ORIGINAL ARTICLES

A Publication of
NOARA
Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بإفريقيا

AfrONet
African Organic Network

ISSN: 2734-2913

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY (AJOAE)

Volume 2, 2019

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY (AJOAE)

Volume 2, 2019

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

ISSN: 2734-2913

www.noara.bio

ABOUT NOARA

Network of Organic Agriculture Researchers in Africa (NOARA) is established to unite and coordinate African organic and ecological agriculture scientific and technical researchers within and outside Africa. NOARA is a membership Network that draws members from national, regional, continental and international organic agriculture organizations, associations, networks and companies within and outside Africa, but whose aims and goals are in support of organic and ecological agriculture.

NOARA Vision
Africa with zero hunger, poverty eradicated, improved livelihood and sustained ecosystem through innovative organic agriculture research/ une Afrique sans faim, sans pauvreté, avec de meilleurs moyens de subsistance et un écosystème durable grâce à une recherche innovante en matière d'agriculture biologique.

Mission
To establish and disseminate evidence-based scientific organic agricultural knowledge that can ensure healthy, ecological, fairness and care of organic agriculture actors in Africa for sustainable livelihood and ecosystem, leading to food security and sustainable development / Établir et diffuser des connaissances scientifiques en agriculture biologique fondées sur des données factuelles, susceptibles de garantir des moyens de subsistance durables et un écosystème sain, écologique, équitable et responsable aux acteurs de l'agriculture biologique, menant à la sécurité alimentaire et au développement durable.

NOARA OBJECTIVES

A. *Research and Training / Recherche et formation*
- Lead research agenda on organic and ecological agriculture in Africa / Programme de recherche principal sur l'agriculture biologique et écologique en Afrique
- Coordinate organic and ecological agriculture training and research in Africa / Coordonner la formation et la recherche en agriculture biologique et écologique en Afrique
- Support or initiate research activities that contribute to the social, cultural and economic productivity of Africa's smallholder farmers, processors and marketers, particularly, women and youths who have been largely marginalized / Soutenir ou lancer des activités de recherche qui contribuent à la productivité sociale, culturelle et économique des petits exploitants, transformateurs et commerçants africains, en particulier des femmes et des jeunes largement marginalisés

B. *Policy and Stakeholder Engagements / Politique et engagement des parties prenantes*
- Promote collaboration among organic and ecological agriculture researchers, practitioners, farmers and policy makers in Africa / Promouvoir la collaboration entre les chercheurs, les praticiens, les agriculteurs et les décideurs de l'agriculture biologique et écologique en Afrique.
- Improvement of ecological organic agriculture database for influencing policy development in Africa / Amélioration de la base de données sur l'agriculture biologique écologique pour influer sur l'élaboration des politiques en Afrique
- Advocate for mainstreaming of organic and ecological agriculture into agricultural research and innovation to enhance food security in Africa / Plaider pour l'intégration de l'agriculture biologique et écologique dans la recherche et l'innovation agricoles afin de renforcer la sécurité alimentaire en Afrique
- Engage organizations producing organic and ecological inputs in confirmatory and adaptive research for possible recommendation of their products to end users in Africa and beyond / Engager les organisations produisant des intrants biologiques et écologiques dans la recherche de confirmation et la recherche adaptative en vue de la recommandation éventuelle de leurs produits aux utilisateurs finaux en Afrique et au-delà.

C. *Conferences and Information Dissemination / Conférences et diffusion de l'information*
- Organize conferences and meetings for the exchange of information on organic and ecological agriculture / Organiser des conférences et des réunions pour l'échange d'informations sur l'agriculture biologique et écologique.
- Publish research and technical results on organic and ecological agriculture / Publier des recherches et des résultats techniques sur l'agriculture biologique et écologique
- Organize consortia of experts in addressing specific or emerging issues relating to organic and ecological agriculture in Africa / Organiser des consortiums d'experts pour traiter des problèmes spécifiques ou émergents liés à l'agriculture biologique et écologique en Afrique

D. *Advocacy and Awards / Plaidoyer et récompenses*
- Honour distinguished members as fellows of the network / Honorer les membres distingués en tant que membres du réseau
- Represent the interest of organic and ecological agriculture researchers beyond Africa / Représenter les intérêts des chercheurs en agriculture biologique et écologique en dehors de l'Afrique

NOTES TO AUTHORS

African Journal of Organic Agriculture and Ecology (AJOAE) – A journal of Organic Agriculture and Ecology is published biannually to create an effective medium for dissemination of information on organic agriculture research findings in all areas of Agriculture, Food Sciences and Ecology.

Scope:
Contributions may be on Agricultural Economics, Agricultural Engineering, Agricultural Extension, Agroforestry, Animal Science, Crop/Environmental Protection, Crop Science, Environmental Sciences, Fishery/Aquaculture, Pharmacy, Soil science, Veterinary Medicine, Wildlife Management. Manuscripts can be submitted in both English and French Languages.

Preparation of manuscripts:
- Articles could be written in either English or French with moderate technical terminologies to facilitate wide readership.
- All manuscripts should be typed, Times New Roman (12), 1.5 spacing on A4 size (210 x 297mm) paper.
- The length of the manuscript should in general not exceed 12 pages (tables, figures and other illustrations inclusive).
- Leave ample margins, 2.54 cm to the left and 2.54 cm to the top and bottom of the page.
- The cover sheet should contain (a) Title of the article (b) Author (s) name, followed by a line at the tail end giving name and address to which all correspondence should be addressed.
- The manuscript should be organized as follows: TITLE, ABSTRACT (250 words max), INTRODUCTION, MATERIALS AND METHODS or METHODOLOGY), RESULTS, DISCUSSION (or RESULTS AND DISCUSSION), CONCLUSION AND RECOMMENDATION, ACKNOWLEDGEMENTS (where necessary) and REFERENCES.
- The main heading should be centered and capitalized; the secondary and tertiary headings should be typed in lower case letters to the left of the page.
- Use only international system of Unit (SI) and ensure that units are quantitative measurements, e.g. 3kg; when they are preceded by a capitalized noun, e.g. Table 8.
- Tables and figures should be numbered in Arabic numerals, cited in the text, sources indicated if not original (i.e. not made by the author), and on separate sheet(s).
- Each table and figure should have an explanatory legend, which should be typed at the bottom of the page.
- Reference citation in the text should follow the name, years system; all references cited must be listed in alphabetical order of the sole/senior/first author's names; each reference should be systematic as for journal; surname of the author(s) initials; year of publication (in parenthesis), title of paper, name of Journal (italicized), volume number, number of issue (if applicable) in Arabic numerals on the first and the last pages of the references, e.g. Ladele A.A. (1991) …………………………………………."A Descriptive Analysis of Agriculture Cooperative Model in Rural Development". ***Journal of Rural Development and Administration.*** 23 (3):1-8.

For two or more authors – Tanimu, J., Iwuafor, E. N. O., Odunze, A .C. and Tian. G. (2007). Effect of incorporation of leguminous cover crops on yield and yield components of maize. *World Journal of Agricultural Sciences* 3 (2): 243-249.

For the citation of books, the author's name comes first followed by year of publication in bracket, title of book (underlined), edition and volume number (if any) page or pages, city of publication and publishers e.g.
Brady, N.C. and R.R. Weil, (2002). *The nature and properties of soils*, 13th Ed. Prentice- Hall Inc., New Jersey, USA. 960p.

For a chapter in a book, e.g. Benjamin, T.K., Pan, I.K. and Kum, O.A. (2004). Mechanised Agriculture in the 21st Century. In Babajide, O.L., Otuoke, G.J. and Nwakwo I.A. (Eds.) Agriculture and Mankind. Casablanca: Hopewell. 12-23pp.

Cost of publishing in AJOAE
Careful editing and scrutiny are required before sending manuscript to the editor as there may be no opportunity for alteration once an article is accepted for publication based on reviewers' comments. A **processing fee of $100 (one hundred US Dollars)** upon acceptance of each article shall be paid by authors before publishing such article.

Contributors are to send their manuscripts, not previously published or being considered for publication elsewhere to:

The Editor-in-Chief
African Journal of Organic Agriculture and Ecology (AJOAE).
Emails; editor@noara.bio ; noaraafrica@gmail.com
Website: www.noara.bio

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY (AJOAE)

Volume 2, 2019

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

ISSN: 2734-2913

A publication of

Network of Organic Agriculture Researchers in Africa

RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE

شبكة الباحثين في الزراعة العضوية بإفريقيا

With support from

AfrONet

African Organic Network

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY (AJOAE)

EDITORIAL TEAM

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY (AJOAE)

Volume 2, 2019

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

Table of Contents

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

ISSN: 2734-2913

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

NOARA Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بإفريقيا

www.noara.bio

Influence of Planting Seasons and Residual Fertility from Jack Bean Fallow and Compost on Yield of *Corchorus olitorus* I. in an Organic Farming System

AdeOluwa, O. O.
Department of Soil Resource Management, Faculty of Agriculture,
University of Ibadan, Nigeria.
Corresponding Author E-mail: adeoluwaoo@yahoo.com;orcid.org

Abstract
Ability of applied soil fertiliser to sustain crop production beyond a cropping season is an advantage to farmers. Thus, this report presents evaluation of residual soil fertility influence of previous Jack bean fallow and a commercial compost application on the yield of *corchorus* in an organic farming system in both dry and rainy seasons. The experiment was conducted at the Organic Vegetable Garden of Teaching and Research Farm, University of Ibadan. *Corchorus* seeds were sown in plots treated with Brewery Waste Compost grades A and B, Brewery Waste Compost Grade A +Jack bean residual fertility, Brewery Waste Compost Grade B + Jack bean residual fertility, Jack bean residual and Control (no soil additive). The experiment was laid out in a Randomized Complete Block Design (RBCD) replicated four times with 24 beds of 1.5m x 1m each. Soil analytical data generated were analysed descriptively with means and standard deviation, while error bar at 0.05 significant level was used to analyse statistical significance of yield data. Although the control soils relatively had better pre-planting soil fertility status in both planting seasons, the Brewery Compost Grade B resulted in the highest dry weight of *corchorus* (1.93 t/ha) in the dry season. This was not significantly higher than that of combination of Brewery Compost Grade A+ Jack bean (1.84 t/ha), while Brewery Compost Grade A+ Jack bean (2.21 t/ha) resulted in highest dry matter yield in the rainy season. Therefore, combination of Brewery Compost Grade A and Jack bean fallow in the rainy season is recommended as an alternative soil fertility measure for resource constrained organic *corchorus* farmers who may not be able to frequently apply organic fertilisers in their production.

Keywords: Compost, soil fertility, organic agriculture, fertilisers.

Influence des saisons de plantation et de la fertilité résiduelle de la jachère et du compost de Jack Bean sur le rendement de *Corchorus olitorus* I. dans un système d'agriculture biologique

Abstrait
La capacité de l'engrais appliqué au sol à pouvoir soutenir la production agricole au-delà d'une campagne agricole se révèle comme un avantage pour les agriculteurs. A cet effet, cette étude présente une évaluation de l'influence résiduelle de la fertilité du sol de la jachère précédente de haricots Jack et une application commerciale de compost sur le rendement de l'espèce *corchorus* dans un système d'agriculture biologique en saison sèche et pluvieuse. L'expérience a été menée au Jardin potager biologique de la ferme d'enseignement et de recherche, de l'Université d'Ibadan. Le semis a été fait dans des parcelles traitées avec du compost de déchets de brasserie de grades A et B, de

ISSN: 2734-2913
Volume 2, 2019, pp 1-10
Date Published: December 16, 2019

compost de déchets de brasserie de grade A + fertilité résiduelle de haricot Jack, de déchets de compost de brasserie de grade B + fertilité résiduelle de haricot Jack, de haricot Jack résiduel et témoin (sans additif pour le sol). L'expérience a été présentée dans un modèle de bloc complet randomisé (RBCD) répété quatre fois avec 24 parcelles élémentaires de 1,5 m x 1 m chacun. Les données relatives au sol ont été analysées de manière descriptive avec des moyennes et un écart type, tandis qu'une marge d'erreur à un niveau significatif de 0,05 a été utilisée pour analyser la significativité statistique des données de rendement. Bien que les sols témoins aient relativement eu un meilleur état de fertilité des sols avant la plantation pendant les deux saisons de plantation, le Compost de Brasserie de catégorie B a donné le poids sec le plus élevé de *corchorus* (1,93 t/ha) pendant la saison sèche. Ce n'était pas significativement plus élevé que celui de la combinaison du compost de brasserie de catégorie A + haricot Jack (1,84 t/ha), tandis que le compost de brasserie de catégorie A + haricot Jack (2,21 t / ha) a entraîné le rendement en matière sèche le plus élevé pendant la saison des pluies. Par conséquent, une combinaison de compost de brasserie de catégorie A et de jachère de haricots verts pendant la saison des pluies est recommandée comme mesure alternative de la fertilité du sol pour les agriculteurs de corchorus organiques aux ressources limitées qui pourraient ne pas être en mesure d'appliquer fréquemment des engrais organiques dans leur production.

Mots clés: compost, fertilité des sols, agriculture biologique, engrais.

Introduction

Poor soil fertility as a result of unsustainable agricultural practices is one of the major threats to agricultural productivity and food security in the smallholder farming systems in the tropics (Sanchez and Leakey, 1997). Each year, tropical soils' finite capacity to grow food and fibre has progressively decreased, largely because of the decline in soil fertility (AdeOluwa *et al*., 2009).

Continuous and intensive cropping without any effort to restore soil fertility has depleted the nutrient base of most soils (Bationo *et al*., 1998). Increasing population pressure on agricultural land has resulted in higher nutrients' out-flow thus creating a vicious circle of food insecurity and poverty (Sanchez *et al*., 1997). Soil fertility depletion is therefore a fundamental biophysical constraint which needs to be tackled to ensure food security in Africa (Sanchez and Leakey, 1997). Soil organic matter plays a major role in soil fertility as it affects both physical and chemical properties, and also controls soil microbial activity by serving as a source of mineralizable carbon (C) and nitrogen (N) (Solomon *et al.*, 2002).

Productivity losses in the tropics are often attributed to loss of N, soil organic carbon and accelerated water depletion resulting from severe soil degradation (Lakew *et al.,* 2000). Therefore, the management of the soil in order to prevent further degradation and soil productivity is imperative.

While most farmers are familiar with improving crop yields with application of fertilisers, there is a dearth of information on the influence of planting seasons on residual fertility of previously applied fertilisers on subsequent crops. Residual soil fertility (Güerena *et al*., 2016) is very important for resource constrained farmers who may not have the capability of applying fertilisers to soils frequently. This is the situation of most organic farmers in many developing countries including Nigeria. Complete residue removal for fodder and fuel, intensive and excessive tillage have depleted soil organic carbon (C) stocks. This has led to the deterioration of soil fertility and soil water storage capacity, resulting in frequent crop failures.
Therefore, the management of the soil in order to prevent further degradation and soil productivity is imperative (Ogban and Babalola, 2003). Compost application is reported to have positive effects on the physical, chemical and biological properties of the soil which often leads to higher crop yields (Abedi *et al*., 2010; Hafldi *et al*., 2012). Compost provides a steady supply of nutrients to the crop, thus improving productivity (Hafldi *et al.,* 2012).

The residual effect from one year application of compost has been reported to increase the yield of straw ranging from 7 - 271% as reported on rice (Sarwar *et al*., 2007), wheat (Sarwar *et al*., 2007; Abedi *et al.,* 2010) and sorghum (Ouedraogo *et al*., 2001). Nahar *et al.* (1995) reported 97% yield increase in wheat from residual effects of compost.

Fertilisers from plant sources (e.g. jack bean) have been reported as substitutes for commercial N fertilisers cropping systems (Follett *et al*., 1991). Jack bean (*Canavalia ensiformis*) is a legume cover crop that is an efficient, low-cost source of nitrogen with considerable potential to improve soil fertility in intensified cropping systems (Carsky *et al.,* 1998). Legumes can play an important role in management of nitrogen (N) for vegetable production, especially in tropics where low native fertility is a major constraint to crop production. Fertile soils are used for the cultivation of leafy vegetable because they require heavy dose of major elements (N, P and K) (NIHORT, 1986). Biological nitrogen from legumes has been observed to sustain tropical agriculture at a moderate level of output, as well as climate, soil physical and biological properties (Giller *et al*., 1997; Giller, 2001).

In the same vein, composts are widely used as soil amendments to improve soil structure, provide plant nutrients and facilitate the re-vegetation of disturbed soils (Brady and Weil, 2002; Adugna, 2018). The sole use of compost or leguminous crops for soil fertility purposes in organic farms has financial implications which most resource constrained farmers may not be able to adopt at all times. Thus, there is a need to investigate the influence of planting seasons on residual soil fertility from previously applied fertilisers for crop production.

Jack bean (*Canavalia ensiformis*) is a legume cover crop that is an efficient, low-cost source of nitrogen with considerable potential to improve soil fertility in intensified cropping systems (Carsky *et al.,* 1998). *Corchorus olitorus* also is a leafy vegetable consumed in many parts of West Africa, Asia and in the Middle East (Akoroda and Akinlabi, 1987). *Corchorus olitorus* is an annual dicotyledonous flowering herb belonging to the family of *Tiliaceae*. It is found in many parts of India as well as China and many parts of Australia and Africa especially South Western Nigeria (Carter and Varina, 2001). *Corchorus olitorus* is a vegetable food to many families in Africa, Asia and the Middle East; it is also used for fibre production in the Americas, known by the common name: jute (Masarirambi *et al.,* 2010). The temperature range for *Corchorus olitorus* is 25 - 32°C and it performs better in an area with rainfall between 600 and 2000 mm/yearThe crop has been reported to respond positively to compost application at the rate of 75kg N/ha with average yield of 20.5 to 40 t/ha for cuttings and 7.8 to 9.0 t/ha of uprooted yield in a cropping season (Denton, 1997).

Although, organic fertilisers generally have been reported to have potential in supplying plant nutrients beyond a cropping season (Sarwar *et al*., 2007; Abedi *et al*., 2010), however, seasonal variation could also affect release of nutrients in soil. Therefore, investigating the influence of planting seasons on residual fertility of compost-Jack bean on yield of *corchorus* is important. Hence, the study evaluated residual fertility potentials of compost and Jack bean- fallow on the yield of *corchorus*, as well as the influence of dry and rainy seasons on residual nutrient status of the treatments in an organic farming system.

Materials and Methods

The experiments were conducted between March and June 2015 at the Organic Vegetable Garden Teaching and Research Farm, University of Ibadan, Nigeria. The research farm is located in the derived savannah of South-west Nigeria which lies at latitude 7°24'N and longitude 3°54'E with elevation of 62m above sea level. The mean monthly temperature ranges between 24°C and 30°C and the mean annual rainfall ranges between 1800 mm and 2100 mm. The rainy season occurs between April and November. The experimental site has a bimodal annual distribution of rainfall that assumes the first peak in June and the second peak in September, with break in August during this period. The dry season follows immediately starting from

November to March with associated Harmattan winds. The experimental plot had previously been used to plant vegetable in an organic system.

This investigation was based on residual fertility effects of the following treatments previously applied to the experimental soil:

i. IBBW1 (Ibadan brewery waste based grade A)
ii. IBBW2 (Ibadan brewery waste based grade B)
iii. IBBW1(Ibadan brewery waste based grade A) + Jack bean residual fertility
iv. IBBW1(Ibadan brewery waste based grade B)+ Jack bean residual fertility
v. Jack bean residual fertility
vi. Control (no fertiliser treatment)

In a previous experiment, compost was applied at the rate of 100 kg N/ha in an inter-crop of Jack bean and *corchorus* with resultant yields of fresh biomass of *corchorus* from compost grade B (31.24t/ha^{-1}) > grade A (26.80t/ha^{-1}) > grade B + Jack-bean > and compost grade A + Jack-bean. No fertiliser was applied during the reported investigation. Pre-cropping soil analysis was carried out using standard chemical procedures. The experiment was laid out in a Randomized Complete Block Design (RBCD) replicated four times having a total land area of 166.4m^2 with 24 beds of 1.5m x 1m each. The soil texture ranged from sandy to loamy sand which is slightly acidic.

Soil Sampling and Laboratory Soil Analysis

The soil samples were collected at random from the experimental site at a depth of 0 - 15 cm using a soil auger before sowing of seed. Soil tests were conducted on the experimental area before planting to determine the nutrient status of the soil. The soil samples were air-dried and sieved through a 2 mm and a 0.5 mm mesh sieve. It was the analysed in the laboratory as follows:

Soil pH was determined using distilled water (1:1) on pH meter (Peech, 1965). Organic carbon was analysed by the dichromate wet oxidation method of Walkley-Black (1934). Total nitrogen was determined by macro Kjeldahl method of Jackson (1973). Available phosphorus was extracted with Mehlich III (Mehlich, 1984) and determined with a spectrophotometer.

Exchangeable bases were extracted using Mehlich III extracting solution (Mehlich, 1984). Exchangeable Ca and Mg were determined by Atomic Absorption Spectrophotometer, while exchangeable K was determined with a Flame photometer.

Agronomic Activities

Corchorus seeds were sown in March and July 2014, respectively for dry and rainy seasons' plantings, using drill method with spacing of 0.3 m inter-row and 0.5 m inter-bed spacing. The plants were thinned to an average of 270 plants/bed at two weeks after planting, arrive at an average population of 1.8 million plants/ha. During the dry season, watering was done daily, while the plants were subjected to rainfall during the rainy season. Collection of data started three weeks after sowing with four plants in the middle of each plot and was done weekly for three weeks.

Although parameters including number of leaves, stem girth, leaf area and plant heights were assessed on weekly basis, however, only dry plant weights are reported in this paper. The dry weight was obtained five weeks after sowing by drying plant samples in an oven of 65℃ temperature until constant weights were obtained. All weighing operations were done using a top loading digital weighing balance.

Statistical Analysis

Soil analytical data generated were analysed descriptively with means and standard deviation, while error bar at 0.05 significant level was used to analyse statistical significance of yield data.

Results

The pre-planting chemical properties of both planting cycles are shown in Tables 1 and 2. The results showed that soil pH range of the dry season was moderately acidic ranging from 5.9 - 6.1, with a mean of 6.0±0.1, while that of the wet season was slightly acidic to moderately acidic, ranging from 5.6 - 5.7, with a mean of 5.6±0.1. The organic carbon across the two planting cycles ranged from 3.2 - 4.9 g/kg. The pre-planting total nitrogen content of all the plots ranged from 0.1 to 0.2 g/kg in the two planting cycles. The residual available phosphorus of the experimental plots at the dry season ranged from 43 (Brewery Compost Grade B+JB) – 50 mg/kg (Control) with a mean of 46±2.7. However, the residual available phosphorus of the experimental plots at the rainy season ranged from 14 (Brewery Compost Grade A) – 26 mg/kg (Control and Jack bean) with a mean of 22±4.4.

Residual potassium of the experimental soils resulting from previous application of the soil fertility treatments ranged from 0.1 – 0.2 cmol/kg at both planting cycles. At the dry session, residual calcium ranged from 2.1 to 5.1 cmol/kg with a mean of 3.5±1.1, however, at the rainy season, residual calcium ranged from 1.6 to 3.0 cmol/kg with a mean of 2.1±0.6. In the case of magnesium, residual nutrient was 0.1 cmol/kg during the dry season, however, at the rainy season, residual magnesium ranged from 1.2 to 3.5 cmol/kg with a mean of 1.8±0.9.

Figure 1 presents the impact of residual soil fertility of the previously applied treatments on *corchorus*. At the dry season, Brewery Compost Grade B resulted into the highest dry weight of *corchorus* (1.93 t/ha), which was not significantly higher than the combination of Brewery Compost Grade A+ Jack bean (1.84 t/ha). Brewery Compost Grade A had the lowest dry weight of 1.24 t/ha and it performed lower than Jack bean (1.42 t/ha) and control (1.51 t/ha) at the end of the dry season planting. At the end of the rainy season, the highest dry weight was produced by soils treated with Brewery Compost Grade A+ Jack bean (2.21 t/ha), followed by control (1.99 t/ha), with the least from Jack bean fallow (1.24 t/ha).

