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Weed Species Distribution of Juvenile Oil Palm Tree (*Elaeis guineensis*) Intercropped with Maize (*Zea mays*), Okra (*Abelmoshus esculentus*) and Pepper (*Capsicum anuum* var. *abbreviatum*)

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Abstract

This field experiment was carried out to evaluate the weed species distribution in the experimental plots of an intercrop of juvenile oil palm trees (*Elaeis guineensis* Jacq.) with maize (*Zea mays* Linn.), okra (*Abelmoschus esculentus* Moench) and pepper (*Capsicum annuum* var. abbreviatum). This was carried out during the cropping season between July and October 2012. The crops were intercropped with the juvenile oil palm trees of about 3-years-old. The experiment was laid out in a completely randomized block design with five (5) replicates. The treatments comprised of intercropping distances of 1 m, 2 m and 3 m each for the three (3) crops (maize, okra and pepper) and a plot for each of the three (3) arable crops without oil palm trees as control. Weed species distribution was carried out in each of the plots to determine the Simpson's Diversity Index (D), Simpson's Index of Diversity (1-D) and Simpson's Reciprocal Index ($^1/_D$). Weed species' frequency, density, relative density, relative frequency, importance value, abundance, dominance and relative dominance were also computed from data collected at 3WAP and 6WAP. The results showed that the control plot has the highest weed species distribution at 3WAP having the lowest Simpson's Diversity Index (D) of 0.0930. Okra plot has the least weed species distribution with the highest Simpson's Diversity Index (D) of 0.2726. At 6WAP, the pepper plot has the highest weed species distribution having the lowest Simpson's Diversity Index (D) of 0.1741. Control plot has the least weed species distribution with highest Simpson's Diversity Index (D) of 0.2831.

Keywords: crops, distribution, diversity index, intercrop, Simpson, weed

Introduction

Species distribution in terms of species richness is measured as the number of species in a community. Distribution could be within or between communities. Two communities with an identical number of species can differ in terms of evenness, and hence it is also useful to know the proportional or relative abundance of species within the community. 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 (Geiler *et al*., 1991; Willey, 1979). Intercropping has been reported to increase crop diversity, biological stability of the ecosystem and labour efficiency (Okigbo, 1977). Many tree crops notably oil palm, cocoa, coffee have been successfully intercropped with other trees and food crops (Ofoli and Lucas 1988; Okpala Jose and Lucas 1989; Famaye, 2004). 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. This biodiversity can in turn help to limit outbreaks of crop pests (Altieri, 1994) by increasing the diversity or abundance of natural enemies, such as spiders or parasitic wasps. Increasing the complexity of the crop environment through intercropping also limits the places where pests can find optimal foraging or reproductive conditions (Adeyemi, 1988). Greater crop yield and less weed growth can be obtained more frequently in intercrops than in sole crops. In East Africa fruit crops are usually intercropped with annual crops; for example, banana is intercropped with food and/or fodder crops (Clark and Francis, 1985), while in India bananas are intercropped with potato which had resulted in good returns (Okigbo, 1979).

Indices have been developed to combine species richness with proportional abundance within a single value. Examples include the Shannon index, the Simpson index and 'a' of the log series. 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 (Smith and Akinde, 2000; Olorunmaiye and Olorunmaiye, 2008). In order to determine weed control strategy for a successful weed control programmes in oil palm tree cropping systems, it is worthy to know the weed type and species composition in any ecology. It is therefore the objective of this study to investigate the weed flora and species diversity in the plots where the research was carried out.

Materials and methods

The field work was conducted during the cropping season between July and October 2012 at the oil palm plantation of Matkis Farms and Agroservices Ltd. located at km 3 Ilado road, Lanlate, Ibarapa-East Local Government, Oyo state, Nigeria.

Materials include cutlass, hoe, bucket, bowl, drum, measuring tape, polythene bags, wooden quadrats (0.5 m x 0.5 m), maize grains, okra seeds, pepper seedlings and weighing balance.

Six plots (juvenile oil palm trees/maize intercrop plot, juvenile oil palm trees/okra intercrop plot, juvenile oil palm trees/pepper intercrop plot, sole maize plot, sole okra plot and sole pepper plot) were selected within the oil palm tree plantation. It is an oil palm plantation with a layout of 6 m X 6 m triangular spacing. The maize, okra and pepper were intercropped at 1 m, 2 m and 3 m from the juvenile oil palm trees separately within each plot. The weed survey was carried out using the quantitative survey method of Thomas (1985). 0.5 m x 0.5 m quadrat was thrown randomly within each plot three times at 3WAP and at 6WAP. Weeds within each quadrat were uprooted, sorted into species, identified, counted and recorded.

