International Journal of Science and Technology Research Archive

ISSN: 0799-6632 (Online)

Journal homepage: https://sciresjournals.com/ijstra/

(RESEARCH ARTICLE)

Check for updates

Multi-cropping practice: Means to sustainable agriculture in the high humid rainforest agroecology of Southern Nigeria

Chinedum A Ogazie *, Edache B Ochekwu, Ikechukwu O Agbagwa and Ifeoma G Ugiomoh

Department of Plant Science and Biotechnology, Faculty of Science, University of Port Harcourt, Nigeria.

International Journal of Science and Technology Research Archive, 2022, 03(01), 066–090

Publication history: Received on 08 June 2022; revised on 23 July 2022; accepted on 27 July 2022

Article DOI: https://doi.org/10.53771/ijstra.2022.3.1.0066

Abstract

Agricultural crop production systems are constantly evaluated to measure its impact on the crop producer, soil, crops and the environment. Hence this investigation was carried out to examine the place of multicropping practice in the drive for sustainable agricultural production in the high humid rainforest agroecology of southern Nigeria. Multicropping allows crop producer to plant two or more crops at a time on the same piece of arable farmland. This practice offers some benefits to crop producer's resilience, harvest more crop species, income, community and soil quality improvement due to various dead plants and animals parts, nutrients balance due to planting shallow and deep rooted crops; and environmental biodiversity. Our findings revealed multicropping as a practice which offers hope to crop producer with more crops harvested throughout the cropping season, extra income and rich dietary intake of the community. It provides effective pests and diseases control of crops due to crop mix and canopy formation of crops, ameliorate soil physicochemical properties and biodiverse of the environment and act as carbon sink.

Keywords: Multicropping; Biodiversity; Dietary intake; Sustainable; Pests and diseases

1 Introduction

Unarguable, agriculture is the foremost occupation of many developed and developing economics of the world even before and after the break through in industrial revolution of the eighteenth century. In the more advanced agricultural production systems, less than 5 % of its populations engage in agricultural production while in less developed countries about two-third engage in agricultural production [1].

The adoption of any agricultural farming systems practices in any region of the world are often times determined by some essential factors for example climate, soil types, vegetation, availability of water either rain fed or irrigation, sources of planting materials either from the wild or domesticated, consumption pattern of the people or taste, market/economic and the social life of the people in the region [2] [3]. All these factors and many more determine the crops species suitable in a given region. It is therefore very imperative for crop producers to look at which of the farming systems practices more favorably disposed to crop species/types production which offer protection to the soil from degradation, provide room for food security, improve the livelihood of the producer, reduces pests and diseases, enable the producer to manage the soil with little or no risk to biodiversity and the environment [4].

Agriculture has contributed to the development of most sub-Saharan countries that solely depended on agriculture to earn foreign exchange in the past before the now. Nigeria for example, before the discovery of oil in the late 1950s had a substantial income from the export of agricultural produce. With this, the then regional governments of the North, West, East and Mid-West were able to concentrate on developing crops species which had comparative advantage over the other regions.

* Corresponding author: Chinedum A Ogazie
Department of Plant Science and Biotechnology, Faculty of Science, University of Port Harcourt, Nigeria.

A lot of incentives and encouragement were given to individual or farmers' groups and cooperatives. Crop producers were proud to be called farmers because they were important and accorded respect based on the amount of farmland cultivated, crop species produced yearly and the amount of income accrued from such farm produce sales. They were further supported by the government through motivated polices and establishment of marketing boards to buy off the excess crop species paying the appropriate prices for each of crop species produced for internal consumption and export to earn foreign exchange [5].

However, the discovery of oil changed the narratives and up till today, Nigeria as a nation is still struggling to manage and coordinate the agricultural sector towards increase in food production to feed its growing population. The population of Nigeria now four times from what it was before oil discovery in 1950s. Hence the demand for food stuffs has increased so much that we have resorted to importing food items ordinarily which we can produce to meet up with the short fall from local crop production which has been declining ever since due to so many factors which include climate change, lack of fertilizer, pesticides, farm equipment, incentives to farmers all these were further compounded with insecurity in the country as a whole in the last 10 years [6] [7].

In the early days of agricultural food crops and tree crops plantation systems, the practice were mostly slash and burn (shifting cultivation) and the bush fallow system was between 5 – 10 years or even more in most cases for a piece of land to recover from use after crop yield declined.

But this trend has changed due to population explosion, provision of infrastructural facilities such as housing provisions, schools, health care facilities, roads construction, sporting complex and railway lines which caused serious reduction on the available arable farmlands for agricultural purposes [8] [9].

The impact from climate change caused by the increase of greenhouse gas accumulation due to anthropogenic activities and those from natural sources have impose it on man to search for a more sustainable approach towards the agroecosystems and the environment in general [10].

The climate of a place and soil determines to some extent the agricultural practices to adapt, the crop species to plant and the methods of land preparations that would protect the soil from being degraded, washed away by water and wind erosion, reduced interference of pests competing with crops [12].

Due to climate change, increasing population, degradation of the soil, increase in poverty level, crop yield decline, lack of water, reduction of available arable crop farmlands and increase in the demand of crop species as food items has initiated the consideration of a more purposeful crop production practice of which multicropping has been considered as a sustainable agricultural practice that can reduce the impact on the soil, crop species yield decline, farmer and the environment.

This investigation of multicropping practice, means to sustainable agriculture in the high humid rainforest agroecology of Southern Nigeria, shall be examined based on the wet and dry cropping season scenario:(i) weeds species associated with multicropping practice in arable crop farmland, (ii) weed seedling size and composition of soil weed seed bank (iii) the differences and similarities between arable weeds and soil weed seed bank seedlings (iv) crops species associated with multicropping in the study area and (v) soil physicochemical properties in active farmlands and fallow control.

2 Material and methods

This study was carried out in the University of Port Harcourt and its environs, which lies on Latitude and Longitude coordinates: of 4.824167 and 7.033611 and with a GPS readings of 4º 46´38.71" N and 7º.00´48.24" E. The study area experiences (wet) rainy and dry seasons respectively. Rainy season starts from April into October, with one or more intermittent rains during the dry season from November to March. However, the magnitude of rainfall varies within the rainy season, and its distribution is nearly all the year round in high humid rainforest agroecology of Southern Nigeria. The widely adapted farming systems is cultural land clearing practices which are slash, burn and make mounds/ridges on continuously cultivated multicropping. Crop species are mostly annual crops with a few perennials crops and shrubby vegetables which grow beyond 12 months. This study was carried out in June 2020 as wet/rainy and in January 2021 as dry seasons respectively and data was collected for both seasons.

2.1 Arable weeds and soil weed seed bank study

Reconnaissance survey methods of [13], [14], added to diagonals walk through and on the spot assessments were used to evaluate weeds in the 22 newly cropped arable farmland. The weed species were identified using [15] [16] [17] [18].

The difficult weed species were collected and sent to the herbarium of University of Port Harcourt, Nigeria for proper identification, confirmation and documentation.

In the soil seed bank study, 4 augers of soils at 0-5, 5-10 and 10-15cm depth were collected from each of the 22 farmlands for soil weed seed bank; and for physicochemical analyses were air dried and composite samples was taken. Soil weed seed bank study in the greenhouse, individual sample arranged according to depths and watered as at when water is needed. Weeds seedlings in the greenhouse soils were identified and counted right there in the greenhouse on a weekly interval for 12 weeks. The soils were turned at 4 and 8 weeks to give equal opportunity for every weed seed in soil to germinate, and difficult seedling transferred to another pot with humus soil, labeled and allowed to grow for proper identification with [15]; [16]; [17]; [18].

2.2 Popular crop species of choice

The most planted crops species are corn (*Zea mays* L.); cassava (*Manihot esculenta* Crantz); okra (*Abelmoschus esculentus* (L) Moench; pumpkin (*Telfairia occidentalis* Hook. f.; cocoyam (*Xanthosoma mafaffa*) Schott; yam (*Dioscorea rotundata* Poir); plantain (*Musa paradisiac* L.; bitter leaf (*Vernonia amygdalina* Delile); water leaf (*Talinum triangulare* (Jacq).Willd.; cucumber (*Cucumis sativus* L.).

2.3 Soil sampling and preparation for physicochemical analysis

Four auger borings of soils per farmland to a depth of 0-5, 5-10 and 10-15cm were collected from 22 cultivated and three fallow farm lands in June 2020 and January 2021 for wet and dry season respectively and properly labeled, were bulked to obtain one composite soil per farmer, air dried in the laboratory, processed with sieve size of 2.0mm for analyses in the laboratory.

The pH soils were prepared in 1:1 soil-water ratio method and measured with EQUIP-TRONICS digital pH meter with model number EQ-610. Nitrogen (N) was estimated by titration of distillation after Kjeldahl readiness tests and examination [19].

Total P in the soil was measured with the perchloric corrosive albimilation strategy technique by [20]. The available Phosphorus (P) of course was analyzed by using molybdenum blue colorimetry [21].

Soil organic matter (SOM) was measured with the potassium dichromate oxidation external heating method. Soil particle size determination was carried out using the hydrometer method as described by [22] and then measured with a standard hydrometer, ASTM No.1. 152H-type with Bouyoucos scale in g $^{L-1.}$

Sand, silt and clay determination, basic procedure was followed (dry basis and is generally reproducible to within ± 8% [22]. Exchangeable cations were extracted from the soil using an extracting solution (1 N NH4OAc) at pH 7.0. Extracted solutions are then analyzed by AA (atomic absorption) for the soil cations [23] [24]. The contents were then in 1/20 dilution (sample/distilled water) soil digests were measured by reading their absorbance on a UNICAM 969 Atomic Absorption Spectrophotometer at 766.5, 422.7 and 285.2 nm respectively.

Sodium (Na) content in 1/20 diluted sample were determined by reading the absorbance at 248.3 nm [25] Exchangeable acidity (H^{++} Al^{3+}) in the soil was extracted with 1M KCl [23]. The solution of the extract was titrated with 0.05M NaOH to a permanent pink end point using phenolphthalein as indicator.

The amount of base (NaOH) used is equivalent to the total amount of exchangeable acidity (H^{+}+Al^{3+}) in the aliquot taken [26]. The addition of both total sum of exchangeable bases (Ca^{2+} + Mg^{2++} K^{+} +Na^{+}) and total exchangeable acidity (H^{+} + Al^{3+}) gave the effective cation exchangeable capacity (ECEC) [27].

The available Cupper (Cu) content was extracted and determined through this method Na-EDTA [28] and the extract filtered in a Waltman No.1 filter paper and amount of Cu clear aliquot part analyzed by means of a Perkin Elmer 3100 atomic absorption spectrometer. The determination of metal in the filtrate of digested soil samples were performed using Buck Model 205 flame Atomic absorption Spectrophotometer.

2.4 Data collection and analysis

The data collected from soil weed seed bank study and from the soil physicochemical analysis were subjected two-way analysis of variance(ANOVA) to compare differences between wet and dry , wet, dry and controls using Paleontological statistics Package (Past) Version 3.16; XLSTAT version 2014 and Statistical Package for Social Sciences (SPSS) version 22. Means were compared using a threshold of ($p<0.05$) to determine statistical significance.

3 Results

3.1 Weeds of arable cropped farmlands and soil weed seed bank seedlings

Weeds identified in all the cropped arable farmlands and the weed seedlings from the soil weed seed bank studies in wet and dry seasons are presented in Table 1. The weeds were classified into families and life forms of annual broad leaves, annual grasses, perennial broad leaves, perennial grasses, sedges, not classified and others like *Selaginella* sp.