Table 1: Influence of soil fertility methods on pre-planting residual chemical properties of the experimental soil during the dry season of 2015

Treatments	pH(H_2O)	Organic C g/kg	Total N g/kg	Avail. P mg/kg	Ca	Mg	K cmol/kg
Control	6.1	4.9	0.1	50	5.1	0.1	0.1
BCGA	5.9	3.2	0.1	47	2.1	0.1	0.1
BCGB	6.0	3.2	0.1	45	2.9	0.1	0.1
BCGA+JB	6.1	3.9	0.1	43	3.8	0.1	0.1
BCGB+JB	6.0	3.7	0.2	49	4.3	0.1	0.1
JB	6.0	4.9	0.2	46	3.0	0.1	0.1
MEAN	6.0	3.9	0.1	46	3.5	0.1	0.1
SD	0.1	0.6	0.1	2.7	1.1	0.1	0.1

Table 2: Influence of soil fertility methods on residual pre-planting chemical properties of the experimental soil at rainy season of 2015

Treatments	pH(H_2O)	Organic C g/kg	Total N g/kg	Avail. P mg/kg	Ca	Mg	K cmol/kg
Control	5.7	3.5	0.2	26	3.0	1.3	0.2
BCGA	5.6	3.4	0.2	14	2.4	1.5	0.1
BCGB	5.7	3.2	0.2	21	1.8	1.9	0.1
BCGA+JB	5.6	3.4	0.2	23	1.7	1.3	0.1
BCGB+JB	5.6	3.3	0.2	23	1.6	3.5	0.1
JB	5.6	4.0	0.2	26	2.1	1.2	0.1
MEAN	5.6	3.5	0.2	22.	2.1	1.8	0.1
SD	0.1	0.3	0.0	4.4	0.5	0.9	0.0

Legend
BCGA - BREWERY COMPOST GRADE A
BCGB - BREWERY COMPOST GRADE B
JB- Jack bean
SD- standard deviation

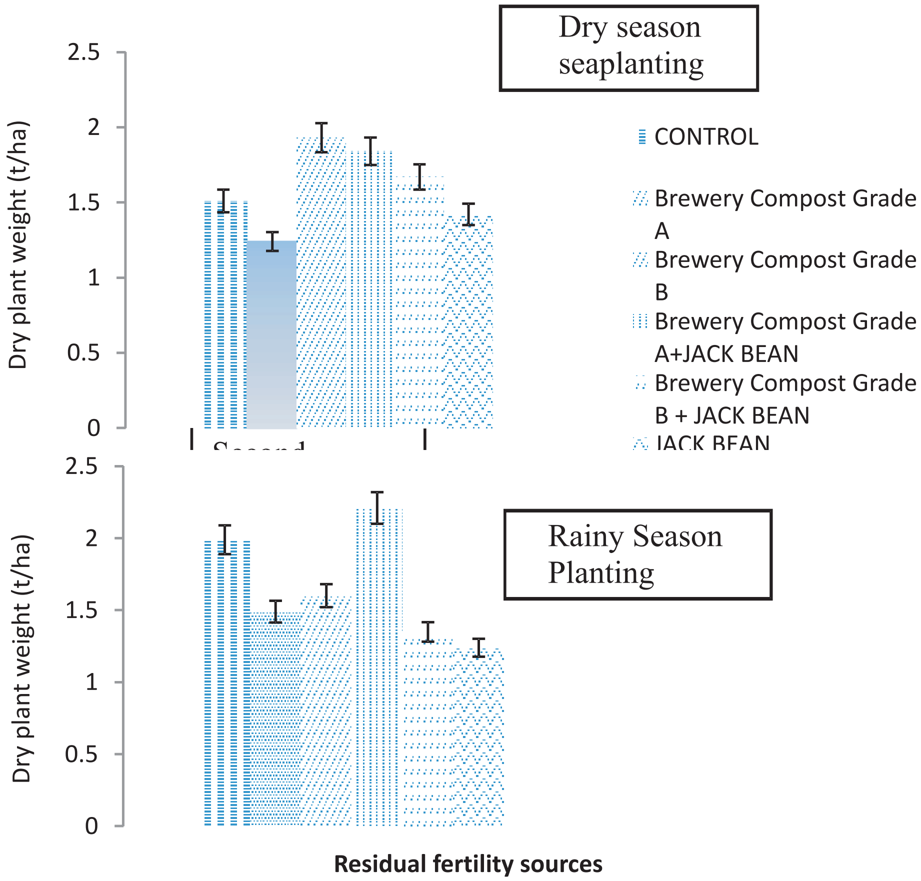

Figure 1: Dry yield of *corchorus* at 5 weeks after sowing as influenced by different residual fertility sources
Bar = standard error at <0.05

Discussion

Based on FFD (2012), residual fertility levels of the experimental soils were generally low, except for the available phosphorus, calcium and magnesium. Generally, it was observed that soil pH, residual organic carbon, available phosphorus and calcium were higher in the dry season than the rainy season. This may be due to leaching and fixation of the nutrient during the rainy season (Mengel and Kirkby, 2001). However, nitrogen was more available during the rainy season, although at lower soil fertility index. This could be due to a relatively favourable soil condition in mineralizing the nutrients from residual soil fertility treatments compared to the situation during the dry season planting. This varied availability of residual nutrients from previously applied nutrients as a result of different planting seasons raise some concerns regarding appropriate seasons that residual fertility soil additives could be optimized by *corchorus*. *Corchorus* being a leaf vegetable requires a reasonable level of soil nitrogen for vegetative development (Musa *et al.*, 2010).
Thus, the availability of more nitrogen during the rainy season could be beneficial to leaf vegetables like *corchorus*.

Despite the fact that the experimental soils have been previously used to raise *corchorus*, low soil nitrogen and no other form of fertiliser was supplied during the investigated planting seasons. The dry plant yields obtained from all the treatments were higher than the range of 0.66 – 1.34 t/ha reported by Adediran *et al.* (2015). The use of organic fertilisers has often been reported to be beneficial to crop production, especially in less fertile soil. It has been reported that N dynamics in compost amended soils could be affected by different site-specific factors, e.g., compost, composting conditions, climate, soil properties and management practices (Amlinger *et al*., 2003). In this study, the residual fertility influence of Jack bean and compost on the yield of *Corchorus* was evaluated. Studies revealed that one possible method of maintaining and improving soil fertility in organic farming is to adopt crop rotations, including a mixture of leguminous fertility-building crops and plants with different rooting depths (Watson *et al*., 2002). However, Dogra and Dudeja (1993) earlier reported that legumes fixed N from the atmosphere through their root nodules by the process of biological nitrogen fixation and high soil nitrogen could inhibit the ability of legumes in carrying out this function. Thus, the low N of the experimental soil could have provided a good environment for the Jack bean used as live fallow in this experiment to exhibit well its N fixing capacity.

Although soil nutrients of the pre-planting soils revealed that the control plots were higher in some nutrients like phosphorus, calcium and potassium in the overlap of both dry and rainy seasons, this did not eventually lead to highest dry matter yield by the control plots. This could be due to the fact that the Brewery Compost Grade B and Brewery Compost Grade A + Jack Bean fallow that performed better in dry matter yield during the dry season and Brewery Compost Grade A + Jack Bean fallow at the rainy season could have had more mineralization of residual nutrients during the planting periods in addition to their status at pre-planting analysis. This situation is in consonance with the report of Bot and Benites (2005), indicating that nature of organic matter could affect their contribution to soil fertility through building of soil organic matter. The implication of this is that results of pre-planting soils may not suffice in predicting yields of crops like *corchorus*, in case of no fertilizer application. Consideration would have to be given to the nature of residual fertiliser treatments.

Generally, higher dry-matter yield obtained in the rainy season compared to the dry season was in consonance with the residual nutrient released to the soil as earlier reported. However, the consistent significantly higher dry matter yield of the Brewery Compost Grade A and Jack bean fallow treatment implied better residual nutrient ability of the treatment in both seasons, compared to other treatments investigated. On the other hand, the yield of Brewery Compost Grade A in the dry season which was significantly lower than that of Jack bean Fallow, was opposite in the rainy season. This situation could imply that elevated soil moisture level in the rainy season might have positively influenced more mineralization of residual Brewery Compost in the soil, while the residual effects of N fixed by Jack bean fallow could have been lowered either by leaching or dilution of concentration.

The better residual soil fertility effect of the combination of Brewery Compost Grade A and Jack bean fallow could have led to increased yield of *Corchorus olitorus* when compared with other treatments. This is in consonance with the report of Abedi *et al.* (2010) and AdeOluwa and Bello (2017), where residual effects of organic nitrogen fortifiers and composts produced high yields of *Amaranthus caudatus*. It has been reported that residual benefits from organic materials are better enhanced when such materials are applied according to good practices, taking into account the needs of the soil, its use and the climatic conditions (Van-Camp *et al*., 2004). The rainy season could thus be regarded as a better climatic condition that could have positively impacted on the residual effects of the Brewery Compost Grade A and Jack bean fallow treated soils. Meanwhile, Olanikan (2006) had reported that organic fertilisers increased organic matter status of the soil and enhanced crop production. Also, Tanimu *et al.* (2007) reported that forage leguminous fallow increased the yield of maize when compared to the control.

All these align with the fact that organic fertilisers and leguminous crops could improve soil nutrients, thereby increasing crop yields. Although Brewery Compost Grade A and Jack bean fallow treatment had resulted into the least yield in the previous experiment when the treatments were applied, however, the observed better performance of same treatment in both dry and rainy seasons is an indicator of its superior residual fertility value compared to other treatments investigated in this report.

Conclusions

The study evaluated residual fertility potentials of compost and Jack bean fallow on the yield of *corchorus*, as well as the influence of dry and rainy seasons on residual nutrient ability of the treatments in an organic farming system.

The result of the pre-planting soil chemical properties revealed that the control soil of no previous soil amendment seemed to be richer than others with soil fertility treatments; however this did not result into the highest dry matter yield of *corchorus*. Findings also revealed that Brewery Compost Grade A and Jack bean fallow that was close to the control in pre-planting soil analysis resulted into relatively better *corchorus* dry matter yield than the control and other residual fertiliser treatments investigated. The study also revealed different effects of dry and rainy seasons on soil nutrients and fertility treatments. Soil pH, residual organic carbon, available phosphorus and calcium from the previously applied fertiliser treatments were higher in the dry season than the rainy season. However, nitrogen and potassium which are index nutrients for *corchorus* were more available in the pre-planting soil of the dry season.

The results of this study generally revealed the importance of soil fertility methods and planting seasons on residual nutrient potentials for dry matter yield of *corchorus*. Therefore, the combination of Brewery Compost Grade A and Jack bean fallow at rainy season is recommended as alternative soil fertility measure for organic *corchorus* production.

References

Abedi T., Alemzadeh, A., Kazemelni, A. (2010). Effect of organic and inorganic fertilisers on grain yield and protein banding pattern of wheat. *Australia Journal of Crop Science* 4:384-389.

Adediran, O. A., Ibrahim,H., Tolorunse, K. D., Gana, U. I. (2015). Growth, yield and quality of jute mallow (*Corchorus olitorius* L.) as affected by different nutrient sources. *International Journal of Agriculture Innovations and Research* Volume 3, Issue 5, ISSN (Online) 2319-1473.

AdeOluwa, O. O., Bello, A. (2017). Influence of velvet bean fallow and compost amendments on amaranths (A*maranthus caudatus*) yield and soil properties in an organic cropping system. *Nigerian Journal of Soil Science* Vol.27.53 – 62.

AdeOluwa, O. O., Adeoye, G.O.,Yusuff, S. A.(2009). Effect of organic nitrogen foerfiers on green Amanranth (*Amaranthus caudatus.L*) production. *Journal of Renewable Agriculture and Food System*: 24(4); 245-250.

Adugna, G. (2018). A review on impact of compost on soil properties, water use and crop productivity. *Agricultural Science Research Journal*. Vol. 4 (3). 93-104.

Akoroda, M. O., Akinlabi, O. A. (1987). Seed Production in Corchorus olitorius. *Acta Horticulture,* 123: 231- 236.

Amlinger, F., Götz, B., Dreher, P., Geszti, J., Weissteiner, C. (2003). Nitrogen in biowaste and yard waste compost: dynamics of mobilisation and availability – a review, *European Journal of Soil Biology*, 39, 107–116.

Bationo, A., Lompo, F. Koala, S. (1998). Research on nutrient flows and balances in West Africa state of-the-art. Agriculture, *Ecosystem and Environment*, 71:19–35.

Bot, A., Benites, J. (2005). Soil organic matter Key to drought-resistant soil and sustained food and production FAO Land and Plant Nutrition Management Service, Food and Agriculture Organization of the United Nations. Rome, Pp 95.

Brady, N. C., Weil, R. R. (2002). *The nature and properties of soils.* 13 th Ed. Prentice- Hall Inc., New Jersey, USA. 960p.

Carsky, R. J., Tarawali, S. A.,Becker,M., Chikoye,D. Tian, G., Sanginga, N. (1998). Mucuna herbaceous cover legume with potential for multiple uses. Resources and crop Management Research

Monograph No.25. IITA, Ibadan, Nigeria.

Carter, A. K., Varina, C. S. (2001). High temperature inhibits germination of jalape and cayenne peppers. *Horticultural Science* 36:724-725.

Denton, O. A. (1997). A review of *Corchorus olitorus* in Nigeria. In: Workshop on African Indigenous vegetables. Limbe Cameroun, (R.Schippers and L.Budd (eds.) January 13-18,1997, Workshop papers. Pp:25-30.

Dogra R.C. and Dudeja, S.S. (1993). Fertilizer N and nitrogen fixation in legume-Rhizobium symbiosis. *Annals of biology* 9:149-164.

FFD - Federal Fertilizer Department (2012). *Fertilizer use and management practices for crops in Nigeria*. In: Chude, V. O., Olayiwola, S. O., Daudu, C. and A. Ekeoma (eds). Federal Ministry of Agriculture and Rural Development (FMA&RD), Abuja. P. p 40-41.

Follet, R. F., Keeney, D. R. (1991). *Managing nitrogen for good water quality and Farm profitability*. Soil Society of America, Madison,W1. P.357.

Giller, K. E. (2001). *Nitrogen fixation in Tropical cropping systems*, 2nd edition, Cabi Series, CABI Publishing Series. International Wallingford, UK. pp. 13-56.

Giller,K. E., Cadisch, G., Adams, E., Sakala,W. D., Mafongoya, P .L. (1997). Building soil nitrogen capital in Africa. In :Buresh, R.J., Sanchez, P.A., Calhoun, F. (Eds). Replenishing soil Fertility in Africa. Soil Science Society of America special publication, vol 51. Madison WI, pp 151-192.

Güerena, D. T., Kimetu, J., Riha, S., Neufeldt, H. Lehmann. J. (2016). Maize productivity dynamics in response to mineral nutrient additions and residual organic soil inputs of contrasting quality. Field Crops Research 188 (2016) 113–120.

Hafldi, M., Amir, S., Meddich, A., Jouraiphy, A., Winterton, P., El Gharous, M., Duponnois, R. (2012). Impact of applying composted biosolids on wheat growth and yield parameters on a calcimagnesic soil in a semi-arid region. *African Journal of Biotechnology* 11:9805–9815.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 498 pp.

Lakew, D., Menale, K., Benin, S., Pender, J. (2000). Land degradation and strategies for sustainable development in the Ethiopian highlands: Amhara Region. *Socio-economics and policy research working paper 32*. ILRI (International Livestock Research Institute), Nairobi, Kenya. Pp 122.

Masarirambi, M. T., Hiawe, M. M., Oseni, O.T, Sibiya, T. E. (2010). Effects of organic fertilizers on fertilizers on growth, yield, quality and sensory evaluation of red lettuce (Lactuca Sativa L) VenezaRoxa. *Agriculture and Biology Journal of North America* 6,1319-1324

Mehlich, A. (1984). Mehlich 3 soil test extractant: A modification of the Mehlich 2 extractant. Commun. Soil Sci. Plant Anal. 15(12):1409-1416.

Mengel, K. and Kirkby, E. A. (2001). *Principles of Plant Nutrition*. Springer-Science+Business Media, B. V. pp 807

Musa, A., Ezenwa, M., Oladiran, J., Akanya, H., Ogbadoyi, E. (2010). Effect of soil Nitrogen levels on some micronutrients, antinutients and toxic substances in Corchorus olitorius grown in Minna, Nigeria. *African Journal of Agricultural Research. 5.3075-3081.*

Nahar, K, Haider, J, Karim, A. J. M. S. (1995). Residual effect of organic manures and influence of nitrogen fertilizer on soil properties and performance of wheat. *Annals of Bangladesh Agriculture* 5:73 –78

NIHORT (1986). Vegetable Programme. Annual Report of the Horticultural Research Institute , Nigeria, 1985.67 pp.

Ogban, P. I., Babalola, O. (2003). Soil characteristics and constraints to crop production in inland valley bottoms in southwestern Nigeria. *Agricultural water Management* 61:13-28.

Olanikan, P. C. (2006). Organic manure as soil amendments in eroded Tropical soils of South western Nigeria. *Journal of Tropical Solis* 5(3): 11-18.

Ouedraogo, E., Mando, A., Zombre, N. P. (2001). Use of compost to improve soil properties and crop productivity under low input agricultural system in *West Africa. Agriculture, Ecosystems and Environment* 84:259–266.

Peech, M. (1965). Hydrogen-ion activity in methods of soil analysis part 2. CA, Blane, pp.914-926.

Sanchez, A. P., Leakey, R. R .B. (1997). Land use transformation in Africa: three determinants for balancing food security with natural resource utilization. *European Journal of Agronomy* 7:5–23.

Sanchez, A.P., Shepherd, K.D., Soule, M. J., Buresh, R. J., Izac, A. M. N. (1997). Soil fertility replenishment in Africa: an investment in natural resource capital. In: Buresh, R. J., Sanchez, A. P., Calhoun, F. (eds.) Replenishing soil fertility in Africa. Soil Science Society of America Special publication No. 51, Madison, pp 1–46.

Sarwar, G., Hussain, N., Schmeisky, H., Muhammad, S. (2007). Use of compost an environment friendly technology for enhancing rice-wheat production in Pakistan. *Pakistan Journal of Botany* 39:1553 –1558.

Solomon, D., Fritzsche, F., Tekalign, M., Lehmann, J., Zech W. (2002). Soil organic matter composition in the Subhumid Ethiopian highlands as influenced by deforestation and agricultural management. *Soil Science Society of America Journal* 66:68–8.

Tanimu, J., Iwuafor, E. N. O., Odunze, A .C. and Tian. G. (2007). Effect of incorporation of leguminous cover crops on yield and yield components of maize. *World Journal of Agricultural Sciences* 3 (2): 243-249.

Van-Camp, L., Bujjarabal, B., Gentile, A. R., Jones, R. J. A., Montanarella, L., Olazabal, C., Selvaradjou, S. K. (2004). *Reports of the technical working groups established under the thematic strategy for soil protection.* EUR 21319 EN/1, 872 pp.

Watson, C., Atkinson, D. A., Gosling, P., Jackson, L. R., Rayns, F. (2002). Managing soil fertility in organic system. *Soil Use and Management.* 18-247. 10.1111/j. 1475-2743.2002.

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

www.noara.bio

ISSN: 2734-2913
Volume 2, 2019
pp 1-10

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

NOARA Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بإفريقيا

www.noara.bio

Farmers' Perception of Eco-friendly Agriculture: Roadmap to a Healthy and Quality Ecosystem in Nigeria

[1]Adeyeye, O.A., [2]Rabiu, I.B., and [3]Olowe V.I.O.
[1]Agricultural Media Resources and Extension Centre (AMREC), Federal University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria.
[2]Department of Agricultural Extension and Rural Development, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State.
[3]Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria
[*]Corresponding Author E-mail:topemay2001@gmail.com; olowevio@funaab.edu.ng

Abstract

Awareness and perception of eco-friendly agricultural practices could be a determinant of adopting organic agriculture as means of livelihood. The study examined farmers' socio-economic characteristics, livelihood activities, as well as awareness and respondents perception on eco-friendly practices in Isaga, Abeokuta North Local Government Area of Ogun State, South Western Nigeria (latitude 7.2114°N and longitude 3.1378°E) . Simple Random Sampling technique was adopted in selection of 90 farmers from the study area. Data collected were analysed using descriptive (frequency and percentages) and Pearson Product Moment Correlation (PPMC) statistical tools. The mean age, farming experience, farm size, and household size were 36 years, 8 years, 2 acres, and 5 persons, respectively. Study showed that 56% of the respondents had formal education, majority (70%) were male farmers, 62% were aware of eco-friendly practices through extension agents and 28% practiced eco-friendly farming between 1and 5years. Maintenance and sustainability of soil fertility guaranteed safety of food produce from eco-friendly practice ($\bar{x}$ = 3.62, SD ±1.54), eco-friendly farming increased agricultural productivity by maintenance of soil biological stand ($\bar{x}$ = 3.56, SD ± 1.73). Significant relationship ($p < 0.05$) existed between age (r = 0.001), farm size (r = - 0.01), household size (r = - 0.02), farming experience (r = 0.01) and eco-friendly practices. The study concluded that respondents have positive perception about eco-friendly farming. The study recommended that workshop be organized for farmers by relevant agricultural agencies with a view to promoting quality ecosystem and increase involvement in eco-friendly farming.

Keywords: Livelihood, information sources, perception, quality ecosystem, eco-friendly farming.

La perception des agriculteurs d'une agriculture respectueuse de l'environnement: feuille de route pour un écosystème sain et de qualité au Nigéria

Abstrait

La sensibilisation et la perception des pratiques agricoles respectueuses de l'environnement pourraient être un facteur déterminant de l'adoption de l'agriculture biologique comme moyen de subsistance. La présente étude a examiné les caractéristiques socio-économiques des agriculteurs, les activités de subsistance, ainsi que la sensibilisation et la perception des répondants sur les pratiques

Date Published: December 16, 2019
ISSN: 2734-2913
Volume 2, 2019, pp 11-19

écologiques à Isaga, Abeokuta North Local Government Area of Ogun State, South Western Nigeria (latitude 7,2114 ° N et longitude 3,1378 ° E). La technique d'échantillonnage aléatoire simple a été adoptée dans la sélection de 90 agriculteurs de la zone d'étude. Les données collectées ont été analysées à l'aide des outils de la statistiques descriptive (fréquence et pourcentages) et Pearson Product Moment Correlation (PPMC). L'âge moyen, l'expérience agricole, la taille de l'exploitation et la taille du ménage étaient respectivement de 36 ans, 8 ans, 2 acres et 5 personnes. L'étude a montré que 56% des personnes interrogées avaient une éducation formelle, la majorité (70%) était des agriculteurs de sexe masculin, 62% étaient au courant des pratiques respectueuses de l'environnement par les agents de vulgarisation et 28% pratiquaient une agriculture respectueuse de l'environnement entre 1 et 5 ans. Maintien et durabilité de la fertilité des sols garantis la sécurité des produits alimentaires issus de pratiques respectueuses de l'environnement ($\bar{x}$ = 3,62, ET ± 1,54), une agriculture respectueuse de l'environnement a augmenté la productivité agricole par le maintien du peuplement biologique du sol ($\bar{x}$ = 3,56, ET ± 1,73). Une relation significative ($p < 0{,}05$) existait entre l'âge (r = 0,001), la taille de l'exploitation (r = - 0,01), la taille du ménage (r = - 0,02), l'expérience agricole (r = 0,01) et les pratiques écologiques. L'étude a conclu que les répondants ont une perception positive de l'agriculture écologique. L'étude a recommandé qu'un atelier soit organisé pour les agriculteurs par les agences agricoles compétentes en vue de promouvoir un écosystème de qualité et d'accroître la participation à une agriculture respectueuse de l'environnement.

Mots clés: moyens de subsistance, sources d'informations, perception, écosystème de qualité, agriculture respectueuse de l'environnement.

Introduction

The rising trend in Nigeria's population over the years and the unpredictable climate condition could be attributed to constraints associated with food security in the country. Therefore, in order to combat the challenges of food insufficiency, various attempts were made to increase food production in the country. This brought about the expansion of farming areas with farmers adopting conventional agricultural practices (Cong Tu *et al.,* 2006). These practices largely depended on the use of intensive inputs such as synthetic fertilizers, herbicides and pesticides (Cong Tu *et al.* 2006). Increase in yield was targeted without considering effects of an increase in the use of agro-chemicals on sustainable agriculture (Oyesola *et al*., 2010). Though, the use of agrochemicals by farmers was due to its high rate of effectiveness in improving agricultural production (Abanyam *et al.,* 2017). However, the extensive and inappropriate use of chemical inputs over the years despite its role in improving agricultural production have resulted in serious health risks, as well as environmental challenges (Abanyam, *et al.,*2017).

Therefore, substitution of conventional agriculture with organic farming which is eco-friendly is essential in a bid to avert health and environmental hazards that could emanate from unfriendly agricultural practices. For instance, according to Smil (2001), some of the inorganic fertilizers that are used to increase crop yield are leached or eroded into the nearby rivers, thus causing water pollution which is dangerous to aquatic life and health.

Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships as well as a good quality of life for all involved (IFOAM, 2008a). Organic agriculture promotes ecological resilience, improved biodiversity, healthy management of farms and the surrounding environment, as well as builds on community knowledge and strength (FAO, 2008).

Although, organic farming system presents lower yields than conventional agriculture, but awareness creation, knowledge acquisition and emphasis on environmental benefits of organic farming such as improved biodiversity, lower greenhouse gas emissions, and organic matter incorporation to the soil (Brito *et al,* 2012; Meng *et al.,* 2017) would not only enhance full adoption of eco-friendly agriculture and increase stakeholder's perception, but could further enhance a healthy and quality eco-system which promotes sustainable agriculture as a form of livelihood in Nigeria.

Therefore, protection and promotion of good health and well-being as well as sustainable agricultural production in form of livelihood will not be achievable if stakeholders are not knowledgeable on the significance of eco-friendly agricultural practices. Hence, stakeholder's knowledge acquisition on sustenance of eco-friendly practices as livelihood activities would improve, if it is premised on the principle which delve on sustenance of soil, plant, animal and human health as well as planet's ecology, fairness and its care as one and indivisible unit of interest (IFOAM 2005; 2006; 2008a).

The resultant effect of the use of agrochemicals could be averted if there is more awareness on the inherent dangers associated with the continuous use of inorganic inputs (agrochemicals) on the environment and human health. This is germane in order to reduce the consumption of unhealthy agricultural products and the long-term effect which does not support sustainable agriculture (Bhat, 2009). Thus, there is a need to encourage more farmers to participate in organic farming, this is germane since the world statistics on organic agricultural land (including in-conversion), revealed that Nigeria has 53,402 hectares of organic agricultural land and only 0.1percent is subjected to organic share (FiBL and IFOAM 2019). The adoption of organic farming practices among other reasons would assist farmers conserve resources, enhance biodiversity, maintain ecosystem for sustainable production and also lead to an increase in food production. It is against this background that the study identified livelihood activities, respondents' perception on eco-friendly farming and determined the relationship existing between socio-economic characteristics of farmers and respondents' perception.

Methods and Methods

The study was conducted in Isaga (latitude 7.2114°N and longitude 3.1378°E), Abeokuta North Local Government Area (7^0 12^{1}E and 3^0 12^{1}E) of Ogun State, (latitude 7^{0}00^1 N and longitude 3^{0}35^{1}E) Nigeria. The study area covers a total of about 808 km^2 and a population of 201,329 (NPC, 2006). The Local Government Area is bounded in the south by Abeokuta South, in the north by Imeko Afon Local Government Area, in the east by Odeda Local Government Area and Ewekoro Local Government Area in the west. The major livelihood activity in the study area is farming. Data were gathered from 90 farmers selected through simple random sampling technique.

Data analysis

Data obtained were subjected to descriptive and correlation analysis; using the Statistical Package for Social Sciences (SPSS) 16.0 version. Results were presented in frequencies, percentages, mean ($\bar{x}$), Standard Deviation (SD) and correlation (r).

Correlation analysis was carried out between respondent's socio-economic characteristics and perception on eco-friendly farming. The relationship was significant at $p < 0.05$ (negative but significant relationship existed between farm size, household size and perception on eco-friendly farming).

Results

The mean age, farming experience, household size and farm size of the respondents were 36 years, 8 years, 5 persons and 2 acres respectively as presented in Table 1. More than half (55.6 percent) of the respondents had primary education, majority of the respondents were male. Moreover, 57 percent and 34 percent of respondents had general farming experience between 6-10 years and 1-5years respectively. Furthermore, results showed that 28 percent of the respondents had been involved in eco-friendly farming between 1 and 5 years.
Moreover, 62 percent of the respondents had the awareness through the extension agents.