Statistical analysis

Data collected were computed and important quantitative analysis such as density, frequency, relative frequency, relative density, importance value (IVI), abundance, dominance and relative dominance of tree weed species encountered were determined as per Curtis and McIntosh (1950).

Frequency: It is expressed as number of quadrates where species is/are found.

Density: It is expressed as number of species per unit area. (Quadrat area = 0.25 m^2)

$$\text{Density} = \frac{\text{number of species}}{\text{area of quadrant}}$$

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.

$$\text{Relative frequency} = \frac{\text{frequency of species}}{\text{total frequencies of all the species}} \times 100$$

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:

$$\text{Relative density} = \frac{\text{density of species}}{\text{total density of all the species}} \times 100$$

Importance value: This index is used to determine the overall importance of each species in the community structure. Importance Value (IVI) = Relative Frequency + Relative Density

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:

$$\text{Dominance} = \frac{\text{absolute density of species}}{\text{number of quadrats where species is or are found}} \times 100$$

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:

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

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).

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

Where n = the total number of weeds of particular species; N = the total number of weed of all species. With this index, zero (0) represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the 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. Another way of overcoming the problem of counter-intuitive nature of Simpson's Index is to take the reciprocal of the Index.

Simpson's reciprocal index (1/D): 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. The maximum value is the number of species (or other category being used) in the sample. For example if there are five weed species in the sample, then the maximum value is 5.

Results

13 different weed species were found at 3WAP in maize plot (Tab. 1) and they belong to 8 different families, with Poaceae having the highest number of members (3 species). Rubiaceae, Solanaceae, Malvaceae and Asteraceae all have 1 member each. 8 broadleaf species (61.539%), 3 grass species (23.077%) and 2 sedges (15.385%) were found at 3WAP. The 13 different species found at 6WAP (Tab. 2) belong to 9 different families, with Poaceae having the highest number of members (3 species). Cyperacceae, Leguminosae: Caesalpinioideae, Leguminosae: Mimosoideae, Solanaceae, Malvaceae and Loganiaceae have one member each. 9 broadleaf species (69.231%), 3 grass species (23.077%) and 1 sedge (7.692%).

Tab. 1. Weed flora and species parameter for maize plot at 3WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Qm_1	Qm_2	Qm_3	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Andropogon gayanus* Kunth var. *gayanus*	18			18	1	72	5.556	10.455	16.011	8.006	7200	16.418	M	Poaceae
2	*Andropogon tectorum* Schum. & Thonn.		1		1	1	4	5.556	0.581	6.137	3.069	400	0.912	M	Poaceae
3	*Cyperus esculentus* Linn.		8		8	1	32	5.556	4.647	10.203	5.102	3200	7.297	M	Cyperaceae
4	*Euphorbia heterophylla* Linn.	5	20	1	26	3	34.67	16.667	5.034	21.701	10.851	1155.57	2.635	D	Euphorbiaceae
5	*Euphorbia hirta* Linn.			5	5	1	20	5.556	2.904	8.460	4.230	2000	4.560	D	Euphorbiaceae
6	*Imperata cylindrica* Linn. Raeuschel var. *africana*		4	39	43	2	86	11.111	12.488	23.599	11.800	4300	9.805	M	Poaceae
7	*Mariscus alternifolius* Vahl (=*M. umbellatus* Vahl)		3		3	1	12	5.556	1.743	7.299	3.650	1200	2.736	M	Cyperaceae
8	*Oldenlandia herbacea* (Linn.) Rox b.			1	1	1	4	5.556	0.581	6.137	3.069	400	0.912	D	Rubiaceae
9	*Physalis micrantha* Linn.	47	14		61	2	122	11.111	17.715	28.826	14.413	6100	13.909	D	Solanaceae
10	*Sida acuta* Burm. f.	6			6	1	24	5.556	3.485	9.041	4.521	2400	5.473	D	Malvaceae
11	*Spigelia anthelmia* Linn.	4			4	1	16	5.556	2.323	7.879	3.940	1600	3.648	D	Loganiaceae
12	*Spigelia pudica* Linn.		4		4	1	16	5.556	2.323	7.879	3.940	1600	3.648	D	Loganiaceae
13	*Tridax procumbens* Linn.	15		108	123	2	246	11.111	35.721	46.832	23.416	12300	28.047	D	Asteraceae
		95	54	154	303	18	688.7					43855.6			

