International Journal of Plant Science and Ecology
Vol. 7, No. 3, 2021, pp. 69-77
http://www.aiscience.org/journal/ijpse
ISSN: 2381-6996 (Print); ISSN: 2381-7003 (Online)

Diversity and Importance Value Indices of Weeds in Selected Maize and Cassava Farms in Joseph Sarwuan Tarka University, Makurdi, Nigeria

Okoh Thomas*, Okekporo Efe Stephen, Esah Faith Agbenu, Godwin Tochukwu Christiana

Department of Botany, Joseph Sarwuan Tarka University, Makurdi, Makurdi, Nigeria

Abstract

A survey was conducted in maize and cassava farms at the Joseph Sarwuan Tarka University Makurdi research farm between 2018 and 2019 cropping seasons. The objective of the study was to identify the most important weed species and to determine their relative frequency, density, abundance and important value indices. A quantitative method was employed for the enumeration and identification of weed species. Quadrats were laid along transects and individual weed species in each quadrat was identified and counted. A total 484 plants belonging to 68 species and 22 families were sampled in the maize farms. The species with highest relative frequency (FrR,), Relative Density (DeR) and Relative Abundance (AbR) were *Commelina benghalensis* (0.55), *Synederela nodiflora* (8.47) and *Setera babarta* (10.94) respectively. Also, *S. babarta* had the highest Important Value Index (IVI; 18.84). The family value indices (FVI) were highest in Poaceae (114.22) and least in Fabaceae, Malvaceae, Scrophulariaceae and Caryophylaceae (1.41), respectively. A total of five hundred and fifty-five (555) individuals belonging to forty-one (41) species and fourteen (14) families were sampled in the cassava farms. *Tridax procumbens* has the highest FrR, (13.89), DeR (42.34), AbR (15.98), IVI (72.22), while Asteraceae had the highest FVI (129.8). The most abundant species include: *T. procumbens, Vernoria cinerea, Bracharia lata, Tephrosia braceteolata,* respectively. Variation in the species IVI and FVI in both farms suggests the possible ecological effects (shade, competitive ability) on the pastures by the individual crops on the farm. Results obtained from this study could be useful in creating a weed management programme and in making informed decision on choice of herbicides and directing research towards new or improved weed control measures.

Keywords

Weed, Quadrats, Maize, Cassava, Importance Value Index, Family Value Index, Makurdi

Received: July 27, 2021 / Accepted: August 13, 2021 / Published online: August 30, 2021

1. Introduction

Weeds exhibit diversity in distribution and levels of occurrence at various locations and different seasons [29]. They thrive in disturbed habitats and produce abundant seeds that germinate independent of crop density, spatial arrangement and species. Weed spectra also vary in occurrence, diversity, distribution, and infestation at various locations and in different seasons [28, 35]. In Nigeria, yield losses due to weed interference range between 40-100%, depending on type of crops, location, types of weed and weed density, topography, soil type, temperature, season, cultivated crops, field management [12, 14, 28, 26].

Cassava (*Manihot esculenta* Crantz) is a significant food crop grown in Nigeria, which feeds its populace and also provides sources of income to small-scale farmers. It is valued for its outstanding ecological adaptation, low labor requirement, ease of cultivation and high yields [33]. According to [11] cassava is important because it provides about 70% of the daily calorie intake of over 50 million Nigerians and about

* Corresponding author
E-mail address: thomasokoh@gmail.com (O. Thomas)

40% of all calories consumed in Africa. Cassava production is greatly affected by weeds in the tropics, probably due to its initial slow growth rate, wide plant spacing, and the long maturity period of between 12 and 18 months [6, 29, 18]. Such weeds therefore compete with the crop for nutrient and space, thereby reducing the yield quality and quantity in the fields. Uncontrolled weed infestations throughout the life cycle of cassava have been reported to cause losses in root yield of 40 - 90% [4, 6, 36].

Maize (*Zea mays* L.) is prioritized by the small-scale farmers to secure the basic food requirements of households [22]. Weeds pose a serious challenge to maize production in several places around the world. Yield reduction in maize due to weed infestation range from 20% to 100% [8, 7, 1]. Substantially higher yields are obtained from weed-controlled plots compared to un-weeded plots. According to [31] maize is highly sensitive to weed infestation between the third and sixth week after germination due to narrower canopy, which cannot suppress excessive weed growth. Maize is highly susceptible to weed infestation 6 weeks after sowing (WAS), significantly decreasing final grain yield [9]. The most abundant weeds that infest maize farms in West Africa are *Amaranthus spinosus, Bidens pilosa, Commelina benghalensis, Mariscus alternafolius* and *Cynodon dactylon* [25]. Furthermore, in Sudan, weed infestation decreased maize grain yield by 58-62% and 67-79% during winter and summer seasons, respectively [24]. Weeds are very tolerant to several biotic and abiotic factors. They are serious competitors in taking up nutrients relative to crop plants; their share in the total uptake of micro elements from the soil by the maize crop and weeds together was considerable and it averaged as follows: for K – 35%, Ca – 27.3%, Mg – 27.4% [32].