Table 1: Socio-economic characteristics of respondents (n = 90)

	Frequency	Percentage	$\bar{x}$	S. D
Age (in years)				
20-30	08	8.9		
31-40	22	24.4	35.5	0.8
41-50	44	48.9		
51-60	16	17.8		
Sex				
Male	63	70.0		
Female	27	30.0		
Marital status				
Single	09	10.0		
Married	81	90.0		
Ethnic group				
Igbo	03	3.3		
Yoruba	83	92.2		
Hausa	04	4.4		
Educational status				
No formal education	38	42.2		
Primary education	50	55.6		
Secondary education	02	2.2		
General Farming Experience				
1-5	31	34.4		
6-10	51	56.7	8.0	0.6
11-15	08	8.9		
Primary occupation				
Farming	90	100.0		
Farm size (acres)				
1.0 -1.5	69	76.7		
1.6- 2.1	21	23.3	2.2	0.4
Household size (number)				
2-5	64	71.1	5.0	
6-10	24	26.7		
11-15	02	2.2		
Source(s) of awareness*				
Radio	32	35.6		
Extension Agents	56	62.2		

$\bar{x}$ = mean, SD = Standard Deviation, *multiple responses

Table 2 shows that 92 percent of the respondents were smallholder farmers who were solely involved in various cropping activities as livelihood activity. Majority of the respondents engaged in various land preparation practices ranging from land clearing to farm weeding. Most (80percent) of the respondents perceived that organic fertilizer is safe for use. More than half of the respondents regularly used organic fertilizers, hence farm produce were free from harmful chemicals. About half of the respondents carried out farm activities with the assistance of family labour. Most of the respondents were engaged in weeding activity thrice /month before harvesting of crops.

Table 2: Livelihood activities and agronomy practices engaged in by farmers (n = 90)

Variables	Frequency	Percentage (%)
Farming Scale		
Subsistence	83	92.2
Commercial	07	7.8
Types of crop grown (*)		
Cassava, Maize and Vegetables	61	67.8
Pepper, Tomatoes, and Vegetables	55	61.1
Land preparation practices (*)		
Land clearing (cutting of trees and shrubs)	90	100.0
Removal of stumps	77	85.6
Bush burning	90	100.0
Land cultivation (ridges and heaps construction)	79	87.8
Planting	90	100.0
Farm weeding	72	80.0
How often do you carry out cleanliness activities on the farm		
Regularly	47	52.2
Always	43	47.8
Frequency of weed control before harvesting		
Twice	07	7.8
Thrice	83	92.2
Organic fertilizer usage		
Regularly	51	56.7
Occasionally	39	43.3
Do you think organic fertilizer is safe for use		
Yes	72	80.0
No	18	20.0
If yes, how (*)		
Builds healthy soil	32	35.6
Don't cause environmental pollution	52	57.8
The practice is environmentally friendly	60	66.7
Produce are free from harmful chemical	85	94.4
Source of farm labour		
Family labour	47	52.2

*Multiple responses

Result in Table 3 showed respondents' perceptions on eco-friendly farming. The mean score of the perception statements is 3.42. Therefore, any respondent with mean score greater than 3.42 is said to have a positive perception.

The results of perception statement from respondents showed that involvement in eco-friendly practices reduced constraints associated with availability, timely access to fertilizers during planting seasons and also reduced the bottle-neck of middle men. It was perceived by the respondents that the practice of organic farming promotes recycling and re-use of local resources which makes farming economically viable. Furthermore, respondents perceived that sustenance of eco-friendly farming as livelihood activity is achievable through organic farming.

The result of the hypothesis in Table 4 revealed that there was significant relationship between socioeconomic characteristics and perception on eco-friendly farming using Pearson Product Moment Correlation (PPMC) at 5% (0.05)

Table 3: Farmer's perception on eco-friendly farming (n = 90)

Statements	SA Freq	%	A Freq	%	D Freq	%	SD Freq	%	$\bar{x}$	Standard Deviation	Rank
Maintenance and sustainability of soil fertility guarantee safety of food produce from eco-friendly farming.	44.0	48.9	11.0	12.2	27.0	30.0	8.0	8.9	3.62	1.54	9th
Involvement in eco-friendly practice reduces constraints associated with availability, timely access of fertilizers during planting seasons and also reduces the bottle-neck of middle men.	32.0	35.6	22.0	24.4	24.0	26.7	12.0	13.5	3.42	1.52	10th
Eco-friendly farming increases agricultural productivity by maintenance of soil biological stand.	49.0	54.4	6.0	6.7	16.0	17.8	19.0	21.1	3.56	1.73	1st
The practice of organic farming promotes recycling and re-use of local resources which makes farming economically viable.	18.0	0.0	19.0	21.1	20.0	22.2	33.0	36.7	3.48	1.65	4th
Organic farming helps in the build-up and formulation of healthy soil.	50.0	55.6	6.0	6.7	21.0	23.3	13.0	14.4	3.66	1.64	5th
Eco-friendly farming should be adopted and well practiced by farmers because of high yield and nutritional value of the produce.	44.0	48.9	11.0	12.2	19.0	21.1	15.0	16.7	3.56	1.63	7th
Organic farming is a measure of achieving healthy eco-systems with a view to sustaining eco-friendly farming as a form of livelihood in agrarian communities.	48.0	53.3	7.0	7.8	22.0	24.4	13.0	14.4	3.61	1.64	5th
Organic farming increases yield through the use of affordable inputs and also allows for self-reliance.	45.0	50.0	10.0	11.1	17.0	18.9	18.0	20.0	3.52	1.69	2nd
It encourages the use of indigenous knowledge by farmers.	42.0	46.7	13.0	14.4	17.0	18.9	18.0	20.0	3.49	1.67	3rd
It allows for implementation of other farming techniques	38.0	42.2	17.0	18.9	21.0	23.3	14.0	15.6	3.49	1.59	8th
Group Mean									**3.42**		

SA, Strongly agree; A, Agree; SD, Strongly disagree; D, Disagree; Freq, frequency; %, percentage; $\bar{x}$, mean, group mean = 3.42

Table 4: Correlation analysis of the relationship between respondent's socio-economic characteristics and perception on eco-friendly farming

Variables	r	p value	Decision
Age	0.966	0.001	S
Farm size (in acres)	0.957	-0.01	S
Household size	0.936	-0.02	S

S, significant; P-value is significant at 0.05 level (2-tailed)

significance level. Results indicated that there was a significant correlation between age and farmers perception on eco-friendly practices. There was a negative but significant correlation between farm size, household size and farmer's perception on eco-friendly farming. The result showed that respondents' positive perception on eco-friendly farming could be attributed to their age.

Discussion

The result indicating male involvement in this study is corroborated by the findings of Dipeolu *et.al.* (2006), Solomon (2008) and Oyesola *et.al.* (2010) where majority of farmers practicing organic farming in Ogun and Ekiti States were male. Result from farmers practicing eco-friendly farming in this study suggested that their involvement in eco-friendly farming practice was less than a decade. This could be as a result of late adoption of innovation. This is corroborated by Edeogbon (2008), that farmers are more usually involved in practices they are familiar with than other practices. Furthermore, Padel (2001) indicated that organic producers are newer entrants to farming. The mean household size could be a contributing factor to respondents' farm sizes because most peasant farmers rely more on household members as source of farm labour. This is an indication that availability of farm-labour in agrarian communities among other factors could hinder production capacities of peasant farmers due to small household size. In addition, the result of findings is supported by the reports of Compassion (2017) that the cultural expectation of having big families is to combat their need for extra labour. The literacy level could be an essential/determinant factor associated with an individual's perception on a particular innovation with a view to be equipped with information that could enhance decision making. This corroborates the assertion of Solomon (2008) that high literacy level among farmers could enhance adoption of innovations that are related to organic farming.

The respondents mean age is an indication that they are within the economically- active age-group (41-50years), this could positively influence the adoption of innovation and more participation of youths in organic farming, thus reducing rural-urban drifts. This finding is supported by Ogunyemi (2005), that the adoption of any innovation on organic farming may not be as high as expected, as adoption could vary inversely with age.

Furthermore, Adesope *etal.*, (2012) affirmed that farmers in the middle age are in their economically active age and as such, could undergo stress that has implication on their productivity. The awareness through the extension agents who are closer to grassroots might be a facilitating factor to adoption of the practice. The findings of this study is also supported by Adesope *et.al.*, (2012) assertion that the visits or contacts with extension agents provide opportunity for transfer of skill, knowledge and information which facilitate adoption. The positive perception of respondents revealed that eco-friendly farming increased agricultural productivity by maintenance of soil biological stand.

Furthermore, it increased yield output through the use of affordable inputs and also allowed for self-reliance. Moreover, it encouraged the use of indigenous knowledge by farmers.

Conclusion and Recommendations

Based on the findings of this study, it is concluded that respondents were within economically active age and were smallholder farmers who majorly depended on family labour for agronomy activities.

Furthermore, respondents were aware of eco-friendly farming through extension agents. Therefore, the study concluded that respondents had positive perception about eco-friendly farming, while respondents' positive attitude could be attributed to their age.

The study therefore recommended that stakeholders' knowledge and perception could be modified through capacity building training workshop on healthy and sustainable livelihood. This is germane with a view to further promote adoption and extensive practice of eco-friendly farming. Also, it is recommended that for effective adoption and practice of organic farming, more awareness should be created by all governmental agricultural agencies as well as stakeholders (local leaders, farmers and the youths).

References

Abanyam, V. A. and Okadi, A. O. (2017)."Adoption of Environment Friendly Agricultural Practices among Farmers in South – South, Nigeria. *International Journal of Education Benchmark (IJEB),* 8: 69-78.

Adesope, O.M., Matthews-Njoku, E.C., Oguzor, N.S., and Ugwuja, V.C. (2012). "Effect of Socio-Economic Characteristics of Farmers on their Adoption of Organic Farming Practices, Crop Production Technologies". Edited by Peeyush Sharma (Edition), ISBN:978-953-307-787-1, InTech, Available from: http://www.intechopen.com /books/crop-production-technologies/effect-of-socio-economic-characteristics-offarmers-on-their-adoption-of-organic-farming-practices.

Brito, L.M., Pinto, R., Mourão, I., and Coutinho, J. (2012). "Organic lettuce, rye/vetch, and Swiss chard Growth and Nutrient Uptake Response to Lime and Horse Manure Compost". *Journal of Organic Agriculture.* 2:163–171.

Compassion (2017). Why do the Poor have large families? Retrieved from *http://www. compassion.com.au/blog/why-do-poor-have-large-families.* January 11, 2017.

Cong Tu., Frank J. L., Nancy, G. C., Paul, M., Cavell, B., Ken, F., Melisa, B. and Shuijin, Hu. (2006). Responses of Soil Microbial Biomass and N availability to Transition Strategies from Conventional to Organic Farming Systems". *Journal of Agriculture, Ecosystems and Environment*, 113 (1-4):206–215.

Dipeolu, A. O., Bello, K.A., and Akinbode, S.O. (2006). "Comparative Economic Analysis of Organic and Inorganic Vegetable Production in Ogun State, Nigeria". Proceedings of the 2nd National Conference on Organic Agriculture, University of Ibadan, Ibadan, Nigeria 27 – 29 November, 24pp.

Edeoghon, C.O. (2008). "Awareness and Use of Sustainable Agricultural Practices by Arable Crop Farmers in Ikpoba Local Government Area of Edo State". *Journal of Sustainable Development in Agricultural and Environment* 3(2):55-63.

Ellis, F. (2000). The Determinant of Rural Livelihood Diversification in Developing Countries. *Journal of Agricultural Economics*, 51(2):289-302.

Food and Agricultural Organization (2008). Organic Agriculture and Climate Change. Food and Agriculture Organization, Rome.

IFOAM (2008a). "Definition of Organic Agriculture". Retrieved 4 August 2009, from http://www.ifoam.org /growing_organic/definitions/doa/index.html.

IFOAM. (2006). "Principles of Organic Agriculture". Bonn: International Federation of Organic Agriculture Movements (IFOAM).

IFOAM. (2005). "General Assembly of IFOAM approves Principles of Organic Agriculture (press release edition.)". Bonn: International Federation of Organic Agriculture Movements (IFOAM).

Meng, F., Qiao, Y. W., Smith, P., and Scott, S. (2017). "Environmental Impacts and Production Performances of Organic Agriculture in China": A Monetary Evaluation. *Journal of Environmental Management*, 188:49–57.

National Population Commission (2006). Nigeria's Current Estimated Population. Data for National Planning and Development. Retrieved from http//www.population.gov.ng.

Ogunyemi, O. M. (2005). "Principles and Practice of Agricultural Extension". Deen-Lat Lithoprint and Publishers, Ado-Ekiti, Nigeria, 56pp.

Oyesola, O. B., and Obabire, I. E. (2010). "Farmers' Perception of Organic Farming in Selected Local Government Areas of EkitiState, Nigeria". *Journal of Organic Systems, 6(1)*. p7.

Padel, S. (2001). "Conservation to Organic Farming:

A Typical Example of the Diffusion of An Innovation?" *Journal of Sociologia Ruralis*, 41 (1):40-61. European Society for Rural Sociology ISSN 0038-0199.

Research Institute of Agriculture FiBL, IFOAM Organics International. (2019). The World of Organic Agriculture. Statistics and Emerging Trends available http:www//.organic world.net/ yearbook/yearbook-2019 html pp 346. Accessed June 2020.

Smil, V. (2001). *Enriching the Earth: Fritz Haber, Carbosch, and the Transformation of World Food*, MIT Press, Boston.

Solomon, O. (2008). "Small Scale Oil Palm Farmers Perception of Organic Agriculture in Imo State, Nigeria", *Journal of Environmental Extension*, 7: 67-71.

Wikipedia, Ogun State biz.https://en.wikipedia.org /wiki/abeokutanorthlocalgovernment/id9html

ISSN: 2734-2913
Volume 2, 2019
pp 11-19

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

ISSN: 2734-2913

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

NOARA Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بإفريقيا
www.noara.bio

Application de la mobilisation des connaissances d'experts: Contribution de l'agriculture naturelle à la sécurité alimentaire dans la région centrale du Cameroun

*De La Paix Bayiha, G., Kobou, G., Makowski, D., Mathe, S., and Temple, L.
[1]CIRAD, UMR Innovation, 73 Rue J-F Breton, 34398 Montpellier, France
[2]Université de Yaoundé II, Faculté des Sciences Economiques et de Gestion, BP 1365, Yaoundé Cameroun
[3]INRA AgroParisTech, Université de Paris-Saclay, UMR Agronomie, F-78850 Thiverval-Grignon, France.
*Adresse de l'auteur Tél : +237 675 43 65 83; Email : gerarddelapaixbayiha@yahoo.fr

Résumé

De nombreux agriculteurs Camerounais pratiquent l'agriculture naturelle, un type d'agriculture potentiellement qualifiable de « biologique ». Pourtant, peu de références expérimentales sont disponibles sur sa capacité à contribuer aux enjeux de la sécurité alimentaire au Cameroun. De ce fait, la question de sa performance par rapport à l'agriculture conventionnelle reste cruciale pour sa reconnaissance institutionnelle. L'objectif est d'identifier des situations (régions et espèces cultivées) où les performances de l'agriculture naturelle sont proches ou supérieures à celle de l'agriculture conventionnelle. Pour atteindre cet objectif, nous avons mobilisé l'élicitation probabiliste des jugements d'experts. Cette méthode est appliquée auprès de 56 experts dans la région du Centre Cameroun. Les résultats montrent que les rendements en agriculture naturelle sont inférieurs de 28 % à ceux conventionnelle tandis que pour les prix bord champ des spéculations en agriculture naturelle sont sensiblement identiques de celles en conventionnelle. De plus, le temps de travail exprimé en nombre d'heure/jour est élevé dans le système naturel par rapport au système conventionnel. Par ailleurs, la quantité de travail exprimé en nombre d'homme/jour est plus faible en système naturel.

Mots clés : Agriculture biologique, agriculture conventionnelle, élicitation probabiliste, cultures vivrières, Région du Centre, Cameroun.

Abstract

Many Cameroonian farmers practice natural agriculture, a type of agriculture that can potentially be described as "organic". However, few experimental references are available on its capacity to contribute to food security issues in Cameroon. As a result, the question of its performance compared to conventional agriculture remains crucial for its institutional recognition. The objective is to identify situations (regions and cultivated species) where the performance of natural agriculture is close or superior to that of conventional agriculture. To achieve this objective, we have mobilized the probabilistic elicitation of expert judgements. This method is applied to 56 experts in the Centre Cameroon region. The results show that yields in natural agriculture are 28% lower than those in conventional agriculture, while for field edge prices of speculation in natural agriculture are more or less identical to those in conventional agriculture. Moreover, the working time expressed in number of hours/day is high in the natural system compared to the conventional

ISSN: 2734-2913
Volume 2, 2019, pp 21-35
Date Published: December 16, 2019

system. Moreover, the quantity of work expressed in number of man/day is lower in the natural system.

Keywords: Organic agriculture, conventional agriculture, probabilistic elicitation, food crops, Centre Region, Cameroon.

Introduction

L'agriculture a un fort impact sur la biodiversité, la qualité des sols, la ressource en eau et le climat (Mijatović et al. 2013 ; Lin *et al.*, 2015). Il est donc indispensable de disposer de systèmes de production minimisant les dommages sur l'environnement (Willbois et Schmidt, 2019) et sur la santé (Baudry *et al.*, 2018) tout en maintenant des rendements suffisants. Dans le contexte actuel de diversification des systèmes agricoles, l'Agriculture Biologique (AB), définie par l'International Federation of Organic Farming Movements (IFOAM) comme un système de production qui maintient et améliore la santé des sols, des écosystèmes et des personnes (IFOAM ,2009) est mis en avant comme un modèle de production permettant de concevoir des systèmes alimentaires durables (Muller *et al.*, 2017). Mais sa capacité à répondre aux enjeux que pose la sécurité alimentaire (Touzard et Temple, 2012) en Afrique en général et au Cameroun en particulier reste mal connue.

Les performances de l'AB ont été évaluées dans plusieurs méta-analyses internationales (De Ponti *et al.*, 2012; Seufert *et al.*, 2012; Lesur-Dumoulin *et al.*, 2017; Wilbois et Schmidt, 2019). A travers une quantification des rendements relatifs de l'AB par rapport à l'agriculture conventionnelle (AC), ces études ont montré des rendements en moyenne inférieurs de 8 à 25% dans les systèmes biologiques par rapport aux systèmes conventionnels selon la zone géographique, les espèces cultivées, les conditions pédo-climatiques, les pratiques de gestion et les méthodes utilisées par les auteurs (Lesur-Dumoulin *et al.*, 2017). Les synthèses quantitatives sur d'autres variables que le rendement (rentabilité économiques, qualité des produits etc.) sont plus rares et les études réalisées en Afrique sont peu nombreuses et peu fiables (Willer et Lernoud, 2019).

Or, les caractéristiques de l'AB en font un mode de production potentiellement adapté à l'agriculture africaine, qui est familiale, peu mécanisée, diversifiée en termes de variété de plantes cultivées, basée sur l'utilisation des ressources locales et répondant à différents débouchés : nourrir la famille, générer un revenu (De bon *et al.*, 2018). Le fait que l'agriculture africaine traditionnelle repose sur de faibles intrants externes constitue une excellente base sur laquelle l'AB peut s'appuyer pour améliorer la productivité, la résilience et la rentabilité des petits exploitants agricoles en Afrique. C'est donc une option de développement à priori idéale pour l'Afrique (Willer et Lernoud, 2019).

Au Cameroun par exemple, Bayiha *et al.*, (2019) ont mis en évidence l'existence de 3 types d'AB dans les systèmes agricoles dont celui qualifié d'« agriculture naturelle (AN) sans certification ». Elle est définie comme une agriculture fondée sur les savoirs locaux ou qualifiée de traditionnelle à faible ou sans recours aux intrants de synthèse (par choix ou par contrainte). L'AN renvoie dans cette étude à une forme non certifiée de l'AB.

La Revue du secteur rural éditée pour le Cameroun en 2003 par la Banque Mondiale identifie six produits de base stratégiques (dont la banane-plantain et le manioc) pour la sécurité alimentaire et la création d'emplois ou ayant un potentiel compétitif sur les marchés nationaux, régionaux et à l'exportation (Banque Mondiale et FAO, 2008). Il est donc important d'analyser leurs performances dans le système biologique. Malheureusement, très peu d'informations sont actuellement disponibles dans le domaine public sur l'AN au Cameroun. De ce fait, le gouvernement est confronté à de nombreuses incertitudes lors de la prise de décisions politiques, car toute modification de l'agriculture aura un impact sociétal (Whitney et al. 2018).

Ces limites en matière de données peuvent empêcher l'utilisation d'approches statistiques classiques pour produire des estimations probabilistes de certains paramètres (Frey *et al.,* 2003) pour accompagner les décideurs. Dans ce cas, il est possible malgré tout, de s'appuyer sur l'élicitation probabiliste des jugements scientifiques, politiques et traditionnelles d'experts (Bootz *et al.,* 2019; Albert *et al.,* 2015) pour faire des scénarios concernant le futur (Morgan et Henrion, 1992; Chen *et al.,* 2019).

Au vu de ce constat, l'objectif de ce travail est d'identifier, à travers l'élicitation probabiliste du jugement d'experts, des situations (régions et espèces cultivées) où les performances de l'AN sont proches ou supérieures à celle de l'AC. Plusieurs critères sont considérés pour comparer ces deux types de système : rendement moyen, prix bord champ et coût de travail (quantité et temps de travail). Ces situations seront alors des cibles privilégiées pour promouvoir le système biologique.

Nous proposons donc pour cela d'analyser *la différence de performance relative de l'AN par rapport à l'AC en mobilisant plusieurs types d'expert afin d'évaluer quantitativement les performances de l'AN sur la sécurité alimentaire dans la région du Centre Cameroun.*

Plus spécifiquement, il s'agit d'analyser la performance de l'AN (plantain, manioc) sur deux dimensions (disponibilité et accessibilité) de la sécurité alimentaire dans la région du Centre du Cameroun.

Principe et intérêt de l'élicitation probabiliste du jugement d'experts

L'élicitation est une méthode qui vise à formaliser les connaissances ou les croyances d'une personne au sujet d'une ou de plusieurs quantités incertaines sous la forme d'une distribution de probabilité de cette/ces quantités (Garthwaite *et al.,* 2005). Cette distribution peut être utilisée seule, ou en combinaison avec des données dans le cadre de la statistique bayésienne (Albert *et al.,* 2015). Elle représente les niveaux de confiance d'un expert dans les valeurs que prendront la quantité étudiée (O'Hagan, 2012). Dans la littérature scientifique, l'avis d'expert prend le terme de « jugement d'expert » qui représente l'état de la connaissance de l'expert au moment de sa réponse à la question (Ortiz *et al.,* 1991).

L'élicitation probabiliste permet à un expert d'exprimer son incertitude sur un paramètre donné (Soll et Klayman , 2004).

Pour un sujet où les experts peuvent avoir des opinions diverses, il est souvent préférable d'avoir un groupe plus large pour obtenir une couverture représentative de l'éventail des opinions (Morgan, 2014). Les distributions de probabilité des différents experts peuvent alors être comparées et même combinées afin d'obtenir une seule distribution résumant l'ensemble des connaissances du groupe d'experts. Le résultat de la combinaison peut idéalement être considérée comme un résumé de l'état actuel de l'expertise concernant un sujet d'intérêt (Clemen et Winkler, 1999) . De ce fait, l'élicitation peut donc constituer un outil précieux pour la prise de décision en matière de politique publique (Morgan, 2014).

Matériels et méthode

La méthodologie de cette étude est basée sur l'application de la méthode d'élicitation des jugements d'experts à travers une enquête dans la région du Centre Cameroun. Elle s'est déroulée de Septembre à Octobre 2018/

Pour l'application de cette méthode, nous avons défini un cadre formel pour comparer AN et AC dans des sites ayant des caractéristiques similaires afin de limiter les risques de confusion d'effet. Pour cela, nous avons pris en compte les caractéristiques pédoclimatiques de chaque site, la localisation des experts, la taille moyenne de la parcelle mobilisée, la période considérée. L'enjeu de ce cadre est de pouvoir montrer que l'analyse de la performance de l'AN par rapport à l'AC se fait dans des conditions identiques pour les deux systèmes. Ces informations sont regroupées dans le tableau 1 ci-dessous.

Tableau 1 : Caractéristiques du site des systèmes de production

Caractéristiques	**Spécificités**
Zone agro-écologique	forestière bi-modale
Zone d'enquête spécifique	Région du Centre
Localisation d'experts (CST)	Yaoundé et ses alentours
Localisation d'experts (producteurs)	Monatélé et Ngog-Mapubi
Typologie de sols	ferralitiques, argileux
Climat (pluviométrie)	Deux saisons humides
Agriculture naturelle	Aucun cahier de charge, pas de formation subie par les producteurs, utilisation des techniques traditionnelles, pas ou faible utilisation d'intrants chimiques de synthèse, main d'œuvre familiale, le matériel végétal est traditionnel, pas de certification.
Agriculture conventionnelle	Mobilisation d'un cahier de charge, formation subie par les producteurs, utilisation d'intrants chimiques de synthèse, main d'œuvre salariale (saisonnière) et familiale, association avec la cacaoculture, le matériel végétal est amélioré.
Type de culture	Vivrier (Banane Plantain et manioc)
Espace temporel moyen sollicité pour la collecte des données	2013 – 2017 (5 ans)
Parcelle moyenne sollicitée	1 hectare

Sur la base des données bibliographiques, de la littérature grise et des entretiens semi-directifs réalisés ex-ante, nous mettons en regard deux arrondissements (Monatélé et Ngog Mapubi) dans la région du Centre pour les producteurs par rapport à l'ensemble de la région du Centre pour la communauté scientifique et technique (CST) (formateurs, chercheurs et techniciens).

Un ensemble d'experts a été identifié à travers la méthode « effet boule de neige » suivant les matrices des profils des experts (profils d'experts adaptés, compétences recherchées, types d'expertises requises) que nous avons élaborés (tableaux 2.a et 2.b). Cette méthode a été utilisée car il n'y a pas de base de données sur les experts en AN et AC au Cameroun en général et dans les zones d'enquêtes en particulier.

Pour identifier les producteurs, nous avons présenté le tableau 2.a ci-dessous aux Délégués des arrondissements des zones d'enquêtes. Ce tableau leur a permis de nous dresser une liste des producteurs ou groupement des producteurs ayant ces caractéristiques (spéculation, système de production, taille de la parcelle, année d'expérience) dans les arrondissements indiqués. Par la suite, les producteurs rencontrés nous ont communiqué leurs domaines d'expertises et nous ont donné les contacts d'autres experts que nous avons rencontrés sur la base de la matrice présentée. Concernant les experts de la CST, nous avons présenté le tableau 2.b. ci-dessous aux responsables des centres de recherche et techniques agricoles que nous avons identifiés. Ces derniers nous ont dirigé vers les experts des spéculations.