Tab. 2. Weed flora and species parameter for maize plot at 6WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	$Q m_1$	$Q m_2$	$Q m_3$	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Daniella oliveri* (Rolfe) Hutch. & Dalz.	4			4	1	16	4.546	5.217	9.763	4.882	1600	8.911	D	Leguminosae: Caelsalpinioideae
2	*Digitaria horizontalis* Willd.		3		3	1	12	4.546	3.913	8.459	4.230	1200	6.683	M	Poaceae
3	*Euphorbia heterophylla* Linn.	9	9	4	22	3	29.333	13.636	9.565	23.201	11.601	977.767	5.446	D	Euphorbiaceae
4	*Euphorbia hirta* Linn.	2		1	3	2	6	9.091	1.957	11.048	5.524	300	1.671	D	Euphorbiaceae
5	*Mariscus alternifolius* Vahl (=*M. umbellatus* Vahl)			2	2	1	8	4.546	2.609	7.155	3.578	800	4.455	M	Cyperaceae
6	*Mimosa pudica* Linn.		2	1	3	2	6	9.091	1.957	11.048	5.524	300	1.671	D	Leguminosae: Mimosoideae
7	*Paspalum scrobiculatum* Linn. (= *P. orbiculare* Forst., = *P. commersonii* Lam.		8	2	10	2	20	9.091	6.522	15.613	7.807	1000	5.569	M	Poaceae
8	*Perotis indica* (Linn.) O. Ktze		8		8	1	32	4.546	10.435	14.981	7.491	3200	17.822	M	Poaceae
9	*Physalis micrantha* Linn.	11	3	12	26	3	34.667	9.091	11.304	20.395	10.198	1155.567	6.436	D	Solanaceae
10	*Sida cordifolia* Linn.	2			2	1	8	4.546	2.609	7.155	3.578	800	4.455	D	Malvaceae
11	*Spigelia anthelmia* Linn.	5			5	1	20	4.546	6.522	11.068	5.534	2000	11.139	D	Loganiaceae
12	*Tridax procumbens* Linn.	18	33	26	77	3	102.67	9.091	33.478	42.569	21.285	3422.233	19.060	D	Asteraceae
13	*Vernonia ambigua* Linn.			3	3	1	12	9.091	3.913	13.004	6.502	1200	6.683	D	Asteraceae
		51	66	51	168	22	306.67					17955.57			

17 different species were found at 3WAP okra plot (Tab. 3). They belong to 9 different families, with Poaceae having the highest number of members (6 species). Leguminosae: Papilionoideae, Leguminosae: Mimosoideae, Solanaceae, Loganiaceae and Asteraceae all have 1 member each. Summarily, 9 broadleaf species (52.941%), 6 grass species (35.291%) and 1 sedge (5.882%) were found. The 17 different species found at 6WAP okra plot (Tab. 4) belong to 9 different families, with Poaceae having the highest number of members (5 species). Commelinaceae, Leguminosae: Mimosoideae, Solanaceae, Malvaceae and Loganaceae all have 1 member each. Summarily, 12 broadleaf species (70.588%) and 5 grasses (29.412%) were found.

16 different species were found at 3WAP in pepper plot (Tab. 5) and they belong to 10 different families. Poaceae and Euphorbiaceae were the dominant families with 3 species

Tab. 3. Weed flora and species parameter for okra plot at 3WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Q_{01}	Q_{02}	Q_{03}	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Andropogon gayanus* Kunth var. *gayanus*		7		7	1	28	4.167	4.924	9.091	4.546	2800	7.868	M	Poaceae
2	*Brachiaria deflexa* (Schumach.) C.E. Hubbard ex Robyns	14			14	1	56	4.167	9.848	14.015	7.008	5600	15.735	M	Poaceae
3	*Cyperus esculentus* Linn.		7		7	1	28	4.167	4.924	9.091	4.546	2800	7.868	M	Cyperaceae
4	*Diodia sarmentosa* Sw. (=*Diodia scandens* Sw.)			13	13	1	52	4.167	9.144	13.311	6.656	5200	14.611	D	Rubiaceae
5	*Eriosema psoraleoides* (Lam.) G. Don			3	3	1	12	4.167	2.110	6.277	3.139	1200	3.372	D	Leguminosae: Papilionoideae
6	*Euphorbia heterophylla* Linn.	24	14	11	49	3	65.333	12.500	11.489	23.989	11.995	2177.767	6.119	D	Euphorbiaceae
7	*Imperata cylindrica* Linn. Raeuschel var. *africana*		3		3	1	12	4.167	2.110	6.277	3.139	1200	3.372	M	Poaceae
8	*Mariscus alternifolius* Vahl (=*M. umbellatus* Vahl)			2	2	1	8	4.167	1.407	5.574	2.787	800	2.248	M	Cyperaceae
9	*Mimosa pudica* Linn.	1			1	1	4	4.167	0.703	4.870	2.435	400	1.124	D	Leguminosae: Mimosoideae
10	*Oldenlandia herbacea* (Linn.) Roxb.			2	2	1	8	4.167	1.407	5.574	2.787	800	2.248	D	Rubiaceae
11	*Panicum maximum* (Jacq.)	3	16		19	2	38	8.333	6.682	15.015	7.508	1900	5.339	M	Poaceae
12	*Paspalum conjugatum* Berg.		2		2	1	8	4.167	1.407	5.574	2.787	800	2.248	M	Poaceae
13	*Phyllanthus amarus* Schum. & Thonn.			2	2	1	8	4.167	1.407	5.574	2.787	800	2.248	D	Euphorbiaceae
14	*Physalis micrantha* Linn.	4	11	5	20	3	26.667	12.500	4.689	17.189	8.595	888.9	2.498	D	Solanaceae
15	*Spigelia anthelmia* Linn.		6		6	1	24	4.167	4.220	8.387	4.194	2400	6.744	D	Loganiaceae
16	*Sporobolus pyramidalis* P. Beauv.	1			1	1	4	4.167	0.703	4.870	2.435	400	1.124	M	Poaceae
17	*Tridax procumbens* Linn.	25	37	78	140	3	186.667	12.500	32.825	45.325	22.625	6222.233	17.484	D	Asteraceae
		72	103	116	291	24	568.667					35588.9			