Cassava and maize seem to be the most common crop combination preferred by small-scale farmers. Weeds affecting maize and cassava plants include *Rottboellia cochichinensis, Eleusine indica, Setaria barbata, Cleome viscose, Commelina benghalensis, Imperata cylindrica, Pentodon Pentandrus, Tridax procumbens, Cyperus esculentus and C. rotundus* [15, 10].

Weed infestation remains a major barrier to economic crop yield, yet the relative importance of common weed species in major crops and cropping systems is not well documented [32]. The knowledge of weed species affecting productivity is essential for effective management and improved agricultural productivity [10]. Understanding weed species distribution provides baseline information for monitoring changes in weed populations over time, provides weed biologists and ecologists with quantitative information on weed communities, which is used in the development of integrated weed management strategies [32].

Consequently, the study was carried out in Joseph Sarwuan Tarka University Makurdi, Nigeria research farm, to identify the most important weed species associated with cassava and maize farms, and to determine their relative frequency, relative density, relative abundance and importance value indexes.

2. Materials and Methods

Four locations were selected for study. In each farm, a 50 m × 50 m location was mapped out for study. A 2 * 2 * 10 factorial experiment were laid out in completely randomized blocked design. The design comprised of two crops (maize and cassava) and 2 sampling units each. 10 quadrats of (1 m^2) were thrown at different points in each farm and a total of 40 quadrats were obtained. The weed species were identified using methods described by [2] and recorded according to their plots. Data generated from the farms were analyzed for Relative Frequency (FrR), Relative Density (DeR), Relative Abundance (AbR) Importance Value Index (IVI), and Family Value Index according to [23]. IVI is a reasonable measure of assessing the overall significance of a species since it takes into account several properties of the species in the locations.

$$\text{Relative Frequency (FrR)} = \frac{\text{Frequency of Species}}{\text{Total Frequency of all Species}} \times 100$$

$$\text{Relative Density (DeR)} = \frac{\text{Density of Species}}{\text{Total Density of all Species}} \times 100$$

$$\text{Relative Abundance (AbR)} = \frac{\text{Abundance of Species}}{\text{Total Abundance of all Species}} \times 100$$

$$\text{Importance Value Index (IVI)} = \text{FrR} + \text{DeR} + \text{AbR}$$

$$\text{Family Value Index (FVI)} = \text{Sum of IVI of all species in each family}$$

3. Results

3.1. Weed Species Distribution in Maize Farms

A total of 484 plants belonging to 68 species and 22 families were sampled from the maize farms (Table 1). The species with highest Fr), DeR and AbR were *Commelina benghalensis* (0.55)*, Synederela nodiflora* (8.47) and *Setera babarta* (10.94) respectively. Furthermore, *S. babarta* had the highest IVI (18.84; Figure 1). The FVI were highest in Poaceae (114.22) and least in Fabaceae, Malvaceae, Scrophulariaceae and Caryophylaceae (1.41; Figure 2), respectively.

3.2. Weed Species Distribution in Cassava Farms

A total of 555 plants belonging to 41 species and 14 families were sampled in cassava farms (Table 2). *Tridax procumbens* had the highest FrR, (13.89), DeR (42.34), AbR (15.98), IVI (72.22; Figure 3), while Asteraceae had the highest FVI (129.78; Figure 4). The most abundant species include: *T. procumbens, Vernoria cinerea, Bracharia lata, Tephrosia braceteolata,* respectively.

Table 1. Weeds found in maize farms.