Table 1 List of weed species identified in arable cropped farmlands and soil seedbank in wet and dry seasons respectively

Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Euphorbiaceae	*Acalypha ciliata* Forsk	+	+	-	+	Abl
Poaceae	*Acroceras zizanioides* Dandy	-	+	-	-	Pg
Mimosoideae	*Aeschynomene sp*.	+	+	-	-	Abl
Asteraceae	*Ageratum conyzoides* Linn	+	+	-	+	Abl
Amaranthaceae	*Alternanthera bettzickiana* (Ragel) Nicholson	+	+	-	+	Abl
Amaranthaceae	*Alternanthera sessilis* (Linn.) R.Br. ex Roth	+	+	-	+	Abl
Amaranthaceae	*Alternanthera sp.*	-	-	-	+	Abl
Amaranthaceae	*Amaranthus hybridus* Linn.	-	+	-	-	Abl
Amaranthaceae	*Amaranthus spinosus* Linn.	-	+	-	-	Abl
Amaranthaceae	*Amaranthus viridis* Linn.	+	+	-	-	Abl
Poaceae	*Andropogon sp.*	-	-	-	+	Pg
Asteraceae	*Aspilia africana* (Pers.) C.D. Adams	+	+	-	+	Abl
Acanthaceae	*Asystasia gangetica* (Linn.) A. Anders.	+	+	+	-	Abl
Poaceae	*Axonopus compressus* (Sw.) P.Beauv.	+	+	+	+	Pg
Rubiaceae	*Borreria sp*.	+	+	+	+	Abl
Poaceae	*Brachiaria deflexa* (Schumach.) C.E. Hubbard ex Robyns	-	+	-	-	Ag
Araceae	*Caladium bicolor* (Ait.) Vent.	-	+	-	-	Pbl
Papilionoideae	*Calopogonium mucunoides* Desv.	+	+	-	-	Abl
Amaranthaceae	*Celosia leptostachya* Benth.	+	+	+	+	Abl
Papilionoideae	*Centrosema pubescens* Benth.	+	+	-	-	Pbl

Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Asteraceae	*Chromoleana odorata* (Linn.) King & Robinson	+	-	-	-	Pbl
Cleomaceae	*Cleome rutidosperma* DC.	+	-	+	+	Abl
Lamiaceae	*Clerodendrum sp*.	+	-	-	-	Pbl
Araceae	*Colocasia esculenta* (Linn.) Schott	+	-	-	-	Pbl
Commelinaceae	*Commelina diffusa Burm*. f. subsp. *diffusa* J.K. Morton	-	+	-	-	Pbl
Commelinaceae	*Commelina diffusa* Burm.f.	+	-	-	-	Pbl
Commelinaceae	*Commelina erecta* Linn.	+	+	-	-	Pbl
Commelinaceae	*Commelina erecta* subsp. *erecta* R.Br.	-	+	-	-	Pbl
Commelinaceae	*Commelina thomasii*	-	+	-	-	Pbl
Convolvulaceae	Convolvulaceae unidentified	+	-	-	-	Abl
Tiliaceae	*Corchorus aestuans* Linn.	+	-	-	-	Abl
Tiliaceae	*Corchorus olitorius* Linn.	-	+	-	-	Abl
Tiliaceae	*Corchorus tridens* Linn.	-	+	-	-	Abl
Zingiberaceae	*Costus afer* Ker-Gawl.	-	+	-	-	Pbl
Euphorbiaceae	*Croton hirtus* L'Hérit.	+	+	+	+	Abl
Euphorbiaceae	*Croton lobatus* Linn.	+	+	-	-	Abl
Acanthaceae	*Cyathula prostrata* (Linn.) Blum	+	+	+	+	Abl
Poaceae	*Cynodon dactylon* (Linn.) Pers.	+	+	+	+	Pg
Cyperaceae	*Cyperus compressus* Linn.	+	+	-	-	Ps
Cyperaceae	*Cyperus distans* Linn.f.	+	-	-	-	Ps
Cyperaceae	*Cyperus esculentus* Linn.	+	+	-	-	Ps
Cyperaceae	*Cyperus haspan* Linn.	+	+	-	-	Ps
Cyperaceae	*Cyperus iria* Linn.	+	-	-	-	Ps
Cyperaceae	*Cyperus polystachyus* (Rottb.) P.Beauv. *var. polystachyus*	+	-	-	-	Ps
Cyperaceae	*Cyperus pustulatus* Vahl.	-	+	-	-	Ps
Cyperaceae	*Cyperus rotundus* Linn.	+	-	-	-	Ps
Cyperaceae	*Cyperus tuberosus* Rottb.	-	+	-	-	Ps
Poaceae	*Dactyloctenium aegyptium* Willd.	+	-	-	-	Ag
Papilionoideae	*Desmodium triflorum* (Linn.) DC.	+	+	-	-	Pbl

Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Poaceae	*Digitaria horizontalis* Willd.	+	+	+	+	Ag
Poaceae	*Digitaria longiflora* (Ret.) Pers	+	-	-	-	Ag
Rubiaceae	*Diodia sarmentosa* Sw.	+	+	-	-	Pbl
Dioscoreaceae	*Dioscorea sp.*	+	-	-	-	Abl
Caryophyllaceae	*Drymaria cordata* (Linn.) Willd.	-	+	-	-	Abl
Poaceae	*Echinochloa colona* (Linn.) Link	-	+	+	+	Ag
Asteraceae	*Eclipta alba* (Linn.) Hassk.	+	+	-	+	Abl
Poaceae	*Eleusine indica* (Linn.) Gaertn.	+	+	+	+	Ag
Asteraceae	*Eleutheranthera ruderalis* (Sw.) Sch. Bip.	+	+	+	+	Abl
Asteraceae	*Emilia praetermissa* Milne-Redhead	+	+	-	-	Abl
Asteraceae	*Emilia sonchifolia* (Linn.) DC	+	+	-	-	Abl
Poaceae	*Eragrostis tenella* (Linn.) P.Beauv. ex Roem. & Schult	+	+	+	+	Ag
Asteraceae	*Erigeron floribundus* (H.B. & K.) Sch.Bip.	+	-	-	-	Abl
Euphorbiaceae	*Euphorbia heterophylla* Linn.	+	+	-	-	Abl
Euphorbiaceae	*Euphorbia hirta* Linn.	+	+	-	-	Abl
Euphorbiaceae	*Euphorbia hyssopifolia* Linn.	+	+	-	-	Abl
Cyperaceae	*Fimbristylis ferruginea* (Linn.) Vahl	-	+	-	-	Ps
Cyperaceae	*Fimbristylis littoralis Gaudet*	+	+	-	-	Ps
Tiliaceae	*Glyphaea brevis* (Spreng). Monachino	-	+	-	-	Pbl
Acanthaceae	*Gomphrenia celosioides* Mart.	+	+	-	-	Abl
Poaceae	*Grasses*	-	-	-	+	Ncl
Melastomatacea e	*Heterotis rotundifolia* (Sw.) Jac.-Fél.	-	+	+	+	Abl
Papilionoideae	Indigofera *sp.*	-	-	+	-	Abl
Papilionoideae	*Indigofera spicata* Forsk	+	+	-	-	Pbl
Convolvulaceae	*Ipomoea cordatotriloba* Dennst.	-	+	-	-	Abl
Convolvulaceae	*Ipomoea involucrata* P.Beauv.	+	+	-	+	Abl
Cyperaceae	*Kyllinga bulbosa* Beauv.	+	-	-	-	Ps

Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Cyperaceae	*Kyllinga erecta* Schumach.	+	+	-	-	Ps
Cyperaceae	*Kyllinga erecta* Schumach. *var. polyphylla* (Kunth) Hooper	+	+	-	-	Ps
Cyperaceae	*Kyllinga erecta* Schumacher var. *erecta*	+	-	-	-	Ps
Cyperaceae	*Kyllinga pumila* Michx.	+	-	-	-	Ps
Cucurbitaceae	*Lagenaria breviflora* (Benth.) Roberty	+	-	-	-	Abl
Urticaceae	*Laportea aestuans* (Linn.) Chew.	-	+	-	+	Abl
Urticaceae	*Laportea ovalifolia* (Schumach. & Thonn.) Chew	+	-	-	-	Pbl
Mimosoideae	*Leuceana leucocephala* (Lam.) de Wit	+	+	-	-	Pbl
Linderniaceae	*Lindernia crustacea* (Linn.) var. *diffusa*	+	+	-	-	Abl
Linderniaceae	*Lindernia diffusa* (Linn.) var. *diffusa*	+	+	-	-	Abl
Linderniaceae	*Lindernia olivariana* Dandy	+	-	-	-	Abl
Linderniaceae	*Lindernia sp*.	-	+	+	+	Abl
Onagaraceae	*Ludwigia abyssinica* A. Rich	-	+	-	-	Abl
Onagaraceae	*Ludwigia decurrens* Walt.	+	+	-	-	Abl
Onagaraceae	*Ludwigia erecta* (Linn.) Hara	+	-	-	-	Abl
Onagaraceae	*Ludwigia hyssopifolia* (G. Don) Exell	+	-	-	-	Abl
Onagaraceae	*Ludwigia octovalvis* (Jacq.) P. Raven	-	+	-	-	Abl
Onagaraceae	*Ludwigia sp.*			+	+	Abl
Cucurbitaceae	*Luffa aegyptica* Mill	+	+	-	-	Abl
Malvaceae	*Malvastrum coromandelianum* (Linn.) Garcke	+	+	-	-	Abl
Cyperaceae	*Mariscus alternifolus* Vahl	+	+	-	-	Ps
Cyperaceae	*Mariscus flabelliformis* Kunth var. *flabelliformis*	+	-	-	-	Ps
Cyperaceae	*Mariscus longibracteatus* Cerm.	+	-	-	-	Ps
Mimosoideae	*Mimosa diplotricha* C.Wright ex Sauvalle	-	+	-	-	Abl
Mimosoideae	*Mimosa pudica* Linn.	+	+	+	+	Abl

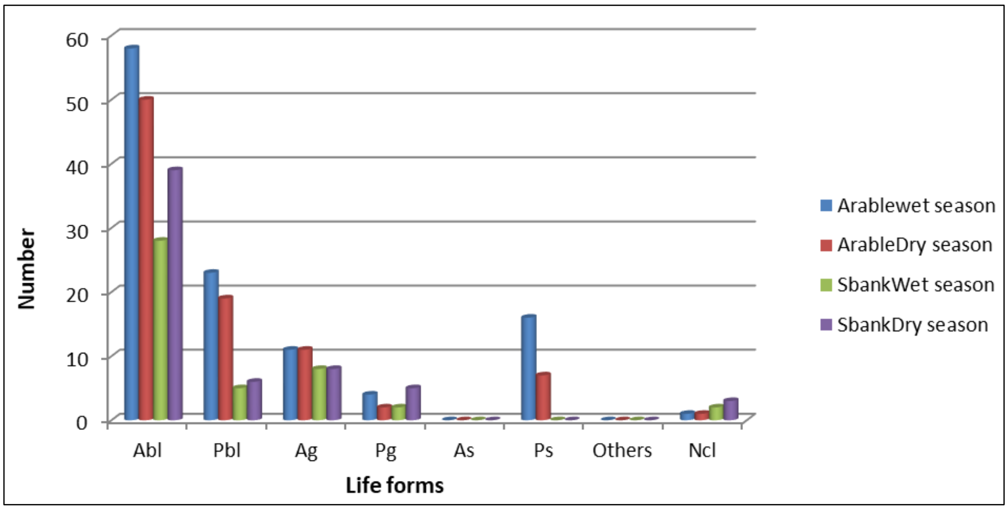
Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Mimosoideae	*Mimosa sp*.	+	-	-	-	Abl
Rubiaceae	*Mitracarpus villosus* (Sw.) DC.	+	+	+	+	Abl
Molluginaceae	*Mollugo nudicaulis* Lam	-	+	+	+	Abl
Cucurbitaceae	*Momordica charantia* Linn.	-	+	-	-	Abl
Rubiaceae	*Oldenlandia corymbosa* Linn.	+	+	+	+	Abl
Rubiaceae	*Oldenlandia lancifolia* (Schumach.) DC.	+	+	-	-	Abl
Rubiaceae	*Oldenlandia sp*.	-	+	-	-	Abl
Poaceae	*Panicum brevifolium* Linn.	+	-	-	-	Ag
Poaceae	*Panicum laxum* Sw.	+	+	+	-	Ag
Poaceae	*Panicum maximum* Jacq.	+	+	-	+	Pg
Poaceae	*Paspalum conjugatum* Berg.	+	+	-	-	Ag
Poaceae	*Paspalum scrobiculatum* Linn.	+	+	+	+	Ag
Passifloraceae	*Passiflora foetida* Linn.	-	+	-	-	Abl
Poaceae	*Pennisetum polystachion* (Linn.) Schult.	-	+	-	-	Ag
Poaceae	*Pennisetum sp.*			+	+	Ag
Piperaceae	*Peperomia pellucida* (Linn.) H.B. & K.	+	+	+	+	Pbl
Phyllanthaceae	*Phyllanthus amarus* Schum. & Thonn.	+	+	+	+	Abl
Phyllanthaceae	*Phyllanthus fraternus* G.L Webster	+	-	-	-	Abl
Phyllanthaceae	*Phyllanthus muellerianus* (O.Ktze) Exell	-	+	-	-	Abl
Phyllanthaceae	*Phyllanthus niruri* Linn.	-	+	-	-	Abl
Phyllanthaceae	*Phyllanthus niruroides* Müll.Arg	+	+	-	+	Abl
Solanaceae	*Physalis angulata* Linn.	+	+	-	-	Abl
Solanaceae	*Physalis sp.*			+	+	Abl
Lamiaceae	*Platostoma africanum* P. Beauv.	+	+	+	+	Abl
Portulacaceae	*Portulaca oleracea* Linn.	+	+	-	+	Pbl
Urticaceae	*Pouzolzia guineensis* Benth	+	+	+	+	Abl
Papilionoideae	*Pueraria phaseoloides* (Roxb.) Benth.	+	+	+	-	Pbl
Solanaceae	*Schwenckia americana* Linn.	+	+	+	+	Pbl

Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Scrophulariacea e	*Scoparia dulcis* Linn.	-	+	+	+	Abl
Cyperaceae	Sedges	+	+	+	+	Ncl
Selaginaceae	*Selaginella sp*			+	+	Sm
Papilionoideae	*Senna hirsuta* (Linn.) Irwin & Barneby	+	-	-	-	Abl
Poaceae	*Setaria barbata* (Lam.) Kunth	+	+	-	+	Ag
Malvaceae	*Sida acuta* Burm. f.	+	+	-	+	Pbl
Malvaceae	*Sida cordifolia* Linn.	+	+	-	-	Pbl
Malvaceae	*Sida corymbosa* R.E. Fries	-	+	-	-	Pbl
Malvaceae	*Sida rhombifolia* Linn.	+	+	-	-	Pbl
Malvaceae	*Sida veronicifolia* Lam.	-	+	-	-	Pbl
Malvaceae	*Sida sp.*			-	+	Abl
Smilacaceae	*Smilax kraussiana* Meisn.	+	-	-	-	Pbl
Solanaceae	*Solanum nigrum* Linn.	-	+	-	-	Abl
Solanaceae	*Solanum torvum* Sw.	+	+	-	-	Pbl
Solanaceae	Solanaceae	-	-	-	+	Abl
Solanaceae	*Solanum sp.*	-	-	-	+	Abl
Lamiaceae	*Solenostemon monostachyus* (P.Beauv.) Briq. Subsp. *monostachyus*	+	+	+	+	Pbl
Rubiaceae	*Spermacoce ocymoides* Burm.f.	+	-	+	+	Abl
Rubiaceae	*Spermacoce ruelliae* DC.	-	+	-	+	Abl
Rubiaceae	*Spermacoce scabra*	-	-	+	-	Abl
Rubiaceae	*Spermacoce verticillata* Linn	+	-	-	-	Abl
Longaniaceae	*Spigelia anthelma* Linn.	+	+	+	+	Abl
Asteraceae	*Spilanthes uliginosa* Sw.	+	+	-	-	Abl
Poaceae	*Sporobolus pyramidalis* P.Beauv.	+	+	-	+	Pg
Verbenaceae	*Stachytarpheta cayennensis* (L.C. Rich) Schau.	+	+	+	-	Abl
Verbenaceae	*Stachytarpheta jamaicensis* (Linn.) Vahl	-	+	-	-	Abl
Scrophulariacea e	*Stemodia verticillata (Mill.)Hassl.*	-	-	-	+	Abl
Poaceae	*Stenotaphrum secundatum* (Walt) Kuntze	-	+	-	+	Ag
Asteraceae	*Synedrella nodiflora* Gaertn.	+	+	+	+	Abl

Family	Weed species	Arable	Arable	Soil Seedbank	Soil Seedbank	Life form
		Wet	Dry	Wet	Dry	
Portulacaceae	*Talinum triangulare* (Jacq.) Willd.	+	+	+	+	Pbl
Ulmaceae	*Trema orientalis* (Linn.) Blume	-	+	-	-	Pbl
Asteraceae	*Tridax procumbens* Linn.	+	+	-	+	Abl
Tiliaceae	*Triumfetta cordifolia* A. Rich	-	+	-	-	Abl
Tiliaceae	*Triumfetta rhomboidea* Jacq.	+	+	-	-	Abl
Tiliaceae	*Triumfetta sp.*	-	-	+	+	Abl
Unknown Family	*Unknown weed*	-	-	+	+	Abl
Malvaceae	*Urena lobata*	-	-	+	-	Abl
Asteraceae	*Vernonia cinerea* (Linn.) Less	+	+	+	-	Abl
Asteraceae	*Vernonia sp.*	-	+	-	-	Abl
Papilionoideae	*Vigna sp.*	+	-	-	-	Abl
Araceae	*Xanthosoma mafaffa* Schott	+	-	-	-	Pbl

Legend: + =Present; - = absent; Abl = annual bread leaf; Pbl = perennial broad leaf; Ps = perennial sedge; Pg = perennial grass; ncl = not classified; Sm= *Selaginella sp.*

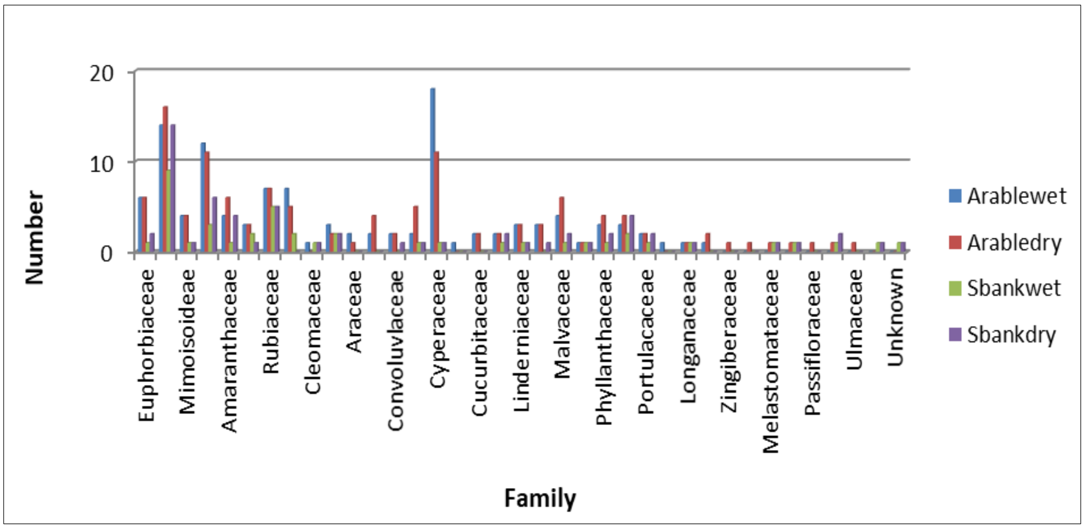
Arable weeds enumeration revealed that there were 113 weed species in the wet season and 120 in the dry season. Wet and dry season weed species were further categorized in their life forms: annual broad leaves 58,50; perennial broad leaves 23,19; annual grasses 11,11; perennial grasses 4,2; annual sedges 0,0; perennial sedges16,7 ; others 0,0; and not classified with 1,1.



Legend: Abl: Annual broad leaves; Pbl: Perennial broad leaves; Ag: Annual grasses; As: Annual sedges; Ps: Perennial sedges; Others: Others not known; Ncl: Not classified; ArableWet season: Arable weeds wet season; ArableDry season: Arable weeds dry season; SbankWet season: Soil weed seed bank wet season; SbankDry season: Soil weed seed bank dry season

Figure 1 Life forms and numbers for arable weeds and soil weed seedbank seedlings in wet and dry seasons respectively

The study on soil weed seed bank revealed that there were 44 and 61 weed seedlings species in wet and dry seasons respectively. They were also classified into life forms: annual broad leaves 28,39; perennial broad leaves 5,6; annual grasses 8,8; perennial grasses 2,5; annual sedges 0,0; perennial sedges 0,0; others 0,0 and not classified with 2,3.



Legend: ArableWet: arable weed at wet season; ArableDry: arable weed at dry season; SbankWet: soil weed seed bank at wet season; SbankDry: soil weed seed bank at dry season

Figure 2 Numbers of weeds species in each individual family for arable weeds and soil weed seed bank seedlings

The soils for weed seed bank study were collected from the cropped arable farmlands and fallow controls in wet and dry season revealed the following mean values for weed seedlings richness counted across each of the three depths 5cm:wet (2465,1243); dry (5245, 1958); 10cm: wet (3179,1238); dry (3789,1985) 15cm: wet (1828,1157); dry (3092,981) and the importance value index are 5cm wet: (1.69,1.21); dry (1.86,1.48);10cm: wet (1.41,1.07); dry (1.86,1.33); 15cm wet: (1.84,1.27); dry(1.90,1.41).

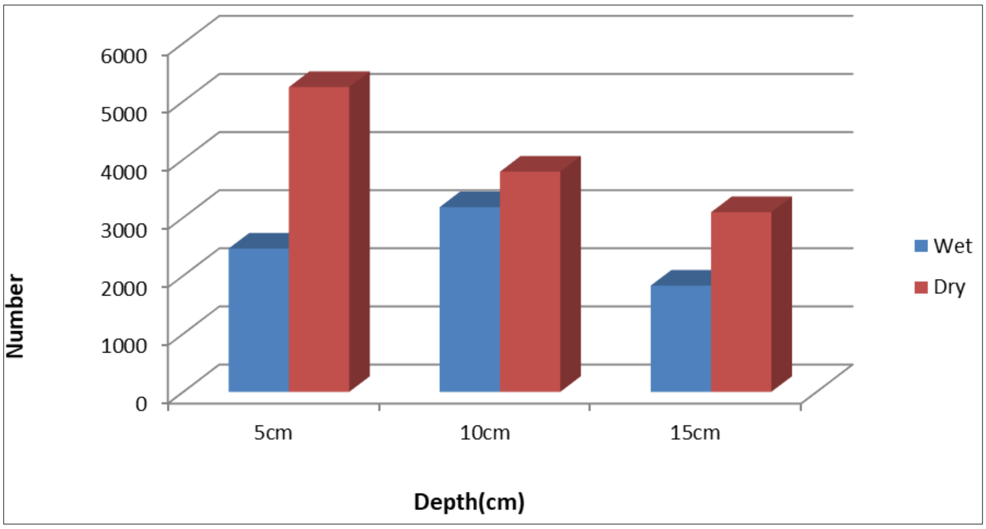


Figure 3 Soil weed seed bank seedlings mean values across depths of 5, 10 and 15cm for wet and dry seasons respectively

3.2 Arable weeds and soil weed seed bank seedlings compared

Comparison between arable weeds and soil weed seed bank seedlings in the study revealed that there were 78 and 30 weed species common to wet and dry seasons respectively. The result further revealed 34 weed species present during wet season and these were not seen in the dry season in arable farmlands; while in dry season 41 weed species present were not recorded in wet season.

The weeds common to arable farmlands in wet and dry season are 78 and further classified into annual broad leaves 43; perennial broad leaves 16; annual grasses 7; perennial grasses 4; annual sedges 0; perennial sedges 7; others 0 and not classified 1. Soil weed seed bank seedlings of 30 on classification: annual broad leaves 19; perennial broad leaves 4; annual grasses 5; perennial grasses 2; annual sedges 0; perennial sedges 7; others 0 and not classified 1.

We also examined weeds species that were found present in arable farmlands and soil weed seed bank study in respective of both season to be 57. These weeds species are listed as follows: *Acalypha ciliata* Forsk; *Ageratum conyzoides* Linn.; *Alternanthera bettzickiana* (Ragel) Nicholson; *Alternanthera sessilis* (Linn.) R.Br. ex Roth; *Aspilia africana* (Pers.) C.D. Adams; *Asystasia gangetica* (Linn.) A. Anders.; *Axonopus compressus* (Sw.) P.Beauv.; *Borreria sp.*; *Celosia leptostachya* Benth.; *Cleome rutidosperma* DC.; *Croton hirtus* L'Hérit.; *Cyathula prostrata* (Linn.) Blum; *Cynodon dactylon* (Linn.) Pers.; *Digitaria horizontalis* Willd.; *Echinochloa colona* (Linn.) Link; *Eclipta alba* (Linn.) Hassk.; *Eleusine indica* (Linn.) Gaertn.; *Eleutheranthera ruderalis* (Sw.) Sch; *Eragrostis tenella* (Linn.) P. Beauv. ex Roem. & Schult; *Heterotis rotundifolia* (Sw.) Jac.-Fél.; *Indigofera sp.*; *Ipomoea involucrata* P. Beauv.; *Laportea aestuans* (Linn.) Chew.; *Lindernia spp.*; *Ludwigia spp.*; *Mimosa pudica* Linn.; *Mitracarpus villosus* (Sw.) DC.; *Mollugo nudicaulis* Lam; *Oldenlandia corymbosa* Linn.; *Panicum laxum* Sw.; *Panicum maximum* Jacq.; *Paspalum scrobiculatum* Linn.; *Pennisetum sp.*; *Peperomia pellucida* (Linn.) H.B. & K.; *Phyllanthus amarus* Schum. & Thonn.; *Phyllanthus niruroides* Müll.Arg; *Physalis sp.*; *Platostoma africanum* P. Beauv.; *Portulaca oleracea* Linn.; *Pouzolzia guineensis* Benth; *Pueraria phaseoloides* (Roxb.) Benth.; *Schwenckia americana* Linn.; *Scoparia dulcis* Linn.; *Setaria barbata* (Lam.) Kunth; *Sida acuta* Burm. f.; *Sida sp.*; *Solanum sp.*; *Spermacoce ruelliae* DC.; *Spigelia anthelma* Linn.; *Sporobolus pyramidalis* P.Beauv.; *Stachytarpheta spp.*; *Stenotaphrum secundatum* (Walt) Kuntze; *Synedrella nodiflora* Gaertn.; *Talinum triangulare* (Jacq.) Willd.; *Tridax procumbens* Linn.; *Triumfetta sp.*; *Vernonia cinerea* (Linn.) Less.