Tableau 2.a : Matrice des profils des producteurs

Expertise	Zone (départements)	Arrondissement	Spéculations	Systèmes de production	Taille moyenne de la parcelle (ha)	Indicateurs à éliciter	Année d'expérience
Production	Lekié	Monatélé	Plantain et manioc	Forte et absence d'utilisations des pesticides et herbicides	1	Rendement moyen, Cout de travail (quantité et temps)	≥ 5 ans
Commercialisation	Nyong et Kélé	Ngog- Mapubi	Plantain et manioc	Forte et absence d'utilisations des pesticides et herbicides		Prix bord champ	≥ 5 ans

Tableau 2.b : Matrice des profils des experts de la communauté scientifique et technique

Expertise	Zone	Spéculations	Systèmes de production	Taille moyenne de la parcelle (ha)	Indicateurs à éliciter	Année d'expérience
Production	Région du Centre	Plantain et manioc	Forte et absence d'utilisations des pesticides et herbicides	1	Rendement moyen, Cout de travail (quantité et temps)	≥ 5 ans
Commercialisation	Région du Centre	Plantain et manioc	Forte et absence d'utilisations des pesticides et herbicides		Prix bord champ	≥ 5 ans

Méthode d'élicitation

Chaque expert a fait l'objet d'une enquête préalable à l'aide d'un questionnaire détaillé.
Pour l'élicitation proprement dite, nous avons utilisé le package *SHELF*[1] version 1.5.0 qui a été compilé dans l'environnement R version 3.4.4.
Parmi les méthodes d'élicitation existantes, c'est la méthode de la « roulette » que nous avons mobilisé du fait de sa simplicité et de son côté intuitif (Johnson *et al.*, 2010; Morris *et al.*, 2014) . Cette relative simplicité est due au fait que plusieurs experts préfèrent utiliser des représentations graphiques des probabilités et des incertitudes, comme des histogrammes (Morgan *et al.*, 1992). De plus, la plupart des experts ne sont pas des spécialistes en statistiques et pourraient ne pas être à l'aise d'exprimer leurs jugements en utilisant les autres méthodes (Morgan *et al.* 1992).
La méthode roulette fournie une représentation des connaissances d'experts sous la forme d'un histogramme, puis permet d'ajuster une loi de probabilité continue. Sur la base des travaux de (European Food Safety Authority, 2014; Andriamampianina *et al.*, 2018), nous avons appliqué cette méthode en cinq étapes :[2]
Etape 1 : L'expert choisit une quantité à éliciter, la défini et en donne l'unité de mesure.
Etape 2 : L'expert fixe les bornes inférieure et supérieure des valeurs de la quantité sélectionnée. Ces bornes définissent la gamme possible de variation. L'enquêteur divise cet intervalle en P sous-intervalles de valeurs (en abscisse). Chaque sous-intervalle définit une colonne qui est divisée elle-même en M cases (en ordonnée), définissant ainsi une grille comportant un total de P*M cases.
Etape 3 : L'expert place des jetons sur la grille. Le nombre de jetons attribués dans chaque sous intervalle doit refléter la probabilité que la valeur de l'indicateur soit située dans ce sous-intervalle, selon l'expert. L'axe des ordonnées représente le nombre de jetons compris entre (0-10) et l'axe des abscisses les différentes valeurs possibles de la quantité à éliciter. Le résultat obtenu correspond à un histogramme.
Etape 4 : Une série de lois de probabilités (Normal, Student-t, Gamma, Log-normal, Log-Student-t, Beta) est ajustée à l'histogramme et celle qui s'ajuste le mieux est sélectionnée automatiquement par l'outil (SHELF). Chaque distribution de probabilité obtenue est décrite par sa médiane et les deux déciles (0.1 et 0.9) qui représentent les bornes de l'intervalle de crédibilité (IC) à 80%. Cet IC couvre l'ensemble des valeurs plausibles de réalisation de la quantité d'intérêt compris entre les deux déciles de la distribution élicitée par l'expert.
Etape 5 : Les 33ème et 66ème percentiles des valeurs

Tableau 3: Typologie d'experts enquêtés

Spéculations / Type d'acteurs	Plantain	Manioc	Total
Communauté scientifique et technique	6	6	12
Producteurs	26	18	44

des quantités d'intérêt obtenues à partir de la distribution sélectionnée sont calculés et présentés à l'expert. Ils représentent les valeurs atteintes une fois sur trois et deux fois sur trois. L'expert juge ensuite si ces valeurs représentent bien ses connaissances. Dans le cas contraire, l'expert ajuste son histogramme et modifie la distribution proposée. Le processus est répété jusqu'à ce que l'expert soit satisfait.

Durant la collecte des données, nous avons essayé de mobiliser le plus d'experts possible pour obtenir une couverture représentative de l'éventail des opinions (Morgan, 2014). Au total, 56 experts (Tableau 3) ont été élicité séparément, 12 pour la CST et 44 chez les producteurs.

Plus spécifiquement, pour les experts de la CST, pour chacune des spéculations, les étapes présentées ci-dessus sont réalisées deux fois (une fois pour le système naturel, une fois pour le système conventionnel) ce qui nous permet d'obtenir deux distributions de probabilité pour chaque quantité d'intérêt. Pour établir la relation entre les deux systèmes, nous demandons à l'expert d'éliciter le coefficient de corrélation. Clemen *et al.*, (2000) considère que l'expert élicite la corrélation de Spearman. Par la suite, pour passer de la corrélation de Spearman à la corrélation de Pearson, nous allons utiliser la formule suivante : Cor. Pearson = 2 sin (Pi* (Cor. Spearman/6)). Puis nous utilisons cette corrélation pour déterminer la probabilité de concordance (Pc) pour la spéculation entre les deux systèmes de production. Par la suite, la Pc obtenue nous permet de définir la distribution conjointe pour la spéculation entre les deux systèmes de production à l'aide d'une copule gaussienne (Clemen et Winkler, 1999). Des tirages aléatoires sont ensuite réalisés pour estimer la distribution de la perte relative (%) 100*(AN-AC)/AC par spéculation.

Pour les producteurs, pour chacune des spéculations, les étapes présentées ci-dessus sont réalisées une fois (soit pour le système naturel, soit pour le système conventionnel) en fonction du système qu'il mobilise. Par la suite, nous combinons les courbes de distribution des experts obtenues par les producteurs par système de production et par spéculation en rapport à une quantité d'intérêt. Cette combinaison se fait pour les experts appartenant à un même arrondissement (Ngog-Mapubi ou Monatélé). Pour obtenir le coefficient de corrélation pour une quantité d'intérêt, nous avons fait la moyenne des coefficients de corrélation fournis par les experts de la CST pour cette quantité par rapport à la spéculation. Et la procédure pour obtenir la perte de la distribution conjointe est identique à celle adoptée chez les experts de la CST.

Pour les quantités pour lesquelles la perte relative n'a pas pu être obtenue, nous avons mis en débat les informations fournies par les deux types d'experts après avoir fait la combinaison des différentes courbes de distribution de probabilité de leurs jugements.

Analyse statistique

A partir de chaque élicitation d'expert, une distribution ajustée a été estimée grâce à la fonction fitdist du package SHELF de R. Chaque distribution est décrite par sa médiane et son IC à 80 %. Plus cet IC est grand, plus le niveau d'incertitude de l'expert sur la valeur de l'indicateur est élevé. Inversement, plus l'IC est petit, plus le niveau d'incertitude de l'expert est faible. La valeur médiane représente la valeur pour laquelle il y'a 50% des chances que la quantité élicitée soit atteinte.

Pour l'analyse interannuelle des rendements moyens en AN, après avoir calculé la perte des rendements en AN par rapport à l'AC, nous allons les comparer avec les résultats issus de la littérature pour les pays en développement et en Afrique.

Table 4: Correlation analysis of the relationship between respondent's socio-economic characteristics and perception on eco-friendly farming

Variables	R	P value	Decision
Age	0.966	0.001	S
Farm size (in acres)	0.957	-0.01	S
Household size	0.936	-0.02	S

S, significant; P-value is significant at 0.05 level (2-tailed)

Pour le prix bord champ, la quantité de travail et le temps de travail, nous n'avons pas pu calculer la perte relative de ces quantités car les experts de la CST ont estimé une différence nulle entre les systèmes notamment pour les prix[3] et n'ont pas été en mesure d'éliciter le coût de travail (quantité et temps). Cet aspect à empêcher par la suite d'utiliser le coefficient de corrélation qui aurait été fourni par les experts de la CST afin de calculer la perte relative estimée par les producteurs pour ces quantités. Face à ce constat, nous allons combiner pour chacune de ces quantités les courbes de distribution estimée par chaque type d'experts dans un système de production en fonction de sa zone. Par la suite, nous allons :

(i) pour les prix bords champs, comparer plusieurs quantiles (10,25,50,75,et 90%) compris dans l'IC de la courbe de distribution élicitée par chaque type d'expert dans sa zone d'enquête. Les experts de la CST estimant une différence nulle entre les systèmes, ils n'auront qu'une seule courbe de distribution. La première étape consiste donc à comparer ces quantiles entre les deux systèmes estimés par les producteurs dans une zone afin de voir si l'écart peut être nul, faible ou significatif. La deuxième étape consiste par la suite à comparer ces différents quantiles entre les deux types d'experts par système de production tout en sachant que ceux de la CST estiment des valeurs identiques pour le système naturel et conventionnel;

(ii) pour le coût de travail, comparer les valeurs médianes estimées par les producteurs dans chaque zone d'enquête. Les informations fournies par les experts de la CST pour le coût de travail n'ont pas été utilisées car ils n'ont pas été en mesure d'éliciter cette quantité.

Résultats et discussion

Des résultats sur la différence performance relative des rendements moyens de l'AN par rapport à l'AC dans la région du Centre

La figure 1 présente l'ensemble des valeurs plausible des pertes relatives des rendements de l'AN par rapport à l'AC sous l'IC à 80% estimées par les deux types d'experts. La ligne bleue représente le seuil pour lequel les rendements naturels et conventionnels sont identiques. Chaque point indique la médiane exprimée en pourcentage de la perte des rendements de la distribution élicitée. Les valeurs entre parenthèses représentent le nombre d'experts élicités chez les producteurs dans les deux systèmes (AN et AC) pour chaque spéculation dans un arrondissement. La combinaison des courbes de distribution sur le rendement est faite par la suite pour chaque spéculation en fonction du système pour obtenir qu'une seule courbe c'est-à-dire une courbe en AN et une courbe en AC. Ensuite, la courbe de distribution de la perte relative pour une spéculation dans un arrondissement obtenue est calculée sur la base des deux courbes de distribution obtenues précédemment. De ce fait, l'expert 12 résume l'estimation de la distribution de la perte relative des producteurs de manioc à Ngog-Mapubi. La procédure est identique pour les experts 13 et 14.

Pour le manioc, exprimé en filet de 50 Kg/ha, les résultats montrent que les cinq experts[4] de la CST indiquent qu'il y'a 50% de chance d'obtenir une perte des rendements de manioc naturel de 18 % par rapport au manioc conventionnel dans la région du Centre. Parmi les experts de la CST, on observe que l'expert 1 estime une perte de rendement en AN strictement inférieure par rapport en AC. Cette perte est robuste car l'IC couvre des valeurs strictement inférieures à 0, et est très petit. Par contre, les IC des experts 2, 3, 4 et 11 qui coupent la valeur 0 ce qui indique que ces experts estiment une possibilité d'avoir des rendements similaires dans les deux systèmes de culture, voire un gain de rendement dans le système naturel. Les experts 11 et 2 sont incertains car leurs IC sont relativement grands, et les experts 3 et 4 sont assez sûrs de leurs résultats car leurs IC sont relativement petits. (Figure 1).

Comparativement aux résultats estimés par les experts de la CST, le producteur de manioc de Ngog-Mapubi (expert 12) estime qu'il y a plus de 50% de chance d'obtenir un gain de rendement de manioc naturel par rapport au manioc conventionnel mais le gain est incertain car l'IC inclus la valeur zéro. (Figure 1). Les onze producteurs de manioc rencontrés à Monatélé n'utilisant que le système naturel nous n'avons pas pu calculer leurs pertes relatives.

Pour la banane-plantain, exprimé en nombre de régimes/ha, les cinq experts[5] de la CST estiment qu'il y'a 50% de chance d'obtenir une perte des rendements de la banane-plantain naturel de 55 % par rapport à la banane-plantain conventionnel dans la région du Centre. Tous les experts ont des IC relativement grands, de tailles sensiblement égales et strictement inférieurs à 0. Cela signifie qu'ils ont tous la même incertitude et qu'ils n'estiment pas des rendements de plantain naturel supérieurs à ceux conventionnels. Par contre, chez les producteurs, les experts 13 et 14 estiment respectivement qu'il y'a 50% de chance d'obtenir une perte des rendements de banane-plantain naturelle de 41 % par rapport à la banane-plantain conventionnelle et 47% de la banane-plantain naturel par rapport au plantain conventionnel respectivement à Ngog-Mapubi et Monatélé. Soient pour les producteurs en moyenne une perte médiane des rendements de banane-plantain naturelle de 44% [(- 41% - 47%)/2] par rapport à la banane-plantain conventionnelle. En comparant les résultats des estimations des pertes des rendements médians estimés par les deux types d'experts (55% et 44%), nous constatons qu'il n'existe pas une grande différence (10%) sur les estimations des pertes.

En résumé, pour la banane plantain, les deux types d'experts confondus estiment en moyenne une perte médiane en AN de 49 % en moyenne par rapport à l'AC pour la banane plantain. Ces experts ont des IC strictement inférieurs à 0 mais sont relativement incertains (Figure 1).

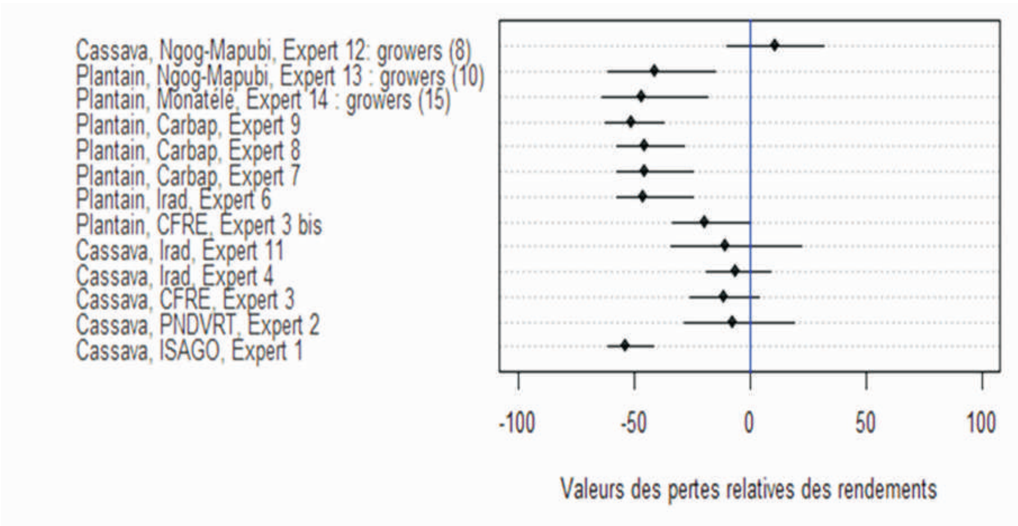

Figure 1 : Pertes relatives des rendements de l'agriculture naturelle par rapport à l'agriculture conventionnelle dans la région du Centre du Cameroun

En moyenne, pour ces deux cultures, et pour les deux types d'experts confondus, il en ressort une perte médiane des rendements en AN de 28 % à ceux conventionnels. En d'autres termes, en moyenne, il y'a 50% de chance d'obtenir les rendements en AN inférieurs de 28 % à ceux conventionnels. Une méta-analyse basée sur les mesures expérimentales de rendements (Seufert *et al.,* 2012) a montré que dans les PED, les rendements en AB certifiée sont en moyenne inférieurs de 43% aux conventionnels. Une étude plus récente sur l'élicitation d'experts qui s'est déroulé en Afrique subsaharienne a montré des résultats comparables avec en moyenne des rendements en AB certifiée inférieurs de l'ordre de 41% à ceux conventionnels (Andriamampianina, 2018). Ainsi, ce travail, malgré que l'on soit en AB non certifiée (AN) donne des résultats meilleurs.

En conclusion, au regard des résultats compable obtenus et du niveau d'incertitude des experts, une amélioration des performances du système naturel est souhaitable dans la région du Centre, d'après la plupart des experts.

Des résultats sur les prix bords champs médians dans la Région du Centre

Concernant les prix bord champ de ces mêmes produits, la perte relative n'a pas été calculée pour les deux types d'experts car les experts de la CST indiquent qu'il y a une différence nulle des prix bord champs entre les deux systèmes. Sur cette base, pour obtenir le maximum d'informations sur les prix bords champs des deux systèmes, nous comparons les quantiles 10, 25, 50,75, 90% (Tableau 4). Ces quantiles nous permettrons de voir la gamme de variabilité des prix et s'il existe des différences importantes pour certains quantiles entre les deux systèmes pour les deux types d'experts.

Tableau 4: Quantiles des prix bords champs du plantain et manioc en fonction du système de production et du type d'experts

Experts	**Spéculation**	**Zone**	**Système de production**	**Quantiles (prix en 10^3 Fcfa)**				
				10%	**25%**	**50%**	**75%**	90%
Producteurs (10)	Banane-Plantain (régime)	Monatélé et Ngog-Mapubi	AN	1.338	1.859	2.433	3.006	3.527
Producteurs (16)	Banane-Plantain (régime)	Monatélé et Ngog-Mapubi	AC	1.419	1.949	2.524	3.094	3.620
Scientifiques et techniques (6)	**Banane-Plantain (régime)**	**Région du Centre**	**AN et AC**	**1.434**	**2.019**	**2.659**	**3.304**	**3.910**
Producteurs (17)	Manioc (filet de 50kg)	Monatélé et Ngog-Mapubi	AN	3.756	4.405	5.120	5.835	6.486
Producteur (1)	Manioc (filet de 50kg)	Monatélé et Ngog-Mapubi	AC	3.373	4.124	4.958	5.792	6.543
Scientifiques et techniques (6)	**Manioc (filet de 50kg)**	**Région du Centre**	**AN et AC**	**3.662**	**4.247**	**4.860**	**5.455**	**5.992**

Source : Auteurs, 2019

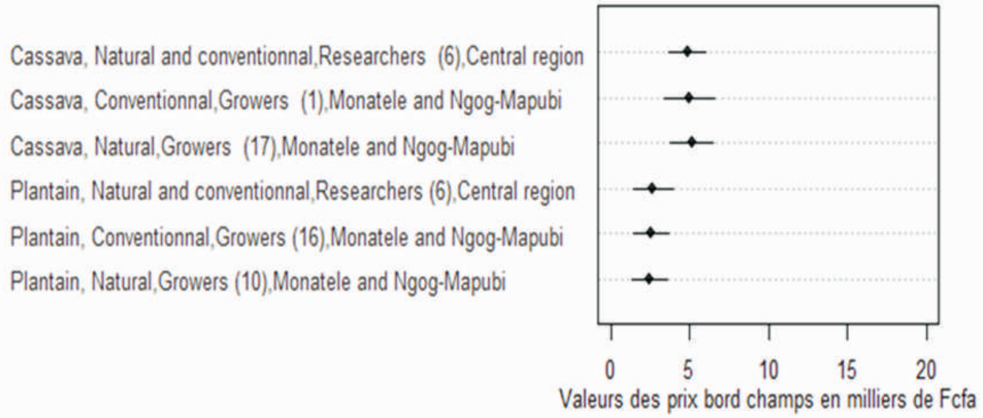

Figure 2 : Valeurs des prix bord champs médians des spéculations en agriculture naturelle et en agriculture conventionnelle pour les deux types d'experts dans leurs zones d'enquêtes

La figure 2 présente les IC à 80% des prix bords champ en Fcfa pour chaque spéculation dans les deux systèmes (AN et AC). Chaque point indique la médiane exprimée en 10^3 Fcfa de la distribution élicitée. Le tableau 4 donne d'avantage d'informations sur l'ensemble des valeurs plausibles des prix compris entre les deux déciles (0.1 et 0.9). Les valeurs entre parenthèses représentent le nombre d'experts élicités dont les courbes ont été combinées pour une obtenir une courbe de distribution. Cette courbe de distribution obtenue correspond pour les producteurs (i) soit au système naturel, (ii) soit au système conventionnel, et pour les experts de la CST (iii) soit résumant les deux systèmes confondus car ces derniers estiment une différence nulle entre les deux systèmes. Cette figure nous permet aussi de présenter le niveau d'incertitude des experts. Ces résultats confirment que la différence de prix bord champ pour chaque spéculation entre les deux systèmes de production est relativement faible.

Les résultats montrent que pour les deux spéculations, quelques soit le système de production et les différents quantiles estimés par les producteurs dans leurs zones d'enquêtes, l'écart de prix est en moyenne relativement faible. De plus, quelques soit l'estimation des prix faite par les producteurs pour une spéculation dans un système et dans une zone, ils sont relativement proche des prix estimés par les experts de la CST. Donc, nous pouvons conclure que les deux types d'experts sont sensiblement en adéquation sur les valeurs des prix bords champs du manioc et de la banane-plantain quelques soit le système de production dans la région du Centre. Il n'existe donc pas une grande différence de prix bords champs entre le manioc et la banane-plantain en AN et AC. De plus, tous deux types d'experts sont très certains au regard de la taille de leurs IC.

Des résultats sur la quantité et temps de travail médian dans la Région du Centre

Concernant les experts de la CST, les résultats sont les suivants :

Les six experts de la CST ont été interrogés sur la quantité de travail en nombre d'homme/jours et le temps de travail en nombre d'heure/jours pour les spéculations choisies. Mais ces derniers ne sont pas arrivés à éliciter ces grandeurs car pour eux, elles varient en fonction du ménage. De ce fait, nous avons basculé à la question suivante : « *Diriez-vous que la quantité/temps de travail sur une parcelle naturelle de ...... (culture) est «Equivalent(e), Inférieur(e) ou Supérieur(e)» à la quantité/temps de travail sur une parcelle conventionnelle de … .(culture) ?* ».Ces derniers ont été tous unanimes pour les deux spéculations sur le fait que la quantité de travail en système naturel peut être soit équivalente, inférieure ou supérieure à celle en conventionnelle. Cela est dû au fait que la main d'œuvre en système naturel est familiale et celle en système conventionnelle peut associer la main d'œuvre salariale. Par contre, pour le temps de travail en AN, ils estiment qu'il est supérieur à celui en AC. Ces réponses sont dues au fait que pour ces experts, les producteurs en AN n'ont subi aucune formation, ne possèdent aucun cahier de charge donc ils passent une majeure partie de leurs temps dans les champs sans chronogramme de travail rationnel.

La figure 3 présente les médianes et les IC à 80% du temps de travail exprimée en nombre d'heures-jour pour les producteurs de Ngog-Mapubi et de Monatélé dans les deux systèmes (AN et AC). Chaque point indique la médiane exprimée en nombre d'heures/jour de la distribution élicitée. Les valeurs entre parenthèses représentent le nombre d'experts élicités par système de production et la spéculation dont les courbes ont été combinées pour obtenir une distribution. La figure 4 présente les mêmes types de résultats mais pour une quantité de travail exprimée en nombre d'hommes-jour sous l'IC à 80% estimées par les producteurs de Ngog-Mapubi et de Monatélé dans les deux systèmes (AN et AC). Chaque point indique la médiane en nombre d'Hommes/jour de la distribution élicitée. Les valeurs entre parenthèses représentent le nombre d'experts élicités dont les courbes ont été combinées pour obtenir une distribution.

Concernant les producteurs, les résultats sont les suivants :

Pour la banane-plantain conventionnelle, les quatre producteurs à Ngog Mapubi et les dix à Monatélé indiquent qu'en moyenne, le nombre d'Hommes/jour médian est de 3 personnes. Les IC sont assez grands ce qui renvoient à une incertitude élevée (figure 4). Mais les producteurs de Monatélé sont plus confiants pour cette valeur. Cela est dû au fait que le nombre de personnes adéquat pour une tâche précise n'est pas toujours respecté à cause du coût de la main d'œuvre. A cette quantité de travail, ils indiquent en moyenne un temps de travail médian dans les deux sites confondus de 3.5h/jours. Pour cette quantité, leurs IC sont petits (figure 3).

Par contre, pour la banane-platain naturelle, les six producteurs en Ngog-Mapubi et les quatre à Monatélé IC est relativement plus petit que les producteurs conventionnels. Donc, ils sont plus certains que ces derniers (figure 4). Ce nombre est expliqué par le fait que la main d'œuvre est familiale et majoritement exercé par le chef du ménage et sa femme. A cette quantité de travail, ils indiquent en moyenne un temps de travail médian dans les deux sites confondus de 4h/jour. Ils sont plus certains que les producteurs en AC (figure 3). Cela est dû au fait que le travail au niveau des champs n'est pas coordonné dû aux manques de formation de producteurs.

Pour le manioc conventionnel, le seul producteur rencontré dans ce système qui se retrouve à Ngog-Mapubi indique en moyenne un nombre médian de 3 personnes. Il est assez incertain (figure 4). Cette information est expliquée par le fait que cet expert en fonction de sa capacité financière peut recruter la main d'œuvre et defois mobilise exclusivement la main d'œuvre familiale. Il associe un temps de travail médian de 3h/jours. Il est assez certain (figure 3).

A contrario, pour le manioc naturel, les sept producteurs à Ngog-Mapubi et les dix à Monatélé indiquent qu'en moyenne, le nombre d'Hommes/jour médian est de 2 personnes. Ils sont plus certains que le producteur en AC (figure 4) car la main d'œuvre familiale ne varie pas beaucoup. A cette quantité de travail, ils indiquent en moyenne un temps de travail médian dans les deux sites confondus de 3h/jours. Ils sont légèrement moins certains que le producteur conventionnel (figure 3).

Mais nous tenons à préciser que les producteurs en système conventionnel ne travaillent pas de lundi à samedi durant le cycle de production de la spéculation. Contrairement aux producteurs dans le système naturel qui interviennent de lundi à samedi.