S/N	Scientific Name	Family	Number of Plot Occurrence	Number of Individual Per Species
1	*Ageratum conyzoides*	Asteraceae	3	7
2	*Amaranthus spinosus*	Amaranthaceae	1	3
3	*Andropogon gayanus*	Poaceae	1	6
4	*Aneilema beniniense*	Commelinaceae	1	4
5	*Axonopus compressus*	Poaceae	1	7
6	*Boerhavia diffusa*	Nyctaginaceae	1	2
7	*Boerhavia erecta*	Nyctaginaceae	2	9
8	*Brachiara deflexa*	Poaceae	1	4
9	*Brachiara falcifera*	Poaceae	1	3
10	*Brachiaria lata*	Poaceae	2	9
11	*Calopogonium mucunoides*	Fabaceae	1	1
12	*Celosia isertii*	Amaranthaceae	1	3
13	*Cenchrus biflorus*	Poaceae	1	1
14	*Chloris pilosa*	Poaceae	1	8
15	*Cleome viscosa*	Cleomaceae	6	26
16	*Commelina benghalensis*	Commelinaceae	11	36
17	*Cynodon dictylon*	Poaceae	1	10
18	*Cyperus iria*	Cyperaceae	1	1
19	*Cyperus esculentus*	Cyperaceae	3	12
20	*Cyperus rotundus*	Cyperaceae	1	2
21	*Dactyloctenium aegyptium*	Poaceae	1	4
22	*Desmodium scorpiurus*	Fabaceae	1	1
23	*Desmodium velutinum*	Fabaceae	1	8
24	*Digitaria horizontalis*	Poaceae	1	6
25	*Digitaria longiflora*	Poaceae	1	13
26	*Digitaria nuda*	Poaceae	1	3
27	*Digiteria horizontalis*	Poaceae	1	1
28	*Eleusine indica*	Poaceae	3	13
29	*Eragrostis tenella*	Poaceae	1	17
30	*Eragrostis tremula*	Poaceae	1	1
31	*Euphorbia heterophylla*	Euphorbiaceae	6	31
32	*Euphorbia hirta*	Euphorbiaceae	4	17
33	*Euphorbia hyssopifolia*	Euphorbiaceae	2	9
34	*Gompherna celosioides*	Amaranthaceae	1	1
35	*Imperata cylindrica*	Poaceae	1	1
36	*Ipomoea involucrata*	Convolvulaceae	1	2
37	*Ipomoea vagans*	Convolvulaceae	1	1
38	*Kyllinga pumila*	Cyperaceae	1	3
39	*Laportea aestuans*	Urticaceae	3	4
40	*Mariscus flabelliformis*	Cyperaceae	2	8
41	*Merremia aegyptia*	Convolvulaceae	1	1
42	*Oldenlandia herbaceae*	Rubiaceae	1	1
43	*Oplismenus burmannii*	Poaceae	1	3
44	*Paspalum scrobiculatum*	Poaceae	1	2
45	*Pennisetum pedicellatum*	Poaceae	1	6
46	*Pentodon pentandrus*	Rubiaceae	2	12
47	*Perotis indica*	Poaceae	1	6
48	*Phyllanthus amarus*	Euphorbiaceae	1	10
49	*Physalis angulate*	Solanaceae	1	1
50	*Physalis micrantha*	Solanaceae	1	2
51	*Platostoma africanum*	Lamiaceae	1	2
52	*Polycarpaea corymbosa*	Caryophyllaceae	1	1
53	*Portulaca quadrifida*	Portulacaceae	1	14
54	*Rottboellia cochinchinensis*	Poaceae	3	5
55	*Schwenckia amaricana*	Solanaceae	1	1
56	*Scoparia dulcis*	Scrophulariaceae	1	1
57	*Setara barbata*	Poaceae	1	34
58	*Setaria pumilia*	Poaceae	1	9
59	*Spermacoce verticillata*	Rubiaceae	1	7
60	*Spigelia anthelmia*	Loganiaceae	2	7

S/N	Scientific Name	Family	Number of Plot Occurrence	Number of Individual Per Species
61	*Sporobolus pyramidalis*	Poaceae	2	4
62	*Stachytarpheta cayennensis*	Verbenaceae	1	3
63	*Synedrella nodiflora*	Asteraceae	2	41
64	*Tridax procumbens*	Asteraceae	6	4
65	*Triumfetta rhomboidea*	Tilliaceae	1	2
66	*Urena lobata*	Malvaceae	1	1
67	*Vernonia cinerea*	Asteraceae	1	3
68	*Zornia latifolia*	Papilionoideae	1	3