Tab. 4. Weed flora and species parameter for okra plot at 6WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Q_{01}	Q_{02}	Q_{03}	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Ageratum conyzoides* Linn.	3			3	1	12	4.348	2.679	7.027	3.514	1200	3.762	D	Asteraceae
2	*Commelina benghalensis* L.	1			1	1	4	4.348	0.893	5.241	2.621	400	1.254	D	Commelinaceae
3	*Digitaria gayanus* (Kunth) Stapf ex A. Chev.	8			8	1	32	4.348	7.143	11.491	5.746	3200	10.031	M	Poaceae
4	*Diodia sarmentosa* Sw. (=*Diodia scandens* Sw.)	1			1	1	4	4.348	0.893	5.241	2.621	400	1.254	D	Rubiaceae
5	*Eleusine indica* Gaertn.			3	3	1	12	4.348	2.679	7.027	3.514	1200	3.762	M	Poaceae
6	*Euphorbia heterophylla* Linn.	7			7	1	28	4.348	6.250	10.598	5.299	2800	8.777	D	Euphorbiaceae
7	*Mimosa pudica* Linn.	3			3	1	12	4.348	2.679	7.027	3.514	1200	3.762	D	Leguminosae: Mimosoideae
8	*Oldenlandia herbacea* (Linn.) Roxb.			6	6	1	24	4.348	5.357	9.705	4.853	2400	7.524	D	Rubiaceae
9	*Paspalum scrobiculatum* Linn. (=*P. orbiculare* Forst., =*P. commersonii* Lam.		9	8	17	2	34	8.696	7.589	16.285	8.143	1700	5.329	M	Poaceae
10	*Pennisetum pedicullatum* Trin.	2	3		5	2	10	8.696	2.232	10.928	5.464	500	1.567	M	Poaceae
11	*Phyllanthus amarus* Schum. & Thonn.			1	1	1	4	4.348	0.893	5.241	2.621	400	1.254	D	Euphorbiaceae
12	*Physalis micrantha* Linn.	37	4		41	2	82	8.696	18.304	27.000	13.500	4100	12.853	D	Solanaceae
13	*Sida acuta* Burm.f.		7	4	11	2	22	8.696	4.911	13.607	6.804	1100	3.448	D	Malvaceae
14	*Spigelia anthelmia* Linn.			4	4	1	16	4.348	3.571	7.919	3.960	1600	5.016	D	Loganiaceae
15	*Sporobolus pyramidalis* P. Beau		8	3	11	2	22	8.696	4.911	13.607	6.804	1100	3.448	M	Poaceae
16	*Tridax procumbens* Linn.	37	45		82	2	164	8.696	36.607	45.303	22.652	8200	25.705	D	Asteraceae
17	*Vernonia amygdalina* Linn.			1	1	1	4	4.348	0.893	5.241	2.621	400	1.254	D	Asteraceae
		99	76	30	205	23	448					31900			

each. Commelinaceae, Leguminosae: Caesalpinioideae, Leguminosae: Mimosoideae, Solanaceae, Malvaceae and Loganiaceae all have 1 member each and hence least dominant. Summarily, 11 broadleaf species (68.75%), 3 grasses (18.75%) and 2 sedges (12.5%) were found in pepper plot at 3WAP. The 18 different species found at 6WAP in pepper plot (Tab. 6) belong to 9 families. Poaceae was the dominant family with 6 species. Cyperaceae, Leguminosae: Mimosoideae, Rubiaceae, Solanaceae, Malvaceae and Loganiaceae all have 1 member each. Summarily, 11 broadleaf weeds (61.111%), 6 grass species (33.333%) and 1 sedge (5.556%) were found.