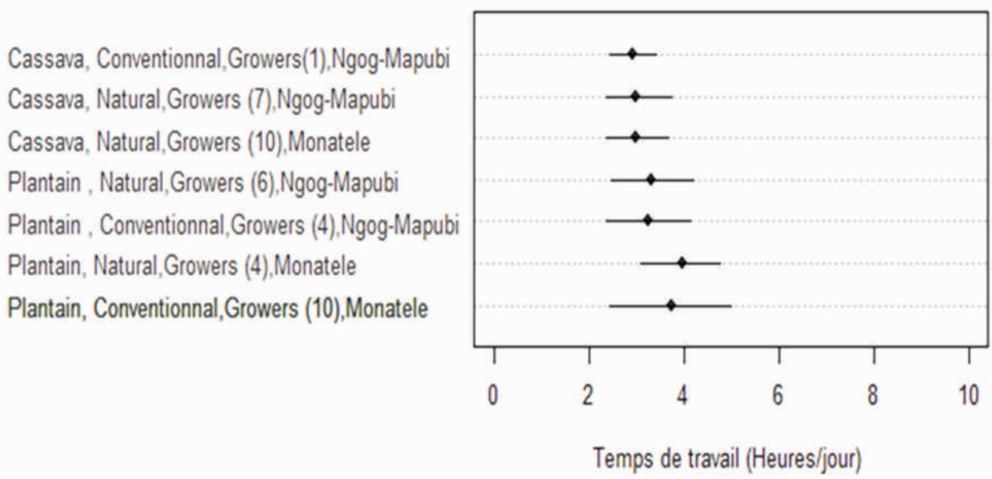

Figure 3 : valeurs des temps de travail en agriculture naturelle et en agriculture conventionnelle du manioc et la banane-plantain pour les producteurs de Ngog-Mapubi et Monatélé

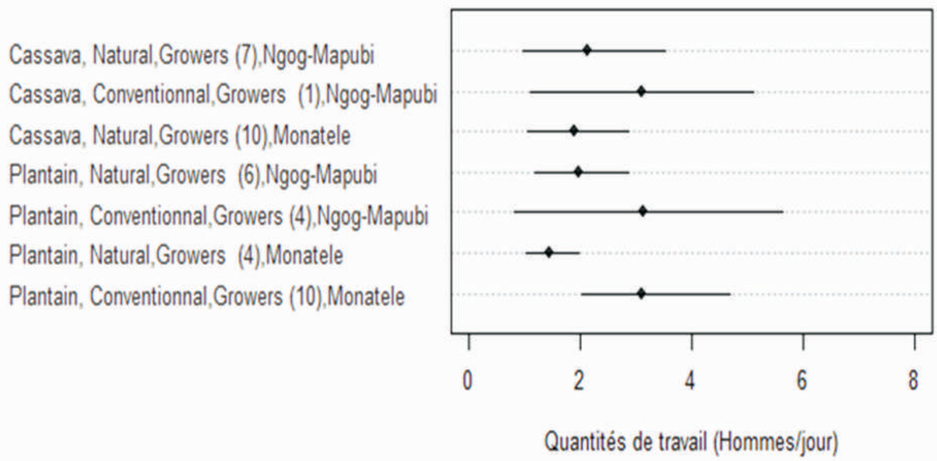

Figure 4 : valeurs des quantités de travail en agriculture naturelle et en agriculture conventionnelle du manioc et la banane-plantain pour les producteurs de Ngog-Mapubi et Monatélé

En somme, pour ces deux quantités et pour les deux experts confondus, les résulats montrent qu'en AN, la quantité de travail qui est exclusivement familiale est relativement plus faible qu'en AC qui associe parfois la main d'œuvre salariale. Mais, les résultats sur ces quantités sont assez incertains au regard de leurs IC.

Conclusion

Au Cameroun, les données sur l'AB sont inexistantes. Ce travail se base sur un des types d'AB (AN) existants au Cameroun pour analyser sa performance par rapport à l'AC en mobilisant deux dimensions (disponibilité et accessibilité) de la sécurité alimentaire dans la région du Centre. Il mobilise pour cela l'élicitation probabiliste des jugements d'experts.

Les résultats montrent que l'incertitude pour les deux types d'experts s'est avérée parfois élevé (quantité de travail en hommes par jour), moyenne (rendement moyen) ou faible (prix bord champ, temps de travail en heures par jour) selon la quantité élicitée pour chacune des spéculations. Les résultats montrent que pour les deux types d'experts considérés (les experts de la communauté scientifique et technique et les producteurs), les rendements en AN sont meilleurs que ceux reportés dans la littérature en AB certifiée pour le manioc et la banane plantain. Concernant le prix bord champ en AN et AC, les résultats indiquent qu'en moyenne, après avoir comparé les informations fournies par les deux types d'experts, il n'y a pas une différence significative entre les deux systèmes. Pour le coût de travail, les résultats montrent que la quantité de travail est plus faible en AN par rapport à l'AC et que le temps de travail est sensiblement égal dans les deux systèmes.

Cette étude montre que l'élicitation fournit une distribution plausible des valeurs des quantités élicitées. Nous avons montré qu'elle peut être utilisée pour présenter de manière transparente le jugement d'un expert et l'incertitude associée. Mais, il semble nécessaire de réaliser de nouvelles élicitations car notre échantillon est de taille relativement modeste.

Remerciement

Le travail de David Makowski a été en partie financé par l'institut Carnot Plant2Pro (projet Licite) et par le projet du méta-programme GloFoods ABASS (INRA). Les auteurs remercient le projet SERVInnov d'avoir financé la participation à cette conférence.

Notes de fin

1. https://cran.r-project.org/web/packages/SHELF/ SHELF.pdf
2. Ces étapes sont menées indépendemment pour le système naturel et le système conventionnel pour chaque quantité élicitée.
3. Le prix bord champ en AN est égal au prix bord champ en AC
4. La perte a été calculée sur 5 experts car il y'a un qui nous a fourni des informations sur un système de production.
5. Idem

Bibliographie

Albert I., Ancelet S., David O., Denis J.B., Makowski D., Parent E., et al.(2015). Initiation à la statistique bayésienne-Bases théoriques et applications en alimentation, environnement, épidémiologie et génétique. Paris, FRA: Edition Ellipses.

Andriamampianina L., Temple L., de Bon H., Malézieux E., et Makowski D. (2018). « Évaluation pluri-critères de l'agriculture biologique en Afrique subsaharienne par élicitation probabiliste des connaissances d'experts. Cahiers Agricultures, 27,4, 45002.

Banque Mondiale, et FAO. (2008). Etude de compétitivité de la chaine de valeur agricole au Cameroun . Banque mondiale.

Baudry J., Karem E., Touvier M., Allès B., Seconda L et al. (2018). The Frequency of Organic Food Consumption Is Inversely Associated with Cancer Risk: Results from the NutriNet-Santé Prospective Cohort , JAMA Internal Medicine, 10.

Bayiha G.D.L.P., Temple L., Mathe S., et Nesme T. (2019). Typologie et perspective d'évolution de l'agriculture biologique au Cameroun. Cahiers Agricultures, 28, 3, 1-8.

Bolger F., et Wright G. (2017). Use of expert knowledge to anticipate the future: Issues, analysis and directions . International Journal of Forecasting, 33, 1, 230–43.

Bootz J.P., Lièvre P., et Schenk E. (2019). L'enquête comme logique de sollicitation des experts en mode exploration : analyse de deux expéditions en milieux extrêmes . Innovations, 58, 1, 49.

Chen M., Brun F, Raynal M., Debord C., et Makowski D. (2019). Use of Probabilistic Expert Elicitation for Assessing Risk of Appearance of

Grape Downy Mildew. Crop Protection, 126 (décembre), 104926.

Clemen R.T., et Winkler R.L. (1999). Combining probability distributions from experts in risk analysis. Risk analysis, 19, 2, 187–203.

Clemen R.T., Fischer G.W., et Winkler R.L. (2000). « Assessing dependence: Some experimental results ». Management Science 46 (8): 1100–1115.

Clemen R.T., Reilly T. (2001). Making Hard Decisions with DecisionTools. [2nd rev. ed.]. [Pacific Grove, CA], Duxbury Thomson Learning.

De Bon H., Temple L., Malézieux E., Bendjebbar P., Fouilleux E. (2018). L'agriculture biologique en Afrique: un levier d'innovations pour le développement agricole. Perspective - Cirad, 48, 1 - 4.

De Ponti T., Rijk B., and van Ittersum M.K. 2012. The Crop Yield Gap between Organic and Conventional Agriculture. Agricultural Systems, 108, 4 , 1–9.

European Food Safety Authority. (2014). « Guidance on Expert Knowledge Elicitation in Food and Feed Safety Risk Assessment: Guidance on Expert Knowledge Elicitation ». EFSA Journal, 12, 6, 3734.

Frey H.C., Crawford-Brown D., Junyu Z., et Loughlin D. (2003). Hierarchy of methods to characterize uncertainty: State of science of methods for describing and quantifying uncertainty. Research Triangle Park, NC: Prepared Under EPA Contract No. 68-D-00-265, Work Assignment 2–24, via E.H. Pechan and Associates, for U.S. Environmental Protection Agency.

IFOAM. (2009). Définitions: Ifoam. https://www.ifoam.bio/fr/organic-landmarks/definition-organic-agriculture

Johnson S.R., Tomlinson G.A., Hawker G.A., Granton JT, Grosbein HA, et Feldman BM. (2010). A valid and reliable belief elicitation method for Bayesian priors. Journal of clinical epidemiology, 63, 4, 370–383.

Lin B.B., Philpott S.M., et Jha S. (2015). « The Future of Urban Agriculture and Biodiversity-Ecosystem Services: Challenges and next Steps ». *Basic and Applied Ecology*, 16, 3, 189-201.

Mijatović D., Oudenhoven F.V., Eyzaguirre P., et Hodgkin T. (2013). « The role of agricultural biodiversity in strengthening resilience to climate change: towards an analytical framework ». *International Journal of Agricultural Sustainability*, 11, 2, 95-107.

Morgan M.G. et Henrion M. 1992. Uncertainty: a guide to dealing with uncertainty in quantitative risk and policy analysis. Cambridge university press.

Morgan M.G. (2014). Use (and abuse) of expert elicitation in support of decision making for public policy. Proceedings of the National Academy of Sciences, 111, 20: 7176–7184.

Morris D.E., Jeremy E.O., et John A.C. (2014). A Web-Based Tool for Eliciting Probability Distributions from Experts. Environmental Modelling & Software, 52 (février), 1‑4.

Muller A., Schader C., El-Hage Scialabba N., Brüggemann J., Isensee A., Erb K.H., et al. (2017). Strategies for Feeding the World More Sustainably with Organic Agriculture. Nature Communications, 8, 1.

Ortiz N.R., Wheeler T.A., Breeding R.J., Hora S., Meyer M.A., et Keeney R.L. (1991). Use of expert judgment in NUREG-1150. Nuclear Engineering and Design, 126, 3, 313‑31.

O'Hagan A., Buck C.E., Daneshkhah A., Eiser J.R., Garthwaite P.H., Jenkinson D.J., et al. (2006). Uncertain Judgements: Eliciting Experts' Probabilities. » Hoboken, NJ: Wiley. Xiii+321 Pp. US$75.00. ISBN: 978-0-470-02999-2. Psychometrika, 73, 1, 163.

O'Hagan A. (2012). Probabilistic uncertainty specification: Overview, elaboration techniques and their application to a mechanistic model of carbon flux. Environmental Modelling & Software, 36, 35–48.

Seufert V., Ramankutty N., et Foley J. (2012). Comparing the yields of organic and conventional agriculture. Nature, 485, 7397, 229-32.

Soll J.B., et Klayman J. (2004). Overconfidence in interval estimates. Journal of Experimental Psychology: Learning, Memory, and Cognition, 30, 2, 299.

Touzard J.M., et Temple L. (2012). Sécurisation alimentaire et innovation dans l'agriculture et l'agroalimentaire: vers un nouvel agenda de recherche? 21, 5, 1-9.

US Environmental Protection Agency. (2011). Expert elicitation task force. White paper, DOI:https://yosemite.epa.gov/sab/sabproduct.nsf/0/F4ACE05D0975F8C68525719200598B

C7/$File/Expert_Elicitation_White_Paper-January_06_2009.pdf

Whitney C.W., Lanzanova D., Muchiri C., Shepherd K.D., Rosenstock .T.S. Krawinkel M, et al. (2018). « Probabilistic Decision Tools for Determining Impacts of Agricultural Development Policy on Household Nutrition ». Earth's Future, 6, 3, 359–72.

Wilbois K.P., et Schmidt J. (2019). Reframing the Debate Surrounding the Yield Gap between Organic and Conventional Farming. Agronomy, 9, 2, 82.

Willer H., et Lernoud J. (2019). The World of Organic Agriculture. Statistics and emerging trends 2019. Frick. Switzerland: FiBL and IFOAM.

ISSN: 2734-2913
Volume 2, 2019
pp 21-35

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

ISSN: 2734-2913

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

NOARA Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بإفريقيا

www.noara.bio

Effect of Composted Poultry Manure on Selected Soil Properties and Organic Carbon Under Tomato Cultivation in Abeokuta, Nigeria

Wahab, A.A.[1], Agboola, K[4]., Aina, O[4]., Dada, O. A.[2] and Hamza, A.[3]
[1]Kwara State University, Malete, Kwara State
[2]Federal University, Ndufu-Alike Ikwo, Ebonyi State, Nigeria
[3]University of Ibadan, Ibadan, Nigeria
[4]Kogi State University, Ayingba, Kogi State
*Corresponding Author E-mail: loukinse@gmail.com

Abstract
Soil quality improvements provide an environment for plant nutrients uptake that influences the development and yield of the crop. This study evaluated the effect of applied composted poultry manure (CPM) on selected soil physical attributes and soil organic carbon content (SOC) under two tomatoes (UC82B and BESKE) varieties planted in succession. Three rates: 0, 10, and 20 t/ha of CPM was applied to two tomato varieties. The treatments were arranged in a randomized complete block design. The parameters considered are soil physical properties - bulk density, aggregate stability, total porosity, water retention capacity, and SOC. It was observed that the application of CPM increased SOC, total porosity, saturated hydraulic conductivity, aggregate stability and decreased bulk density in the tomato cropped area. Water retention did not show any significant difference (P<0.05) between depth at different suctions (0, 30,100 kPa). The SOC was highest in 10 ton/ha of CPM. Application of 10 ton/ha compost is adequate to improve carbon content and soil physical properties for studied soil.

Keywords: Compost, soil physical attributes, soil quality, tomato.

Effet du fumier de volaille composté sur certaines propriétés du sol et du carbone organique dans la culture de la tomate à Abeokuta, Nigéria

Abstrait
L'amélioration de la qualité des sols offre un meilleur environnement pour l'absorption des nutriments des plantes qui influencent le développement et le rendement des cultures. La présente étude a évalué l'effet du fumier de volaille composté appliqué (CPM) sur certaines propriétés physiques du sol et la teneur en carbone organique du sol (SOC) de deux variétés de tomates (UC82B et BESKE) plantées successivement. Trois taux: 0, 10 et 20 t / ha de CPM ont été appliqués à deux variétés de tomates. Les traitements ont été organisés suivant une disposition aléatoire en blocs complets. Les paramètres considérés sont les propriétés physiques du sol - densité apparente, stabilité des agrégats, porosité totale, capacité de rétention d'eau et SOC. Il a été observé que l'application de CPM augmentait le SOC, la porosité totale, la conductivité hydraulique saturée, la stabilité des agrégats et la diminution de la densité apparente dans la zone cultivée de tomates. La rétention d'eau n'a montré aucune différence significative (P <0,05) entre la profondeur à

Date Published: December 16, 2019
ISSN: 2734-2913
Volume 2, 2019, pp 37-44

différentes succions (0, 30,100 kPa). Le SOC était le plus élevé avec 10 tonnes / ha de CPM. L'application de 10 tonnes / ha de compost est suffisante pour améliorer la teneur en carbone et les propriétés physiques du sol pour le sol étudié.

Mots-clés: compost, attributs physiques du sol, qualité du sol, tomate.

Introduction

Soil degradation poses a major threat to sustainable agricultural practices and has become a major environmental threat among others due to excessive soil erosion, nutrient run-off, and loss of soil organic matter. Its ineffective management has resulted in soil quality deterioration, reduced air, nutrient, and water flow, and consequently crop development (Golehin *et al*., 1995; Tejuda *et al*., 2006). Therefore, soil organic matter (SOM) improvement and stability is one major discussion in sustainable agriculture. This is often advantageous for crop production (Arriaga and lowery, 2003) because sustaining soil organic carbon (SOC) is of primary importance in terms of cycling plant nutrients and improving the soil's physical, chemical, and biological properties. SOM enhances water holding capacity and aggregation of the soil inhibits erosion and provides a reservoir of nutrients that can be released into the soil. These provide ease of cultivation, penetration, seedbed preparations, and greater aggregate stability as well as improve water holding capacity at low suction. For this reason, agricultural utilization of organic material with high organic matter such as fresh and composted urban waste (Ron *et al*., 2003) shredded and composted plant material derived from municipal landscape (Walker, 2003) as well as cotton gin compost and poultry manure (Tejada *et al*., 2006) to semi-arid soil has become an environmental practice for soil restoration, maintaining SOM, reclaiming degraded soils and supplying plant nutrients (Ros *et al*., 2003; Walker, 2003). Furthermore, application of organic amendments to the soil can increase SOM content as it enhances the soil carbon level and increases soil organic matter which is associated with the change in the structure and adsorption properties of the soils, and thus their physical properties (Khaleel *et al*., 1985; Edmeades, 2003). Previous studies have consistently found that the application of manure can increase soil aggregation (Paglai *et al*., 2004) and total porosity (Schjonning *et al*., 2002). Miller *et al*., (2002) reported that the manure amendment significantly ($P<0.05$) increased soil water retained compared to the control across the whole range between 0 and 1500kPa. It has also been observed that changes in water retention may depend more on the soil type and its initial carbon content than the addition of organic material i.e., soil porosity (Paglai *et al*., 1987). But little or no information is available on the role of CPM in the improvement of soil physical properties. This study, therefore, compared the residual effect of organic manure i.e., poultry-composted organic manure on the physical properties such as hydraulic conductivity, water retention, soil aggregate stability, soil bulk density and total porosity of soil previously planted with tomato.

Materials and Methods

The site for the experiment is located behind Fadama area in Alabata, Ogun State which lies on latitude 7^0 15'21" N and longitude 3^0 28'19" E. This area is within the transition zone of the sub-humid forest to the south and derived savannah to the North and West (Keay, 1959). The total plot size is 720m^2 (36 plots) and each experimental plot is 4m x 5m laid in randomized complete block design. Initial soil samples were collected before and after first and second planting which were analyzed in the laboratory for chemical and physical soil properties. Soil samples were collected at 0-20cm and 20-40cm depth from each experimental plot after first and second harvesting, that is two different soil samples were collected at the two depths. Core samplers were used to take the undisturbed sample to determine saturated hydraulic conductivity, bulk density and soil auger were used for the disturbed sample. The CPM treatments were applied on the plots at the rate of 0, 10, and 20 ton/ha; where tomato had been cultivated. The Total Organic Matter was determined using the Walkley-Black method (1964). The organic carbon content value derived was multiplied by a standard factor (1.724) to get the corresponding percent organic matter. Aggregate Stability was estimated using wet sieving techniques as described by Emerson (1997) and edited by Udo *et al*. (2009).

Saturated Hydraulic Conductivity was determined using a constant head method (Klute and Dirksen, 1986). This procedure allows water to move through the soil under a steady-state head condition while the quantity (volume) of water flowing through the soil sample is measured over some time. Bulk Density was determined by using the core method (Harte and Horn, 1989). Water Retention was determined by using the pressure plate apparatus. The moisture capacity was determined gravimetrically. Total Porosity was determined in undisturbed water-saturated cores assuming no air was trapped in the pores (Klute and Dirksen, 1986).

Land preparation was done by ploughing and harrowing. Compost was applied at the rate of 0, 10, and 20 t/ha which was thoroughly mixed with the soil before two tomato varieties were transplanted. The experimental design was a randomized complete block; replicated three times. The crop residues of the tomato varieties were left to decay on the plot.

Land preparation for the succeeding crop was carried out by hoeing before transplanting. No compost was applied to the succeeding tomato. The two tomato varieties succeeding in the preceding varieties (UC82B and BESKE) were transplanted accordingly. The spacing was 80 X 30cm with planting a population of 56,000 plants per hectare.

Weed control took place twice in the third and seventh weeks after transplanting using a hand hoe.

Statistical Analysis

Data generated were subjected to analysis of variance using Genstat statistical package release 7.2 DE (2007). Means were separated using Duncan multiple range tests (DMRT) and a significant difference was reported at $P = 0.05$.

Results and Discussion

Pre-planting soil analysis

Soil reaction of the studied site was slightly acidic (6.04 and 5.59) before planting and after first planting (Table 1). The analyzed results also revealed that the soil of the studied site had very low Av. P, TN, K, and OC according to the Federal Department of Agricultural Land Resources' fertility range (1990) before planting. This was however amended reasonably after the first planting of tomato varieties as shown in Table 1. Therefore, there were good responses to soil amendment from the crop and soil.

Table 1: Soil analysis results of the studied sites before and after first planting

Parameters	Value	
	Pre planting soil Analysis	**After the first planting Analysis**
pH (H_2O)	6.04	5.59
Total Nitrogen, TN (g/Kg)	0.09	0.46
Potassium, K^+ (Cmol/Kg)	0.42	1.01
Available Phosphorus, Av. P (mg/Kg)	1.55	1.25
Sodium, Na^+ (Cmol/Kg)	0.23	0.18
Magnesium, Mg^{2+} (Cmol/Kg)	1.47	1.16
Calcium, Ca^{2+} (Cmol/Kg)	2.35	1.87
Total Exchangeable Acidity, TEA (Cmol/Kg)	0.17	0.14
Cation Exchangeable Capacity, CEC (Cmol/Kg)	4.62	3.47
Organic Carbon, OC (%)	1.01	2.17
Base Saturation, BS (%)	96.1	89.1
Bulk density (g/cm^3)	1.63	1.47
Sand (g/Kg)	805	800
Clay (g/Kg)	80	92
Silt (g/Kg)	105	108
Texture	Loamy Sand	Loamy Sand
Porosity (%)	46	48
Permeability (cm/hr)	4.50	5.15

Soil Organic Carbon

The soil organic carbon (SOC) concentrations within two depths i.e. 0 - 20cm and 20 – 40cm, were significantly higher than the control in both tomato varieties. However, the SOC was higher in the control than in the plot treated with organic manure at 0 - 20cm in okra plot (Table 2). In tomato plot amended with 10 t/ha, CPM showed higher at both depths. The increase in SOC due to the application of organic manure could be due to higher root biomass accumulation (Sharma *et al*., 2002) in the fertilized plot than in the control plot.

Soil Bulk Density

The soil bulk density (BD) with depth (0 - 20cm, 20 - 40cm) revealed that CPM decreased soil bulk density as compared with the control plot in both crops (Table 3). The BD in surface layer 0 - 20cm was significantly lower than that of the

Table 2: Organic carbon (%) as affected by CPM under tomato cultivation

Tomato varieties	Compost rate (t/ha)	Depth (cm)	
		0 – 20	**20 - 40**
UC82B	0	1.357	0.883
	10	1.917	1.368
	20	1.765	1.173
BESKE	0	2.207	0.870
	10	2.678	1.082
	20	2.298	1.063

lsd at (p>0.05) for treatment[a] x depth is 0.6440
treatment[a]= tomato varieties x compost rate

Table 3: Soil bulk density as affected by CPM under tomato cultivation

Tomato varieties	Compost rate (t/ha)	Depth (cm)	
		0 – 20	20 - 40
UC82B	0	1.357	1.593
	10	1.340	1.487
	20	1.312	1.502
BESKE	0	1.435	1.457
	10	1.252	1.410
	20	1.375	0.883

lsd at ($p>0.05$) for treatment[a] x depth is 0.1244
treatment[a]= tomato varieties x compost rate

subsurface layer (20 - 40cm) (Table 3). This may be due to high soil organic matter content in the top layer and higher compaction with low suction in the sub-surface layer (Ghuram and Sur, 2001). Schjonning *et al.*, (2002) reported a reduction in the BD of the soil due to the application of animal manure; while Rose (1991) also found a decrease in BD in plots receiving farmyard manure. Lower bulk density on manure treated plots was due to higher organic matter content in the soil.

Total Porosity

The total porosity (TP) was higher in treated plots compared with the control (Figure 1). The highest TP was recorded in the plots amended with 20 t/ha CPM for both tomato varieties (49.83-UC82B and 49.75-BESKE respectively). Thus, the trend of the TP for the applied soil amendment rate was 20 t/ha > 10 t/ha > 0 t/ha. This is in agreement with Celik *et al.*, (2004) report that total porosity with soil organic amendments depends on the amount added. Organic amendment promotes TP of the soil as microbial decomposition products of organic manure such as polysaccharides and bacterial gums are known to act as a soil particle agent. These binding agents decrease the bulk density of the soil by improving soil aggregation and therefore increase the porosity (Bhatia and Shukin, 1982).

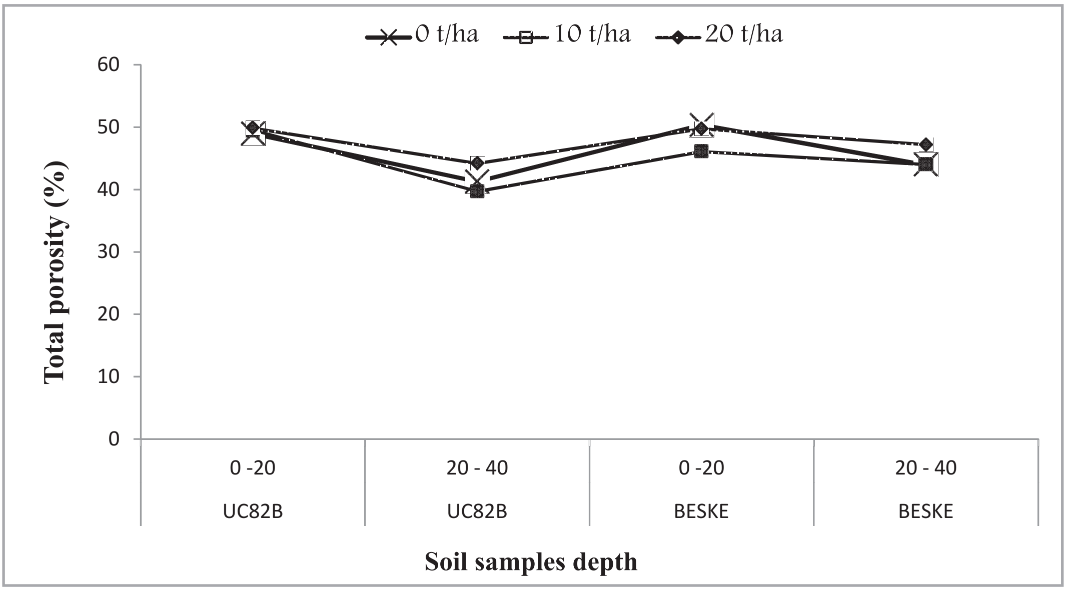

Figure 1: Total porosity as affected by poultry manure under tomato cultivation

Aggregate Stability

The aggregate stability expressed in terms of mean weight diameter (MWD) increased with an increase in the application rate of CPM. Plot amended with 20ton/ha showed a decrease in the trend in both tomato varieties plots (Figure 2). The MWD was highest in the plot treated with 10t/ha. The OM stabilizes the aggregates by forming and strengthening bonds between the clay domain and between quartz particles and clay domain (Emerson, 1997).

