ISSN: 2141-8454 VOLUME 17 (2021)

IJOARD

International Journal of Organic Agriculture Research & Development

(An official Journal of the Association of Organic Agriculture Practitioners of Nigeria – NOAN)

INTERNATIONAL JOURNAL OF ORGANIC AGRICULTURE RESEARCH & DEVELOPMENT

Website: http://www.ijoardjournal.org

Affiliation: International Journal of Organic Agriculture Research & Development is an official Journal of the Association of Organic Agriculture Practitioners of Nigeria (NOAN)

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Founded: 1 December 2007

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Impact of Vermicompost and Its Residual Effect on Soil Properties, Nutrient Uptake and Yield Of Cucumber (*Cucumis sativus* L.)

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ABSTRACT

Application of vermicompost to soil has been found to play a vital role in soil nutrient augmentation and adequate maintenance of soil organic. Two pot trials were conducted to investigate impacts of vermicompost application and its residual on soil properties, nutrient uptake and yield of cucumber (*Cucumis sativus* L) in a screen house. Treatments were control (0 kg N ha^{-1}), vermicompost providing 70, 80, 90, 100 kg N ha^{-1} and NPK fertilizer (100 kg N ha^{-1}). Growth, yield and nutrient uptake of cucumber were improved by vermicompost at 90 kg N ha^{-1} in both cropping cycles. Cucumber applied with vermicompost at 90 kg N ha^{-1} gave the highest yield of 184.4 and 128.4 g/plant at first and residual harvest respectively. Result also showed that residual soil pH, organic C, P and K contents increased when vermicompost, 90 kg N ha^{-1} was applied. A significant positive correlation exists between cucumber fruit yield and nutrient uptake Vermicompost, 90 kg N ha^{-1} significantly improved nutrient uptake with higher nutrient residuals than other treatments.

Keywords: *Cucumis sativus*, mineral fertilizer, screen house, vermicompost

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INTRODUCTION

Cucumber productivity in Nigeria is low due to low native fertility status of the soil among other factors (Law-Ogbomo *et al*., 2018). This crop required high amount of soil nutrients from seedling stage to maturity and highly sensitive to excessive water or waterlogs environment and adequate soil tillage for easy fragile root penetration, is required prior to sowing or planting (Nweke et al., 2014). Non-use of fertilizer, inappropriate plant population, varying amount of moisture, and low soil fertility contribute to low yields (Law-ogbomo and Osaigbovo, 2018).

Most Nigerian soils have low nitrogen and are supplemented with N fertilizer. Application of fertilizer is the easiest strategy for increasing cucumber yield (Agu *et al*., 2015.). However, the production and the use of chemical fertilizers impact various negative effects on the agricultural ecosystems, such as degradation of the soil, loss of genetic diversity, reduction in soil microbial diversity, contamination of ground-water resources, and pollution of the atmosphere. (AdeOluwa *et al*., 2021) One way of improving soil and water conditions is use of vermicomposting. Vermicompost is finely-divided mature material produced by a non-thermophylic process involving interactions between earthworms and microorganisms (Edwards and Burrows, 1988) leading to bio-oxidation and stabilization of organic material (Aira *et al*., 2000). Vermicompost contains N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which positively affects plant nutrition, photosynthesis, chlorophyll content of the leaves and nutrient content of plant tissues (Theunissen *et al*., 2010). It increased nutrient uptake in plants, due to higher concentrations of humic acid (HA) and a larger population of microorganisms, was shown to result in improved germination, flowering and growth in plants (Arancon *et al*., 2006; Hatamzadeh, 2011)

Vermicompost increases cucumber yield, improve soil properties, and reinforces the soil environment (Esmaielpour *et al*., 2020). There is little or no information on the influence of vermicompost on the production of cucumber in Nigeria. The objective of the study was to determine the impact of vermicompost and its residual effect on soil properties, nutrient uptake and yield of cucumber.

MATERIALS AND METHODS

Pot experiments were carried out at Kwara State University, Faculty of Agriculture Screen House, (Latitude 80°71'N and Longitude 40°44'E) at Malete, Kwara State, Nigeria. Soil samples were randomly collected from Kwara State University Teaching and Research Farm, Malete, from a depth of 0-15 cm, air-dried and passed through a 2 mm sieve. Chemical and physical properties were determined in the laboratory by procedure described by Okalebo *et al*. (2002).

Vermicompost was produced in a vermicomposting bin. Organic materials used in production of vermicompost were fresh gliricidia leaves, poultry manure, maize straw and dry plant from which leaves were obtained which were chopped into pieces. The chopped maize straw was used as a bedding material, the mix of poultry manure, dry leaf litter and the fresh gliricidia leaves were used as worm feed. The quantity of material required to fill the bin was 2 kg of bedding materials and 4 kg of worm feed. This quantity was added based on the day-to-day ability of worms to decompose the organic matter. The organic materials were partially decomposed over a 2 week period before adding *Eudrilus euginea* earthworms, 100 earthworms·m^{-2}. The earthworms were introduced to initiate the vermicomposting process over a 30 day period. During vermicomposting moisture content was maintained at 80%. The vermicomposting bin was covered with a black cloth as shade. After 30 days, the ripe vermicompost was harvested and analyzed for nitrogen, phosphorous and potassium content in the laboratory.

Twenty-four pots were individually filled with 25 kg of soil. The treatments were 0 kg ha^{-1} N, vermicompost at 70, 80, 90, 100 kgN ha^{-1} and NPK fertilizer at the rate of 100 kgN ha^{-1} (Kuranga, 2014). The organic sources were applied 2 weeks before planting; mineral fertilizer was applied 2 weeks after planting. Each treatment was thoroughly mixed. Treatments were arranged in a completely randomized design with 4 replicates. Cucumber seed were sown in a pot and was watered immediately. Developing plants were staked when they reached a height of about 50 cm. The plants were watered to field moisture capacity every 3 days and weeding was carried out as required. The experiment was continued using the same pots without any fertilizer application at a second planting to

determine its residual effect on soil properties, nutrient uptake and yield of cucumber.

Plant samples were randomly selected during the first and second cropping. Samples were oven dried in a laboratory oven at 70°C to a constant weight as dry matter yield. Dry samples were ground and analyzed for N, P and K contents based on procedures described by Okalebo *et al*. (2002).

Nutrient uptake was determined by multiplying total dry matter yield (g) with nutrient content (%). Chemical analysis of the soil was carried at first and second harvest to determine nutrient status. Data on growth and yield parameters collected include; vine length, vine girth, number of leaves, number of branches, number of days to 50% flowering, number of fruit/plant, fruit diameter and weight of fruit/plant. The data were subjected to analysis of variance and differences among means separated using Duncan's Multiple Range Test. Pearson correlation was performed on relationship of cucumber yield and nutrient uptake.

RESULTS

The textural class of the soil was a loamy sand, with pH (H_2O) 6.7 making it slightly acidic. Organic carbon, total N and available P values were 7.9, 0.82 ($g \cdot kg^{-1}$) and 2.77 $mg \cdot kg^{-1}$, respectively. Exchangeable K, Mg, Na and Mn were 0.28, 0.78, 0.43 $cmol \cdot kg^{-1}$ and 106 $mg \cdot kg^{-1}$, respectively.