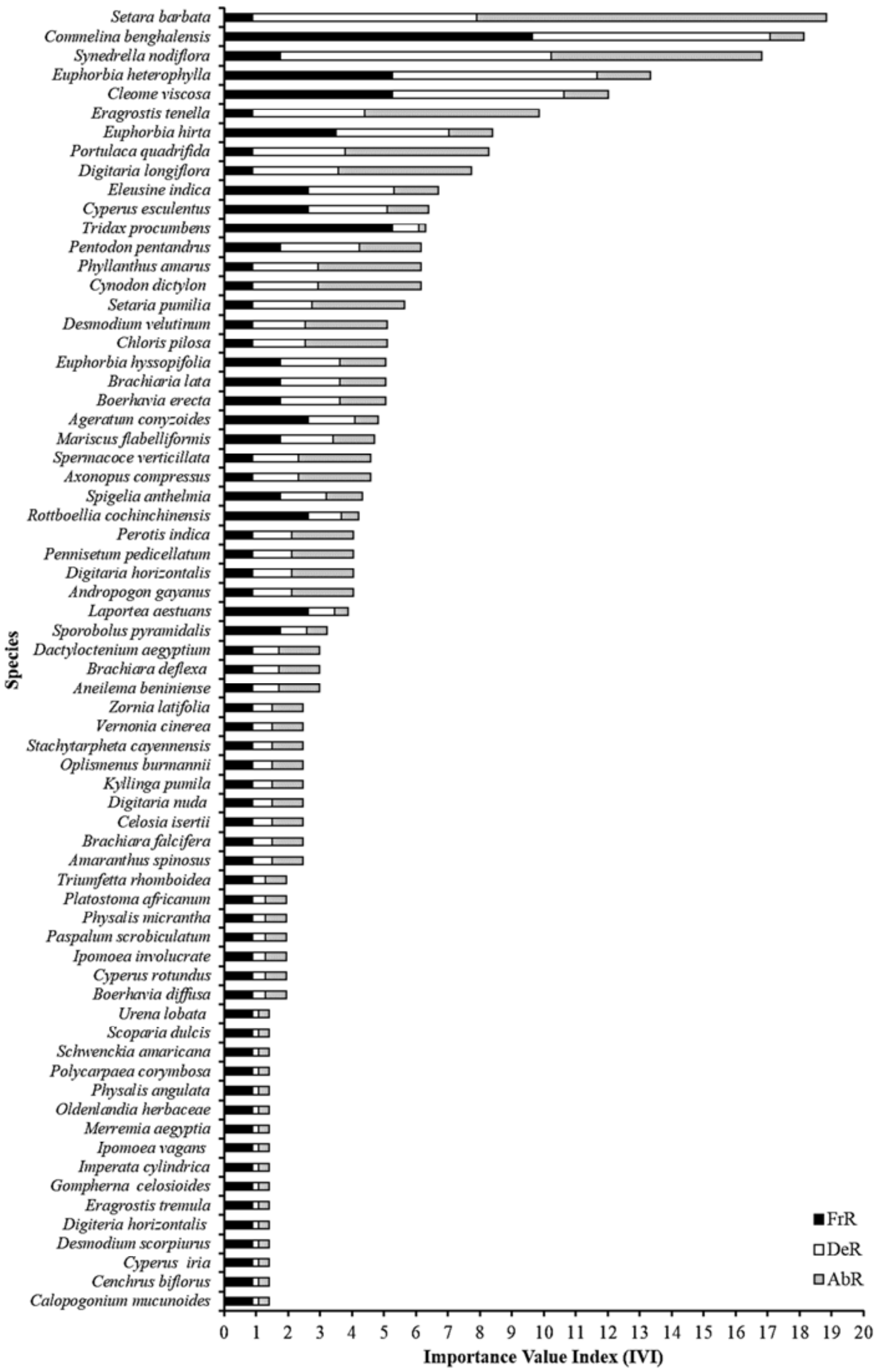

Figure 1. Relative Frequency (FrR), Relative Density (DeR) and Relative Abundance (AbR) of 68 weed species collected in maize farms in Joseph Sarwuan Tarka University Makurdi, Nigeria 2019.

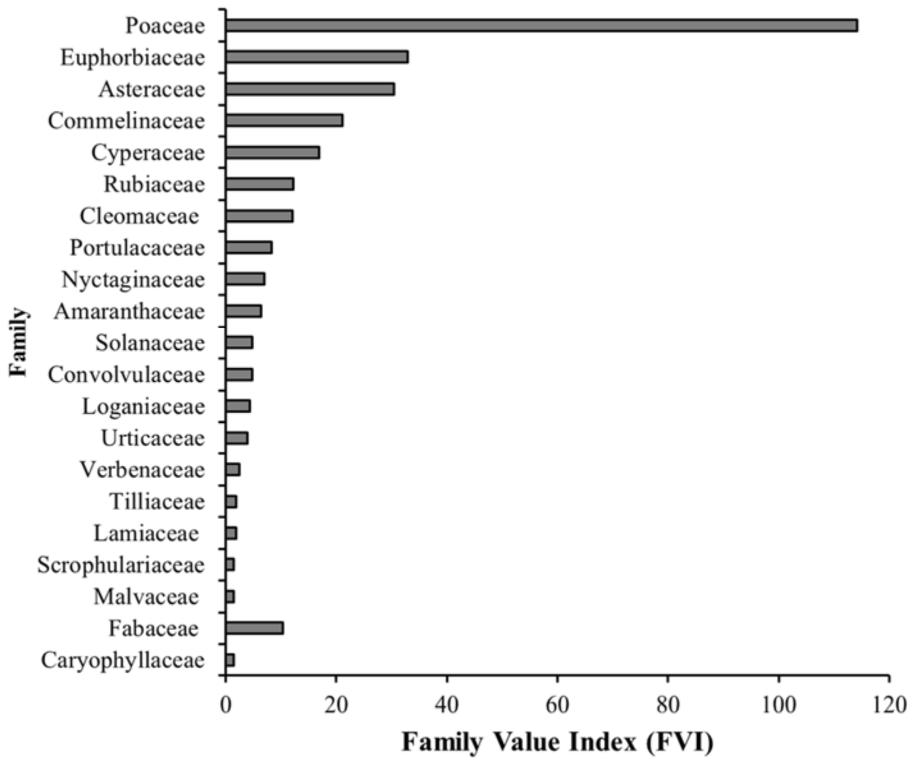

Figure 2. Family Value Index of weed species collected in maize Farms Markurdi, 2019.

Figure 2. Family Value Index (FVI) of 22 weed families sampled in maize farms in Joseph Sarwuan Tarka University Makurdi, Nigeria 2019.

Table 2. Weeds found in cassava farms.