Tab. 5. Weed flora and species parameter for pepper plot at 3WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Qp 1	Qp 2	Qp 3	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Brachiaria lata* (Schumach.) C. E. Hubbard	1			1	1	4	5	0.599	5.599	2.800	400	0.927	M	Poaceae
2	*Chromolaena odorata* (L.) R. M. King & Robinson (=*Eupatorium odoratum* L.)	1			1	1	4	5	0.599	5.599	2.800	400	0.927	D	Asteraceae
3	*Commenlina benghalensis* L.		3		3	1	12	5	1.798	6.798	3.400	1200	2.781	D	Commelinaceae
4	*Cyperus esculentus*Linn.	1			1	1	4	5	0.599	5.599	2.800	400	0.927	M	Cyperaceae
5	*Dactyloctenium aegyptium* (Linn.) P. Beauv.			2	2	1	8	5	1.199	6.199	3.100	800	1.854	M	Poaceae
6	*Daniella oliveri* (Rolfe) Hutch. & Dalz.			1	1	1	4	5	0.599	5.599	2.800	400	0.927	D	Leguminosae: Caesalpinioideae
7	*Euphorbia heterophylla* Linn.	9	12	7	28	3	37.333	15	5.599	20.594	10.297	1244.433	2.884	D	Euphorbiaceae
8	*Euphorbia hirta* Linn.	1			1	1	4	5	0.599	5.599	2.800	400	0.927	D	Euphorbiaceae
9	*Mariscus alternifolius* Vahl (=*M. umbellatus* Vahl)			2	2	1	8	5	1.199	6.199	3.100	800	1.854	M	Cyperaceae
10	*Mimosa pudica* Linn.			3	3	1	12	5	1.798	6.798	3.399	1200	2.781	D	Leguminosae: Mimosoideae
11	*Panicum maximum* (Jacq.)		1		1	1	4	5	0.599	5.599	2.800	400	0.927	M	Poaceae
12	*Phyllanthus amarus* Schum. & Thonn.			1	1	1	4	5	0.599	5.599	2.800	400	0.927	D	Euphorbiaceae
13	*Physalis micrantha* Linn.	62		18	80	2	160	10	23.976	33.976	16.988	8000	18.542	D	Solanaceae
14	*Sida acuta* Burm. f.	1			1	1	4	5	0.599	5.599	2.800	400	0.927	D	Malvaceae
15	*Spigelia anthelmia* Linn.		34		34	1	136	5	20.380	25.380	12.690	13600	31.522	D	Loganiaceae
16	*Tridax procumbens* Linn.		58	73	131	2	262	10	39.261	49.261	24.631	13100	30.363	D	Asteraceae
		76	108	107	291	20	667.333					43144.43			

Tab. 6. Weed flora and species parameter for pepper plot at 6WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Qp_1	Qp_2	Qp_3	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Andropogon gayanus* Kunth var. *gayanus*	2			2	1	8	4.348	1.482	5.830	2.910	800	1.861	M	Poaceae
2	*Aspilia africana* (Pers) C.D. Adams	2			2	1	8	4.348	1.482	5.830	2.910	800	1.861	D	Asteraceae
3	*Cyperus rotundus* Linn.		4		4	1	16	4.348	2.963	7.311	3.656	1600	3.721	M	Cyperaceae
4	*Eleusine indica* Gaertn.		2	8	10	2	20	8.696	3.704	12.400	6.200	1000	2.326	M	Poaceae
5	*Euphorbia heterophylla* Linn.	15			15	1	60	4.348	11.111	15.459	7.730	6000	13.954	D	Euphorbiaceae
6	*Euphorbia hirta* Linn.			2	2	1	8	4.348	1.482	5.830	2.915	800	1.861	D	Euphorbiaceae
7	*Imperata cylindrica* Linn. Raeuschel var. *africana*			15	15	1	60	4.348	11.111	15.459	7.730	6000	13.954	M	Poaceae
8	*Mimosa pudica* Linn.	2	3		5	2	10	8.696	1.852	10.548	5.274	500	1.163	D	Leguminosae: Mimosoideae
9	*Oldenlandia herbacea* (Linn.) Roxb.	4			4	1	16	4.348	2.963	7.311	3.656	1600	3.721	D	Rubiaceae
10	*Paspalum scrobiculatum* Linn. (=*P. orbiculare* Forst., =*P. commersonii* Lam.			4	4	1	16	4.348	2.963	7.311	3.656	1600	3.721	M	Poaceae
11	*Pennisetum pedicullatum* Trin.			12	12	1	48	4.348	8.889	13.237	6.619	4800	11.163	M	Poaceae
12	*Phyllanthus amarus* Schum. & Thonn.	1			1	1	4	4.348	0.741	5.089	2.545	400	0.930	D	Euphorbiaceae
13	*Physalis micrantha* Linn.			12	12	1	48	4.348	8.889	13.237	6.619	4800	11.163	D	Solanaceae
14	*Sida acuta* Burm. f.		2	1	3	2	6	8.696	1.111	9.807	4.904	300	0.698	D	Malvaceae
15	*Spigelia anthelmia* Linn.		4		4	1	16	4.348	2.693	7.311	3.656	1600	3.721	D	Loganiaceae
16	*Sporobolus pyramidalis* P. Beauv.	3			3	1	12	4.348	2.222	6.570	3.285	1200	2.791	M	Poaceae
17	*Tridax procambens* Linn.	28	43		71	2	142	8.696	26.296	34.992	17.496	7100	16.512	D	Asteraceae
18	*Vernonia ambigua* Linn.	2	19		21	2	42	8.696	7.778	16.474	8.237	2100	4.884	D	Asteraceae
					71	23	540					43000			