Growth parameters of cucumber to application of vermicompost during the first and second cropping in the screen house were shown in Table 1. At first planting, cucumber plants grown with vermicompost at 90 kgN ha^{-1} produced the highest vine length and this was significantly ($p< 0.05$) higher than other treatments. The highest vine girth recorded in cucumber plant was from vermicompost at 90 kgN ha^{-1}. This was significantly ($p< 0.05$) higher than other treatments by 12.8% - 31.9%. Cucumber number of leaves influenced by the application of vermicompost at 90 kgN ha^{-1} was found to be significantly ($p< 0.05$) higher from that of control and other fertilizer treatments. At second planting, vermicompost at 90 kgN ha^{-1} produced the highest value of vine length closely followed by vermicompost at 80 kgN ha^{-1} and control produced the least vine length. Similarly, application of vermicompost at 90 kgN ha^{-1} produced plant with significantly higher vine girth than NPK fertilizer, vermicompost at 70, 80,

100 kgN ha^{-1} and control respectively. Number of leaves and number of branches produced from vermicompost at 90 kgN ha^{-1} resulted in highest values which were significantly ($P< 0.05$) different from value obtained from control, NPK fertilizer and vermicompost at 70, 80, 100 kgN ha^{-1} respectively. In this study, vermicompost application showed better results on growth parameters than inorganic fertilizer treatment during the two cropping cycle.

Table 1: Response of cucumber growth parameters to vermicompost application

Means having the same letter along the columns indicate no significant difference using Duncan Multiple Range Test at 5% probability level

Response of yield parameters of cucumber as influenced by vermicompost

The yield components of cucumber as influenced by application of vermicompost and NPK during the first and second cropping in the screenhouse were shown in Table 2. According to first planting results, there were significant different among fertilizers on days to attained 50% of flowering. There were no significant differences between treatments comprised of vermicompost at 80 and 90 kgN ha^{-1}, including vermicompost at 100 and NPK at 100 kgN ha^{-1}. However, control took the highest number of days to achieve 50% flowering.

At second planting, there were no significant differences between treatments comprised of vermicompost at 70, 80, 90 and 100 kgN ha^{-1}. NPK fertilizer and control took the highest

Treatment	Rate of N (kg ha^{-1})	Vine length (cm)	Vine girth (mm)	Number of leaves	Number of branches
		First planting			
Control	0	43.3e	5.68d	11.09e	12.7e
NPK	100	75.0b	7.63b	18.8b	18.1b
Vermicompost	70	56.4d	6.22c	14.5d	15.1c
Vermicompost	80	57.3d	6.98c	16.4c	14.3d
Vermicompost	90	89.5a	8.34a	22.1a	21.6a
Vermicompost	100	72.6c	7.27b	17.4b	17.1b
		Second planting			
Control	0	36.4d	3.53d	8.8d	7.3d
NPK	100	38.1d	3.66c	9.4c	9.4c
Vermicompost	70	43.4c	3.64c	9.9c	9.8c
Vermicompost	80	48.3b	4.55b	10.8b	10.5b
Vermicompost	90	53.4a	5.02a	15.0a	12.5a
Vermicompost	100	45.4c	4.49b	10.1b	9.4c

number of days respectively. Concerning fruit diameter per plant, at first planting, vermicompost at 90 kgN ha^{-1} produced the highest fruit diameter per plant as compared to other treatments, while the least fruit diameter was recorded from control. The result also showed that there was no significant difference ($p<0.05$) between vermicompost at 100 and NPK at 100 kgN ha^{-1} in terms of fruit diameter per plant. There was significant difference between fruit diameter/plant from vermicompost at 70 and 80 kgN ha^{-1}. At second planting, application of vermicompost at 90 kgN ha^{-1} resulted in significantly higher fruit diameter/plant than NPK and others vermicompost, while the control had the smallest fruit diameter. At first planting, application of vermicompost significantly ($p< 0.05$) pose variation in cucumber fruit weight per plant and the highest of cucumber fruit weight was recorded for the plants which were treated with vermicompost at 90 kgN ha^{-1} which was significantly different from Vermicompost at 70, 80, 90, 100 kgN ha^{-1}, NPK and control respectively. At second planting, results from Table 2 indicated that fruit weight / plant produced from vermicompost at 90 kgN ha^{-1} resulted in highest values which was significantly ($P< 0.05$) different from

value obtained from NPK and others vermicompost. Lowest weight was recorded from control pot.

Treatment	Rate (kgN ha^{-1})	Days to 50% flowering	Fruit diameter (mm)	Fruit weight/ plant (g)
		First planting		
Control	0	42.0d	24.8e	78.1f
NPK	100	35.0b	51.5b	169.0b
Vermicompost	70	38.0c	48.8c	93.5e
Vermicompost	80	38.0c	46.5d	107.4d
Vermicompost	90	33.0a	66.6a	184.4a
Vermicompost	100	36.0b	55.2b	128.0c
		Second planting		
Control	0	43c	18.7d	62.3e
NPK	100	41b	40.1c	90.3c
Vermicompost	70	39a	42.7b	70.6d
Vermicompost	80	39a	41.3c	92.8c
Vermicompost	90	39a	50.2a	128.4a
Vermicompost	100	39a	43.6b	102.5b

Means having the same letter along the columns indicate no significant difference using Duncan Multiple Range Test at 5% probability level

Plant nutrient uptake

N, P and K uptake of the first cucumber cropping was significantly ($p<0.05$) affected by the vermicompost and mineral fertilizer applications, whereas vermicompost at 90 kg·ha^{-1} of N provided the highest N uptake, while the residual effect on the second plant, the highest N uptake was also found in vermicompost at 90 kgN ha^{-1} (Figures 1 and 2). Vermicompost at 90 kgNha^{-1} increased N uptake more than NPK and other vermicompost treatments.

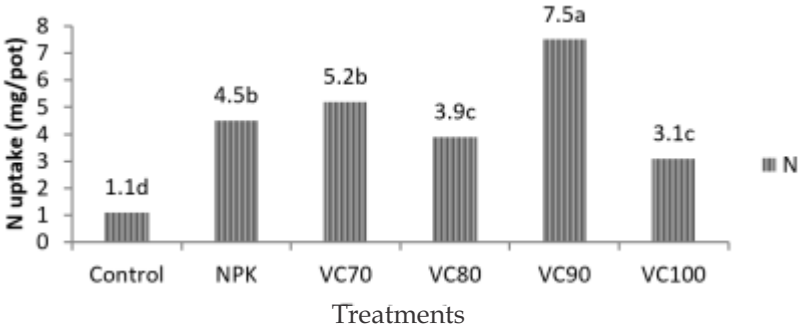


Figure 1. Nitrogen uptake by cucumber as influenced by application of vermicompost during first cropping