The MWD at the subsurface (20-40cm) was higher as compared with the surface (0 - 20cm) (Figure 2). This was due to the absence of tillage practice which induces disruption of soil aggregate in deeper soil layer and compaction of soil due to over-burden pressure, which induced close contact of soil particles and consequently, better adhesions of soil particle to form stable aggregate (Ghuram and Sur, 2001).

Conclusion and Recommendation

This study showed that the application of CPM to soils increased soil organic carbon and decreased soil bulk density thereby causing an increase in total porosity of the soil. The increase in porosity in the topsoil may be due to the increase in the frequency of very small pores. Generally, high soil organic matter (composted poultry manure) increased soil physical properties e.g. saturated hydraulic conductivity, total porosity, water retention, and so on.

Furthermore, the plot amended with 10ton/ha has the highest organic carbon content and shows an increase in soil physical properties than either the control or plot amended with 20 t/ha.

In conclusion, the application of organic manures at 10 t/ha is adequate to improve carbon content and other soil physical properties for fragile soil characteristics of the area.

Acknowledgement

I wish to express my profound gratitude to Prof. Olasantan F. O. of the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria, for mentorship and support accorded me during this research work.

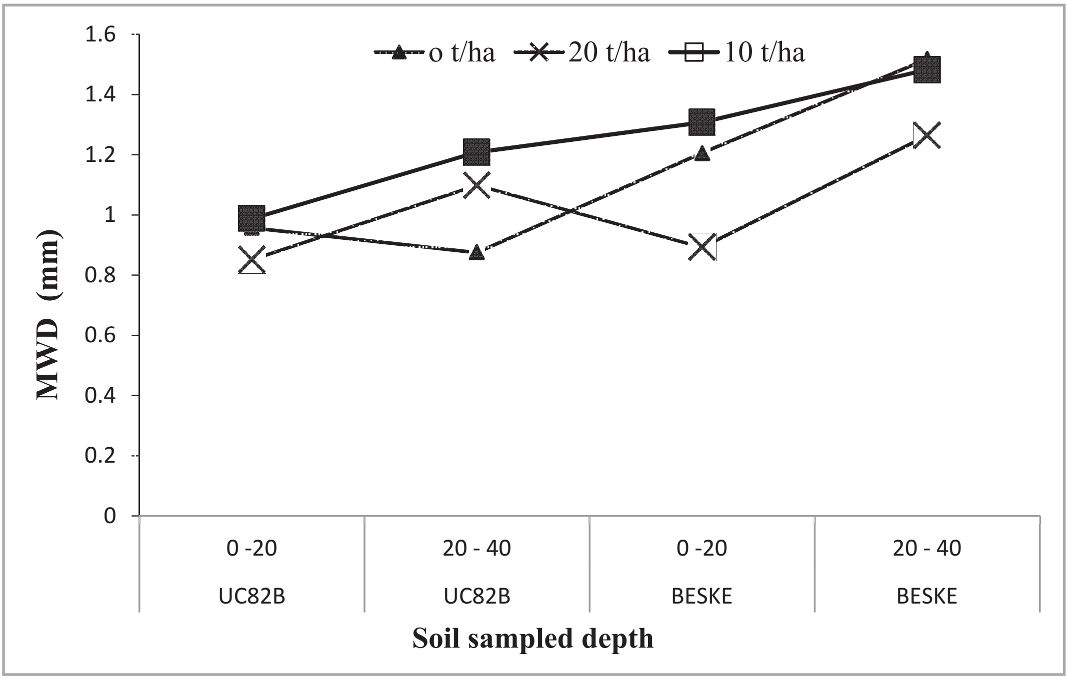

Figure 2: Mean weight diameter (MWD) as affected by poultry manure under tomato cultivation

References

Arriaga, F.I., and Lowery, B. (2003). Soil physical properties and crop productivity of an eroded soil amended with cattle manure. *Soil Science Society America Journal* 168 (12): 888 – 899.

Bhatia, J.M., and Shukin, J. M. (1982). Organic matter and water-stable aggregates in soils. 1. *Soil Science Society America Journal,* 33: 141 – 163.

Celik, R., Griffin, M., and Kimble, J.R. (2004). Conservation tillage for carbon sequestration. *Nutrient Cycling in Agroecosystem,* 49: 243 – 253.

Edmeades, D.C. (2003). The long-term effects of manures and fertilizers on soil productivity and quality: a review. *Nutrient Cycling in Agroecosystem,* 66: 165 – 180.

Emerson, D. (1997). Aggregate stability and assessment of soil crustability and erodibility. 11. Application to humic loamy soils with various organic carbon content. *European Journal of Soil Science,* 48: 39 – 48.

Federal Department of Agricultural Land Resource (FDALR) (1990). Guide on soil fertility range and amendment on Nigeria Soil. pp 35 – 42.

Ghuram J. R. and Sur G. M. (2001). Managing soil carbon. *Soil Science Society America Journal* 304: 393 – 408

Golchin, A., Clarke, P., Oades, J.M., and Skejmstad, J.O. (1995). The effects of cultivation on the composition of organic matter and structural stability of soils. *Australia Journal of Soil Resources*. 33: 975 – 993.

Hartes, R.I., and Horn, R., (1989). Influence of lime, fertilizer, and manure applications on soil organic matter content and soil physical condition: a review. *Nutrient Cycling in Agroecosystems,* 51: 123 – 137.

Khaleel, R., Reddy, K. R., Overcash, M. R. (1985). Changes in soil physical properties due to organic waste additions: a review. *Journal of Environmental Quality,* 10: 133 – 141.

Klute, A., and Dirksen, C. (1986). Hydraulic conductivity and diffusivity: laboratory methods, In Klute, A. (Ed.), Methods of Soil Analysis, Part I. Physical and Mineralogical Methods, 2nd ed. *American Society of Agronomy – Soil Science Society of America, Madison,* WI, pp. 687 – 697.

Miller, O. C., Lal, R., and Bruce, J.P. (2002). Soil carbon dynamics in cropland and rangeland. *Journal of Environmental Pollution,* 116: 353 – 362.

Pagliai, M., La Marca, M., and Lucamante, G. (1987). Changes in soil porosity in remolded soils treated with poultry manure. *Soil Science Society America Journal,* 144 (2): 128 – 140.

Pagliai, M., Vignozzi, N., Pellegrini, S. (2004). Soil structure and the effect of management practices. *Soil & Tillage Research,* 79: 131 – 143.

Rasmussen, P.E., and Parton, W.J. (1994). Long-term effects of residue management in wheat-fallow: I. Inputs, yield, and soil organic matter. *Soil Science Society America Journal,* 58: 523 – 530.

Ros, W.J., Pachepsky, Y.A., Ritchie, L. C., Sobecki, T.M., Bloodworth, H. (2003). Effect of soil organic carbon on soil water retention. *Geoderma,* 116: 61 – 76.

Ron, J.J., Sweetland, N.J., Chang, C. (2003). Hydrological properties of a clay loam soil after long term cattle manure application. *Journal of Environmental Quality,* 31: 989 – 996.

Rose, M.A. (1991). Soil organic carbon pools during early adoption of conservation tillage in Northwestern Canada. *Soil Science Society America Journal,* 60: 1422 – 1427.

Schjonning, P., Munkholm, L.J., Moldrup, P., Jacobsen, O.H. (2002). Modeling soil pore characteristics from measurements of air exchange: the long-term effects of fertilization and crop rotation. *European Journal of Soil Science,* 53 (2), 331-339.

Sharma, R.F., Cooper B., and, Keay, L.R. (2002). Compost effects on soil physical properties and field nursery production. *Compost Science & Utilization,* 10 (3), 226-237.

Tejada, M., Garcl'a, C., Gonzalez, J.L., Herna'ndez, M.T. (2006). Organic amendment based on fresh and composted beet vinasse: influence on physical, chemical, and biological properties and wheat yield. *Soil Science Society America Journal,* 70: 900 – 908.

Udo, E. J., Ibia, T. O., Ogunwale, J. A., Ano, A. O., and Esu, I. E. (2009). Manual of soil, plant, and water analyses. pp 33 – 65.

Walker, C., In, H., Fritton, D.D., 2003. Is the tension beneath a tension infiltrometer what we think it is? *Vadose Zone Journal,* 5: 860 – 866.

Walkley, A., Black, I. (1964). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science Society America Journal,* 37: 29 – 37.

Wu, H.B., Guo, Z.T., Peng, C.H. (2003). Land use induced changes in organic carbon storage in soils of China. *Global Change Biology,* 9 (3): 305 – 315.

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

ISSN: 2734-2913
Volume 2, 2019
pp 37-44

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

NOARA Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بإفريقيا

www.noara.bio

Quality Changes in Sweet Orange with Fruit Maturity in Tropical Humid Climate

*Odeyemi, O.M., Aiyelaagbe, I.O.O. and Olubode, O.O.
Department of Horticulture, Federal University of Agriculture, Abeokuta.
PMB 2240, Ogun State, Nigeria.
*Corresponding Author E-mail: odeyemiom@funaab.edu.ng

Abstract

Production system has a tremendous effect on harvest quality of produce. Sweet orange fruits are non-climacteric in nature, with no further changes in sugar content immediately after harvest. This study investigated changes in the physico-chemical composition of sweet orange (cv. Agege 1) with fruit maturity. Sweet orange fruits were harvested monthly from an 8-year old orchard of Agege 1 variety budded on Cleopatra mandarin cultivated under organic production system of the tropical humid climate. The experiment was conducted for two consecutive seasons between November 2014 and May 2015 and between November 2015 and May 2016 at the Federal University of Agriculture, Abeokuta. Nigeria. Sweet orange trees were fertilized with recommended rate of 10t ha^{-1}poultry manure/tree twice in a year prior fruiting. The fruits were harvested from 90 - 240 days after fruit set (DAFS) to evaluate for quality changes. The 10 t ha^{-1} PM applied supplied 147, 510 and 110 kg ha^{-1} of N, P, and K respectively. Fruit and peel weight, juice volume, number of seeds and total soluble solid (TSS) contents of the sweet orange increased significantly ($p<0.05$) with fruit maturity from 90 -240 DAFS in early season harvest of 2015 and 2016. Vitamin C contents, titratable acidity and firmness decreased with fruit maturity in early season harvest of both years. Maximum moisture content of 92.8% was observed at 240 DAFS in 2015 and 93.3% in 2016in the fruits. There was an improvement in the quality of fruits with maturity but peel colour remained green.

Keywords: *Citrus sinensis*, fruit maturation, organic agriculture, quality, tropics.

Changements de qualité de l'orange douce avec maturité des fruits dans un climat tropical humide

Abstrait

Le système de production a un effet significatif sur la qualité de récolte des produits. Les fruits d'orange douce sont de nature non climatérique, sans autre changement de teneur en sucre immédiatement après la récolte. La présente étude a examiné les changements dans la composition physico-chimique de l'orange douce (cv. Agege 1) avec la maturité du fruit. Les fruits d'orange douce ont été récoltés mensuellement à partir d'un verger de 8 ans de la variété Agege 1 bourgeonné sur mandarine Cléopâtre cultivée dans le système de production biologique du climat tropical humide. L'expérience a été menée pendant deux saisons consécutives

ISSN: 2734-2913
Volume 2, 2019, pp 45-53
Date Published: December 16, 2019

entre novembre 2014 - mai 2015 et entre novembre 2015 - mai 2016 à l'Université fédérale d'agriculture, Abeokuta. Nigeria. Les orangers doux ont été fertilisés avec un taux recommandé de 10 tonnes de fumier de volaille / arbre deux fois par an avant la fructification. Les fruits ont été récoltés de 90 à 240 jours après la nouaison (DAFS) pour évaluer les changements de qualité. Les 10 t ha -1 PM appliqués ont fourni respectivement 147, 510 et 110 kg ha-1 de N, P et K. Le poids des fruits et des écorces, le volume de jus, le nombre de graines et la teneur totale en solides solubles (TSS) de l'orange douce ont augmenté de manière significative (p <0,05) avec la maturité des fruits de 90 à 240 DAFS lors de la récolte de début de saison de 2015 et 2016. Teneur en vitamine C, l'acidité et la fermeté titrables diminuent avec la maturité des fruits en début de saison des deux années. Une teneur maximale en humidité de 92,8% a été observée à 240 DAFS en 2015 et 93,3% en 2016 dans les fruits. Il y a eu une amélioration de la qualité des fruits à maturité mais la couleur de la peau est restée verte.

Mots clés: Citrus sinensis, maturité des fruits, agriculture biologique, qualité, tropiques.

Introduction

Sweet orange is an important nutritious fruit crop with a good amount of vitamin C and several phytochemicals. It belongs to the Rutaceae family and leads other Citrus species in both production area and value (Ritenour, 2016). Generally, citrus fruits are highly appreciated by consumers not only for their taste but also for their positive health values, representing a rich source of bioactive substances that include vitamin C, phenolic compounds such as hydroxycinnamic acids and flavonoids (Strano *et al,* 2017).The cultivation is not only remunerative, but also generates employment. Although exotic to Nigeria, citrus has become fully adapted and features in diverse traditional farming systems, making it one of the most widely planted fruit trees (Aiyelaagbe, 2012).

World leading producers of citrus include China, Brazil, India, Mexico, United States of America and Spain. Nigeria was ranked 9th in the world, producing about 4.08 million tonnes of citrus with a world share of 2.8% harvested from 837,655 hectares (Factfish, 2018).

In sweet orange production, a balanced nutrient management through chemical fertilizers and or organic manures is the key for producing good quality fruits with desired storage ability (Ladaniya, 2008). Maturity determines the compositional quality of fruits (Lee and Kader, 2000). During the last two decades, organic agriculture has undergone a remarkable development throughout the World (Rahmann *et al.,* 2018). The practices have been better coordinated globally and standardized into a sustainable agricultural system that produces adequate amount of high quality food in an environmentally-friendly way (Odeyemi *et al.,* 2013). There has also been an upsurge in the global demand for organic fruits due to envisaged benefits to health and environment (Aiyelaagbe and Afolabi, 2006).Consumers are becoming increasingly conscious of the health benefits of the food consumed, and there is an increasing tendency to avoid consumption of chemically-treated foods (Olubode *et al.,* 2018). It has been proven that some organically-cultivated fruits contain high amounts of vitamins and minerals (Odeyemi *et al.*, 2014). Beside the health benefits associated with organic production of fruits, it has also become necessary to seek alternatives that would supply the soil with more economic sources of fertilizers. In Nigeria, farmers have limited access to synthetic fertilizers due to unavailability, cost of procurement and poor distribution (NISER, 2003). Organic production avoids the use of agrochemicals and relies on recyclable organic materials. It is a viable approach that can be suitable for smallholders, and can be particularly useful in the more difficult environments where resources are scarce and cultivation is problematic. Also, it potentially serves to reduce risk by encouraging localized input production, fostering soil and water conservation as well as encouraging diversification of production (IFAD, 2005).

Due to paucity of information on the quality of sweet orange fruits cultivated under organic practices in Nigeria, this study was carried out to investigate the physical, biochemical and proximate composition changes of sweet orange (cv. Agege 1) with fruit maturity in an organic production system.

Materials and Methods

Description of the experimental site

The study was conducted at the Organic Citrus Orchard of the Department of Horticulture, Federal University of Agriculture, Abeokuta (FUNAAB) (7^0, 15'N, 3^0 25'E, 100m) in South western, Nigeria between 2014 and 2016. This location has an average rainfall of 1062.5mm with bi-modal distribution, temperature of 24.7 °C – 36.4 °C and relative humidity of 88.5%. The area of land lies within the forest transition zone (Aiboni, 2001). The wet season usually extends from March to October while the dry season starts in November and ends in February.

Field management and plant material

The 8 year old sweet orange (cv Agege 1) trees were grafted on Cleopatra mandarin rootstock and spaced at 9.5m between rows and 3.5 m within rows. The organic production system involved biannual application of 10kg ha^{-1} poultry manure/tree. The poultry manure was collected from layer birds raised under battery cage system at the Directorate of University Farms at FUNAAB. It was applied to the plants when the trees were flushing, by digging a trench, 25 cm deep along the drip line and this was covered with top soil. Foliar application of 5.0ml neem (*Azadirachta indica*) oil spray per litre of water was used for insect pest control while 6.5 kg of Jathropha (*Jatropha curcas*) leaves grinded with warm water, extract squeezed with a cloth and diluted with water at ratio 1: 25 was applied as fungicide (Lowell, 1998).Weeding was carried out with the use of a hoe, thrice in the rainy season and twice in the dry season.

Treatments and experimental design

Thirty sweet orange trees were selected randomly and fruits on the trees were tagged 90 days after fruit set. The early season fruits were harvested and evaluated at 30 days interval for quality changes between 90 and240 days after fruit set of November 2014-May 2015 and November 2015-May 2016. The experiment was laid out in a randomized complete block design replicated thrice.

Assessment of fruit quality

At each harvest, the fruits were properly washed with distilled water to remove dirt and air dried. Fruits physical properties determined included fruit weight by weighing individual fruits, using an electronic balance (model Gallenkamp series, London). Fruit diameter was determined using a veneer caliper in the equatorial region. The number of seeds and segments were counted after peeling the fruits and slicing into equal parts. The fruit peel was weighed using a sensitive scale. Juice volume was determined by peeling and slicing individual fruits into two portions. The juice content of both portions was squeezed out using a juice extractor. The juice was filtered to remove seeds and pulp. Juice volume was determined in a measuring cylinder calibrated in milliliters (ml). Fruit firmness of individual fruits was measured using a hand-held penetrometer, expressed as Newton (N). Three independent force measurements were made at three equatorial points on each fruit, 90° from each other (Barman *et al.*, 2014). Colour change was evaluated using a colorimeter (CR-400/410, Konica Minolta, Netherlands) to measure colour coordinates in hunters L*a*b* units.

Biochemical composition determined included total soluble sugar (TSS) determined by placing juice from fresh samples on the reading surface of a hand-held Brix Refractometer (Model Atago 1140, Japan). Readings were taken in Degrees Brix. Titratable acidity (TA) was estimated by titrating 10 mls of freshly-prepared undiluted juice with 0.1N sodium hydroxide in a beaker, using 2-3 drops of phenolphthalein as indicator to a pink colour end point. The pH was determined with the use of a pH metre (Jenway model 3310, UK) previously standardized with buffers 4 and 7. Vitamin C was estimated using titration method with the indicator dye 2,6-dichloroindophenol to a faint pink end point. Proximate composition was determined according to the standard methods of AOAC (2004).

Data Analysis

Data obtained were subjected to analysis of variance (ANOVA) using Genstat Discovery Statistical package (GenStat 2011). Means were separated using least significant difference at 5% level of probability.

Results

The total rainfall observed when the experiment was conducted in 2014, 2015 and 2016 were 1,050mm, 447.9mm and 1,146.3mm respectively. The total rainfall observed in 2015 was very low. Rainfall peaked in October 2014, whereas the peak was observed in September in both 2015 and 2016. There was no rainfall in December in the three years, as this happens to be the harmattan period. Average monthly maximum temperature ranged between 31.4°C and 32.8°C and average minimum temperature was between 22.9°C and 23.47°C, while average relative humidity observed ranged between 53.8% and 65.2% within 2014 - 2016 Table 1. The poultry manure contained 1.47, 0.51 and 1.1% of N, P and K respectively with an organic matter of 15.2%. The 10 t ha^{-1} PM applied was to supply 147, 510 and 110 kg ha^{-1} of N, P, and K respectively Table 2. The A horizon of the soil is an Oxic Paleudulf of the Iwo series with 86.80% sand, 7.40% silt and 5.80% clay with pH of 7.23. Nitrogen was very low at 0.10%. This was below the critical level of 0.25% recommended for citrus. Available P (42.23 mg kg^{-1}) was very high while exchangeable K (0.34 cmol kg^{-1}) was the minimum value recommended for citrus (Tucker *et al.*, 1998) as shown in Table 2.

Table 1: Meteorological data of the experimental site during the period of the study

Months	Rainfall (mm)			Maximum temp (°C)			Minimum temp (°C)			Relative Humidity (%)			Sunshine hours		
	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016	2014	2015	2016
January	8.2	0	32.0	34.2	35.4	35.4	23.6	20.5	20.7	59.4	33.1	56.2	5.1	6.1	4.0
February	15.9	17.1	0.0	35.2	33.1	36.4	23.4	24.6	24.2	53.4	49.4	56.7	5.8	2.1	3.3
March	149.1	35.3	150.3	34.0	35.3	34.8	23.6	25.1	24.4	59.0	51.2	59.1	6.0	5.6	2.0
April	87.2	11.5	68.2	32.9	33.8	34.2	23.5	24.1	24.4	65.4	51.0	63.1	5.7	6.1	6.3
May	113.8	15.1	226.2	32.1	33.1	33.5	23.4	23.8	24.3	67.4	71.1	73.6	5.8	6.7	5.1
June	116.5	14.5	150.5	31.5	31.0	30.6	23.4	22.8	22.7	64.1	62.1	72.0	5.9	4.2	4.0
July	90.7	9.4	65.2	29.9	23.5	29.7	23.3	28.3	23.0	59.1	65.0	72.7	3.8	3.6	2.8
August	92.7	4.2	63.6	29.1	22.9	28.9	22.1	22.9	22.7	70.2	22.9	72.8	2.3	2.4	1.9
September	160.8	165.1	229.0	29.8	30.4	30.5	22.2	22.5	23.6	71.1	71.9	68.9	3.2	2.8	2.7
October	205.9	159.1	155.4	30.5	31.6	32.3	22.0	23.0	22.6	69.5	69.2	65.3	5.3	5.9	4.9
November	17.6	16.6	5.9	32.4	33.5	32.7	22.6	23.8	23.5	67.2	62.3	65.3	5.3	6.3	5.5
December	0.0	0.0	0.0	34.6	33.5	35.3	21.80	19.3	22.5	56.6	36.1	56.6	6.5	5.9	5.5
Total	1,050	447.9	1,146.3												
Mean				32.1	31.4	32.8	22.9	23.4	23.2	63.5	53.8	65.2	5.1	4.8	4.0

Source: Meteorological station, Department of Water Management and Agro meteorology, Federal University of Agriculture, Abeokuta

Table 2: Initial soil chemical and physical properties and poultry manure analysis

Properties	Soil	Poultry manure
pH (H_2O)	7.23	5.91
Organic matter	1.39	15.15
Total organic carbon	0.81%	8.81%
Total nitrogen	0.10%	1.47%
Available phosphorus	42.23 mg kg^{-1}	5.10%
Exchangeable K	0.34 cmol kg^{-1}	1.10%
Exchangeable Ca	4.99 cmol kg^{-1}	2.31%
Exchangeable Mg	1.06 cmol kg^{-1}	1.55%
Exchangeable Na	0.70 cmol kg^{-1}	0.50%
AL + H	0.04 cmol kg^{-1}	-[a]
ECEC	7.13 cmol	-[a]
Base saturation	99.44%	-[a]
Sand	86.80%	-[a]
Silt	7.40%	-[a]
Clay	5.80%	-[a]
Textural class	Sandy loam	-[a]

-[a] = not determined

Table 3: Physical attributes of sweet orange (cv Agege 1) fruit with maturity

Days after fruit set	Fruit weight (g)		Number of seeds		Juice volume (ml)		Number of segments		Peel weight (g)		Fruit diameter (cm)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
90	64.7	58.4	4	3	17.7	10.7	10	11	19.8	10.6	4.9	4.6
120	99.4	73.0	8	4	34.5	26.3	11	11	22.7	12.6	5.3	5.1
150	187.4	132.8	11	9	42.2	33.6	11	11	30.1	21.3	5.7	5.9
180	217.7	196.2	22	17	60.9	38.3	11	11	33.3	33.0	5.8	7.2
210	231.7	253.3	27	28	64.1	47.0	11	11	34.9	45.4	6.2	7.6
240	239.5	255.0	28	29	65.8	47.3	11	11	38.5	46.0	6.5	7.9
Lsd (0.05)	64.3	58.9	7.9	6.2	13.9	11.5	ns	ns	12.8	9.6	0.9	0.8

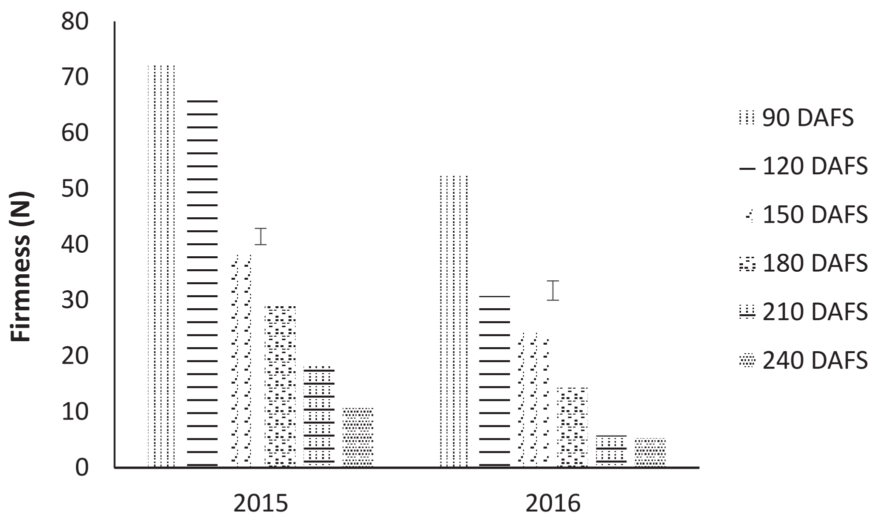

Figure 1: Firmness of sweet orange (cv Agege 1) fruit with maturity

The results showed that there was a significant increase ($p<0.05$) in the physical attributes of the harvested fruits, with increasing fruit maturity from 90 to 240 days after fruit set in the early seasons of 2015 and 2016. Maximum fruit weight and juice volume recorded was 239.5 g and 65.8 ml in 2015, while in 2016, 255 g and 47.3 ml was observed respectively in Table 3.