3.3 Crop species identified in multicropping practice

A cursory of the crops species planted in all the cropped arable farmlands for the study were all recorded based on individual farmer's choice, need and importance attached to each crop species. A total of 27 crop species was recorded, the least number of crop species planted 3 and the highest 12 per farmer's arable farmland.

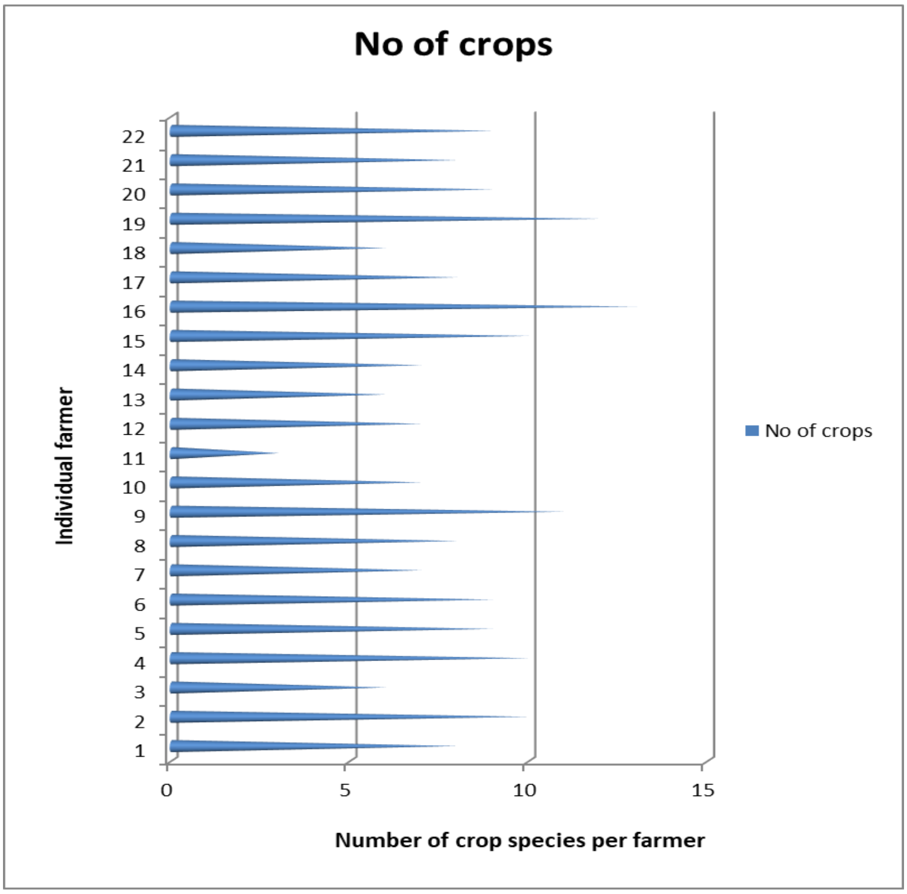


Figure 4 Average crop species per farmer

Percentage of crop species occupied in the overall farmers' choices and preferences in view of the cultivated individual crop species in both season. 27 crop species from 15 families: Malvaceae 1; Amaranthaceae 1; Bromeliaceae 1; Fabaceae 3; Solanaceae 4; Cucurbitaceae 4; Araceae 2; Dioscoraceae 3; Convolvulaceae 1; Euphorbiaceae 1; Poaceae 1; Asteraceae 1; Musaceae 1; Lamiaceae 2 and Portulaceae 1.

Figure 1, also revealed that cassava(*M. esculenta*) and corn(*Z. mays*) were the most preferred crop species planted by all the farmers with 90.90% respectively; followed by okra(*A. esculentus*), pumpkin(*T. occidentalis*), cocoyam (*X. mafaffa*), yam(*D. rotundata*) and plantain (*M. paradisiac*), each with 86.36; 81.81;68.18;59.09 and 54.54%, respectively. It revealed yam (*D. dumetorum*), water leaf (*T. triangulare*), cucumber (*C. sativus*), pepper (*C. annuum*), yam (*D. alata*), melon (*C. colocynthis*), bitter leaf (*V. amygdalina*), pepper (*C. frutescens*) and sweet potato (*I. batatas*) were the next planted crop species with 45.45; 31.81; 27.27; 22.72; 22.72;18.18; 18.18;13.63;13.63% respectively. The least crop species in the table are musking gourd (*C. moschata*), beans (*Vigna unguiculata* L.), groundnut (*A. hypogaea*), pineapple (*A. comosus*), soup thickener (*M. sloanii*), garden egg (*Solanum sp.),* tomato (*S. lycopersicon),* green amaranth (*A. hybridus*) curry leaf (*O. americanum*), cocoyam (*C. esculenta*) with 9.09; 9.09; 9.09; 9.09;9.09;4.54;4.54;4.54;4.54;4.54% respectively. However, the crop species found in the dry season were already established in wet season and crop species like cassava will be harvested at maturity, because the arable cropped farmlands are cultivated yearly and the rest crop species like pineapple, plantain, scent (basil), curry, bitter leaves, water leaves are actually left behind which are scattered in the farmlands and are preserved during bush clearing for the new season's cropping.

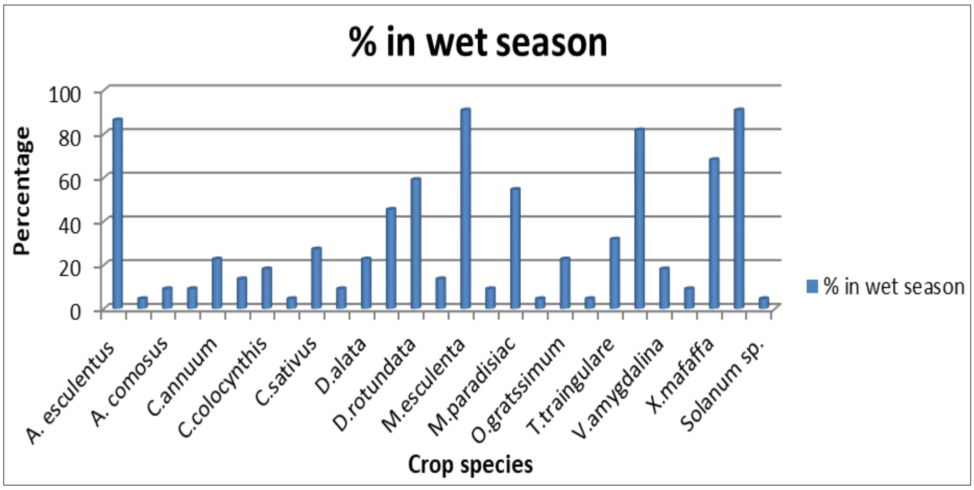


Figure 5 Percentage of importance attached to crop species by farmers in wet season

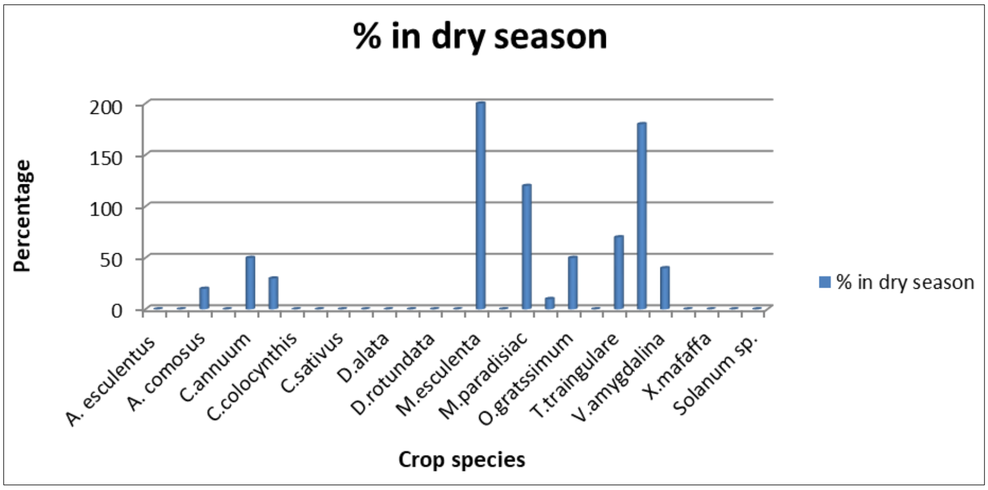


Figure 6 Percentage of importance attached to crop species by farmers in dry season

These 27 crop species enumerated from the 22 arable farmlands were further classified into dietary forms as needed by human beings to maintain healthy food consumption (Tables 2-4) Classifications were based on tubers/corms, vegetables, fruits, spices, drugs, grain legumes, soup thickeners and cereals.

Table 2 Crop species dietary classification

Tubers/corms	**Vegetables**	**Fruits**
Colocasia esculenta	*Amaranthus hybridus*	*Cucumis sativus*
Dioscorea alata	*Cucurbita moschata*	*Abelmoschus esculentus*
Dioscorea dumetorum	*Talinum triangulare*	*Musa paradisiac*
Dioscorea rotundata	*Telfairia occidentalis*	*Solanum lycopersicum*
Ipomoea batatas	*Abelmoschus esculentus*	*Solanum sp.*
Manihot esculenta	*Solanum sp.*	*Ananas comosus*
Xanthosoma mafaffa		

Table 3 Crop species dietary classification

Spices	**Drugs**	**Grain legumes**
Capsicum annuum	*Ocimum gratissimum*	*Vigna unguiculata*
Capsicum frutescens	*Vernonia amygdalina*	*Arachis hypogaea*

Table 4 Crop species dietary classification

Soup thickeners	**Cereals**
Mucuna sloanii	*Zea mays*
Citrillus colocynthis	
Colocasia esculenta	
Xanthosoma mafaffa	
Dioscorea rotundata	

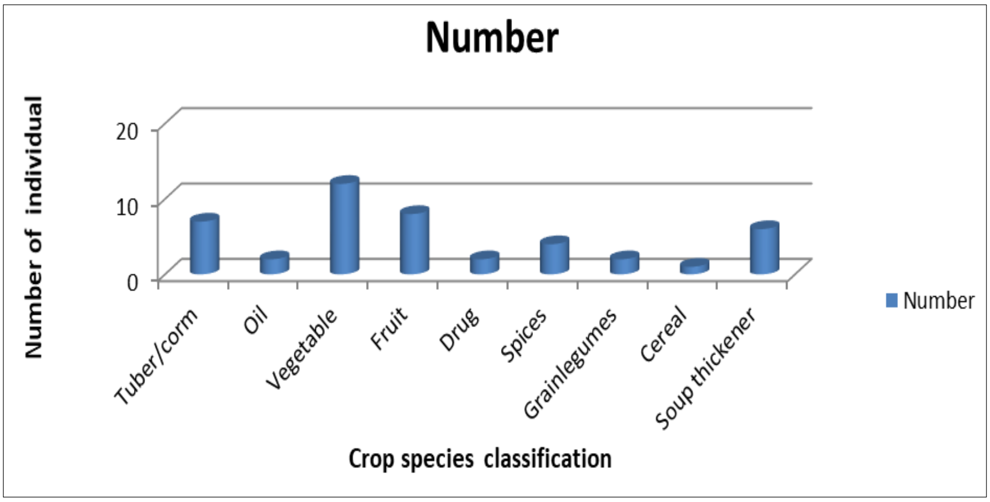


Figure 7 Crop species classification into dietary forms and numbers

Table 5 List of crop species planted in each farmer's sampled arable farmland for the study