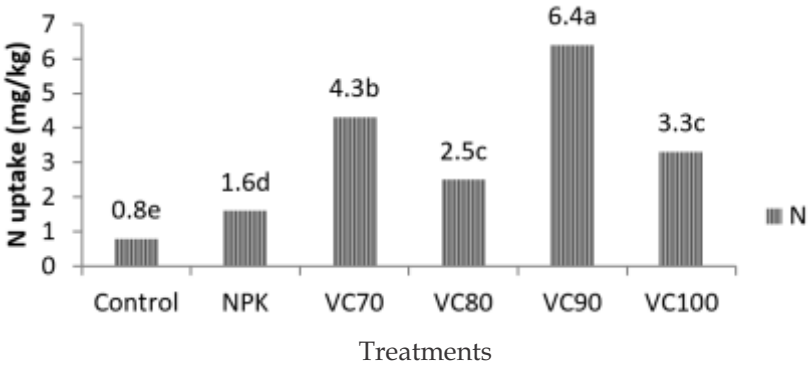


Figure 2. Nitrogen uptake by cucumber as influenced by application of vermicompost during residual cropping

Legend
Control = 0 kg·ha^{-1} N; NPK = 100 kg·ha^{-1} N; VC 70 = Vermicompost at 70 kg·ha^{-1} N; VC 80 = Vermicompost at 80 kg·ha^{-1} N; VC 90 = Vermicompost at 90 kg·ha^{-1} N, and VC 100 = Vermicompost at 100 kg·ha^{-1} N. Bars with the same letter are not significantly different, $p<0.05$, Duncan's Multiple Range Test.

The P uptake of cucumber was influenced by the NPK and vermicompost applications. However, the different rate of vermicompost significantly

affect P uptake of the cucumber where the highest P uptake was found in vermicompost at 90 kgN ha^{-1}. The residual effect of vermicompost on the P uptake of the second cucumber was found on the pot treated with vermicompost at 90 kgN ha^{-1} (Figures 3 and 4).

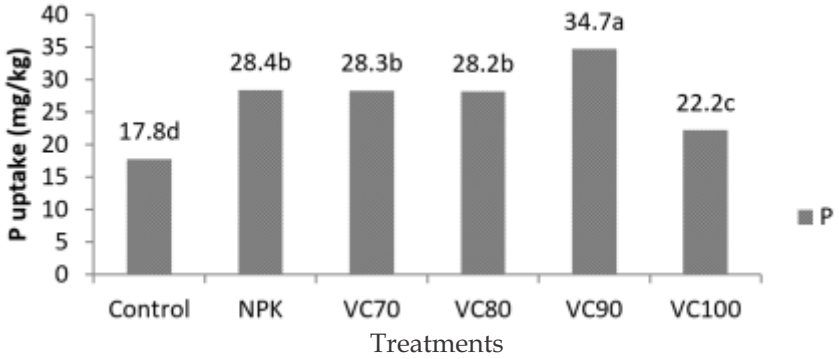


Figure 4. Phosphorus uptake by cucumber as influenced by application of vermicompost during residual cropping

lLegend

Control = 0 kg·ha-1 N; NPK = 100 kg·ha-1 N; VC 70 = Vermicompost at 70 kg·ha-1 N; VC 80 = Vermicompost at 80 kg·ha-1 N; VC 90 = Vermicompost at 90 kg·ha-1 N, and VC 100 = Vermicompost at 100 kg·ha-1 N. Bars with the same letter are not significantly different, $p<0.05$, Duncan's Multiple Range Test.

K uptake of the first cucumber cropping was influenced by the direct effects of NPK fertilizer and vermicompost applications where the vermicompost at 90 kg·ha-1 of N provided the highest K uptake (Figure 5). The highest residual effect of the vermicompost on K uptake of the second cucumber was found in vermicompost at 90 kgN ha-1 (Figure 6).

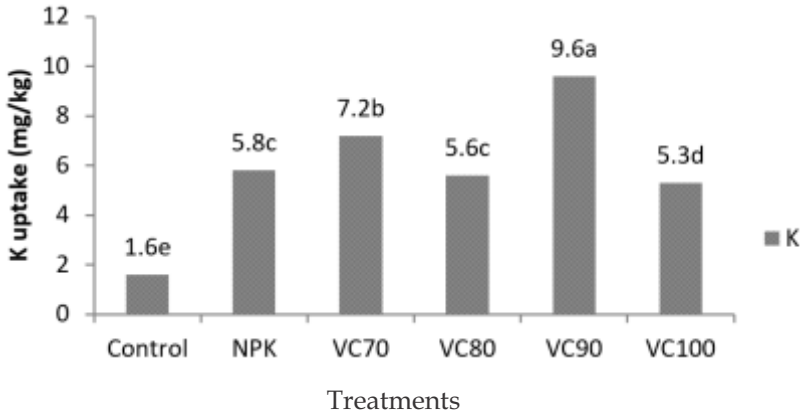


Figure 5. Potassium uptake by cucumber as influenced by application of vermicompost during first cropping

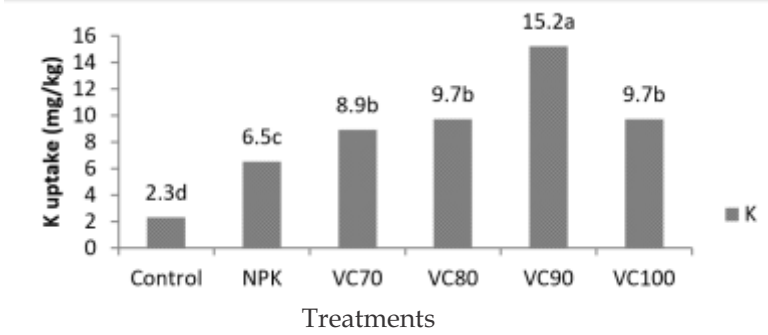


Figure 6. Potassium uptake by cucumber as influenced by application of vermicompost during residual cropping

Physico-chemical analysis of the soil after the harvesting

The effects of application of different rates of vermicompost and NPK on the experimental pot after first and residual harvesting are presented in Tables 3. At first harvesting stage of *Cucumis sativus,* nitrogen application of vermicompost at 90 kgNha-^{1} increased soil pH value than other treatments including control. Soil available P content vermicompost at 90 kgNha-^{1} was higher than the pot treated with other vermicompost and NPK. There is a general increase in the values of organic C from control to other vermicompost. Total N varied between 0.82 g kg^{-1} in control and 3.16 g kg^{-1} in 90 kgNha-^{1} vermicompost pot. The soil in control pot had available K content

of 0.27 cmol kg^{-1}, while that of pot treated with vermicompost increased from 0.50 to 0.64 cmol kg^{-1}. Results from the physical analysis of the soil after harvesting, shows that control pots had the lowest contents of clay and silt. Residual harvest pots treated with vermicompost at 90 kgNha-^{1} had higher pH, P and OC, N and K contents when compared with other fertilizer treatments and control respectively. After residual harvest, the result of physical and chemical analysis shows that control pots had the lowest contents of clay and silt.