Tab. 7. Weed flora and species parameter for control plot at 3WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Q_{c1}	Q_{c2}	Q_{c3}	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Abutilon mauritianum* (Jacq.) Medic	1			1	1	4	2.778	1.172	3.950	1.975	400	1.351	D	Malvaceae
2	*Ageratum conyzoides* Linn.	1	4		5	2	10	5.556	2.930	8.486	4.243	500	1.689	D	Asteraceae
3	*Axonopus compressus* (Sw.) P. Beauv.			25	25	1	100	2.778	29.297	32.075	16.038	10000	33.784	M	Poaceae
4	*Commelina benghalensis* L.		1	4	5	2	10	5.556	2.930	8.486	4.243	500	1.689	D	Commelinaceae
5	*Conyza sumatrensis* (Retz.) Walker (=*Erigeron floribundus* [H.B.&K.])	1			1	1	4	2.778	1.172	3.950	1.975	400	1.351	D	Asteraceae
6	*Cyperus esculentus* Linn.	2		2	4	2	8	5.556	2.344	7.900	3.95	400	1.351	M	Cyperaceae
7	*Dactyloctenium aegyptium* (Linn.) P. Beauv.		1		1	1	4	2.778	1.172	3.950	1.975	400	1.351	M	Poaceae
8	*Daniella oliveri* (Rolfe) Hutch. & Dalz.		1		1	1	4	2.778	1.172	3.950	1.975	400	1.351	D	Leguminosae: Caelsalpinioideae
9	*Digitaria horizontalis* Willd.			5	5	1	20	2.778	5.860	8.638	4.319	2000	6.757	M	Poaceae
10	*Eleusine indica* Gaertn.	2			2	1	8	2.778	2.344	5.122	2.561	800	2.703	M	Poaceae
11	*Eragrotis ciliaris* (Linn.) R.Br.	1			1	1	4	2.778	1.172	3.950	1.975	400	1.351	M	Poaceae
12	*Euphorbia heterophylla* Linn.		1	1	2	2	4	5.556	1.172	6.728	3.364	200	0.676	D	Euphorbiaceae
13	*Euphorbia hirta* Linn.	12		3	15	2	30	5.556	8.790	14.346	7.173	1500	5.068	D	Euphorbiaceae
14	*Launaea taraxacifolia* (Willd.) Amin. MS ex Jeffrey; (*Lactuca taraxacifolia* [Willd.] Schum. ex Homeman; *L. cornuta* [Olive] C. jeffrey)	1		1	2	2	4	5.556	1.172	6.726	3.364	200	0.676	D	Asteraceae
15	*Marisus alternifolius* Vahl (=*M. umbellatus* Vahl)		3	2	5	2	10	5.556	2.930	8.486	4.243	500	1.689	M	Cyperaceae
16	*Mimosa pudica* Linn.		2		2	1	8	2.778	2.344	5.122	2.561	800	2.703	D	Leguminosae: Mimosoideae
17	*Oldenlandia herbacea* (Linn.) Roxb.		1	1	2	2	4	5.556	1.172	6.726	3.364	200	0.676	D	Rubiaceae
18	*Panicum laxum* Sw.	3			3	1	12	2.778	3.516	6.294	3.147	1200	4.054	M	Poaceae
19	*Panicum maximum* (Jacq.)		2		2	1	8	5.556	2.344	7.900	3.950	800	2.703	M	Poaceae
20	*Phyllanthus amarus* Schum. & Thonn.	3	1	2	6	3	8	8.333	2.344	10.677	5.339	266.667	0.901	D	Euphorbiaceae
21	*Schwankia leptocarpa* D.C.	1			1	1	4	2.778	1.172	3.950	1.975	400	1.351	D	Euphorbiaceae
22	*Spigelia anthelmia* Linn.		1		1	1	4	2.778	1.172	3.950	1.975	400	1.351	D	Loganiaceae
23	*Stolenostenum monostachyus* (Brig. Subsp *monostachyus*)	10			10	1	40	2.778	11.719	14.497	7.249	4000	1.351	D	Lamiaceae
24	*Tridax procumbens* Linn.	2	4	16	22	3	29.333	8.333	8.594	16.927	8.464	2933.33	9.91	D	Asteraceae
						36	341.333					29600			