Sample ID	Crops
Farm: 1	Okra, cassava, cocoyam, pepper, pepper, yam, corn, cucumber.
Farm: 2	Okra, cocoyam, pepper, pepper, yam, cucumber, yam, water leaf, scent leaf.
Farm: 3	Okra, pepper, corn, pumpkin, water leaf, pumpkin.
Farm: 4	Okra, cassava, cocoyam, cucumber, pumpkin, yam, water leaf, yam, water leaf, sweet potato, plantain, beans.
Farm: 5	Okra, cassava, cocoyam, corn, pumpkin, yam, sweet potato, plantain, groundnut.
Farm: 6	Okra, cassava, cocoyam, pepper, corn, pumpkin, scent leaf, plantain, bitter leaf.
Farm: 7	Okra, cassava, cocoyam, yam, corn, pumpkin, plantain.
Farm: 8	Okra, cassava, cocoyam, yam, pumpkin, yam, scent leaf, bitter leaf.
Farm: 9	Okra, cassava, cocoyam, yam, yam, corn, pumpkin, scent leaf, sweet potato, melon, bitter leaf.
Farm: 10	Okra, cassava, corn, yam, pumpkin, yam, scent leaf.
Farm: 11	Cassava, corn, pumpkin.
Farm: 12	Okra, cassava, cocoyam, corn, yam, cucumber, plantain.
Farm: 13	Cassava, corn, pumpkin, yam, water leaf, plantain.
Farm: 14	Okra, cassava, cocoyam, corn, pumpkin, yam, plantain.
Farm: 15	Okra, cassava, corn, yam, pumpkin, yam, plantain, beans, melon, pineapple.
Farm: 16	Okra, cassava, cocoyam, pepper, corn, yam, pumpkin, yam, water leaf, pineapple, tomato, soup thickener, garden egg.
Farm: 17	Cassava, cocoyam, corn, yam, cucumber, pumpkin, yam, plantain.
Farm: 18	Okra, cassava, cocoyam, corn, plantain, melon.
Farm: 19	Okra, cassava, cocoyam, pepper, corn, yam, pumpkin, yam, water leaf, plantain, melon, green amaranth.
Farm: 20	Okra, cassava, cocoyam, corn, yam, pumpkin, yam, plantain, bitter leaf.
Farm: 21	Okra, cassava, cocoyam, corn, pumpkin, water leaf, groundnut.
Farm: 22	Okra, cassava, corn, yam, cucumber, pumpkin, yam, pumpkin, soup thickener.
Farm: 23-25	Bush fallow with shruby and annual plants: annual broad leaves, annual and perennial grasses and sedges, with shrubby trees like Alchornea cordifolia (Schumach. & Thonn.)Müll.Arg, Allophylus africanus P.Beauv. Millettia spp, Baphia spp and Glyphaea spp.

Legend: Okra: *Abelmoschus esculentus* (L.) Moench; Cassava: *Manihot esculenta* Crantz; Cocoyam: *Colocasia esculenta* (L.)Schott; Pepper: *Capsicum annuum* L.; Corn: *Zea mays* L.; Pumpkin: *Cucurbita moschata* Duchesne; Curry leaf: *Ocimum americanum* L.; Plantain: *Musa paradisiac* L.; Bitter leaf: *Vernonia amygdalina* Del.; Yam: *Dioscorea alata* L.; Yam: *Dioscorea dumetorum* (Kunth).Pax; Yam: *Dioscorea rotundata* Poir; Sweet potato: *Ipomoea batatas* (L.) Lam.; Melon: *Citrullus colocynthis* (L.) Schrad; Cucumber: *Cucumis sativus* L.; Water leaf: *Talinum triangulare (*Jacq.)Willd.; Beans: *Vigna unguiculata* L.; Pineapple: *Ananas comosus* (L.) Merrill; Tomato: *Solanum lycopersicon* L.; Soup thickener: *Mucuna sloanii* Rendle & Fawc.; Garden egg: *Solanum sp.*; Green amaranth: *Amaranthus hybridus* L.; Pumpkin: *Telfairia occidentalis* Hook. f.; Groundnut: *Arachis hypogaea* L.; Cocoyam: *Xanthosoma mafaffa* Schott; Scent leaf (basil): *Ocimum gratissimum* L.; Pepper: *Capsicum frutescens*

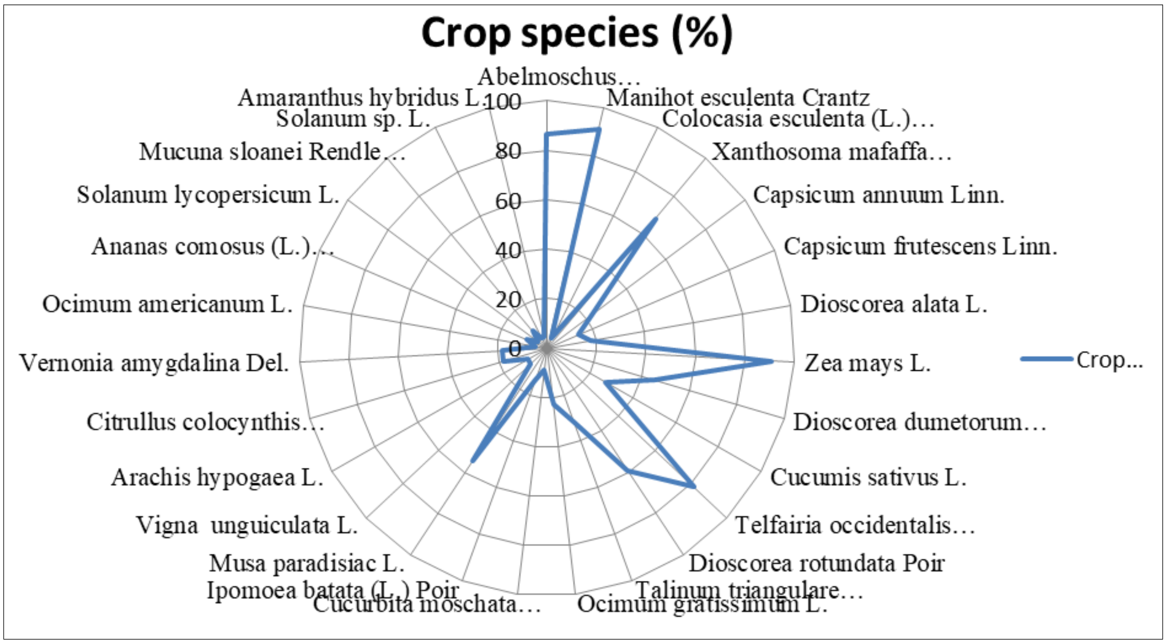


Figure 8 Crop species preference by farmers in percentages

3.4 Physicochemical properties of soils from study arable farmlands

Table 6 Summary of T-test Statistics for differences between Wet and Dry season

Parameters	Means		Standard Devision		T-Statistics	p-Value	Decision
	Wet season	Dry season	Wet season	Dry season			
H_2O(1:1)	5.88	5.85	0.59	0.67	0.16	0.88	significant
P (mg/kg)	69.08	14.30	40.45	5.11	6.3	0.00	
% OC	0.83	1.96	0.25	0.52	9.15	0.00	significant
N(cmol/kg)	0.16	0.16	0.04	0.03	0.12	0.90	
Ca(cmol/kg)	7.94	5.96	5.55	5.79	1.16	0.26	
Mg(cmol/kg)	0.85	0.68	0.21	0.20	2.69	0.01	significant
K(cmol/kg)	0.11	0.08	0.04	0.04	2.4	0.02	significant
Na(cmol/kg)	0.23	0.20	0.02	0.01	6.53	0.00	significant
Acidity(cmol/kg)	0.27	0.62	0.24	0.88	1.77	0.08	
Al(cmol/kg)	0.00	0.11	0.01	0.35	1.4	0.17	
ECEC(cmol/kg)	9.39	7.55	5.61	5.63	1.09	0.28	
Mn(mg/g)	54.11	40.79	20.15	16.79	2.38	0.02	significant
Fe(mg/g)	55.15	56.07	42.93	40.70	0.07	0.94	
Cu(mg/g)	3.63	2.44	3.14	3.39	1.21	0.23	
Zn(mg/g)	16.3	19.75	31.92	26.93	0.39	0.70	
% Sand	73.47	86.91	3.04	3.33	13.97	0.00	significant
% Silt	12.13	10.56	2.10	3.20	1.92	0.06	
% Clay	14.13	2.64	2.66	0.86	19.3	0.00	significant

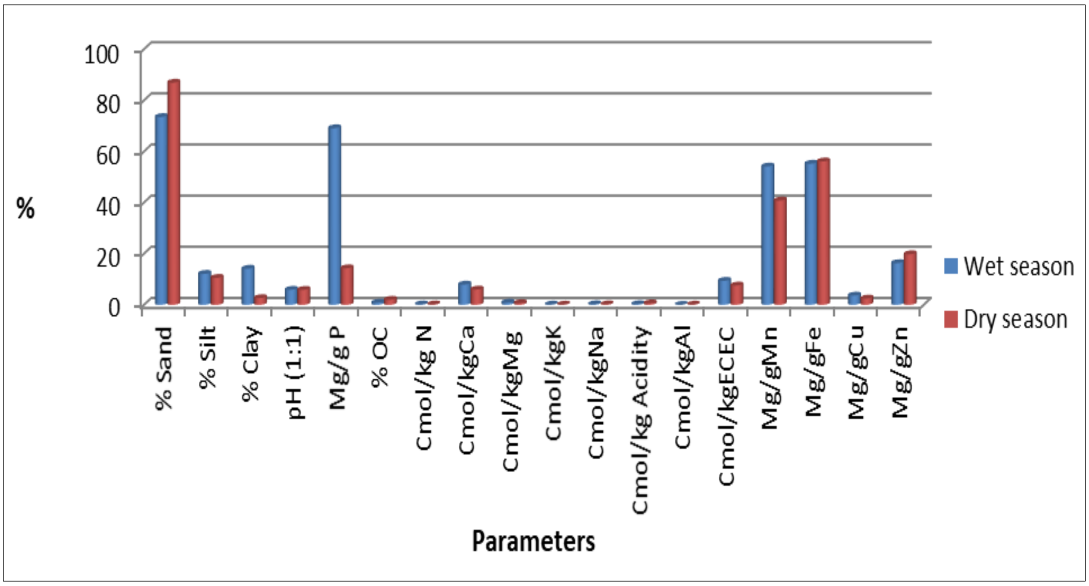


Figure 9 The T-test for differences between wet and dry season

The numbers of parameters evaluated from the soils samples in the study were 18 and the mean values for wet and dry seasons are presented in Table 6.