Table 4: Effects of vermicompost on soil chemical and physical properties at harvest during the first and second cropping

Treatment	Rate ($kgNha^{-1}$)	pH (H_2O)	Available P $mg\ kg^{-1}$	OC $g\ kg^{-1}$	N	K $cmol\ kg^{-1}$	Clay	Silt	Sand
							(%)		
First harvest									
Control	0	6.1d	10.40e	0.60e	0.82d	0.27d	5.0b	9.2b	85.5a
NPK	100	6.5c	33.75b	1.11b	3.08b	0.59b	6.6a	9.4b	84.0b
Vermicompost	70	6.5c	32.33c	1.28b	2.50c	0.52c	6.6a	9.5b	83.9b
Vermicompost	80	6.6b	29.26d	1.22b	2.26c	0.50c	6.6a	9.4b	84.0b
Vermicompost	90	6.8a	34.99a	1.66a	3.16a	0.64a	6.6a	10.0a	83.4b
Vermicompost	100	6.5c	32.58c	1.11b	2.11c	0.54c	6.6a	9.4b	84.0b
residual harvest									
Control	0	5.8d	16.50e	0.91e	1.0e	0.80d	5.2b	12.0c	82.8a
NPK	100	6.4c	26.10d	1.33d	2.0b	1.36c	5.6b	12.2b	82.2a
Vermicompost	70	7.1b	29.70c	2.12c	1.9b	1.10c	5.8a	12.5b	81.7b
Vermicompost	80	7.2b	20.20d	1.80d	1.8b	1.10d	6.0a	12.5b	81.5b
Vermicompost	90	7.6a	37.90a	2.83a	2.8a	2.20a	6.1a	13.8a	80.1b
Vermicompost	100	7.1b	33.60b	2.40b	1.7b	1.80b	6.0a	12.1c	81.9b

Mean having the same letter along the columns indicate no significant difference using Duncan's multiple range tests at 5% probability level

Correlation of fruit yield to NPK uptake at first and residual harvest

Pearson correlation coefficients between cucumber fruit yield and N P K uptake were positively correlated after first and residual harvest respectively (Table 5 and 6). At first harvest, positive relationships exist between yield and N (R^2= 0.1175); P (R^2= 0.7114) and K uptake (R^2= 0.4524). The residual harvest also show that N (R^2= 0.5933); P (R^2= 0.8655) and K (R^2= 0.7937) were positively correlated with cucumber fruit yield.

Table 5: Pearson correlation coefficients between cucumber yield and nutrient uptake after first harvest.

Parameters	N	P	K
P	0.8523**		
K	0.9592**	0.8704**	
Yield	0.1175*	0.7114**	0.45241*

*Significant at the 0.05 level. ** Significant at the 0.01 level.

Table 6: Pearson correlation coefficients between cucumber yield and nutrient uptake after second harvest

Parameter	N	P	K
P	0.6788**		
K	0.7647**	0.9354**	
Yield	0.5933**	0.8655**	0.7937**

*Significant at the 0.05 level. ** Significant at the 0.01 level

Discussion

The pre-planting soil analysis indicated the soil was low in soil nutrients. Values of total nitrogen and available phosphorus, calcium and magnesium were below critical levels (Olowoake, 2019).

The high values of vine length, vine girth, number of branches and number of leaves of cucumber plant grown in the pot treated with vermicompost at 90 kgN ha^{-1} could be attributed to presence of plant growth regulators and humic acid in vermicompost, which are produced by increased activity of microbes such as fungi, bacteria, yeasts, actinomycetes and algae (Arancon *et al*., 2004; Joshi *et al*., 2014;).

The application of vermicompost at 90 kgN ha^{-1} recorded shorter periods in number of days to 50% flowering. This is in line with finding of Kawthar et al. (2010) that fertilizers treated plants could be attributed to acceleration of the vegetative phase through the stimulating effect of the absorbed nutrients during photosynthetic process which reflected on both vegetative growth and flower initiation. Cucumber plants in pots treated with vermicompost at 90 kgN ha^{-1} showed increase in yield parameters than with pots receiving inorganic fertilizer only. This may be due to the presence of high amount of available nitrogen, potassium, and micronutrients that enhance photosynthesis, cell division, and cell enlargement, ultimately improving the growth contributing characteristics content of cucumber (Joshi *et al*., 2014). Furthermore, it may also probably be due to the occurrence of plant growth hormones like auxin giberlins and cytokinins in vermicompost but also its effect on soil physiochemical properties, humic acid content and biology (Atiyeh *et al*., 2002: Opara *et al*., 2012).'The values of yield parameters of cucumber were observed to be low in the pot without any treatment. This might be as a result of low nutrients status of the soil especially N and P.

This study also revealed that vermicompost at 90 kgN ha^{-1} gave the best residual effect on nutrient uptake. Jat and Ahlawat (2006) reported that vermicompost contains high available nutrients, allowing not only a short supply of plant nutrient but also increasing reserves for the succeeding crops. In the study reported here, investigations of the N uptake showed that a higher rate of vermicompost at 100 kgNha-^{1} did not result in a significantly greater N uptake. The higher uptake of N obtained from vermicompost at 90 kgNha-^{1} may have attributed to increased biological activity caused by the vermicompost which resulted to higher availability of N in the soil and consequently enhanced N uptake (Ehsan *et al*., 2019). Plant nutrient uptake highly hinge on the nutrient release from the soil solid phase in the form of

mineral and organic materials to the soil solution. The release of nutrients from organic matter occurs biochemically through the balance of mineralization and immobilization processes, while from mineral materials occurs physico-chemically through adsorption and desorption, and precipitation and dissolution. The mineralization controls the soil solution concentration directly when the soil mineral does not release nutrient into the soil solution (Nurhidayati *et al*., 2017). Vermicompost as an organic fertilizer also undergoes mineralization releasing nutrients into the soil solution. In this study total nitrogen uptake, phosphorus, and potassium by cucumber were significantly enhanced by the application of vermicompost. Similar result was recorded by Nardi *et al*., (2002).

The increase in the soil pH level of the pots after the first and second crop's harvest might be attributed to high content of basic cations in vermicompost which could reduce soil acidity and the contents of exchangeable acidity and Al through replacing the acidic cations from the exchange sites. 'This is in agreement with the findings of Bekele *et al*, (2018) who pointed out that the direction of the change in soil pH as a result of vermicompost application reflected the initial pH of vermicompost. The application of the vermicompost at 90 kgNha-^{1} significantly (P <0.05) increased soil available P more than NPK fertilizer applied at both first and second harvest. This was because the organic material reduced soil P sorption making both the soil native P and the applied fertilizer available for plant uptake. Similar results were reported by Opala *et al*. (2010).

Soil organic carbon increased with application of vermicompost from first to residual harvest. These results are in line with other studies, showing that addition of exogenous organic matter such like vermicompost results in an enhancement of OC storage in addition to improvement of many other soil functions related to the presence of organic matter (Lashermes *et al*., 2009). A decrease of OC contents was observed from first to residual harvest on pot amended with mineral fertilizers. This finding may be related to sieving, which led to breakdown of aggregates and exposure of occluded organic matter to microbial decomposition (Six *et al*., 2000). Pot treated with vermicompost increased the N and K contents of the initial and residual harvest compared to pot treated with inorganic fertilizer. This could be attributed to the relatively higher nutrient concentration in the

vermicompost and nutrients contained in organic materials are released more slowly and are stored for a longer time in soil, thereby ensuring a long residual effect (Sharma and Banik 2014). The positive relationship between yield and NPK explains the importance of nitrogen, phosphorus and potassium to the growth and yield of cucumber, more explicitly. Alcantara and Gonzaga (2019) reported that plant required nitrogen, phosphorus and potassium in high quantity and these elements played a key role in green colouration of leaves, vegetative growth, promote metabolism and transport processes, turgor regulations and fruit development.