Tab. 8. Weed flora and species parameter for control plot at 6WAP

S/N	SCIENTIFIC NAMES OF WEED SPECIES	Q_{c1}	Q_{c2}	Q_{c3}	TOTAL	FREQUENCY	DENSITY	RELATIVE FREQUENCY (%)	RELATIVE DENSITY (%)	IMPORTANCE VALUE	ABUNDANCE	DOMINANCE (%)	RELATIVE DOMINANCE (%)	COTYLEDONS	FAMILY
1	*Chromolaena odorata* (L.) R.M.King & Robinson (=*Eupatorium odoratum* L.)		1		1	1	4	5.263	0.615	5.878	2.939	400	0.969	D	Asteraceae
2	*Commelina benghalensis* L.	5	3		8	2	16	10.526	2.459	12.985	6.493	800	1.938	D	Commelinaceae
3	*Cyperus esculentus* Linn.	11			11	1	44	5.263	6.762	12.025	6.0125	4400	10.657	M	Cyperaceae
4	*Digitaria aggyanus* (Kunth) Stapf ex A. Chev.		5		5	1	20	5.263	3.074	8.337	4.169	2000	4.844	M	Poaceae
5	*Digitaria horizontalis* Willd.	8			8	1	32	5.263	4.918	10.181	5.091	3200	7.750	M	Poaceae
6	*Diodia sarmentosa* Sw. (=*Diodia scandens* Sw.)		2	12	14	2	28	10.562	4.303	14.829	7.415	1400	3.391	D	Rubiaceae
7	*Eriosema psoraleoides* (Lam.) G.Don		1		1	1	4	5.263	0.615	5.878	2.939	400	0.969	D	Leguminosae: Papilionoideae
8	*Euphorbia heterophylla* Linn.		45	73	118	2	236	10.526	36.271	46.797	23.399	11800	28.579	D	Euphorbiaceae
9	*Marisus alternifolius* Vahl (=*M. umbellatus* Vahl)	7			7	1	28	5.263	4.303	9.566	4.783	2800	6.782	M	Cyperaceae
10	*Oldenlandia herbacea* (Linn.) Roxb.		7		7	1	28	5.263	4.303	9.566	4.783	2800	6.782	D	Rubiaceae
11	*Perotis indica* (Linn.) O.Ktze	11			11	1	44	5.263	6.762	12.025	6.013	4400	10.657	M	Poaceae
12	*Physalis micrantha* Linn.	3			3	1	12	5.263	1.844	7.107	3.554	1200	2.906	D	Solanaceae
13	*Senna obtusifolia* (L.) Irwin & Barneby (=*Cassia obtusifolia* L.)	2			2	1	8	5.263	1.230	6.493	3.247	800	1.938	D	Leguminosae: Caelsapinioideae
14	*Tridax procumbens* Linn.	24	40	46	110	3	146.667	15.790	22.541	38.331	19.166	4888.900	11.841	D	Asteraceae
						19	650.667					412889			

Tab. 9. Weed species diversity at 3WAP and 6WAP

Simpson's diversity / Sampling plots	3WAP			6WAP		
	Simpson's diversity index (D)	Simpson's index of diversity (1-D)	Simpson's reciprocal index (^{1}/D)	Simpson's diversity index (D)	Simpson's index of diversity (1-D)	Simpson's reciprocal index (^{1}/D)
Maize	0.2357	0.7643	4.2427	0.2556	0.7444	3.9124
Okra	0.2726	0.7274	3.6684	0.2141	0.7859	4.6707
Pepper	0.1004	0.8996	9.9602	0.1741	0.8259	5.7439
Control	0.0930	0.9070	10.7527	0.2831	0.7169	3.5323

The 24 different weed species found at 3WAP in control plot belong to 11 different families (Tab. 7) with Poaceae as the dominant family (7 species). Malvaceae, Commelinaceae, Leguminosae: Caesalpinioideae, Leguminosae: Mimosoideae, Rubiaceae, Loganiaceae and Lamiaceae all having 1 member each. Summarily, 15 broadleaf species (62.5%), 7 grasses (29.167%) and 2 sedges (8.333%) were found at 3WAP in control plot. 14 different species found at 6WAP control plot (Tab. 8). They belong to 9 different families, with Poaceae as the dominant family (3 species). Commelinaceae, Leguminosae: Papilionoideae, Euphorbiaceae, Solanaceae and Leguminosae: Caesalpinioideae all have 1 member each. Summarily, 9 broadleaf species (64.286%), 3 grasses (21.429%) and 2 sedges (14.289%) were found.