S/N	Scientific Name	Family	Number of plot occurrence	Number of Individual per species
1	*Ageratum conyzoides*	Asteraceae	1	2
2	*Andropogon gayanus*	Poaceae	2	8
3	*Andropogon tectorum*	Poaceae	1	1
4	*Bracharia lata*	Poaceae	8	57
5	*Calopogonium mucunoides*	Fabaceae	2	3
6	*Cleome viscosa*	Cleomaceae	2	4
7	*Crotalaria retusa*	Fabaceae	4	4
8	*Cyperus esculentus*	Cyperaceae	2	4
9	*Desmodium scorpiurus*	Fabaceae	1	2
10	*Desmodium tortuosum*	Fabaceae	1	1
11	*Digitaria horizontalis*	Poaceae	1	4
12	*Digitaria nuda*	Poaceae	1	1
13	*Diodia sarmentosa*	Rebiaceae	3	4
14	*Euphorbia heterophylla*	Euphorbiaceae	3	6
15	*Euphorbia hirta*	Euphorbiaceae	3	5
16	*Euphorbia hyssopifolia*	Euphorbiaceae	4	5
17	*Fluggea virosa*	Phyllanthaceae	1	1
18	*Gliricidia sepium*	Fabaceae	1	1
19	*Hibiscus asper*	Malvaceae	2	3
20	*Imperata cylindrica*	Poaceae	1	1
21	*Indigofera hirsuta*	Fabaceae	1	2
22	*Kyllinga pumila*	Cyperaceae	1	1
23	*Mariscus flabelliformis*	Cyperaceae	1	2
24	*Mitracarpus villosus*	Rubiaceae	1	2
25	*Momordica charantia*	Cucurbitaceae	1	1
26	*Oldenlandia corymbosa*	Rubiaceae	1	1
27	*Oplismenus burmannii*	Poaceae	1	2
28	*Paspalum scrobiculatum*	Poaceae	1	1
29	*Pennisetum pedicellatum*	Poaceae	3	5
30	*Pentodon pentandrus*	Rubiaceae	2	2
31	*Physalis angulata*	Solonaceae	1	1

S/N	Scientific Name	Family	Number of plot occurrence	Number of Individual per species
32	*Rottboellia cochinchinensis*	Poaceae	2	3
33	*Schwenckia Americana*	Solanaceae	1	2
34	*Setaria pumila*	Poaceae	2	5
35	*Sida linifolia*	Malvaceae	5	7
36	*Spigelia anthelmia*	Loganiaceae	3	8
37	*Striga hermonthtica*	Scrophulariaceae	1	1
38	*Synedrella nodiflora*	Asteraceae	2	6
39	*Tephrosia braceteolata*	Fabaceae	7	11
40	*Tridax procumbens*	Asteraceae	15	235
41	*Vernonia cinerea*	Asteraceae	12	140

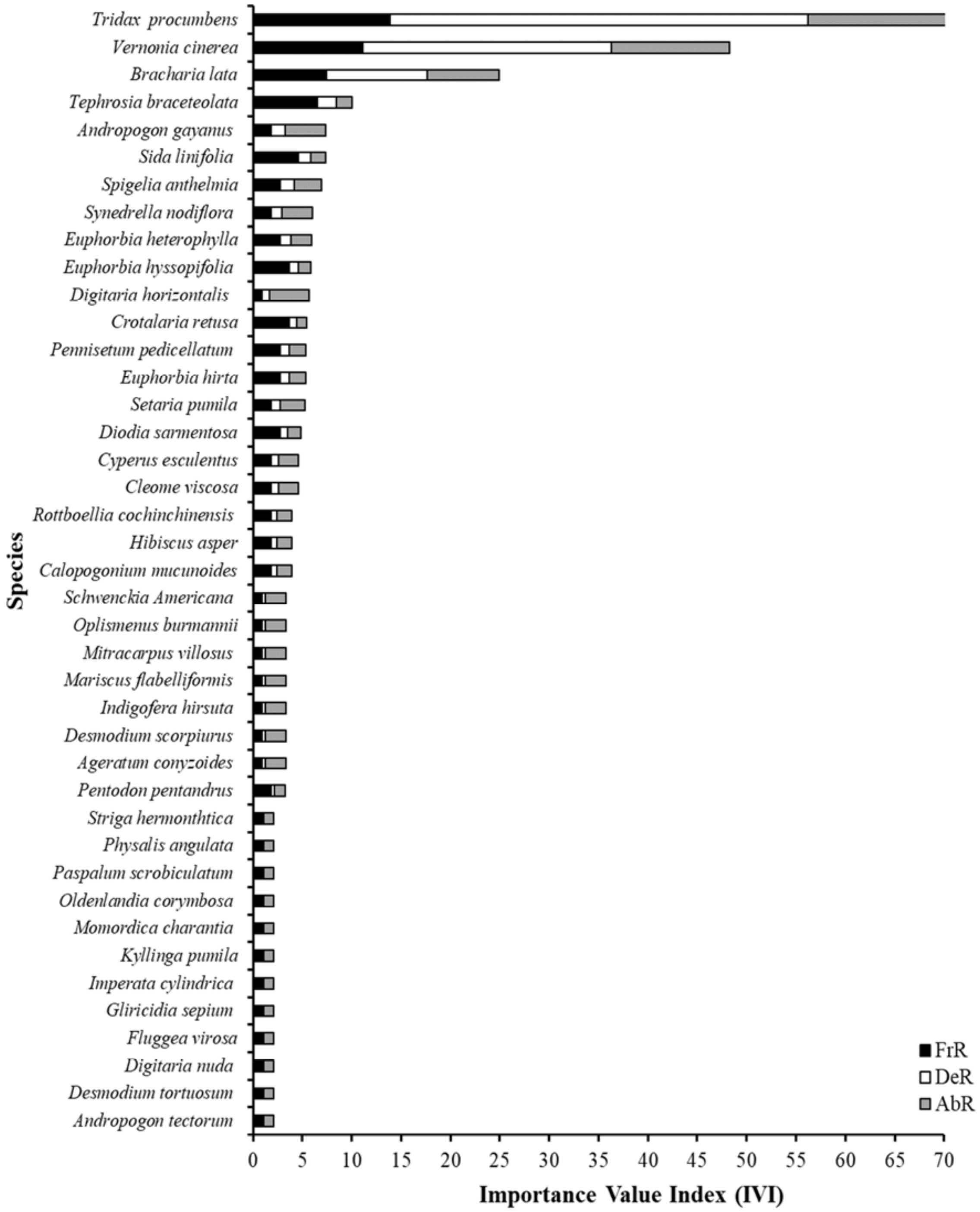

Figure 3. Relative Frequency (FrR), Relative Density (DeR) and Relative Abundance (AbR) of 41 weed species collected in cassava farms in Joseph Sarwuan Tarka University Makurdi, Nigeria 2019.