Conclusion

This study confirmed that the application of vermicompost significantly increased cucumber growth and yield parameters, higher NPK uptake more than mineral fertilizer. Furthermore, vermicompost at 90 $kgNha^{-1}$ improved physical and chemical properties of soil and is an excellent organic fertilizer.

Acknowledgment: The authors thank the Tertiary Education Trust Fund (TetFund) Abuja and the Management of Kwara State University, Malete, Ilorin, Nigeria, for providing funds for conducting this research.

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A Review of Quantifying the Social and Environmental Benefits-Costs (externalities) of Organic Foods

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ABSTRACT
The cost-benefit externalities for organic agriculture are improving. For the past few decades, organic agriculture has grown in terms of scale and scope. This growth has led to generally lower costs of expenses related to organic agriculture. Researchers have come up with a plethora of models that can draw cost-benefit analysis in terms of productivity, sustainability, returns and environmental costs (Balmford *et al.,* 2018). At the same time, organic agriculture touches the values of the consumer more acutely than what they have in the past. This paper discusses the improved benefit-cost (externalities) associated with organic agriculture and how they continue to improve. It focuses on the literature review of past and current relevant articles, conference proceedings papers and other reliable sources. The author centre on data sets that focus on the externalities of sustainability and costs. The conclusion of this paper indicates that there will be continued improvement of organic agriculture as an industry as technologies supporting organic agriculture improve. The paper recommends that there is a need to research the cost impact of farming externalities on the welfare of consumers and the choices that they make concerning foods.

Keywords: Benefits/Costs, Externalities, Environment, Human Health, Organic agriculture, Sustainable agriculture.

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INTRODUCTION

The state of organic farming has always led to numerous discussions on how to make suitable improvements in understanding the field. Conferences and convergences of scholars have explored significant theoretical and perspective shifts in the costing processes of production. In "The True Cost of American Food," April 14th – 17th / San Francisco conference, attendees examined the utility of organic food. The debates on organic farming are transposable, according to the parameters of this study to the province of Ontario, Canada. One of the most important factors is the necessity of measuring, monetizing and reflecting on the social health and environmental benefits and costs (externalities) for the sustainability of agriculture, including organic farms. It is not possible to reach the "true cost" of a wide-ranging farming system, without taking into account of these impacts and costs systems. Emerging conceptual frameworks and valuation methods on the "true cost" of the social and environmental externalities (benefits/costs) of sustainable agriculture and organic farming have sought to provide a guiding light toward management practices at the farm level. They have also increased individual citizen's consciousness and affects agriculture policies.

According to Garibaldi *et al.,* (2017), organic agriculture has grown in size and scope over the past few decades. Eyhorn *et al*., (2019) provides that the growth of the economy and technologies associated with organic agriculture systems has led to the development of organics to the point where these foods are becoming comparable in cost and availability to other food options for the consumer (Garibaldi *et al.,* 2017). Recent scholarly work has focused on understanding the exploitability of options in organic foods to make organics a viable competitor against foods which may be purchased for a cheaper price (Magnussona *et al*., 2003; Ozguven, 2012; Shafiea and Rennieb, 2012; Cheng, 2016; Vietoris *et al*., 2016; Baudry *et al.,* 2017; Azizan and Suki, 2017). The organic agriculture system is now at a point where it is essential to consider the actual cost of the food consumed and what the options are for the consumer.

Balford *et al.,* (2018) finds that within in the scope of sustainable food, research drawing conclusions associated with the organic agriculture system can lead to understanding what the cost is for the consumer and how

it is that the consumer could have their tastes exploited. Organic foods have not quite caught up with competitors; however, the economic advantages for organics are growing. Sain *et al.,* (2017) argue that organic foods will soon minimize the cost advantage of competitors. Organic foods will compete more effectively based on the philosophy that foods that have not been genetically modified or received some forms of treatment are better than those that have undergone massive chemical treatments or genetic modifications.

MATERIALS AND METHODS

This paper relies on the literature review of past and current relevant articles, conference proceedings papers and reliable sources in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) convention (Moher *et al.,* (2009). It examines and describes the existing methods and metrics tools in the field of previous studies used to calculate the externalities of sustainable farms in the USA. Using secondary data is crucial in acquiring sufficient information on organic foods and their prospective cost benefits. Notably, the selection of this approach resonates with the fact that secondary research or review of literature allows the analysis of critical points that the initial study may have overlooked (Bryman *et al.,* 2018). It may see additional dimensionalities in the information with a wide range of implications on collaborations within various disciplines.

This report utilizes an inclusion criterion that investigates papers with keywords such as benefits/costs, externalities, human health, environment, sustainable agriculture, organic agriculture. The searches will be on sources such as PubMed, Web of Science, Cochrane Library and other university-related repositories with papers from 2013-2016. The resulting datasets would undergo evaluation based on several significant externalities such as sustainability and cost implications to the farmers and the consumers. The papers would them undergo a thematic analysis to isolate the key issues that arise in bringing down the costs of producing organic foods and making them more competitive. Thus, systemic reviews will additionally look at the methodologies that have led to the outcomes indicated. The framework used is as shown figure 1 below.

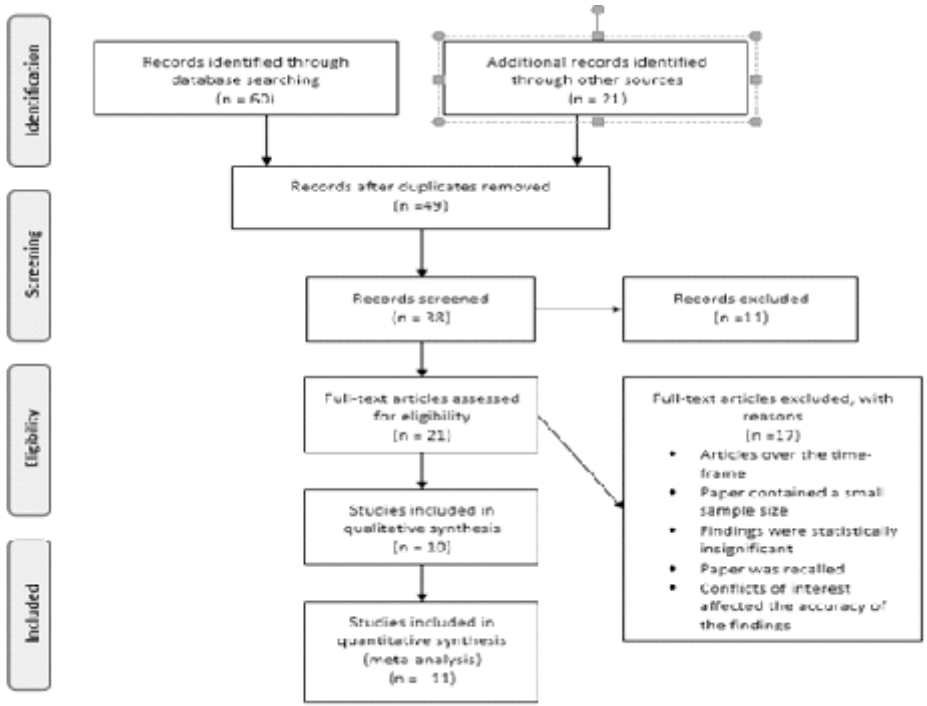


Figure 1: PRISMA Model (Source: Moher et al., 2009)