The number of seeds increased from 4 to 28 in 2015 while in 2016, it increased from 3 to 29 seeds between 90 and 240 days after fruit set. The peel weight and fruit diameter also increased with fruit maturity from 90- 240 days after fruit set. The weight of fruit peel was comparable between 90 and180 days after fruit set in 2015 and 90- 120 days after fruit set in 2016, before increasing significantly. Maximum peel weight observed in 240 days after fruit set was 38.5 g in 2015 and 46.0 g in 2016 while the numbers of segments containing the juice vesicle (sacs) were comparable between 90 and 240 days after fruit set in 2015 and 2016 Table 3. However fruit firmness decreased from 72.9 N to 10.7 N in 2015 and 52.5 N to 5.3 N in 2016 as the fruits became more mature on the tree from 90 to 240 days after fruit set. Figure 1. The fruit peel became significantly lighter (L* value) between 90and 240 days after fruit set with colour development on the fruit. The peel colour changed with advancing maturity of fruits. The green colour decreased as a* value (negative) decreased. As the positive value in the b* value increased, the rind colour turned towards yellow but this was not significant. Similar trend was observed in the fruits produced in both early seasons Figure 2.

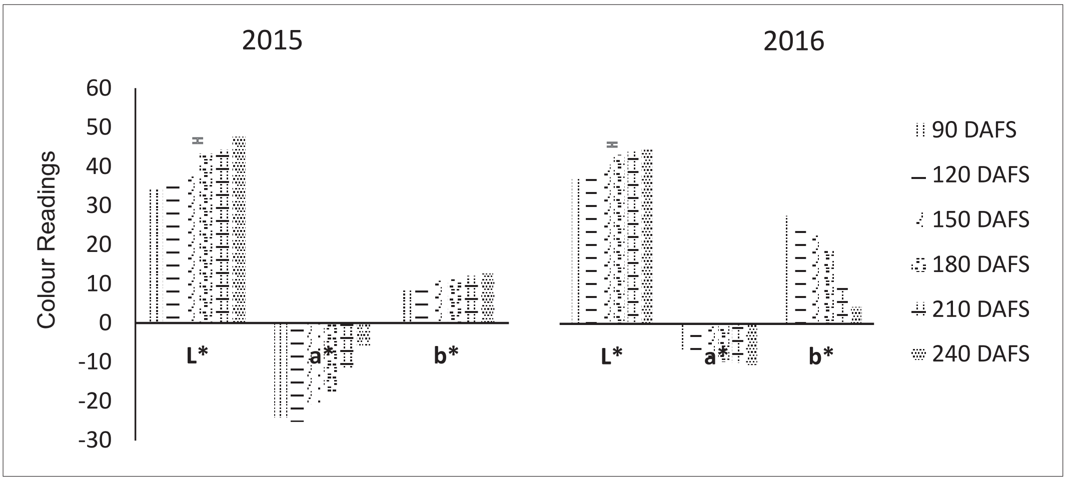

Figure 2: Colour development on sweet orange (Agege 1) peel with fruit maturity
L*=lightness (0=maximum darkness, 100=maximum lightness) a= (+a* redness/ -a* greenness) b= (+b* yellowness/ -b* blueness)

Table 4: Biochemical composition of sweet orange (cv Agege 1) with fruit maturity

Days after fruit set	Total Soluble Sugar (%brix)		Vitamin C (mg/100ml)		Titratable Acidity (%)		pH	
	2015	2016	2015	2016	2015	2016	2015	2016
90	6.9	7.5	46.32	48.84	0.82	0.77	2.32	2.05
120	7.9	8.3	45.11	45.90	0.79	0.68	2.65	2.10
150	8.6	9.7	38.56	40.62	0.66	0.62	2.77	2.64
180	9.2	10.2	38.97	36.42	0.42	0.57	3.41	2.76
210	10.1	10.5	36.79	32.34	0.45	0.49	4.32	2.97
240	10.4	10.6	37.21	32.97	0.31	0.42	4.50	3.08
Lsd (0.05)	1.04	1.03	5.73	4.44	0.09	0.08	0.33	0.47

Table 5: Proximate composition of Sweet orange with fruit maturity

Days after fruit set	Moisture Content (%)		Ash (%)		Fat (%)		Crude Fibre (%)		Crude Protein (%)		Carbohydrate (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
90	79.7	78.4	0.83	0.79	0.93	0.96	3.10	3.07	1.37	1.03	23.21	18.81
120	80.5	89.9	0.80	0.38	0.91	0.92	3.52	3.41	1.54	0.43	16.74	6.73
150	86.7	91.2	0.45	0.27	0.90	0.88	3.57	3.46	1.01	0.39	9.56	8.59
180	92.5	92.5	0.22	0.19	0.87	0.87	3.68	3.73	0.59	0.38	8.12	7.19
210	92.6	92.7	0.21	0.15	0.86	0.84	3.77	3.81	0.47	0.35	4.76	3.17
240	92.8	93.3	0.17	0.14	0.72	0.77	3.98	4.25	0.38	0.33	2.90	2.14
Lsd (0.05)	5.9	4.7	0.09	0.11	0.05	0.06	0.55	0.43	0.03	0.05	3.66	4.75

The biochemical composition of the fruits which include pH and TSS increased significantly ($p<0.05$) between 90 and 240 days after fruit set. The TSS increased from 6.9 % brix to 10.4 % brix in 2015 and 7.5 % brix to 10.6 % brix in 2016 while the pH increased from 2.32 to 4.50 in 2015 and 2.05 to 3.08 in 2016 with fruit maturity. Titratable acidity on the other hand decreased with fruit maturity between 90 and 240 days after fruit set from 0.82 % to 0.32 % in 2015 and 0.77 % to 0.42 % in 2016, while ascorbic acid also decreased from 46.32 to 37.21 mg/100ml in 2015 and 48.84 to 32.97 mg/100ml in 2016 Table 4.

Moisture content of the fruit juice increased significantly ($p<0.0.5$) with maturity. Maximum moisture content of 92.8 % and 93.3 % was observed at 240 days after fruit set in 2015 and 2016 early seasons respectively Table 5. The ash content of the fruits reduced gradually from 90 days after fruit set to 240 days after fruit set. The carbohydrate decreased from 23.21 % to 2.90 % in fruits harvested in 2015, while in 2016 it reduced from 18.81 % to 2.14 %. Crude protein, ash and fats contents of the fruits decreased with fruit maturity from 90 days after fruit set to 240 days after fruit set in both years. However, the crude fibre content of the fruits significantly increased from 90 days after fruit set to 240 days after fruit set.

Discussion

Climatic condition plays an important role on citrus fruit growth and overall quality (Ahmad and Siddiqui, 2016; Zekri, 2011). Optimum temperature, relative humidity, sunshine, and good rainfall distribution pattern can result in heavy yields and excellent quality fruit, provided the nutrient supply is optimum (Ladaniya, 2008).

The average temperature and total rainfall observed were adequate during the experimental period to support fruit development. According to Ladaniya (2008), temperature as low as 5 -10^{0}C in the production area results in fruits with higher acids and lower sugar contents, while fruits produced under temperatures above 35^{o}C results to faster fruits growth but with poor fruit quality.

The reason for this is because the rate of temperature is high; therefore the net carbohydrate accumulation is less. The pH of the poultry manure was slightly acidic with marginal nutrients most likely due to the quality of the poultry feed. The Nitrogen content of the soil in the orchard was low probably due to loss to the environment which is characteristic of soils in the tropics. Canterella *et al*., (2003) stated that citrus fruit yield and quality are greatly influenced by N and K supplied in tropical soils because these nutrients are lost. Adequate plant nutrition is important to facilitate production of good quality fruits.

Agege 1 variety of sweet orange could be classified as a seedy cultivar having more than 15 seeds in the pulp. The increase in TSS with fruit maturity could be attributed to sugar accumulation in the pulp as high amounts of soluble carbohydrates are translocated to the developing fruits as supported by Iglesias *et al* (2001). TSS is an important maturity index for sweet orange that contributes to flavour and determines consumers' acceptability.

Titratable acidity on the other hand decreased with fruit maturity in both seasons due to catabolism of the citric acid. It is important that acidity in fruit is reduced. Increasing pH may be due to decrease in the acidity of the fruit with maturity while carbohydrates decreased because starch disappears with fruit maturity. There was increase in water content of the fruit with maturity as this is the major constituent of the mass of the fruit. Mature citrus pulp contains a very high percentage of water (85-90%) and many different constituents, including carbohydrates, organic acids, amino acids, vitamin C, minerals and small quantities of lipids, proteins, and secondary metabolites, such as carotenoids, flavonoids and volatiles (Davis and Albrigo, 1998). The peel colour of the sweet orange fruits remained green probably because the orange was cultivated in tropical humid region. According to Ladaniya (2008), changes in the peel colour of sweet orange on the tree are due to the weather condition. A high temperature was experienced during fruiting which reduced the rate of chlorophyll degradation and the fruit remained green even with increasing maturity.

Environmental conditions and orchard management including irrigation, pruning and fertilization are known to strongly impact fruit peel colouration (Bouzayen *et al.*, 2010). Pigments are essential for the attractiveness of fruits, accumulating most often in the skin during the ripening process (Bouzayen *et al*., 2010).

Conclusion

The physico-chemical and proximate composition of sweet orange (cv. Agege 1) changed with fruit maturity. The sweet orange fruits became bigger and sweeter with reduced acidity at full maturity. However, the peel colour of the fruits remained green with maturity.

References

Ahmad,M.S. and Siddiqul, M.W. (2016).Postharvest quality assurance of fruits. Springer International Publishing. Switzerland.

Aiboni, V.C. (2001).Characteristics and classification of soils of a representative topographic location in the University of Agriculture, Abeokuta. Nigeria. *ASSET. Journal series A* 1:35-50.

Aiyelaagbe, I.O.O. (2012). Productivity of an intercropped sweet orange orchard in Southwestern Nigeria. *Biological Agriculture & Horticulture,* 18(4): 317-325.

Aiyelaagbe, I.O.O. and Afolabi, A. (2006). Growth and dry matter accumulation of Valencia orange (*Citrus sinensis*) seedlings in response to organomineral fertilizer. In: Organic Agriculture for sustainable food security. *Proceedings of the first National conference on Organic Agriculture Project in Tertiary Institutions in Nigeria. Abeokuta Eds Olasantan et al.,25-28th October, p.66.*

Aiyelaagbe, I.O.O., Afolayan, S.O., Odeleye, O.O., Ogungbayigbe, L.O., and Olufolaji, A.O. (2001). Citrus production in the savannah of western Nigeria: current status and opportunities for research input. In 'Book of Abstracts and Proceedings on CD Rom'One world: Research for a better life'. Duetscher Tropentag 9-11 University of Bonn Germany. p.5.

Association of Official Analytical Chemists, AOAC. (2004). Official methods of analysis of the Association of Official Analytical Chemists, Washington D.C, U.S.A.

Barman, K., Asrey, R., Pal, R. K., Jha, S.K. and Bhatia, K. (2014). Post-harvest nitric oxide treatment reduces chilling injury and enhances the shelf life of mango (*Mangifera indica* L.) fruits during low-temperature storage. *Journal of Horticultural Science & Biotechnology.* 89(3): 253-260.

Bouzayen, M., Latchi, A., Nath, P. and Pech, J.C. (2010). Mechanism of fruit ripening. In: Plant Development Biology. *Biotechnological Perspectives*. Vol 1 Springer USA.

Cantarella, H., Mattos, D. Jr., Quaggio, J.A. and Rigolin, A.T. (2003). Fruit yield of Valencia sweet orange fertilized with different N sources and the loss of applied N. *Nutrient Cycling Agroecosystem.* 67: 215–223.

Davies, F.S. and Albrigo, L.G. (1998). Citrus. CAB International. United Kingdom.

Factfish (2018). Nigeria: Citrus fruits, total production quantity (tons). www.factfish.com. Accessed on 07/02/2019.

Genstat (2011). Procedure Library Release. 4th edition. VSN International Limited, Rothamstead Experimental Station, Hamstead, UK.

IFAD. (2005). Organic agriculture and poverty reduction in Asia: China and India Focus (International Fund for Agricultural Development) Report No. 1664. p 134.

Iglesias, D.J., Cercos, M. Colmenero-Flores, J.M. Naranjo, M.A. Rios, G., Carrera, E., Ruiz-Rivero, O., Lliso, I., Morillon, R., Tadeo, F.R. and Talon. (2007). Physiology of citrus fruiting. *Brazilian Journal of Plant Physiology.* 19 (4):333-362.

Ladaniya, M. (2008). Citrus Fruit; Biology, technology and evaluation. Academic press. USA. p. 89-92.

Lee, S.K. and Kader, A.A. (2000). Pre-harvest and post-harvest factors influencing vitamin C content of horticultural crops. *Post-harvest Biology and Technology*, 20(3):207-220.

Lowell, J.F. (2008).Producing food without pesticides: Local solution to crop pest control in West Africa. CTA. Wageningen . p. 23.

Nigerian Institute of Social and Economic Research. (2003). Understanding poverty in Nigeria. College Press and Publishers Limited, Ibadan, Nigeria. p. 441.

Odeyemi, O.M., Aiyelaagbe,I.O.O, Bodunde, J.G. and Babalola, S.O. (2013). Growth and yield response of pawpaw (*Carica papaya* L) to organic and conventional production systems. *Journal of Organic Agriculture and Environment*, 1:4-12.

Odeyemi, O.M.,Aiyelaagbe, I.O.O. Bodunde, J.G. and Babalola, S.O.(2014). Influence of variety and production system on postharvest quality of pawpaw (*Carica papaya* L) fruits stored in different Media. *Nigerian Journal of Horticultural Science,* 19:53-60.

Olubode, O.O., Joseph-Adekunle, T.T., Hammed, L.A. and Olaiya, A.O. (2018). Evaluation of production practices and yield enhancing techniques on productivity of cashew (*Anacardium occidentale* L). *Fruits* 73(2):75-100.

Rahmann, G., Ardakini, M.R., Neuhoff, D., Olowe, V., Rasmussen, I. and Zanoli, R. (2018). Ready for the future—renewed Aims and Scope. *Organic Agriculture*. 8(3):181-183.Springer. Netherlands.

Ritenour, M.A. (2016). Orange. In: The commercial storage of fruits, vegetables and florist and nursery stocks. Gross K.C., Wang, C. and Saitveit, M. ed. Agricultural Research Service of the United States Department of Agriculture. Agriculture Handbook. No. 66.

Strano, M.C., Altieri, G., Admane, N., Genovese, F. and Di Renzo, G.C. (2017).Advance in Citrus postharvest management: Disease, cold storage and quality evaluation. *Journal of Citrus Pathology*: 139-151.

Tucker, D.P.H., Futch, S.H., Gmitter, F.G. and Kessinger, M.C. (1998). Florida Citrus varieties. University of Florida. Institute of Food and Agricultural Sciences. Gainesville, Florida. USA. p. 186.

Zekri, M. (2011). Factors affecting production and quality of Citrus. Florida Department of Citrus. Bartow. Citrus Industry 6-9.

AFRICAN JOURNAL OF ORGANIC AGRICULTURE AND ECOLOGY

ISSN: 2734-2913
Volume 2, 2019
pp 45-53

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

ISSN: 2734-2913

AFRICAN JOURNAL
OF ORGANIC AGRICULTURE
AND ECOLOGY

NOARA Network of Organic Agriculture Researchers in Africa
RÉSEAU DES CHERCHEURS EN AGRICULTURE BIOLOGIQUE EN AFRIQUE
شبكة الباحثين في الزراعة العضوية بافريقيا

www.noara.bio

Efficacy of Foliar Application Rates of Liquid Poultry Manure Fertilizer on Tomato Performance and Soil Fertility Improvement in Southern Guinea Savanna

Abdulmaliq, S.Y.,[1] Salahudeen, A.,[1] Kumar, N.,[1] Abubakar, A.,[2] Omolaran, B.[3] and Kareem, I.[4]
[1]Department of Crop Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
[2]Department of Biological Sciences, Federal University of Technology, Minna, Nigeria
[3]Department of Agronomy, Federal University Gashua, Yobe State, Nigeria
[4]Department of Agronomy, University of Ilorin, Nigeria.
Corresponding Author E-mail: drsmaliq@gmail.com

Abstract
Nutrition is an essential need of all plants. It is a common belief that if nutrient is in a liquid form it will be easily absorbed by plants. Therefore, field experiment was carried out at the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai (Latitude 09° 02"N and 06° 34"E), Niger State, Nigeria during 2017 and 2018 raining seasons (May to November) to examine the effects of different foliar application rates of liquid poultry manure fertilizer on growth and yield of two tomato varieties. The experiment was a 5 × 2 factorial arrangement in a Randomized Complete Block Design (RCBD) and replicated three times. The two factors were five application rates; 10000, 20000, 30000, 40000 l/ ha, and control (0.00 litre/ ha) and two varieties of tomato (Roma VF and UC82B). Data were collected on growth (plant height, number of leaves per plant, leaf area) and yield (days to first flowering, days to 50% flowering, number of fruits per plant, fruit length (cm), fruit circumference (cm),fresh weight of fruits per plant (kg) and cumulative fruit weight/ha) parameters. All data collected were subjected to Analysis of Variance (ANOVA). Means of significant treatments were separated using the least significant method. The results revealed that application of liquid poultry manure fertilizer had significant ($P<0.05$) effects on vegetative growth and yield performance of tomato varieties in the two cropping seasons. The application of 20,000 l /ha significantly produced highest tomato plant growth (vine length/plant, number of leaves/plant and number of branches/plant)and yield number of fruit/plant, fruit diameter/plant, fruit weight/plant, fruit weight/plot and cumulative yield/ha (tonnes). Also, UC82B variety of tomato significantly supported better growth and yield when compared with Roma VF variety.

Keywords: Liquid poultry manure, growth, yield, tomato varieties, Nigeria.

Efficacité des taux d'application foliaire d'engrais liquide pour fumier de volaille sur la performance des tomates et l'amélioration de la fertilité des sols dans le sud de la savane guinéenne

Abstrait
La nutrition est un besoin essentiel de toutes les plantes. Il est communément admis que si le nutriment est sous forme liquide, il sera facilement absorbé par les plantes. Par conséquent, une

ISSN: 2734-2913
Volume 2, 2019, pp 55-65
Date Published: December 16, 2019

expérience sur le terrain a été réalisée à la Ferme d'enseignement et de recherche de l'Université Ibrahim Badamasi Babangida, Lapai (Latitude 09o 02 "N et 06o 34" E), Etat du Niger, Nigéria pendant les saisons de pluie 2017 et 2018 (mai à novembre) pour évaluer les effets de différentes doses d'application foliaire d'engrais liquide pour fumier de volaille sur la croissance et le rendement de deux variétés de tomates. L'expérience était un arrangement factoriel 5 × 2 dans une disposition de bloc complet aléatoire (RCBD) et répliquée trois fois. Les deux facteurs étaient cinq taux d'application; 10000, 20000, 30000, 40000 l /ha, et le témoin (0,00 litre / ha) et deux variétés de tomates (Roma VF et UC82B). Des données ont été recueillies sur la croissance (hauteur de la plante, nombre de feuilles par plante, surface foliaire) et le rendement (date d'apparition de la première fleur, nombre de jours à 50% de floraison, nombre de fruits par plante, longueur des fruits (cm), circonférence des fruits (cm), poids frais de fruits par plante (kg) et poids cumulé des fruits / ha). Toutes les données recueillies ont été soumises à une analyse de variance (ANOVA). Les moyennes des traitements significatifs ont été discriminées en utilisant la méthode la moins significative. Les résultats ont révélé que l'application d'engrais liquide de fumier de volaille a eu des effets significatifs (P <0,05) sur la croissance végétative et le rendement des variétés de tomates au cours des deux saisons de culture. L'application de 20000 l/ha a produit de manière significative la plus forte croissance des plants de tomates (longueur de la vigne / plante, nombre de feuilles / plante et nombre de branches / plante) et rendement nombre de fruits / plante, diamètre du fruit / plante, poids du fruit / plante, fruit poids / parcelle et rendement cumulé / ha (tonnes). En outre, la variété de tomate UC82B a présenté de meilleures performances en croissance et en rendement comparativement à la variété Roma VF.

Mots clés: Fumier liquide de volaille, croissance, rendement, variétés de tomates, Nigéria.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown in Nigeria. It is the world's largest vegetable crop after potato and sweet potato but it tops the list of canned vegetables. In Nigeria, tomato is regarded as the most important vegetable after onions and pepper (Olaniyi *et al*., 2010). It is widely grown both in most home gardens and commercially because of its importance and values (Adepoju, 2014). It is an important condiment in most diets and a very cheap source of vitamins. It contains a large quantity of water, calcium and niacin all of which are of great importance in the metabolic activities of man. Tomato juice is an excellent source of vitamins, minerals, and antioxidants which helps in the control of cancer as well as improves the general health of man (Ogundare *et al*., 2015).In spite of the importance of the crop in Nigeria, its yield across the country is low and not encouraging.

The tomato yield in Nigeria was reported as (7.0t/ha) compared with average yields recorded in other countries which, are about 9.9 t ha-1 in Thailand, 8.8 t ha-1 in Philippines, 15.6 t ha-1 in India, 25.3 t ha-1 in China, 52.8 t ha-1 in Japan, and 63.6 t ha-1 in USA. In Africa, highest yield was obtained in South Africa (76.25 t ha-1) and the least was from Angola (3.7 t ha-1) (Mohammed and Sighn, 2007).

The use of organic fertilizers is a sustainable way of improving crop productivity because of its ability to support the production of soil without jeopardizing the future productivity of the soil (Abdulmaliq *et al.,* 2016). Organic fertilizer improves the physical and chemical conditions of soil such as anion and cation exchange capacity, organic matter and carbon contents of soil, as well as its biological activities thereby increasing the yield and quality (Nithiya*et al*., 2015). Effective application of organic manure and maximum crop growth and yield depend on its mode of application and concentrations(Amanullah *et al.,* 2010).

Liquid fertilizer is one of the alternative methods of poultry manure application with the aim of improving crop growth and yield. Liquid poultry manure fertilizer is a liquid extract of compost consisting of essential plant nutrients and beneficial microorganisms, and referred to as compost tea (Ingham, 2005 and Arowosegbe, 2010). It boosts the plant and soil life; and has been used as a fertilizer, pesticide and fungicide. Liquid organic fertilizers (poultry manure tea) have been found to contain nitrogen mainly in inorganic form like ammonia (Gross *et al.,* 2007) and can provide nutrients instantly to the plants like the chemical fertilizers. However, there were insufficient information on fertigation of crops by manure teas. Thus, study examined the effects of different foliar application rate of liquid poultry manure fertilizer on growth and yield of tomato varieties.

Materials and Methods

Experimental Site

Field experiment was carried out between May 2017and November 2018 cropping seasons at the Crop Production Department Research Farm of Ibrahim Badamasi Babangida University (IBBUL), Lapai on latitude 09° 02"N and 06° 34"E at an elevation of 162m, with a land mass of 3,051km^2.

Experimental Materials

The organic fertilizer (poultry manure) that was used for the study was collected from the Animal Research Farm of the University (IBBUL) in the two cropping seasons, while the tomato varieties were purchased from an Agro-allied Store in Minna, Niger State, Nigeria. The two tomato varieties were selected based on their growth and yield potentials. The seeds of the tomatoes were raised in the nursery for 28 days before transplanting to the field in June 2017 and 2018 cropping seasons.

Preparation of Poultry Manure Liquid Fertilizer

The liquid poultry manure was prepared using modified method of Peiris and Weerakkody (2015) a week before application using 1:3 ratio of poultry manure to water, gram/ litre (weight/ volume). A total of 20g partly dried poultry manure was weighed and packed in a permeable sack. The tea-bag (the sac) was securely tightened and immersed in a 60 litres of water. The bucket was covered with the lid to discourage flies and other unwanted contaminations. The liquid was manual agitated twice a day to ensure proper mixture and filtration.

Treatments and Experimental Design and Crop Establishment

The experiment was a 5 x 2factorial arrangement in a Randomized Complete Block Design (RCBD) and replicated three times. The two factors were five application rates of liquid poultry manure; 0 l/ha (Control), 10,000 l/ha, 20,000 l/ha, 30,000 l/ha and 40,000 l/haand two varieties of tomato (Roma VF and UC 82B).Each block comprised of 10 plots, each plot was 2 m x 3 m, separated with 1 m and 0.5 m alley ways between blocks and plots respectively. The plot comprised of three rows, with a total of four stands per row, intra and inter spaced by 50 cm x 50 cm given a total of 12 stands per plot.

Physicochemical Analysis of Soil and Poultry Manure Liquid Fertilizer Samples

Prior to commencement of the experiment, top soil samples at the depth of 0 – 30 cm was collected randomly from the field using a core sampler to assess the soil physico-chemical properties with standard laboratory procedure described by Msibi *et al*., (2014). Particle-size analysis was done using Bouyoucous hydrometer method (Gee and Or, 2002). The organic matter was determined by the procedure of Walkley Black using the dichromate wet oxidation method (Nelson and Sommers, 1996). Total N was determined by micro-Kjeldahl digestion method (Bremner, 1996), and available P was determined by Bray-P1 extraction followed by molybdenum blue colorimetry (Frank *et al.,* 1998). Exchangeable K, Ca and Mg were extracted using ammonium acetate, Thereafter, K level was analysed with a flame photometer,Ca and Mg were determined with an atomic absorption spectrophotometer (Okalebo *et al.,* 2002). Poultry manure used for the liquid fertilizer composition was analysed for some pretreatment nutrient contents before application. All analyses were conducted at the National Cereal Research Institute (NCRI) Badeggi, Bida, Niger State, Nigeria.

Nursery Operations and Planting

A nursery (2 × 3 m) was used to raise each variety. A total of 150 g seeds were sown on a flat nursery bed, covered with fine sand and mulched. The beds were watered twice a day to ensure sufficient absorption for proper seed germination. The seedlings were properly taken care of for 28 days in the nursery before transplanting to the permanent field plots. However, the experimental field was cleared and stumped, then ploughed, harrowed and ridged. At the onset of the raining season, healthy grown seedlings were randomly selected from the nursery for transplanting in a well-prepared seed beds. The seedlings were transplanted at the rate of one plant per-hole at a spacing of 50 cm by 50 cm, totalling 12 stands per plot and 36 plants per treatment combination. Thereafter, the seedlings were mulched to preserve soil moisture.

Crop Husbandry

The seedbeds were regularly watered once a day in the absence of rainfall to keep the soil moist. Weeds were manually removed using hand hoe at two weeks interval and the plant stands were staked. Insects and diseases control were done using water and oil extracts of neem (*Azadiracter indica* L.) seeds. Application of the formulated liquid poultry manure (manure tea) was done every two weeks using foliar application method. The foliar application of liquid poultry manure commenced a week after transplanting and thereafter applied biweekly. The application rates were as specified in the experimental design (control, 10000 l/ha, 20,000 l/ha, 30,000 l/ha and 40,000 l/ha). Weeds were controlled by hoe weeding at 4 and 6 weeks after transplanting. Pests and diseases were also controlled using neem seed oil extract. The oil was prepared in emolsifyable concentrations using detergent. Tomato harvesting started at eight weeks after transplanting and continued for about two months.