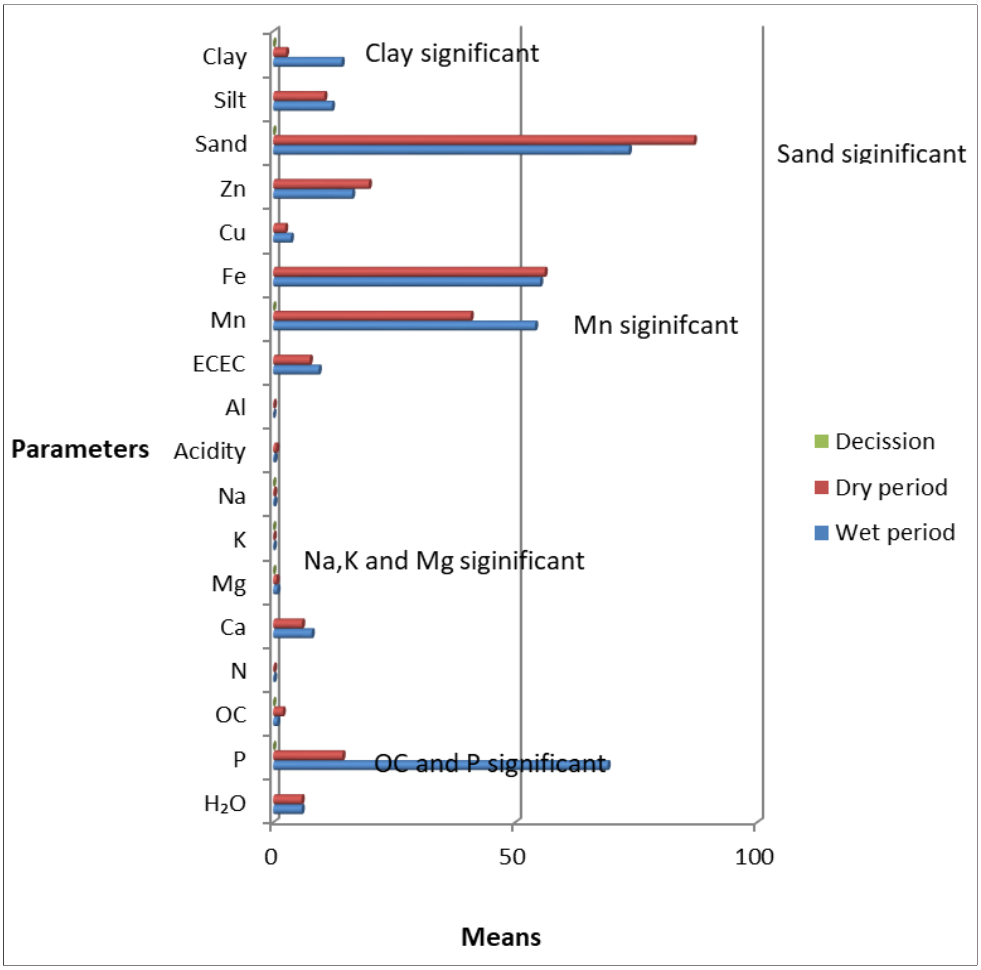


Figure 10 Comparison between wet and dry season on the various parameters tested

Soil physicochemical properties for wet and wet control seasons compared and only the mean value of Na (Sodium) (0.23±0.02), (0.26±0.05) is significant at ($p<0.05$). Mean values of dry season and control revealed the followings been significant at ($p<0.05$), soil pH (5.85±0.67), (4.98±0.25); (Nitrogen) N (0.16±0.03 %), (0.12±0.01 %); (Magnesium) Mg (0.68±0.20 cmol kg^{-1}), (0.42±0.11 cmol kg^{-1}).

These parameters were significant at ($p<0.05$) when wet and dry seasons were compared as follows: (Phosphorus) P (69.08 ± 40.45 $mgkg^{-1}$),(14.30±5.11 $mgkg^{-1}$); (Organic carbon) OC(0.83±0.25 %),(1.96±0.52 %); (Magnesium) Mg(0.85±0.21 cmol kg^{-1}),(0.68±0.20 cmol kg^{-1}); (Potassium) K(0.11±0.04 cmol kg^{-1}),(0.08±0.04 cmol kg^{-1}); (Sodium)Na (0.23±0.02 cmol kg^{-1}),(0.20±0.01 cmol kg^{-1}); (Manganese) Mn(54.11 ±20.15 cmol kg^{-1}),(40.79±16.79 cmol kg^{-1}); Sand (73.47±3.04 %),(86.91±3.33 %), Clay (14.13±2.66 %) ,(2.64 ±0. 86 %).

The pH (1:1) mean values for wet and dry seasons (5.88± 0.59, (5.85±0.67), while the exchangeable bases mean values of Ca^{2+}, Mg^{2+}, K^+ and Na^+ wet and dry season respectively are Ca^{2+} (7.94±5.55), (5.96±5.79); Mg^{2+} (0.85±0.21), (0.68±0.20); K^+ (0.11±0.04), (0.08±0.04); Na^+ (0.23±0.02),(0.20±0.01). The mean values for both wet and dry seasons for (Nitrogen) N (0.16±0.04), (0.16±0.03); Acidity (0.27 ±0.24), (0.62±0.88); (Aluminum) Al (0.00±0.01), (0.11±0.35); ECEC (9.39±5.61), (7.55±5.63). Also the mean values for the trace metals of Mn, Fe, Cu, Zn are Mn (54.11±20.15), (40.79±16.79); Fe (55.15±42.93), (56.07±40.70); Cu (3.63±3.14), (2.44±3.39); Zn(16.30±31.92),(19.75±26.93) respectively.

The mean values of Sand, Silt and Clay are as follows: Sand (73.47±3.04%), (86.91±3.33%); Silt (12.13±2.10%), (10.56 ±3.20%); Clay (14.13±2.66%), (2.64±0.86%). The soil contained high amount of sand in both wet and dry seasons respectively revealing sandy loam soil (Figure 10).

4 Discussion

4.1 Arable weeds and soil weed seed bank seedlings

The result revealed in the wet and dry seasons 113 and 120 individual weed species from the cultivated arable farmlands and categorized into life forms as presented (Table 1 and Figure 1). Dry season had more of weeds species number than wet season and also categorized (Table 1 and Figure 1). The overall increase in the number of individual weed species in dry season which could be as a result of the mature weed seed coming from the ephemeral weeds for example the grasses and some of the annual broad leaves which germinated back through mature weed seed which dropped to the ground and grew to adult for a new cycle due to the moisture in soil. This corroborates the work of [29] they observed that most annual ephemeral weeds have short life span and produces seed which drop back and germinate again due to moisture in the soil which favours germination and produce more seed. Soil disturbance through cultural practices either in soil cultivation, weeding out of weed, soil heaping at the base of stand of crop species could also expose more weed seed hidden below the soil surface either vertically or horizontally, which could also cause the increase in the number of weeds seeds experienced in the dry season. This is in line with the finding of [30], tillage systems encourages the exposure of weed seed in soil to light and influences their densities and species establishment on germination.

We observed that the increase in number of these weeds species seeds could also have been moved to the various arable farmlands due to anthropogenic activities, run off water through soil erosion, by animals, insects as many of them feed on the seed of some of the weeds and equally attached to the fur, skin of animals and man's clothing which helped in its distribution. This assertion corroborates [31], they noted that seeds are dispersed a few meters to several kilometer away by birds and mammals in their work on seed dispersal of fleshy-fruited environmental weeds in New Zealand.

Weed management practices could also be responsible for the increase and the decline in wet and dry seasons of the study for example planting of various crop species which provided different canopy architectures, which interfere with light incidence on the crop species leaves and crop maturity at different times. This was corroborated by the finding of [32] that soil type, crop type, crop sustainability, climate and urbanization had great influence on weed distribution and weed community structure in arable farmland.

In wet season, individual weed species categorized into life forms were more in dry season, with more of annual broad leaves, perennial broad leaves, perennial grasses, and perennial sedges (Table 1 and Figure 1). The increase of weed species in life forms in wet season could be as a result of cultural cropping practices applied for example hoe weeding, cutlass and hand weeding and heaping of soil at the base of crop species stand to provide and give firm support. All these enhance movement of soil along with weed seed both vertically and horizontally. It is in line with [33] noted that weed presence are influenced by cultural practices of continuous planting of crops on the same piece of land and this in effect makes the adapted weeds to remain persistent due to the unchanged cultural practices.

The number of weed species identified from the soil weeds seed bank study in the greenhouse revealed 44 and 61 for wet and dry seasons classified into life forms. The life forms revealed 28, 39 annual broad leaves; 5, 6 perennial broad leaves; 8, 8 annual grasses with 2, 5 perennial grasses for wet and dry season respectively. The increase in annual grasses, perennial broad leaves and annual sedges could be an after effect of climate change and soil tillage. This corroborates [34] who noted changes in atmospheric Co_2 level, rainfall, temperature and other growing conditions which affect weeds species distribution and the ability to compete within weed population and within crop. Climate change could induce early seed production, maturity, and dispersal by wind and animals, while soil tillage systems encourages and make fruit/seed of perennial broad leaves taken with soil samples. This is in line with the review [34] climate change on weed and their management; climate conditions exert a significant impact on the spread, population dynamics, life cycle duration, infestation pressure and the overall occurrence of the majority of agricultural pests.

The study on soil weed seed bank in the greenhouse lasted for 12 weeks for wet and dry seasons respectively further revealed more weed seedlings in the dry season than the wet season irrespective of the depths as indicated by the measure of species diversity and Shannon index which range from 5245 to 3092 seedlings and 1.86 to 1.90; 2465 to 1828 seedlings and 1.41 to 1.84 for dry and wet seasons respectively. This was expected as most annual weeds go into senescence more than once in some instance and the mature seed fall back to the soil and with favourable conditions or precipitation recycle themselves again and therefore would have increased the volume of weed seed in the soil during the dry season when the soil samples were collected. This is in line with the result of [35] they noted that soil seed bank are influenced by both altitude and environmental seasonality and [36] also reported that soil conditions influence not only seed inputs but also potentially seed survival in the soil.

However, comparing wet and dry seasons of soil weed seed bank revealed a substantial increase from 5cm to 10cm and then drop sharply at 15cm depths. This was expected as some of cultural practices carried out for example the tilling of soil, planting of various crop species by opening the soil surface and weeding of weed; crop and weed species canopy effect would have caused the decrease in weed seedling size in wet season. According to [37], which corroborate our result, observed that weed density decreased with depth and the higher number of weed species and density were observed at 0-5, 5-10 and 10-15cm respectively and that weed forms for example grasses, sedges and broad leaves were in abundance in that order of depths 0-5, 5-10 and 10-15cm from the result.

While in dry season, indicated high mean values of 5245, 3789 and 3092 for 5, 10 and 15cm respectively. This was expected at the time of the season as most of all the seasonal herbaceous plants would have reached senescence and died off after the release of the fruit/seed on to the soil surfaces before the soil samples were taken. The findings of [34] [37] corroborates this assertion as distributions of soil weed seed are influenced by climate factors and cultural activities like tillage which assisted in the redistribution of soil weed seed into various depths within the soil profile either vertically or horizontally.

Crop species planted have affinity to encourage the growth of associated weed species in wet and the intensity of rain in the season was conducive to some weed species. This corroborates the findings of [38], in their study on weeds of sugarcane based on rain fed sugarcane production which had more weed species of 41 when compared with irrigated fields 35 and [29] also observed that heavy rain falls during the cropping season encourages seed germination especially when soil are continuously disturbed and exposed to light intensity through weeding of weed.

Arable weeds and those from soil weed seed bank studies compared revealed that 57 weed species common to wet and dry season. The same cultural activities which began from land clearing, burning, heap making and continuous multicropping practice have continued for the last 5 years without a break have encouraged these weed species to have adapted themselves to these cultural practices and remained present in the soil. [39] Corroborates our findings that tillage intensity and soil disturbance increases soil seed bank species, their survival and more so herbicides application induce increase in germination, survival and colonization of weed species with high number of seeds in the soil. In another work by [40] which further corroborated our findings tested climate-smart agriculture on a 6 scenarios of interventions of different tillage with crop types found out that farmers based practice had more abundant weed species than other practices tested in their work.

4.2 Crop species in the multicropping practice

A total of 27 crop species were recorded from the evaluation of farming systems practiced in the study area revealed multicropping as adopted by producers. Multicropping afford crop growers to plant different crop species on the same piece of arable farmland with the assurance of crop security irrespective of the impact of climate change. Farmers in the study showed interest in planning between 3 and 12 crop species per arable farmland. This shows producers resilience in production, income and provides opportunities for all round food items and security. Our findings are corroborated by [41]that sole cropped cassava is more economical and profitable than mixed cropping on one side, however, he noted the enormous benefit accrued in mixed cropping as it provides the farmer with an all year round harvest to serve as a better poverty alleviating mechanism. Crop species are harvested at different times of the cropping season, and complement each other in terms of nutrients, water and space requirement management. Our findings are in line with [12] that multicropping provide resilience in crops production and income biodiverse systems; environmental contributions which are very valuable to the society compared with monoculture system practice.

Multicropping output in terms of crop species which provide in essence different food stuffs for consumption at various times of the cropping season, adequately provides food in spite of the climate change effect as crop species nutritional demand for growth and development are different from one another hence the soil is adequately protected, preserved and sustained for continuous crop production. Poverty and malnutrition within the farming community is reduced to a level that the socioeconomic status of the people are improved and add value to lives as there are more crop species to sale or exchange with neighbours for the need of the family as applicable in some places.

These crops species are sources of minerals and vitamins needed by the body to meet the daily requirement for the optimal body function which in turn reduces diseases and ill health from the people. Our findings are slightly contradictory to [42], argued that multiple cropping cannot be used as a cure-all strategy to provide all year round income, food and dietary security with peculiarity to seasons and sustainability, but rather as practice that combines the provision of income and nutrition strategies with more diverse home garden, income portfolio, clean cooking fuel for an all-round dietary and food security.