DISCUSSIONS

Understanding Farm Sustainability

De Olde *et al.,* (2016) and Ryan *et al.,* (2016) present that farm sustainability is an essential element of the overall system of food production. The farm must not be inundated with different technologies and methods of production that will eventually damage the quality of the goods that people receive on the farm. Ryan *et al.,* (2016) argue that calculating these costs could be difficult for the farm because of all the different variables involved. Sandhu, (2016) determined that the farm is an entity where the nature of inputs will impact the nature of environmental outputs, as well as the social and natural capital of the farm. According to Balmford *et al.,* (2018), externalities of the farm are such that foods can be produced in a way that does not create a significant environmental or social damage to life. Sandhu, (2016) notes the several environmental benefits such as water regulation, carbon

sequestration, nitrogen fixation and nutrient cycling as being benefits of farming; however, the nature of how it is that farmers engaged in these activities can have a significant impact on society as a whole.

Informing the Public on the True Cost of Foods

Ferreti *et al.,* (2017) argue for the consideration of the total cost of organic foods. Nierenberg et al. (2016) encourage the discussion of cost beyond the scope of economics. Issues such as natural resource use and damage, human rights and animals are critical determinants in the true cost of the food people eat. This consideration may be due to discrepancies in costs that can contribute to damage in the scope of what is justifiable concerning environmental, economic or socially sustainable production methods (Carlson, 2016; Chen and Saghanian, 2017; Hilmi *et al.,* 2018). Some foods have a greater presence all over the supply chain, which may affect the cost implications on other products.

The case of corn is perhaps one of the most elaborate instances of foods that have significant impacts on the supply chain. About 65% of all of the world's maize production comes from the US; however, only about 1% of that food will go to humans (Nierenberg *et al.,* 2016). The rest will be processed and added to the feed of animals and used to produce goods such as high fructose corn syrup (HFCS). There is a specific threat that comes from processing corn into HFCS because fructose in high amounts can lead to obesity. Nierenberg *et al.,* (2016) concluded that it is best for a full-cost accounting that expresses the negative impact of production. Costs have to expose the costs of unhealthy practices associated with the way that the food system works and how food is stored. Subsidies must also consider contrary practices that arise from the production of food.

Giraudeau, (2017) explains that despite efforts to create a model of accounting for agricultural systems, determining exact numbers related to social and environmental costs and benefits is challenging. Dubois, (2018) highlights that this problem arises from the lack of direct linkage between production and the supply chain for agricultural goods to social and environmental costs is relatively undefined.

Sandhu, (2016) designs an assessment method that could measure costs and benefits in the scope of social capital in terms of the cost of production for agricultural products. The findings reported that environmental and social

benefits depend on natural and social capital on farms. Calculation of costs and benefits must also take into consideration the alternatives for the cost of conventionally produced goods (Chen and Saghanian, 2017). Some examples of this include bushels of corn, soybean, milk and beef. Corn has environmental and social benefits of $1.00 per bushel, with an environmental cost of $1.00 and a farm gate value of $4.00. This data is evidence that in the scope of social and environmental costs and benefits, corn is a value-neutral item.

On the other hand, a bushel of soybean has social and environmental benefits of $3.19 and an environmental cost of $3.17. A gallon of organic milk will generate social and environmental benefits of $.28 and has an economic cost of $.25 (Sandhu, 2016). This data shows that the social and environmental costs of these goods are relatively close to the benefits. The objective should be that the social and environmental benefits of these things should be pointedly more significant than the costs (Chen and Saghanian, 2017). For that reason, lower environmental strain and the wellness of citizens should arise from organic food production.

Treatment and nourishment of the animals held in captivity become a part of our food supply. Andrus *et al.,* (2016) examine the cost of different treatment methods that animals experience. Animal welfare is an essential element of agricultural externalities because the treatment of animals can have a potential impact on the quality of the food.

The researchers estimated that 90% of all eggs come from chicken that will never move their wings. From a fundamental economic standpoint, there is a lack of support for this approach as gestation crates create an average value for the farmer of $.34 a point and cost less than $.07. At the same time, there is only a cost of $.01-.02 per egg. The savings are insignificant. However, there is a direct economic value to free-ranging chickens and other livestock that is not exploited by farmers. There is some form of cost-benefit in more progressive approaches to farming and agriculture.

Skaf *et al.,* (2019) asserts that there is still difficulty in general associated with quantifying the benefits which come from the implementation of sustainability methods. This case is because of the lack of direct links between benefits and changes in activities from conventional to organic methods of production. Sandhu *et al.,* (2016) discussed potential methods for

assessing sustainability in agriculture. The researchers noted that four primary boundaries understate sustainability and the cost of food production. The researchers noted that good governance, environmental integrity, social wellbeing and economic resilience are four critical dimensions associated with successful measurement of how sustainability can occur in farming. Essentially, measuring production in the scope of determining the extent to which production conforms to a bottom line is a key for how an accounting system can account for the costs of production in agriculture and agricultural gains can potentially be measured (Skaf *et al.,* 2019).

FINDINGS

With the growth of organic farming, Balmford *et al.,* (2018) articulate that there exists more data that can enable the determination of cost-benefit externalities. Researchers have come up with extensive data models that have increasingly improved the quality and value of cost-benefit analysis. The manipulation of consumers is a critical evaluation point in the determination of costs, given that as many more people seek to use organic foods, the costs of foods has increased. Nonetheless, as Balmford *et al.,* (2018) insinuate, this costing does have negative implications on the prospective sustainability of foods. Sain *et al.,* (2017), however, proposes that this shift may be due to a decrease in the competitive advantages that existing players in the market. As cost models increasingly improve their costing accuracy, the information will allow a decrease in the prices by increasing the bargaining power of consumers.

Sustainability is critically one of the value propositions within food production. Maintaining the quality of food requires, according to Ryan *et al.,* (2016), to use technologies that do not induce harm to the systems within the farm. This sustainability thrives on limitations of the environmental damage that is permissible in food production (Balmford *et al.,* 2018). The social implications should be in line with efforts towards water regulation and nutrient cycling (Sandhu, 2016). The costs on the environment are perhaps one of the crucial calculations in the cost-benefit externalities. It adds to what are the socially acceptable ways of producing foods.