Growth Development and Yield Parameters

Growth parameters such as plant height, number of leaves per plant, leaf area were taken from three randomly selected tagged plants from each plot two weeks after transplanting (WAT) following the method of Ogundare*et al.*,(2015).

Development and yield parameters such as days to first flowering, days to 50% flowering, number of fruits per plant, fruit length (cm), fruit circumference (cm) and fresh weight of fruits per plant (kg) were also taken from selected tagged plants.

Statistical Analysis

The Proc Mixed procedure in SAS (SAS version 9.1.3, SAS Institute, 2012) was used to to test for significant differences among the treatments mean. Significant means were separated using Least Significant Differences (LSD) at 5% probability level.

Results

Physico-chemical Properties of the Soil

The physico-chemical properties of the soil from the experimental sites and liquid poultry manure in the 2017 and 2018 cropping seasons are presented in Table 1. The soil was sandy loamy and slightly acidic. It also contained low organic carbon, total nitrogen and exchangeable Mg as compared to liquid poultry manure. With the exception of exchangeable K of the soil sample, the exchangeable Ca, Mg and P of the two samples were adequate.

Effect of liquid poultry manure application rates on the growth of two tomato varieties

Table 2 showed the vine length (cm) of tomato varieties as affected by the application of liquid poultry manure. In both years, there were significant ($P < 0.05$) differences in the vine length of tomato as a result of application of different rates of liquid poultry manure at 3, 6, 9, and 12 WAT. The application of 20,000 l/ha liquid poultry manure consistently and significantly ($P<0.05$) produced longer vine at 3, 6 and 9 WAT. The least vine length was recorded from the application of 40,000 l/ ha. However, at 12 WAT, there was no significant difference in the vine length for all the treatments. The two tomato varieties were significantly different in their vine length at 3 and 6 WAT, with UC82B recording significantly ($P<0.05$) longer vine than Roma VF.

Significant and consistent highest number of leaves per plant was obtained from the application of 20,000 l /ha treated tomato plants

Table 1: Physicochemical Properties of Experimental Soil, Poultry Manure and Liquid Poultry Manure

	2017	2018	2017	2018	2017	2018
Sample Description	**Soil**		**Poultry Manure**		**Liquid Poultry manure (Manure Tea)**	
pH (H_2O)	6.80	6.58	5.86	5.89	6.02	6.05
Organic Carbon (%)	0.77	0.77	1.32	1.45		
Organic Matter (%)	1.33	1.28	1.42	1.55		
Total N (%)	0.16	0.15	3.14	3.15	2.84	2.95
Available P (ppm)	25.98	20.95	16.54	17.55	23.23	24.85
Na ($cmolKg^{-1}$)	0.15	0.8	0.36	0.45	0.21	0.25
Potassium ($cmolKg^{-1}$)	0.05	0.08	1.36	1.52	0.33	0.35
Calcium ($cmolKg^{-1}$)	2.80	2.75	2.32	2.85	3.28	3.45
Magnesium ($cmolKg^{-1}$)	3.28	3.45	7.02	6.95	6.77	6.55
Exchangeable Acid ($CmolKg^{-1}$)	0.44	0.43	0.53	0.58		
CEC ($CmolKg^{-1}$)	6.72	6.50	6.25	7.15		
Sulphur (ppm)+					0.066	0.064
Zinc (ppm)			0.373	0.385		
Sand (%)	84.4	83.5				
Silt (%)	6.36	6.30				
Clay (%)	9.24	9.20				
Texture	Loamy Sandy	Loamy Sandy				

Table 2: Effects of Liquid Poultry Manure rates and Varieties on the Vine Length (cm) of Tomato

Treatment	**Tomato Vine Length (cm)**							
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	3 WAT		**6 WAT**		**9 WAT**		**12 WAT**	
Application Rates								
Control	15. 40	16.50	26.70	30.25	52.20	54.50	60.55	65.30
10,000 l/ha	19.77	20.42	34.83	40.80	58.10	58.25	65.80	64.40
20,000 l/ha	21.47	20.65	38.14	41.50	62.70	65.20	80.65	82.20
30,000 l/ha	14.79	13.80	23.52	30.75	49.10	50.60	67.10	68.50
40,000 l/ha	11.67	12.70	20.28	28.20	42.66	43.20	53.00	55.20
$LSD_{(0.05)}$	3.438	3.522	6.174	6.255	7.104	7.322	9.400	9.625
Varieties								
Roma VF	14.76	15.52	26.14	27.30	50.47	54.30	69.95	69.80
UC82B	18.48	20.85	30.45	31.50	58.45	72.80	76.54	77.30
$LSD_{(0.05)}$	2.175	2.245	3.902	3.925	5.758	5.955	6.016	6,255
PM xV	ns	ns	ns	ns	ns	ns	ns	ns

Means followed with same letter(s) along each column are not significantly different at 5% probability level

throughout the experimental period in the two cropping seasons (Table 3). Least number of leaves/plant was obtained from the application of 40,000 l/ha during experimental study periods. However, there were no significant differences between the application of 40,000L/ha and 30,000 l/ha in the number of leaves/plant. UC82B variety produced higher number of leaves per plant, although, there were no significant differences among the two varieties in the two cropping seasons.

Table 3: Effects of Liquid Poultry Manure and Varieties on Tomato Number of Leaves/Plant

Location/year Treatment	Tomato Number of Leaves/Plant							
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	3 WAT		**6 WAT**		**9 WAT**		**12 WAT**	
Application Rate								
Control	11.45	11.10	17.50	17.20	46.20	46.20	66.80	67.10
10,000 l/ha	12.10	11.45	27.10	27.60	49.30	49.60	79.30	79.80
20,000 l/ha	14.20	14.45	32.50	32.80	61.20	62.10	104.60	106.40
30,000 l/ha	8.60	9.00	13.70	13.20	32.50	33.80	59.20	59.30
40,000 l/ha	6.60	6.70	10.45	11.40	21.20	22.10	60.30	60.20
$LSD_{(0.05)}$	2.008	2.025	6.790	7.042	13.212	13.642	20.400	21.050
Varieties								
Roma VF	10.30	10.80	18.60	19.80	41.40	41.80	65.70	65.10
UC82B	10.90	11.10	21.90	22.50	42.60	44.20	82.30	84.80
$LSD_{(0.05)}$	NS	1.274	4.294	4.500	8.358	8.536	12.912	13.062

Means followed with same letter(s) along each column are not significantly different at 5% probability level

Table 4: Effects of Liquid Poultry Manure and Varieties on Tomato Number of Branches

Treatments/Year	Number of Branches/Plant							
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
	3 WAT		**6 WAT**		**9WAT**		**12WAT**	
Rates								
Control	8.67	8.90	17.67	18.20	25.17	26.30	39.33	38.40
10,000 l/ha	10.17	10.35	21.17	22.10	25.50	26.40	42.50	43.80
20,000 l/ha	12.33	12.40	24.83	25.50	32.17	33.50	63.50	63.20
30,000 l/ha	8.33	8.35	14.50	15.30	25.00	26.40	40.50	40.80
40,000 l/ha	6.17	6.20	12.17	13.10	19.17	20.60	36.33	77.20
$LSD_{(0.05)}$	2.274	2.282	5.435	5.845	6.212	6.314	9.256	9.825
Varieties								
Roma VF	9.13a	9.80	15.27	15.50	21.40	22.10	39.87	38.60
UC82B	9.13a	10.20	19.67	20.30	27.20	27.50	49.00	49.60
$LSD_{(0.05)}$	NS	1.555	4.437	4.255	5.664	5.825	8.386	8.555

Means followed with same letter(s) along each column are not significantly different at 5% probability level using LSD

The number of branches/plant was significantly affected by liquid poultry manure rates throughout the evaluation period in both cropping seasons (Table 4). The application of 20,000 l/ha significantly supported highest number of branches/plant when compared with other poultry liquid poultry manure application rates at 3, 6, 9 and 12 WAT. The least number of branches was produced from the application of 40,000 l/ha with no significant difference among the two varieties. However, the UC8 2 B variety consistently supported higher number of branches/plant when compared with Roma VF.

Effect of Liquid Poultry Manure Rates and Varieties on Days to Flowering and Fruiting of tomato

Table 5 shows that there were significant differences ($p < 0.05$) in days to 50% flowering. On average 50% of plants treated with 20,000 l/ha liquid poultry manure attained 50% flowering earlier than all other treatments and the least was the control treatment which attained 50% flowering at latter days. First days to fruiting, were not significantly different ($p > 0.05$) among all the treatments plants. Plants treated with 10,000 l/ha liquid poultry manure commenced its fruiting earlier when compared with other poultry manure treatments. The varieties of the tomato examined differed significantly in the number of days to first and 50% flowering ($p < 0.05$). The UC82B variety commenced its first flowering, 50% flowering and first fruiting earlier than Roma VF variety.

Effect of Liquid Poultry Manure Rates and Varieties on Yield Parameters of Tomato

Table 6 shows significant variations ($p < 0.05$) in yield parameters of tomato varieties among all the treatments of liquid poultry manure for all the yield parameters evaluated. Plants treated with 20,000 l/ha liquid poultry manure significantly produced highest number of fruit/plant, widest fruit diameter/plant, heavier fruit weight/plant and fruit weight/plot in the two cropping seasons. The least number of fruit/plant and fruit weight /plant were recorded in control plants while the least fruit diameter/plant and fruit weight/plot were obtained from 40,000 l/ha treatments. The result also revealed that there were significant differences between the two varieties yield parameters evaluated. UC 82 B supported highest number of fruit/plant, widest fruit diameter/plant, fruit weight/plant and fruit weight/ plot respectively than Roma VF for all the yield parameters in the two cropping seasons.

Across the cropping seasons, cumulative yield/ha (tonnes) showed that there were significant differences among the application rate of liquid poultry manure. Significantly higher cumulative yield was obtained from 20,000 l/ha followed by both 10,000 and 30,000 l/ha and the least was obtained from 40,000 l/ha in the two cropping seasons. However, there were no significant differences among the cumulative yield of the control, 10,000 and 30,000 l/ha. The UC 82 B was significantly superior in cumulative yield ha^{-1} when compared with Roma VF.

Table 5: Effects of Liquid Poultry Manure and Varieties on Days to First and 50% Flowering and First Fruiting of Tomato

Treatment Application rates	Days to First Flowering		Days to 50% Flowering		Days to First Fruiting	
	2017	2018	2017	2018	2017	2018
Control	60	60	70	71	70	70
10,000 l/ha	57	56	64	63	67	68
20,000 l/ha	49	50	62	62	68a	68
30,000 l/ha	50	50	66	64	71	71
40,000 l/ha	54	52	67	65	74	75
$LSD_{(0.05)}$	NS	NS	5.908	5.805	7.286	7.955
Varieties						
Roma VF	59	60	69	70	71	71
UC82B	49	51	62	64	69	68
$LSD_{(0.05)}$	6.404	6.454	4.737	4.386	NS	NS

Means followed with same letter(s) along each column are not significantly different at 5% probability level using LSD

Table 6: Effects of Liquid Poultry Manure and Varieties on Yield Parameters of Tomato

Treatment	Number of Fruits per plant		Fruit Diameter per plant (cm)		Fruit Weight per plant(g)		Fruit Weight Per plot (kg)		Cumulative Yield/Ha (tonnes)	
Application Rate	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
Control	23.20	25.30	6.62	6.65	207.40	210.50	21.28	20.82	0.22	0.35
10,000 l/ha	40.80	39.80	10.25	11.80	269.73	250.20	24.14	24.19	2.24	2.40
20,000 l/ha	47.30	47.50	14.40	15.20	359.31	358.60	29.94	30.50	3.30	2.95
30,000 l /ha	34.40	35.50	10.97	10.65	271.86	280.50	24.32	24.52	2.24	2.45
40,000 l/ha	30.80	30.20	10.10	10.20	257.94	245.60	21.50	21.90	1.21	1.40
$LSD_{(0.05)}$	2.198	2.164	3.158	3.254	32.166	32.326	2.685	2.755	0.270	0.355
Varieties										
Roma VF	30.80	32.89	12.35	12.40	274.28	268.30	22.86	25.48	1.23	1.25
UC82B	39.76	40.20	13.86	14.50	312.22	315.25	26.02	28.32	3.26	3.42
$LSD_{(0.05)}$	1.3862	1.565	0.735	0.785	20.346	20.426	1.695	1.785	1.170	1.235

Table 7: Physical and Chemical Properties of Experimental Plot Soil after Harvest in 2017 and 2018

Soil Property	Control (l/ha)		10,000 (l/ha)		20,000 (l/ha)		30,000 (l/ha)		40,000 (l/ha)	
	2017	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**	**2017**	**2018**
pH (H_2O) 1:1	6.40	6.45	6.80	6.82	5.90	5.95	6.60	6.70	6.40	6.50
Organic Carbon (%)	0.92	0.96	1.82	1.79	3.55	3.54	1.99	1.95	3.51	3.50
Organic Matter (%)	1.60	1.59	3.14	3.18	6.12	6.09	6.06	6.00	6.09	6.10
Total Nitrogen (%)	0.07	0.09	1.05	1.09	0.53	0.55	1.97	2.00	0.43	0.45
Available Phosphorus (ppm)	22.36	22.30	21.16	20.80	22.20	22.80	21.05	21.00	20.22	20.25
Sodium ($cmolKg^{-1}$)	0.17	0.19	0.12	0.10	0.08	0.07	0.13	0.15	0.11	0.10
Potassium ($cmolKg^{-1}$)	0.13	0.12	0.28	0.30	0.23	0.25	0.10	0.10	0.26	0.30
Calcium ($cmolKg^{-1}$)	3.92	3.90	4.48	4.50	2.24	2.26	3.60	3.55	2.92	2.95
Magnesium ($cmolKg^{-1}$)	5.65	5.55	5.99	6.01	4.60	5.00	5.08	5.05	4.84	4.90
Exchangeable Acid ($cmolKg^{-1}$)	0.23	0.25	0.20	0.20	0.18	0.20	0.06	0.10	0.39	0.40
CEC ($CmolKg^{-1}$)	10.1	9.8	11.07	11.05	7.33	8.20	8.97	8.80	8.52	8.55
Sand (%)	85.52	85.50	74.24	74.20	78.24	77.80	78.24	78.00	76.24	76.20
Silt (%)	5.20	5.18	3.48	3.40	7.48	7.68	8.48	8.75	6.48	6.35
Clay (%)	9.28	9.32	22.28	22.40	14.28	15.52	13.28	13.25	17.28	17.45

L/ha = Litre per Hectare

Physicochemical Properties of Experimental Plot Soil after Harvest

The results of physical and chemical characteristic of each experimental plot soil after harvest in 2017 and 2018 cropping seasons showed that the pH of all the liquid poultry manure treated soils and the control (Non-manure) samples were slightly acidic even at the end of each of the years (Table 7). The liquid poultry manure treated plots contained higher organic carbon, organic matter and total Nitrogen than the control soil. Among the manure tea treated plant soils, the highest organic carbon and organic matter were obtained from the plots applied with 20,000 l/ha and the lowest was 10,000 l/ha. The exchangeable acid was observed in all the treated plant soil to be lower than the value of control.

Discussions

The consistent highest vine length/plant, number of leaves/plant and number of branches/plant recorded following the application of 20,000 l/ha of liquid poultry manure application rates in 2017 and 2018 cropping seasons could be attributed to the availability of appropriate quantity of nutrients in the liquid poultry manure supplied in required form for rapid uptake by the plants. This result is in line with Toluwase *et al*., (2014) who reported that processing of organic manure (materials) into liquid form eases the decomposition processes and enhances the release of nutrient for plant use.

The effectiveness of liquid poultry manure on plant growth is attributed to the presence of essential nutrients such as nitrogen, phosphorus and potassium and their vital role in physiological processes in the plants such as photosynthesis, carbohydrate transport, protein formation, control of ionic balance, regulation of stomata size and activation of plant enzymes (El-Dissoky, 2008). Also, the result obtained could be due to high phosphorus content of the sample which is an important constituent in nucleic acid and coenzyme for cell division. This result is in line with earlier report that organic manure increased soil nitrogen and phosphorus which play significant role in promotion of plants vegetative growth through their ability to enhance cell division and elongation (Qamar-uz-Zaman *et al*., 2011).The result is also in agreement with Fayed (2010), who found that the compost manure tea significantly increased the vegetative parameters of the Roghini olive trees. El-Tantawy (2009) also reported that farmyard compost tea increased the height and leaf area of potato plant.

The non-significant effects of application rates of liquid poultry manure on the days to first flowering and first fruiting indicated that these traits are not influenced by quantity of the liquid poultry manure in this study. This can be attributed to the response of some plants basically to photoperiodic phenomenon. This result is in agreement with the work of Abdulmaliq *et al.,* (2016) who also reported that soil amendment had no significant effect on days to first flowering and other flowering and fruiting characteristics of okra plant.

The superiority of UC 82 B over the Roma VF in terms of vine length, number of leaves, number of branches as well as earliness to flowering and fruiting could be attributed to variation in the genetic make-up of the two varieties. The findings of this study is also similar to that of Enujeke and Emuh (2015) who reported higher growth rate of UC 82 B variety over other varieties examined and attributed the differences in plant height and other growth parameters to genetic composition and suitability of the variety to the agro-ecological conditions of the environment.

Also, it has been reported that genetic constitution of crop varieties influences the growth expressed by the plant (Sajjan *et al.,* 2002). The mean days to 50% flowering of 62.67 and 69.20 obtained in this study falls within the earlier range of 50-72 days reported by Ullah *et al*., (2015), who worked on some genotypes of tomato and attributed their variability in growth and development to their genotypic variations.

The significant variation in the number of fruit and fruit parameters obtained in this study is an indication that the application rate of the liquid poultry manure had effect on the production rate of the crop. The significant yield of the liquid poultry manure treated with 20,000 l/ha plants could be due to the consistent release of nutrients in an appropriate quantity to the soil. These are made available for use by the plants, in addition to several interrelated positive influence of foliar application of liquid poultry manure tea which leads to availability of nutrients in a soluble form, beneficial microorganisms and microbial metabolites in the manure that plays a vital role in increased plant growth and yield. This finding is in agreement with Jigme *et al*., (2015) that liquid organic fertilizers contain nitrogen mainly in inorganic form like ammonia, which are instantly available in nutrients form for plants uptake during growth periods leading to better growth and higher yield.

The differences in the number of fruits and fruit yield parameters observed from the two varieties in this study could be attributed to the difference in their genetic make-up. Similar affirmation had been made by earlier authors, Ibrahim *et al*. (2000) and Abdulmaliq *et al*. (2016). They affirmed that the disparity in growth of crops under similar environmental conditions can be due to their genetic make-up differences. Similarly, the higher fruit weight per plant and per plot obtained in this study was in conformity with the result of Enujeke and Emuh (2015), who obtained higher fresh fruit weight from UC82B over Roma VF and other varieties.

Conclusion and Recommendation

The results from this study showed that the liquid poultry manure had significant effect on the growth, development and yield of tomato varieties in the Southern Guinea Savanna Ecology of Nigeria. The 20,000 litres/ ha of liquid poultry manure supported significantly better growth and yield of tomato when compared with other treatments. Also, the local variety UC82B significantly produced better growth and yield. From the results of this study, it is recommended that the farmers should be encouraged to be using liquid manure for the fertilization of tomato at 20,000 litre/ha since it resulted in better growth and higher yield of tomato.

References

Abdulmaliq, S. Y., Abayomi, Y. A., Aduloju, M. O. and Olugbemi, O. (2016). Effects of curing period of livestock droppings on the growth and yield of okra (*Abelmoschusesculentus* L.) Varieties. *International Journal of Agronomy*, volume, pp.1-7.

Amanullah, M. M., Sekar, S. and Muthukrishnan, P. (2010). Prospects and potential of poultrymanure. *Asian Journal of Plant Sciences,* 9: 172-182.

Adepoju, A. O. (2014). Post-harvest losses and welfare of tomato farmers in Ogbomosho, Osun State, Nigeria. *Journal of Stored Products and Postharvest Research*, 5(2), 8-13.

Arowosegbe, S. (2010). Impact of organic and folia fertilizer application on the growth, yield and medicinal potential of *Hybiscussabdariffa* L. *Global Journal of Agricultural Research*, 4(2), 7-17.

Bremner, J. M., (1996). Nitrogen-total. In: Sparks, D.L. (Ed.), *Methods of Soil Analysis*. Part 3. Chemical Methods, second ed., SSSA Book Series No. 5 ASA and SSSA, Madison, WI, USA, pp. 1085–1121.

El-Dissoky, R. A. (2008). Studies on the use efficiency of potassium and organic fertilizers on potatoes and its role in improving soil properties. PhD Thesis. Faculty of Agriculture, Mansoura, University, Egypt.

El-Tantawy, I. M., El-Ghamry, A. M. and Habib, A. H. (2009). Impact of farmyard manure and manure compost tea on potato yield and soil fertility. *Journal of Agriculture Science*, 34(1): 669 – 678.

Enujeke, E.C. and Emuh, F.N. (2015). Evaluation of some growth and yield indices of five varieties of tomato (*Solanum lycopersicum* L) in Asaba Area of Delta State, Nigeria. *Global Journal of Bio-Science and Biotechnology*, Vol.4 (1): 21-26.

Frank, K., Beegle, D. and Denning, J., (1998). *Phosphorus*. In: Brown, J.R. (Ed.), *Recommended Chemical Soil Test Procedures for the North.*

Fayed, T. A. (2010). Optimizing yield, fruit quality and nutrient status of Roghiani olive grown in Libya using some organic extracts. *Journal of Horticulture Science and Ornamental Plants*, 2(2): 63-78.

Gee, G.W. and Or, D., (2002). *Particle-size analysis*. In: Dane, J.H., Topp, G.C. (Eds.). Methods of Soil Analysis. Part 4. Physical Methods. Soil Science Society of America, Madison, Wisconsin, USA, 5, 255–293.

Gross, A., Arusi, R. and Nejidat, A. (2007). Assessment of extraction methods with fowl manure for the production of liquid organic fertilizers. *Bioresource Technology*, 99: 327–334.

Ibrahim, M.H., Jaafar, H.Z.E., Karimi, E. and Gbasemzadeh, A. (2000). Impact of organic and inorganic fertilizers application on the phytochemical and antioxidant activity of Kacip Fatimah (*Labisia pumila* Benth). *Molecules,* 18, 10973-10988.

Ingham, E. R. (2005). The Compost Tea Brewing Manual (5th). Soil Food International Inc. In: Kim, J.M., Chang, K. S., Yong, K. K., Sung, J. H., Jong, H.P., Eun, J. H., Jin, H. K. and Suk, C.K. (2015). Effect of Aerated Compost Tea on the Growth Promotion of Lettuce, Soybean, and Sweet Corn in Organic Cultivation. *The Plant Pathology Journal,* 31(3), 259-268.:

Jigme, Jayamangkala, N., Sutigoolabud, P., Inthasan, J. and Sakhonwasee, S. (2015). The effect of organic fertilizers on growth and yield of broccoli (*Brassica oleracea*L. var. *italic* Plenck cv. Top Green). *Journal of Organic Systems*, 10(1), 9 -14.

Msibi, B.M., Mukabwe, W.O., Manyatsi, A.M. Mhazo, N. and Masarirambi, M.T. (2014). Effects of liquid manure on growth and yield of spinach (Beta vulgaris VarCicla) in a Sub-tropical Environment in Swaziland. *Asian Journal of Agricultural Sciences,* 6(2): 40-47.

Muhammad, A. and Singh, A. (2007). Intra-row spacing and pruning effects on fresh tomato yield in Sudan Savanna of Nigeria. *Journal of Plant Sciences,* 2,153-161.DOI: 10.3923/jps. 2007. 153.161 URL: https://scialert.net/abstract /?doi=jps.2007.153.161.

Nelson, D.W., and Sommers, L.E.(1996). T*otal carbon, organic carbon and organic matter*. In: Sparks, D.L. (Ed.), Methods of Soil Analysis, Part 3, 2nd Edn., SSSA Book Series No. 5 ASA and SSSA, Madison WI, USA, pp. 961–1010.

Nithiya, T., Alphonse, J. and Ligoriya, M. (2015). Effect of organic and inorganic fertilizer on growth, phenolic compounds and antioxidant activity of *Solanumnigrum*. L. *World Journal of Pharmacy and Pharmaceutical Sciences*, 4(5), 808 - 822.

Ogundare, S.K, Babalola, T.S, Hinmikaiye, A. S. and Oloniruha, J.A. (2015). Growth and fruit yield of tomato as influenced by combined use of organic and inorganic fertilizer in Kabba, Nigeria. *European Journal of Agriculture and Forestry Research*, 3(3), 48-56.

Okalebo, J. R., Gathua, K. W., Woomer, P. L., (2002). *Laboratory Methods of Soil and Plant Analysis. A Working Manual*. 2nd Edn. TSBF-CIAT, SACRED Africa, KARI, Soil Science Society of East Africa, Nairobi, Kenya, p. 128.

Olaniyi, J. O., Akanbi, W. B., Adejumo, T. A. and Akande, O. G. (2010). Growth, fruit yield and nutritional quality of tomato varieties. *African Journal of Food Science*, 4(6), 398 – 402.

Peiris, P. U. S. and Weerakkody, W.A.P. (2015). Effect of organic based liquid fertilizers on growth performance of leaf lettuce (*Lactuca Sativa* L.). International Conference on Agricultural, Ecological and Medical Sciences. Phuket (Thailand) (AEMS-2015) April 7-8.

Qamar-uz-Zaman, S. S., Ahmad, F. and Hamid, F. S. (2011). Effect of nitrogenous fertilizer on growth and yield of tea (*Camellia sinensis L*)pruned in curved vs. flat shape. *Journal of Agricultural Research.* 49:477-482.

SAS (2012). The Statistical Application Software (SAS) Statistics System for Windows Release Version 9.2. SAS Institute, Inc. Cary, NC, USA.

Sajjan, A.S., Shekhargouda, M. and Badanur, V.P. (2002). Influence of date of sowing, spacing and levels of nitrogen on yield attributes and seed yield in okra. *Karnataka Indian J. Agril. Sci*., 15(2):267-274.

Toluwase, O., Jamiu, I., Azeez, O., Adetunji, M. T. and Oyekanmi, A. A. (2014). Effect of the sequential application of liquid organic manure and phosphorus on maize agronomic traits and P uptake in some tropical soils. *Journal of Plant Nutrition*, 37, 1040–1055.

Ullah, M. Z., Hassan, L., Shahid, S. B. and Patwary, A. K (2015). Variability and inter relationship studies in tomato (*Solanumly copersicum* L.). *Journal of the Bangladesh Agricultural University* 13(1):65-69.

ISSN: 2734-2913
Volume 2, 2019
pp 55-65