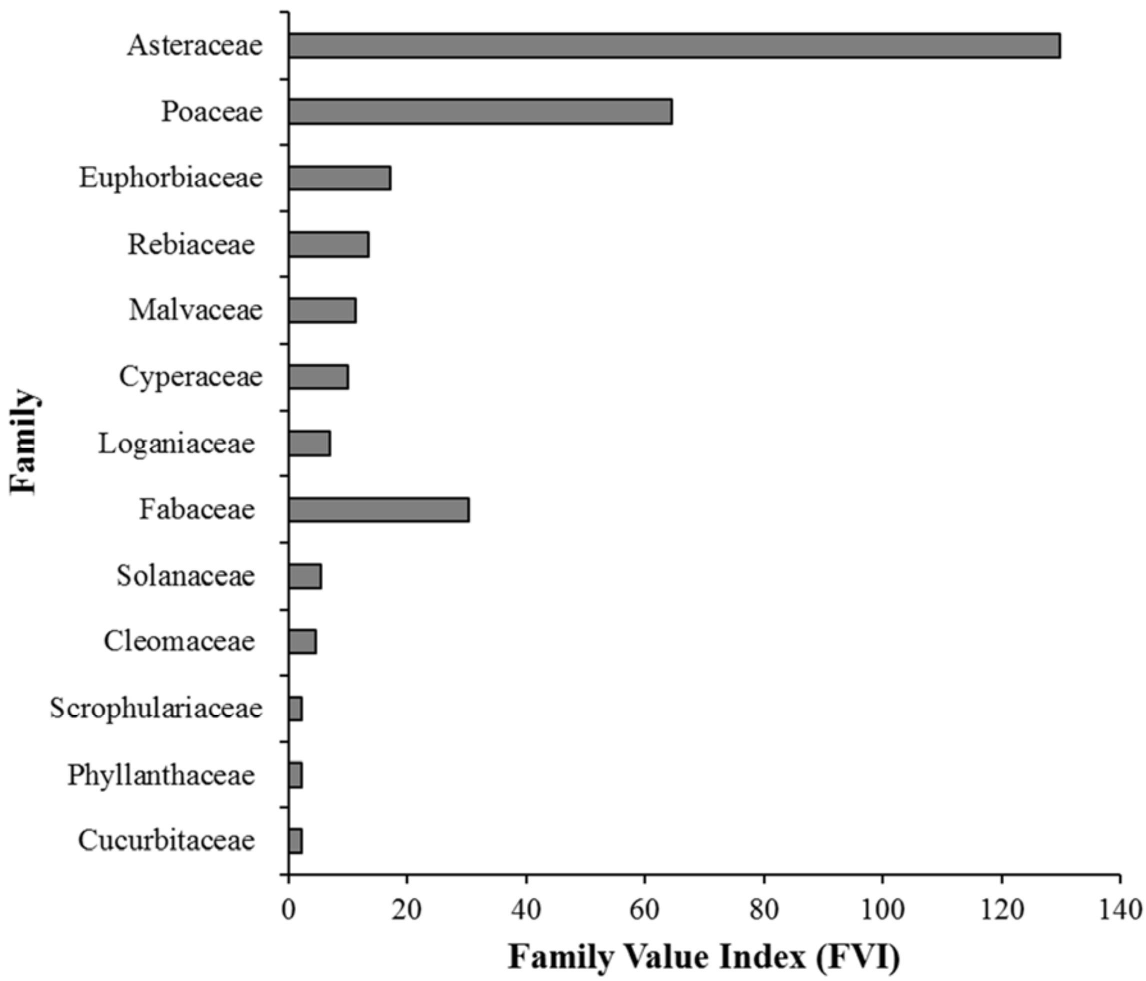

Figure 4. Family Value Index (FVI) of 14 weed families sampled in cassava farms in Joseph Sarwuan Tarka University Makurdi, Nigeria 2019.

4. Discussion

Heavy weed infestations can kill crops, reduce yields by 50% in tropical and temperate regions [5, 34]. In addition, these weed species also produce allelo-chemicals that could have retarded crop growth and further reduced yields or suppressed the growth of other pastures on the farm [3]. Similar results by [30] who reported that species frequency and dominance values are indicative of its economic importance. This suggested that these aggressive weed species are the major social, environmental and economic threats in the study area. Special attention and strategic plan are therefore required for the management of these weed species.