Unfortunately, the cost inclusion of organic foods is complex. Ferreti *et al.,* (2017), mentioned in their quest to allow the consideration of the total

costs of organic foods. This scope would entail the natural resources, human and animal protection and rights, as well as environmental concerns. The production of food concentrates on more than labour costs, land and supply chain operations. The impact that it has on living organisms is fundamental and must be part of calculations. Humans and animals' input to these processes and some of the practices that some farmers engage within have high human cost implications on welfare. (Andrus *et al.,* 2016). Unethical processes have a long-term implication on costs and sustainability (Carlson, 2016; Hilmi *et al.,* 2018). Nieremberg *et al.,* (2016) foster the necessity to involve foods that affect multiple arenas of the food chain. With corn, for instance, the costing can be multifaceted based on consumptions and health outcomes as well (Ferreti *et al.,* 2017). In arguing for true costs of organic farming, the health implications and some of the negative uses to which the product goes into must reflect.

Nonetheless, models for agricultural systems cannot determine the costs of all inputs, as Giradeau, (2017) present. Existing systemic issues related to lack of direct costing across food supply chains and production in relation to social and environmental gaps presents a wide range of gaps in which current modalities are insufficient (Chen and Saghanian, 2017). Consequently, relating the same information to quantifiable benefits of sustainable methods presents widespread challenges (Skaf *et al.,* 2019). The dimensions of good governance, environmental integrity, social wellbeing and economic resilience present key performance measures on sustainability (Skaf *et al.,* 2019). However, their scope does not conclusively assess and present prospective models for costing and benefit analysis. Extensive research can present better articulation on techniques that can reflect adequate measurements and values of the investments made towards sustainable organic farming.

CONCLUSION AND RESEARCH NEEDS

In closing, sustainability in agriculture focuses on accomplishing positive social and environmental goals (Skaf *et al.,* 2019). This scope must ensure that farming systems work towards the realization of better outcomes. Organic foods, despite their massive influence of change toward sustainability, require refinement in assessment tools. Production for farmers is costly, thus requiring modalities that would improve their

completeness with farms using non-organic farming protocols. At the same time, it is vital to understand the implications of production. As technologies lead to more elegant approaches to production, researchers must understand what this means. Organic foods have not quite caught up with competitors; however, the economic advantages for organics are growing, and it is possible that in the future organic foods will minimize the cost advantage that competitors have. The priority of future research will focus on assessing the citizen's awareness of the costs - benefits (externalities) of sustainable agriculture.

Researchers must consider the net social health and environmental benefits/cost (net externalities) to the final production cost; the market price of the organic products appears cheaper than as it is marked. Unveiling the exact monetary value of the benefits and costs would be able to encourage farmers and practitioners to implement technologies and methods to lessen the negative impact on human health and the environment. Again, it will assist consumers in deciding whether to buy products with higher environments and social benefits or less environmental costs based on provided information (benefits/costs) (Chen and Saghanian, 2017). It is worth considering how many people are aware of and concerned about social and environmental costs and how to include benefits in advertising organic farming. Information needs of organic farmers should survey, and information delivery systems should meet their needs.

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Socio-economic factors influencing fish Farmers' Level of awareness of Organic Farming Practices in South -South, Nigeria.

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ABSTRACT

The study **investigated** the socioeconomic factors influencing the level of awareness of organic farming practices among fish farmers in South-South Nigeria. The specific objectives of the study are to describe the socioeconomic characteristics of fish farmers in the study area, ascertain the level of use of organic fish farming practices and relate socioeconomic factors to the level of use of organic farming practices. Data for the study were obtained with a structured questionnaire. The sample size for the study was One hundred and fifteen (115) fish farmers selected purposefully from the list of fish farmers provided by zone managers in the three states under study. The farmers selection were based on accessibility.. Data collected were analysed using multiple regression The findings of the study revealed that fish farmers were aware of organic fish farming practices in the study area. .Farm size (t =2.462; P< 0.05, contact with extension agents (t = 2.282; P <0.05) had significant relationship with level of awareness of organic fish farming practices), and. As farm size increases, the level of awareness of organic farming practices increases whereas increased extension contact culminated in increasing the level of awareness of organic fish farming practices.. The study therefore recommends that training on organic fish production practices should be emphasized in extension activities in the study area.

Keywords:: Socioeconomic factors, fish farmers,, Organic Farming Practices, Nigeria

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INTRODUCTION

Fish is an important source of protein and income (World Bank, 2000). Fish that are produced under natural condition according to the organic agricultural principles, not exposed to any protective additives or genetic modification, fed with baits prepared with completely natural materials and certificated by a control agency are called "organic fish' (Awuror and Karugu 2014). Organic fish production is a model of production which raises fishes with low stock density and attaches importance to human health without using any chemical such as pesticides or any products that are modified genetically (Do cytowanian *et al,* 2010). The Council of Europe adopted a recommendation on the welfare of farmed fish in 2005 and in 2008 the World Organization for animal health adopted guiding principles for fish welfare. (European Food Safety Authority (EFSA), 2009). Organic fish farming system rely on practices such as cultural and biological disease management and virtually prohibit utilization of synthetic chemicals in fish production. Ponds and cages are the recommended rearing system for organic aquaculture. Tank systems are permitted for hatcheries and nurseries but not for grow out operations on the farm. The stocking density of cultured species is limited and must be less than that of conventional aquaculture 10 kg/m^2 Organic aquaculture aims at reduce instances of diseases and emphasizes preventive treatments. Chemicals and antibiotics are not permitted but vaccines and pro biotic are permitted in aquaculture (Prein *et al*., 2012). Feeds should come from certified organic agricultural inputs or from aquatic sources that have been cultured under controlled organic conditions.

The nutrient content of organic fertilizers varies greatly among source materials, and readily biodegradable materials make better nutrient sources in aqua cultural practices. However, it is highly recommended that the nutrient content of the organic fertilizer should be determined before its application. Ponds with fertilized water will turn into a rich green or reddish color when the plankton are abundant. This means that food will be available for the fish. Ponds/tanks with clear water are not fertile and lack plankton (Murnyak, 2010). Most farmers reported that they fertilize their ponds using manure from domestic animals before stocking the fingerlings. This is supported by the observation of Chenyambuga *et al.,* 2011 that 70 percent of the fish farmers had ponds with greenish water, indicating

abundance of plankton for fish to feed on The commonly used organic fertilizer is chicken manure (Amisah*et et al.,* 2008), which stimulates abundant growth of zooplanktons and insect larvae and other forms of fish food organisms (Akand, 1986; Kumar *et al.,* 2014).