We classified these 27 crop species into tubers/corms, vegetables, fruits, spices, drugs, grain legumes, soup thickeners and cereals. These are the food classification largely required by all. Some of these classifications if not all are needed in macro or micro proportions, while some are not really quantified. Hence too much or little intake daily determines the health status of an individual in the community. They serve many purposes of repairing and building cells, antioxidant and curative properties in the body and therefore are found in multicropping practice in arable farmlands in the study area. Apart from providing various food crop species, the environment benefits as well because of its crops diversification and land management strategy. This corroborates the findings of [43] where they found out that multicropping system or practice occupies about 12% of global arable cropped lands and 85 million hectares in irrigated agriculture. To further corroborates on our findings multicropping according to [44] noted from his findings that crop species richness and house diet diversity score were positively associated, as well as daily adult intake equivalent of energy in kilocalories, protein in grams, iron in milligrams, vitamin A in micrograms of retinol activity equivalent and zinc in milligrams. He concluded that crop species richness could be used to support enhanced diet quality and diversity and at the same time creating market opportunity for smallholder farmers in a subsistence agricultural practice.

Apart from providing different crop species for consumption which supplies essential nutrients and vitamins, provide income, food security, reduction of pests and diseases of which weed control have become a serious issue in crop production generally, ameliorate the soil nutrients dynamics in the agroecosystems through the addition of legumes in the planting and support biodiversity services to the environment at large. [45] in his findings from the review on the comparative advantages of intercropping to mono-cropping system conformed with our findings which he enlisted as crop yield, various plant constituents' production, yield stability, social benefits, pest control, nutrients efficiency and complementary role between above and below ground interaction which involves short and tall crop species as well deep and shallow rooted crop species which balances water and nutrient intake.

4.3 Physicochemical properties of soils samples in multicropping practice

This result could be a reflection of the anthropogenic activities on the study area which has been under cultivation for more than 5 years on a continuous multicropping practice and the method of bush clearing has been slash, burn, soil cultivation and crop species planted. The soils samples were collected when crop species have established as wet season and at the peak of the dry season when most crop species have been harvested and left with those that grows beyond one year as dry season when soils were collected for physicochemical properties.

The t-statistics for differences between wet season and its control revealed that Na is significant difference ($p<0.05$) (Table 6, Figures 9 and 10) and there were significant difference ($p<0.05$) between dry and its control for H_2O, N and Mg (Table 6 and Figures 9 and 10). Comparison between wet and dry seasons revealed significant difference ($p<0.05$) for P, OC, Mg, K, Na, Mn, Sand and Clay respectively (Table 6 and Figures 9 and 10).

Sand mean value in wet season (73.47%) compared with control (71.87%) was higher, while dry season (86.91%) was lower than control (87.93%). Comparison between wet (73.47%) and dry season (86.91%) mean values revealed more sand in dry season and therefore both wet and dry seasons are sandy loam. The increase in sand either in wet and dry and controls could be attributed to cropping activities which involves the tillage of soil and movement of soil by erosion from one place to another and this could have reduced the amount of organic matter and silt in the soil top which helps to bind and improve the soil texture and structure. [46], corroborated our findings that farm activities especially tillage reduces silt, moisture, organic matter, organic carbon, total nitrogen, available phosphorus, pH, cation exchange capacity and exchangeable bases contents, but increases bulk density, electrical conductivity, exchangeable acidity and sand content significantly ($p<0.05$).

Silt mean values revealed differences between wet season and its control. Control was higher and the reverse was the case with dry and its control in which experiment was higher than control. Wet and dry seasons compared revealed wet higher than dry (12.13%) and (10.56%) respectively. Our finding is in line with [46] [29] the conversion of natural ecosystems managed into farming lands reduces the amount of silt, moisture, organic matter, organic carbon, total nitrogen, available phosphorus, pH, cation exchange capacity and exchangeable bases contents, but rather increases bulk density, electrical conductivity, exchangeable acidity and sand content.

The amount of clay in wet season (14.13%) and its control revealed more clay (15.07%) in control, the reverse was the case between dry and its control (2.64%) and (2.00%). Wet and dry seasons compared revealed that wet (14.13) was 5.7 times higher than dry (2.64%). These variations could be as a result of parent materials, soil erosion, soil degradation, farming system practices employed could alter the mean values of clay either in wet or dry seasons. Our findings corroborated [47] with the result they obtained on the evaluation of land use types on selected soil physical and chemical properties of Kuyu District in Ethiopia, which revealed eucalyptus plantation low in sand (24.44%), silt (24.00%), available water content (111.13mm/m) and high in clay **(**52.56%), bulk density (1.39g cm^{-3}) as when compared with other land used in the study.

The pH (1:1) mean values for wet season (5.88), and control (5.19) was lower; the same applied to dry season (5.85) higher than control (4.98). Comparing the mean values between wet and dry revealed that wet (5.88) was higher than dry season (5.85). Cultivation and planting of crop species on an agricultural farmland interferes with soil physicochemical properties which leads to the depletion of plant residues and organic matter and could have caused the change in soil pH. According to [48] which corroborated this result from their work that conversion of farm to cultivation land due impact on its physicochemical properties for example pH, organic matter(OM), available nitrogen, available phosphorus, exchangeable potassium, soil bulk density, moisture content and porosity.

Acidity mean values for wet season is lower than its control (0.27 cmol/kg) (0.42 cmol/kg) same trend were observed with dry season and its control (0.62cmol/kg) (1.41cmol/kg) high about 2.2x, and wet with dry compared shows (0.27 cmol/kg) (0.62cmol/kg).

The acidity mean values of the soil is a reflection of what goes on within clay and organic matter interaction with the five bases and the release of nutrients to plants. It is a system which involves the five most abundant exchangeable cations in the soil. The availability of nutrients to plants depends also on the prevailing soil pH mean values which could either be acidic or alkaline and the amount of cations either positive or negative charged reveals the level of how fertile the soil is in terms of making the nutrients available to the roots of plant as at when needed then expressed effective cation exchange capacity (ECEC).

P mean values between wet and its control revealed that P experiment was higher than P control by 1.6x. It was the same trend for dry season (14.30mg/g) and control (9.22mg/g). Wet and dry season compared revealed that wet (69.10mg/g) was higher than dry season (14.3mg/g) by 4.8 times. The increase in the mean values of P in wet season could be attributed to the initial available P coming from the cultural practices of clearing bush, burning, tilling of soil to plant crop species supplied the initial P which were made available for the crop species planted and weeds as well for growth and development and this could have also led the decrease in dry season P mean values as revealed. The increase in availability P in cropping season through slash and burn were confirmed by [49] in study on effect of burnt and un-burnt land physicochemical characteristics in Ekeya-Okobo Local Government Area, Akwa Ibom State, Nigeria revealed a decrease in pH(H2O) 5.6, pH(KCL) 4.9, increase in sand, silt, K and base saturation, while burnt plot recorded increase in clay, SOC,SOM,TN, available P, Ca^{2+}, Mg^{2+}+,Na^{+} and EC(H^{+}+Al^{3+}). [50] confirmed that management system influence the content and distribution, availability and mobility of P forms and total organic P in the soil on the study of Phosphorus forms in Ultisol submitted to burning and Trituration of vegetation in Eastern Amazon.

Organic carbon (OC) values in wet season (0.83%) was lower compared with its control (1.00%); while in dry season (1.96%) compared with its control (1.70%) was also lower. Wet (0.83%) compared with dry (1.96%) revealed that dry was higher than wet season by 2.4x. The presence of organic carbon, materials from vegetation covers, plant parts, animals and insects residues, weeds and crop species left over after harvest to decay and in turn forms humus and made available for plants. Most of these materials are scattered in the farms towards the end of the season when last weeding were carried out. Moisture left in the soil before on set of dry season caused decay and break down by soil micro and macroorganisms for example termites, crickets, soil boring animals which upturn soils and including earth worms. All these are locked up in the soil till the next cropping season which would have resulted in the high mean values for OC in dry season an indication of healing processes within the soil profile. Some cultural practices for example crop rotation, multiple cropping, mulching increase OM, while decrease in OM in soil could be by plants or soil erosion and other climate factors [51].

Nitrogen is one of the 3 essential elements for plant growth and development and can easily lose through anthropogenic activities either directly or indirectly. The result revealed N in wet season (0.16cmol/kg N) was slightly higher than its control (0.14cmol/kg N) by (0.02cmol/kg N). N in dry season (0.16cmol/kg N) and control (0.12cmol/kg N) was also slightly higher than its control by (0.04cmol\kg N). Wet and dry season compared were of the same mean value (0.16cmol/kg N). This revealed that cropping activities and the multicropping whose leaves and plant parts forms crop residues and weeds from weeding could have contributed to the value obtained in the wet season which was same in the dry season with less farm activities and reduction in soil microbial activities. Our finding is corroborated by [52] long term study on cropping system under different crops combination of continuously cropped alfalfa, continuously cropped wheat and legume-grain rotation and fallow, which revealed increase in stocks of OC and N in total soils (0-40cm) at mean rates of 15.6g OC m^{-2} yr^{-1} and 1.2g N m^{-2} yr^{-1} relative to a fallow control.

The exchangeable bases (Ca^{++}, Mg^{++}, K^{+}, Na^{+}, Al^{+++}) are necessary in the soil as it has bearing on its physical, biological and chemical properties. The analyzed soils samples revealed that Ca mean values in wet season (7.94cmol/kg) higher than control (3.53cmol/kg) by 2.2x; while in dry season(5.96cmol/kg) higher than its control (2.76cmol/kg); wet (7.94cmol/kg) and dry (5.96cmol/kg) compared revealed that wet season is higher than dry season. Mg mean values for wet season (0.85cmol/kg) and control (0.84cmol/kg) difference very negligible. Dry season mean value (0.68cmol/k) compared with its control show experiment was higher than control (0.42cmol/kg). Wet and dry season compared revealed wet (0.85cmol/kg) higher than dry (0.68cmol/kg). K mean value in wet (0.11cmol/kg) season is higher to that of its control (0.10cmol/kg) by (0.01cmol/kg), while in dry season (0.08cmol/kg) was slightly higher than its control (0.05 cmol/kg). The same trend was observed with wet and dry season compared (0.11 cmol/kg) and (0.08 cmol/kg). Na mean value for wet season is higher than its control (0.23 cmol/kg)(0.20cmol/kg) and same with dry season and its control (0.20 cmol/kg) (0.11 cmol/kg). Wet and dry season compared revealed wet higher than dry season. This is the same trend across all the exchangeable bases. The increase in mean values in wet season and drop in dry season mean values for controls could be attributed to the initial land preparation which involved slash, burn and tillage of soil which provided the initial and available nutrients for crop species and weeds in which some elements initiated germination, while some elements are needed for flower, fruit, tuber and corm formation. [29] [53] [54] corroborated our findings that active and cropped arable farmland that passes through slash and burn do experience increases of exchangeable bases as they are mobile in the rainy season and are locked up during the dry season.

Trace metals are generally needed in micro quantities in the soil for the use of planted crop species and other vegetative matter on the soil, and lack or more of trace elements in soil could cause a considerable impact on the crop species, other plants and man. The result revealed trace metals mean values in wet season were higher than its control and same with dry season and control (Table 6). However, the comparison between wet and dry season also revealed these differences for (Mn and Cu) higher in wet season and while it was the reverse for (Fe and Zn). The increase and decreased of trace elements in the arable farmland are mostly attributed to anthropogenic activities in various forms like slash and burn, application of inorganic and organic manure, soil erosion, dumping industrial wages, sewage sludge, through leaching, crop harvest, surface runoff and volatilization [55] [56] [57].

5 Conclusion

The search for a more friendly farming systems practice for food production in the face of the raising world population, increase in food demand and sustainability of the agroecosystems in spite of climate change seems to be in vogue in national and international discourse nowadays. Multicropping practice seems to be the right candidate of choice due to its multiple benefits to man, the soil, crop species, biodiversity and the environment at large. Several varieties of crop species are cultivated which provide food, income, improve the wellbeing and reduction in poverty of crop producers. Soil benefits from the cropping combinations, which improves the soil physicochemical properties for continuous use, reduce soil degradation; different crop species are planted which helps nutrients distribution dynamics and help to control pests and diseases; biodiversity and environment protect from serious abuse by continuous use for food crops production.

Compliance with ethical standards

Acknowledgments

All individual who has contributed to this work has been listed as authors.

Disclosure of conflict of interest

No potential conflict of interest by the authors.

References

[1] Max R."Employment in Agriculture". OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/employment-in-agriculture'2013, [Online Resource].