Weed species have been reported to germinate throughout the summer and consequently, late germinating plants are never controlled [3]. Weeds such as *A. hybridus,* and *B. pilosa* produce numerous seeds for the next cropping season resulting in more seeds in the subsequent seasons, as more seeds would be added to those already in the seed bank. More weed seed production, coupled with dormancy, could exacerbate the problem. [32]. *C. benghalensis* produces both aerial and subterranean seeds and also reproduces vegetatively. Manual or mechanical removal of weeds causes detachment of stems and roots at nodes, leading to the growth of more weeds. Consequently, weeding may indirectly multiply the plant, thus control at that stage would be difficult except possibly by use of herbicides. It seemed that continuous tillage in arable lands led to more favorable growth conditions for annual weeds in comparison to perennial weeds [17].

The relative higher score of FVI for Asteraceae and Poaceae recorded were evidently due to the greater number of species and better adaptability under dominant environmental conditions compared to other families. These families are therefore, the most important weeds of small-scale farming in the study area [25]. Noxious weed species in Asteraceae and Poaceae got top rankings than other families, thus highlighting their dominance and diversity in the study area. Variation in the species IVI and FVI in both farms suggested the possible ecological effects (shade, competitive ability) on the pastures by the individual crops in the farm.

5. Conclusion

The present weed survey cannot be assumed to be extensive and complete, but the identified species represent a sufficient sample size to serve as basic information on weed as current problems of farming system in the study area. Information about weed composition and abundance could be beneficial in the selection of essential weed management methods and necessary to sufficiently describe the relative ranking of weeds. Large scale extensive field studies are hereby necessary to comprehensively quantify the abundance, dominance and diversity of weeds in the study area.

References

[1] Adigun, J., Osipitan, A. O., Lagoke, S. T.., Adeyemi, R. O., and Afolami, S. O. (2014). Growth and yield performance of cowpea (*Vigna unguiculata* (L) Walp) as influenced by row-spacing and period of weed interference in South-west Nigeria. *Journal of Agricultural science*, 6, (4), 188 – 198. https://doi.org/10.5539/jas.v6n4p188

[2] Akobundu, I. O. (1980). Weed Control Strategies for Multiple Cropping System of the Humid and Sub-humid Tropics. In: Weeds and their Control in the Humid and Sub-humid Tropics: Proceedings of a Conference held at the IITA, Ibadan Nigeria, 3-7 July 1978, edited by I. O. Akobundu, Ibadan IITA, *Weed Science Society of Nigeria* pp 80-95.

[3] Arpana, M. (2013). *Parthenium hysterophorus*: A noxious weed for plant diversity. *International Journal of Scientific Research,* 2 (9): 2277-8179.

[4] Avav, T. (2000). Control of spear grass (*Imperata cylindrica* (L) Raeuschel) with glyphosate and fluazifop-butyl for soybean (Glycine max (L) Merr) production in the savannah zone of Nigeria. *Journal of Science, Food and Agriculture*, 80, 193-196.

[5] Belachew, K. and Tessema, T. (2015). Assessment of weed flora composition in parthenium (*Parthenium hysterophorus L.*) infested area of east Shewa Zone, Ethiopia. Malaysian *Journal of Medical and Biological Research, 2*: 63-70.

[6] Chikoye, D., Ekeleme, F., and Udensi, U. E. (2001). Cogon grass suppression by intercropping cover crops in corn/cassava systems. *Weed Science*., 49, 658-667.

[7] Chikoye, D., Lum, A. F., Abaidoo, R., Menkir, A., Ekeleme, F., and Sanginga, N. (2008). Response of corn genotypes to weed interference and nitrogen in Nigeria. *Weed Science*, *56* (3), 424-433.

[8] Chikoye, D., Schulz, S., and Ekeleme, F. (2004). Evaluation of integrated weed management practices for maize in the northern Guinea savanna of Nigeria. *Crop protection*, *23* (10), 895-900.

[9] Das, A., Kumar, M., Ramkrushna, G. I., Patel, D. P., Layek, J., Naropongla Panwar, A. S., and Ngachan, S. V. (2016). Weed management in maize under rainfed organic farming system. *Indian Journal of Weed Science,* 48 (2): 168–172.

[10] Ekeleme F., Atser, G., Dixon, A., Hauser, S., Chikoye, D., Olorunmaiye, P. M., Sokoya, G., Alfred, J., Okwusi, M. C., Korieocha, D. S., Olojede, A. O., Ayankanmi, T., and Lagoke, S. T. O. (2019). Assessment of Weeds of Cassava and Farmers' Management Practices in Nigeria. *Tropicultura* DOI: 10.25518/2295-8010.586

[11] Enete, A. A., Nweke F. I., Achike, I., and Tollens, E. (2001). Differentiated gender ownership of cassava fields and implications for root yield variations in small holder Agriculture of Southeast Nigeria. *Tropicultura.*

[12] Fadayomi, O., and Olofintoye, J. A. (2005). Weed control in cowpea (*Vigna unguiculata* (L) Walp) with imidazolinone herbicide mixtures. *Journal of Agriculture. Resource and Development. 4 (2): 104 –121.*

[13] Fongod, A. N. (2004). Taxonomy and ecology of weeds in banana production systems in South Western Cameroon., University of Buea, Cameroon (Ph.D. Thesis). In English with English abstract.

[14] Fried, G., Norton, L. R., and Reboud, X. (2008). Environmental and management factors determining weed species composition and diversity in France. *Agriculture, Ecosystems and Environment*, 128: 68–76.