Discussion

The results showed that in the maize plot, *Tridax procumbens* has the highest number of species both at 3WAP and 6WAP. This may be because this plant produces a lot of seeds that are easily dispersed by wind. This observation is in accordance with an earlier report by Olorunmaiye *et al*. (2011) who reported high colonizing power of this family, readily brought about by the high fruit production and the efficient dispersal of fruits and seeds. Similar observation was recorded in the okra and pepper plots, both at 3WAP and 6WAP. In the control plot at 3WAP, *Axonopus compressus* has the highest number of species, closely followed by *Tridax procumbens*. This shows that *Tridax procumbens* is very abundant in this study area. However, at 6WAP in the control plot, *Euphorbia heterophylla* has the highest number of species present, recording the highest number of abundance in the control plot (Tab. 8). *Euphorbia heterophylla* also recorded high abundance in maize, okra and pepper plots. This confirms earlier report of Olorunmaiye *et al*. (2011) 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 observed.

Broad leaf weeds were also found to dominate all the studied plots. This observation was also in accordance with an earlier report by Olorunmaiye *et al*. (2011) who reported high concentration of broad leaf weeds under the canopies of mature citrus trees. However, more weeds were observed in the control plots where there was no intercropping (plots with sole oil palm trees) than in the intercropped plots. This also confirms an earlier report of Yakubu *et al*. (2006) who reported site specificity in both crops and weeds. Similarly, this observation is also in accordance with earlier report by Karaye *et al*. (2007) who reported that some weeds and crops are site specific, while others will thrive over a wide range of habitat.

Generally, the number of weeds found in the plots at 3WAP and 6WAP were the same in maize plot and okra plot. It was higher at 6WAP than at 3WAP in pepper plot, but was significantly reduced in the control plot at 6WAP compared to 3WAP. This observation shows that the intercrop helped to reduce the number of weeds in the plots and it is in accordance with an earlier report by Egbe (2010) and Karkanis *et al*. (2011) who reported that the enhancement of barley and fenugreek weights in the weed free treatments might be attributed to the high efficiency of weeds elimination, which consequently decreased the competitive ability of weeds against crop plants.

The control plot has the highest weed species distribution at 3WAP. This plot has the lowest Simpson's Diversity Index [D = 0.0930] and highest Simpson's Index of Diversity [1 – D = 0.9070] and Simpson's Reciprocal index [^{1}/D = 10.7527]. Okra plot has the least diversity of weed species with highest Simpson's Diversity Index [D = 0.2726] and lowest Simpson's Index of Diversity [1 – D = 0.7274] and Simpson's Reciprocal index [^{1}/D = 3.6684] (Table 9). The high weed species diversity in the control plot might be because the weeds there were not regularly cleared like the intercropped space between the palm trees has attained stable biodiversity, as which is in accordance with earlier report of Yakubu *et al*. (2006) who reported site specificity in both crops and weeds. This is also in agreement with earlier report of Olorunmaiye *et al*. (2011) who reported higher number of weed species in the main citrus orchard plot than other plots. This may also be due to the absence of shade, which probably improves the growth of weeds; this confirms earlier report by Obadoni *et al*. (2009) who reported that shade effect from trees did not encourage undergrowth regeneration or establishment of weed.

The pepper plot has the highest weed species distribution at 6WAP having the lowest Simpson's Diversity Index [D = 0.1741] and highest Simpson's Index of Diversity [1 – D = 0.8259] and Simpson's Reciprocal index [^{1}/D = 5.7439]. Control plot has the least diversity of weed species with highest Simpson's Diversity Index [D = 0.2831] and lowest Simpson's Index of Diversity [1 – D = 0.7169] and Simpson's Reciprocal index [^{1}/D = 3.5323] (Tab. 9). The decrease in the diversity in the control plot might be due to the decrease in the number of weeds observed at 6WAP compared to those observed at 3WAP, which further confirms earlier report by Egbe (2010) and Karkanis *et al*.

(2011) who reported that the enhancement of barley and fenugreek weights in the weed free treatments might be attributed to the high efficiency of weeds elimination, which consequently decreased the competitive ability of weeds against crop plants.

Conclusions

This work has been able to provide a list of weed species and their distribution in the studied area. It has shown that broad leaf weeds were found to dominate all studied plots and *Tridax procumbens* Linn. has been found to have the highest number of species both at 3WAP and 3WAP, in most of the plots studied. The control and the pepper plots were also found to have the highest weed species distribution at 3WAP and 6WAP respectively.

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