knowledge of the priority weed species, the implication of the control methods to the environment and other crop plant as well as cost of controlling the consequence. Recent studies have shown that weed shift occur in continuously cultivated land, which may be as a result of bush burning, high tillage practice, cropping systems, weed control methods and other changes in the habitat.

METHODS OF MANAGING WEEDS IN DIFFERENT COCOA PLANTATIONS.

A number of weed control strategies are available to smallholders. Cultural and mechanical controls include use of shade (both by the cocoa canopy and its shade trees), weed slashing using a machete, and maintaining leaf litter on the soil to function as a mulch. Mulch can consist of naturally occurring leaf litter in cocoa plantations with a complete canopy, which has an add-on benefit of replenishing soil nutrients to some extent. In addition, cocoa leaf litter harbors saprophytes that can reduce pathogen populations on infected cocoa pods, branches or leaves that drop-off or are removed from the trees. In Papua New Guinea for example, it was found that in leaf litter, Black Pod caused by *Phytophthora palmivora*was reduced faster to base levels than in cocoa with grass as a live ground cover. Mulches and cover crops also help to smother weeds and reduce leaching of nutrients. Leguminous cover crops can also add nutrients to the soil. Selective weeding practices are directed at the most problematic weed types such as vines, grasses and tall broad-leaved weeds, while fewer damaging species are left to provide ground cover, while not having a significant effect on the yield of cocoa. The problem weeds may be controlled either by slashing or by spot application of an herbicide. Use of broad-spectrum products and blanket application techniques is not advised for many environmental and health reasons.

CONCLUSION

The floristic composition of weeds planted with *Theobroma cacao* in the study research has shown critical insights into the composition and diversity of weed species around Cocoa plantations. The research revealed a diverse composition of weed flora comprising grasses, herbs, shrubs, trees, bulb, liana and vine with varying dominance and frequency. These weeds play significant roles in influencing soil nutrient competition, micro climatic conditions, pest populations and ultimately cocoa yield. Nonetheless, understanding the floristic composition of these weed species is essential for developing sustainable weed management strategies that balance productivity with environmental conservation. Therefore, appropriate integrated weed management practices and continuous monitoring are recommended towards enhancing the health and productivity of *Theobroma cacao* plantations while preserving the plant diversity within the study locations.

Declarations

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