[15] Głowacka, A. (2011). Dominant weeds in maize (*Zea mays* L.) cultivation and their competitiveness under conditions of various methods of weed control. *Acta Agrobotanica*, 64, (2), 119-126.

[16] Gualbert, G. (2013). Guidance on weed issues and assessment of noxious weeds in a context of harmonized legislation for production of certified seeds. *FAOUN Rome*, p. 39.

[17] Hassannejad, S., and Ghafarbi, S. P. (2012). Introducing new indices for weed flora studies. *International Journal of Agriculture and Crop Sciences (IJACS)*, *4* (22), 1653-1659.

[18] Howeler, R. H. (2007). Agronomy practices for sustainable cassava production, Cassava Research and Development in Asia: Exploring new opportunities for an ancient crop, in: R. H. Howeler (Editor) Proceedings of the Regional Workshop held in Bangkok, Thailand, Oct. 28-Nov.1, 2002.

[19] Mashingaidze, A. B., Nyakanda, C., Chivinge, O. A., Mwashaireni, A., and Dube, K. W. (2000). Influence of a maize-pumpkin live mulch on weed dynamics and maize yield. *African Plant Protection* 6 (1): 57-63.

[20] Mc Neely, J. A., Mooney, A. H., Scheip, E. L., and Waage, K. J. (2001). A Global strategy on Invasive Alien species, IUCN Gland Switzerland and Cambridge, UK, in collaboration with GISP P 50.

[21] Melifonwu, A. A. (1994). Weeds and their control in cassava. *African Journal of Crop Science*, 2, 4, 519-530.

[22] Mkamilo, G. S. (2004). *Maize-sesame intercropping in Southeast Tanzania: Farmers' practices and perceptions, and intercrop performance* (No. 54). Wageningen University and Research Centre.

[23] Mueller-Dombois, D. and Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York, 547 p.

[24] Mukhtar, A. M., Eltahir, S. A., Siraj, O. M., and Hamada, A. A. (2007). Effect of weeds on growth and yield of maize (*Zea mays* L.) in Northern State, Sudan. *Sudan Journal of Agricultural Research*, 8: 1-7.

[25] Ndam, L. M., Enang, J. E., Mih, A. M., and Egbe, A. E. (2014). Weed diversity in maize (*Zea mays* L.) fields in South Western Cameroon. *International Journal of Current Microbiology and Applied Sciences,* 3: 173180.

[26] Ņečajeva, J., Mintāle, Z., Dudele, I., Isoda-Krasovska, A., Čūrišķe, J., Rancāns, K., Kauliņa I., Morozova, O., and Spuriņa, L. (2015). Factors influencing weed species diversity in southeastern part of Latvia: analysis of a two-year weed survey data. *Acta Biologica Universitatis Daugavpiliensis* 15 (1): 147 – 156.

[27] Nyakanda, C., Mashingaidze, A. B., and Kurambwa, C. (1995). Effects of maize groundnut inter- and intra-row spatial arrangements on yield and weed pressure. *Transactions of the Zimbabwe Scientific Association,* 69: 20-23.

[28] Olorunmaiye, P. M., Egberongbe, K. R., Adeoye, P. O., Alamu, O. O., and Taiwo, S., (2011). Weed species composition of citrus-based cropping systems at National Horticultural Research Institute Ibadan, Nigeria. *Agriculture and Biology Journal North America*, 2, 529-537.

[29] Olorunmaiye, P. M., Lagoke, S. T. O., Adigun, J. A., and Orija, O. R. (2013). Effect of intercropping with maize on weed diversity in cassava. *Environmental and experimental Biology* 11: 189 – 193.

[30] Roger, N. M., Owen, D. K., and Swanton, C. J. (2015). Weed Abundance, Distribution, Diversity, and Community Analyses. *Weed Science, 63*:64-90.

[31] Shad, R. A., Chatha, M. Q., and Nawaz, H. (1993). Weed management studies in maize. *Pakistan Journal of Agricultural Research*, *14* (1), 44-50.

[32] Sintayehu, A. (2019). Weed flora survey in field crops of Northwestern Ethiopia. *African Journal of Agricultural Research,* 14 (16), pp. 749-758, DOI: 10.5897/AJAR2019.13947

[33] Survey Report (2004). Cassava: A survey on cassava production, processing and marketing. 147pp.

[34] Tena, E., Hiwet, A. G., and Dejene, M. (2012). Quantitative and Qualitative Determination of Weeds in Cotton-Growing Areas of Humera and Metema, Northwestern Ethiopia. *Ethiopian Journal of Applied Science Technology, 3* (1): 57-69.

[35] Tominaga, T., and Yamasue, Y. (2004). Crop-Associated Weeds, pp 47-63, in: Inderjit (Editor). *Weed Biology and Management.* Springer, Dordrecht, DOI https://doi.org/10.1007/978-94-017-0552-3_3.

[36] Udensi E. U., Akobundu I. O., Ayeni A. O., and Chikoye, D. (1999). Management of cogon grass (*Imperata cylindrica*) using velvet bean (*Mucuna pruriens var. utilis*) and herbicides. *Weed Technology*, 13, 201-208.