[2] [2]Greig L. An Analysis of the Key Factors Influencing Farmer's Choice of Crop, Kibamba Ward, Tanzania. Journal of Agricultural Economics, 2009, 60 [3]:699-715.

[3] Iizumi T. Ramankutty N. How do weather and Climate influence cropping area and intensity? Global food security, 2015, Vol. 4:46-50.

[4] Snapp S and Pound B. Agricultural Systems: In Agroecology and Rural Innovation for Development, (2nd Edition), March 2017.

[5] Nkanga NE. The role of the marketing board in Nigeria, 1947-1986: development or exploitation. Nigerian Journal of Economic History, 2014, Vol.11.

[6] Udemezue JC. Kanu NA. Challenges of Nigerian Agricultural Sector in the Twenty First Century: The Case of Nomadic Insurgence and Terrorist Sects. Universal Journal of Agricultural Research, 2019, 7 [2]: 117-124.

[7] Olukunle OT. Challenges Prospects of Agriculture in Nigeria: The Way Forward. Journal of Economics and Sustainable Development, 2013, 4 [16]: 37-45.

[8] Bacior S. Prus B. Infrastructure development and its influence on agricultural land and regional sustainable development, Ecological Informatics,2018, Volume 44, Pages 82-93.

[9] Edeme RK. Nkalu NC. Idenyi JC. Arazu WO. Infrastructural Development, Sustainable Agricultural Output and Employment in ECOWAS Countries, Sustainable Futures, 2020, Vol. 2, 100010,2666-1888

[10] Stagnari F. Maggio A. Galieni A. Pisante M. Multiple benefits of legumes for agriculture sustainability: an overview. Chem. Biol. Technol. Agric. Feb 2017,4 [2],pages 13.

[11] Kyei-Mensah C. Kyerematen R. Adu-Acheampong S. Impact of Rainfall Variability on Crop Production within the Worobong Ecological Area of Fanteakwa District, Ghana. Advances in Agriculture, HINDAWI, Volume 2019, Article ID 7930127, 7 pages.

[12] Francis CA. Porter P. Multicropping, In: Encyclopedia of Applied Plant Sciences (2nd edition) 2017

[13] Muir KS. Initial assessment of the ground water resources in the Monterey Bay Region, California. US Geological Survey, Water Resources Division.1977 Sept; 77 (46):1-44.

[14] Mueller-Dombois D. Ellenberg H. Aims and Methods of Vegetation Ecology. 1st Ed. New York: John Wiley and Sons; 1974.

[15] Vernon R. Field Guide to Important Arable Weeds of Zambia.1st ed. London: Balding + Mansell Limited London and Wisbech, England; 1983.

[16] Akobundu IO. Agyakwa CW. A Handbook of West African Weeds. 2nd Edition. Ibadan: African Book Builder; 1998.

[17] Akobundu IO, Ekeleme, F. Agyakwa CW, Ogazie CA. A Handbook of West African Weeds. 3rd ed. Lagos: AfKAK; 2016.

[18] [18] Ekeke C, Ogazie CA, Agbagwa IO. Checklist of weeds in University of Port Harcourt and Its environs. J. Appl. Sci. Environ. Manage.2019 April; 23 (4): 585-92.

[19] Bremner J, Mulvaney C. Total nitrogen. In: Page AL, Miller RH and Keeny DR (Eds,), In: Methods of soil Analysis 2nd ed. Wiley Online Library: Hoboken, NJ, USA.1983: 1049-1178.

[20] Sommers L.E, Nelson D.W. Determination of total phosphorus in soils: A rapid perchloric acid digestion procedure. Soil Sci. Soc. Am. J. 1972 Nov 1; 36 [6]:902-4.

[21] Bray RH, Kurtz LT. Determination of total, organic, and available form of phosphorus in soil. Soil Sci.1945 Jan; 59: 39-46.

[22] Gavlack R, Horneck D, Miller R. Plant, soil and water reference methods for the Western Region. Western Regional Extension Publication (WREP) 125, WERA-103 Technical Committee 2005; p. 207.

[23] Thomas GW. Exchangeable Cations. In: A. L. Miller, R.H., and Keeney, D R., (Eds.), Methods of Soil analysis. Part 2, 2nd edition. Am Soc Agr and Soi Sci of Am. Madison. Wisconsin, USA. 1982 p. 159-65.

[24] Warncke D, Brown JR. Potassium and Other Basic Cations. In: Brown, J.R., (Eds.), Recommended Chemical Soil Test Procedures for the North Central Region, NCR Publication No. 221, Missouri Agricultural Experiment Station SB 1001, University of Missouri, Columbia, 1998: p.31-33.

[25] Okalebo JR, Gathna KW, Woomer PL. Laboratory Methods for Soil and Plant Analysis: A Working Manual. 2nd Ed., Tropical Soil Biology and Fertility Programme, TSBF-CIAT and SACRED Africa, Nairobi, 2002: 128 p.

[26] Odu CT, Babalola IO, Udo EJ, Ogunkunle AO, Bakare TO, Adeoye GO. Laboratory manual for agronomic studies in soil plant and microbiology. Department of Agronomy, University of Ibadan, Nigeria.1986; P. 83.

[27] Juo ASR. Selected Methods of Soil and Plant Analysis. IITA Manual Series No. 1, 1978; p.57.

[28] Lindsay WL, Cox FR. Micronutrient soil testing for the tropics. In: Vlek PLG. (Ed.), Micronutrient in Tropical Food Crop Production. Springer, Dordrecht. The Netherlands.1985; pp. 169-200.

[29] Ogazie CA, Ochekwu EB, and Agbagwa IO. Influence of farming systems practices on physicochemical properties of soils in wet and dry season in University of Port Harcourt, Nigeria. GSC Advanced Research and Reviews, 2022, 11(02), 089–101.

[30] Santin-Montanya MI. Sacristan AS. (2019). Effects of soil tillage techniques on weed flora in high input barley systems in Northern Spain. Can. J. Plant Sci., June 2019, Vol. 100 [3]:245-252.

[31] Wotton DM. McAlpine KG. Seed dispersal of fleshy-fruited environmental weeds in New Zealand. New Zealand Journal of Ecology (2015) 39 [2]: 155- 169.

[32] Mahgoub A. (2019). The impact of five environmental factors on species distribution and weed community structure in the coastal farmland and adjacent territories in the northwest delta region, Egypt. Heliyon,, April 2019, 5 [4], e01441.

[33] Fahad S, Adnan M, Noor M, Arif M, Alam M, Khan IA, Hidayat Ullah H. et al. Major Constraints for Global Rice Production. In: Hasanuzzaman M, Fujita M, Nahar K, Biswas JK.(Eds). Advances in Rice Research for Abiotic Stress Tolerance, Woodhead Publishing, 2019, Pages 1-22.

[34] Amare T. Review of impact of climate change on weed and their management. American Journal of Biological and Environmental statistics, Dec 21, 2016 Vol. 2 [3],pp. 21-27.

[35] Abreu V, Dias H, Kunz S, van den Berg E, Garbin M. (2021). The soil seed bank as an indicator of altitudinal gradient in a Montane Tropical Forest. Journal of Tropical Forest Science, Oct 2012 33([4]: 473–481.9 (pages).

[36] Ma M, Dalling JM, Ma Z, Zhou X.(2017). Soil environmental factors drive seed density across vegetation types on the Tibetan Plateau. Plant and Soil , Aug 2017,419 [1]:349-361.

[37] Jannat N, Begum M, Salam MA, Monira S. (2019). Weed seed distribution at different depth of soil in a crop field. Fundamental and Applied Agriculture, 2019, 4 [2]: 815-822.

[38] Takin FO, Amodu AA. A Quantitative Estimate of Weeds of Sugarcane (*Saccharum officinarum* L.) Crop in Ilorin, Southern Guinea Savanna of Nigeria. Ethiopian Journal of Environmental Studies and Management, 2013, 6 [6]:611-619.

[39] Kazakou E, Fried G, Cheptou PO, Gimenez O. (2021). Does seed mass drive interspecies variation in the effect of management practices on weed demography? Ecology and Evolution, 2012 Sep 2,11 [19]: 13166–13174.

[40] Jat HS, Kumar V, Kakraliya SK, Abdallah AM, Datta S, Choudhar M, Gathala MK, McDonald AJ, Jat ML, Sharma PC.(2021). Climate-smart agriculture practices influence weed density and diversity in cereal based agri-food systems of Western Indo-Gangetic plains. Scientific Reports, 2021, 11 [1],15901.

[41] Ajayi JO. Comparative economic study of mixed and sole cassava cropping systems in Nigeria. Agris On-Line Papers in Economics and Informatics*, 2014,* 6(4).

[42] Mondal P, DeFries R, Clark KT, Flowerhill N, Arif Md, Harou A, Downs S, Fanzo J. Multiple cropping alone does not improve year-round food security among smallholders in rural India. Environ. Res. Lett., 2021 June, 16, 065017.

[43] Waha K., Dietrich JP, Portmann FT, Siebert S, Thornton PK, Bondeau A, Herrero M.(2020). Multiple cropping systems of the world and the potential for increasing cropping intensity,Global Environmental Change, 2020, Vol. 64,2020.

[44] Jones AD.(2017). On-Farm Crop Species Richness Is Associated with Household Diet Diversity and Quality in Subsistence- and Market-Oriented Farming Households in Malawi. The Journal of Nutrition, 2017 Jan, Volume 147, [1]: Pages 86–96.

[45] Gebru H. (2015).A review on the comparative advantages of intercropping to mono cropping system. Journal of Biology, Agriculture and Healthcare, 2015, Vol. 5, [9], 28-38.

[46] Tellen VA, Yerima BPK. Effects of land use change on soil physicochemical properties in selected areas in the North West region of Cameroon. Environ Syst Res (2018) 7 [3]:1-29.

[47] Muluget T, Melese A, Tena W. (2019). Effects of land use types on selected soil physical and chemical properties: The case of Kuyu District, Ethiopia. Eurasian soil Sci. 2019, 8 [2]: 94-109.

[48] Bizuhoraho T, Kayirang A, Manirakiza N, Mourad K. The effect of land use systems on soil properties; A case study from Rwanda. Sustainable Agriculture Research, 2018, Vol.7, [2]:30-40.

[49] Ubuoh EA, Ejekwolu CC, Onuigbo IV. The effect of burnt and un-burnt land on soil physicochemical characteristics in Ekey-Okobo Local Government Area, Akwa Ibom State, Nigeria. J. Appl. Sci. Environ. Manage. August 2017 Vol. 21(5): 923-929.

[50] Farias SCC, Mario Lopes da Silva Junior ML, Ruivo MLP, Rodrigues PG, Melo VS, Costa AR, Souza Junior JC. Phosphorus forms in Ultisol submitted to burning and trituration of vegetation in Eastern Amazon. Rev Bras Cienc Sol 2016; V40: e0150198.

[51] Ayanlaja SA, Sanwo JO.(1991). Management of soil organic matter in the farming matter in the farming systems of the low land humid tropics of West Africa: a review. Soil Technology, 1991 Sept, Vol. 4(3):265-279.

[52] Chu J, Zhang T, Cheng W, Zhang D, Zulfiqar S, Fu A. Hao Y. Impacts of cropping systems on aggregates associated organic carbon and nitrogen in a Semiarid Highland Agroecosystem. PLoS ONE, 2016 Oct 20, 11 [10]: e0165018.

[53] Kukla J, Whitfeld TJS, Cajthaml T, Baldrian P, Vesela H, Novotny V, Frouz J. The effect of traditional slash and burn agriculture on soil organic matter, nutrient content and microbiota in tropical ecosystems of New Guinea. Land Degradation and Development,2018 Oct, 30 [2]: 166-177

[54] Ebel RH. Effects of slash and burn farming and a fire-free management on a Cambisol in a traditional Maya farming system. CIENCIA ergo-sum, 2018, Vol. 25, [2]: 193-203.

[55] Montagne D, Cornu S, Bourennane H, Baize D, Ratie C, King D. Effect of agricultural practices on trace element distribution in soil. Communications in Soil Science and Plant Analysis 38 [3-4]: 473-491.

[56] Chang AC, Page AL. Trace elements slowly accumulating, deplecting in soils. California Agriculture 2000, 54 [2]:49-55.

[57] Sudhakaran M, Ramanoorthy D, Savitha V, Balamurugan S. Assessment of trace elements and its influence on physicochemical and biological properties in coastal agroecosystem soil, Puducherry region. Geology, Ecology and Landscapes, 2018 Apr, Vol.2 [3]:169-176.