In spite of the benefits of organic farming, research on organic livestock and fish farming are limited. Previous studies on organic farming concentrated more on crop production. Considering the benefits of organically cultivated fish, it is necessary to find out if fish farmers are aware of the organic farming practices and **Socio-economic determinants of fish farmers' level of awareness of organic farming practices.**

METHODOLOGY

The study was carried out in South-South, Nigeria Multistage sampling technique was employed. The first stage was random selection of three states out of the six states that make up South-south Nigeria. The states sampled are: Bayelsa, Delta and Akwa-Ibom. One-third of the total agricultural zones in each selected State. Delta (Delta North, Delta South and Delta Central), and Bayelsa (Brass, Yenagoa and Sagbama) States has three Agricultural zones respectively- out of which Delta central and Brass agricultural zones were selected. Akwa-Ibom is divided into six Agricultural zones- Abak, Eket, Etinan, Ikot Ekpene, Oron and Uyo zones. Two zones Uyo and Ikot Ekpene were randomly selected from Akwa- Ibom State. From each zone, three blocks were randomly selected for Delta and Bayelsa while two blocks from each of the two zones sampled in Akwa Ibom state giving a total of ten blocks. Two circles were further sampled from each selected block in Delta and Bayelsa. Twelve circles were thus selected from the two states. Two cells were sampled from each block in Akwa-Ibom. Eight circles were sampled in the State. The total number of circles used was twenty. Two rural communities. were then selected from each circle giving a total of forty communities for Delta, Bayelsa and Akwa- Ibom states. Lastly, four fish farmers (Household heads) were purposefully selected from the forty communities giving a total of one hundred and sixty fish farmers. The lists of fish farmers were gotten from the Zonal Managers in charge of each zone. Data for the study were obtained from the respondents with the aid of structured questionnaire. The final sample size used for data analysis was 115 fish farmers ,being the number of usable questionnaire

retrieved. The instrument elicited information on the socio economic characteristics of the farmers and level of awareness of organic fish farming practices. A four-point Likert type scale which consisted: very regular = 4, regularly =3, rarely =2 never =1 was used to summarise data. A decision rule of mean score of 2.50 was used to dichotomise responses into regular and not regular.. Ordinary least square multiple regression analysis was used to determine the relationship between the level of awareness of organic farming practices and the socio-economic characteristics of the fish farmers.

RESULTS AND DISCUSSION

Level of Awareness of Organic Farming Practices among Fish Farmers

In Table 1 out of the fourteen organic farming practices the farmers were aware of seven of such practices. They are Eco- friendly design ($\overline{xx}$=2.91, SD = 1.06), high quality water source ($\overline{xx}$= 2.90, SD = 1.24), pond protection from predators (x – x –3.36, SD = 0.97), use of resistant species (xx= 2.95, SD = 1.21) natural treatment of diseases (xx= 2.64, SD = 1.38), cultivation without genetic engineering (x = x = 2.58, SD = 1.34) and management without growth hormones (xx= 2.60, SD = 1.06). Other practices that had their mean score below the cut- off point include low stock density 10kg/m (xx= 2.46, SD = 1.16), management without synthetic appetizer and colouring ($\overline{xx}$= 2.31, SD = 1.09), organic fertilizer ($\overline{xx}$= 2.24, SD = 1.29), location of site faraway from polluting substances ($\overline{xx}$= 2.11, SD = 1.30), antibiotics only use in critical cases ($\overline{xx}$= 2.10, SD = 1.32) and poly-culture ($\overline{xx}$= 1.79, SD = 1.10).The grand mean was 2.49..

Table 1. Ordinary least square multiple regression analysis of relationship between socio-economic characteristics of the fish farmers and their level of awareness of organic farming practices

Socio-economic determinants of fish farmers' level of awareness of organic farming practices.

Regression models for Fish

Coefficients	Linear	Exponential	Double log	Semi log
Constant	B:18.704	B:1.238	B:1.077	B:9.091
	t:4.314*	t:16.758*	t:9.672*	t:1.393
	sig:0.000	sig:0.000	sig:0.000	sig:0.166
Age	B:.096	B:0.002	B:.091	B:5.640
	t:1.971*	t:1.835	t:1.500	t:1.592
	sig:0.051	sig:0.069	sig:0.134	sig:0.114
Sex	B:-.443	B:-.008	B:-.066	B:-3.378
	t:-.442	t:-.483	t:-1.030	t:-.900
	sig:0.659	sig:0.630	sig:0.305	sig:0.370
Educational	B:-.856	B:-.012	B:-.053	B:-3.908
Level	t:-1.601	t:-1.362	t:-1.163	t:1.464
	sig:0.112	sig:0.176	sig:0.248	sig:0.146
M.status	B:-.987	B:-.017	B:-.099	B:-5.690
	t:-1.379	t:-1.389	t:-1.622	t:-1.5585
	sig:0.171	sig:0.168	sig:0.108	sig:0.116
Religion	B:242.	B:.006	B:.071	B:1.374
	t:1.242	t:1.854	t:.990	t:.326
	sig:0.217	sig:0.067	sig:0.324	sig:0.745
Farm experience	B:0.043	B:.001	B:.028	B:1.832
	t:.810	t:.652	t:1.018	t:1.130
	sig:0.420	sig:0.516	sig:0.311	sig:0.261
Stock Size	B:.0342	B:.001	B:.066	B:3.589
	t:-0.646	t:.900	t:2.462*	t:2.279*
	sig:0.520	sig:0.370	sig:0.015	sig:0.025
House hold	B:-.005	B:1.0883E-00	B:.009	B:.505
size	t:.200	t:.023	t:.253	t:.235
	sig:0.842	sig:0.981	sig:0.801	sig:0.814

Farmers	B:.280	B:.001	B:.051	B:3.944
association	t:249	t:068	t:.762	t:.999
	sig:0.804	sig:0.946	sig:0.448	sig:0.320
Extension	B:-1.873	B:-.029	B:-.175	B:-10.374
contact	t:-1.415	t:-1.298	t:--2.282*	t:-2.306*
	sig:0.160	sig:0.197	sig:0.025	sig:0.023
Income	B:-	B:-2.494E-09	B:-.005	B:-.179
	1.464E-0	t:-.723	t:-.425	t:-.287
	t:-.723	sig:0.471	sig:0.672	sig:0.775
	sig:0.471			
R^2	0.152	0.156	0.168	0.166
F-stat	1.677	1.735	1.889	1.864
P-value	0.089	0.076	0.049	0.053

The level of significance: 0.05 t- value significant at 0.05

Decision Rule: Reject H_0if the P (probability) value is less than 0.05 (level of significance).

Socio-economic determinants of fish farmers' level of awareness of organic farming practices.

Ordinary least square multiple regression analysis was used to determine the relationship between the level of awareness of organic farming practices and the socio-economic characteristics of the fish farmers. The socio-economic characteristics were found to be significant predictors of level of awareness of organic fish farming practices. The null hypothesis was therefore rejected. (p-values of 0.049 less than level of significance 0.05), Farm size is significantly related with level of awareness of organic fish farming practices.(regression coefficients of 0.066; p = 2.462.

Contact with extension agents had a coefficient of - .175; t- value of 2.282; p = 0.025 meaning that contact with extension agents was significantly related with the level of awareness of organic farming practices among the fish farmers. The result implied that as stock size increases, the level of awareness of organic farming practices increases whereas increased

extension contact culminated in reduced level of awareness of organic fish farming practices. This could be attributed to low emphasis on organic farming practices in extension teachings. It could also be that extension agencies still dwelt on conventional farming practices.

The other variables which included education, sex, marital status, household size, farmers association, farming experience, income and religion had no significant relationship with organic farming practices.

CONCLUSION

The findings of the study revealed that fish farmers were aware of organic fish farming practices in the study area. Farm size, contact with extension agents had significant relationship with level of awareness of organic fish farming practices and. as farm size increases, the level of awareness of organic farming practices increases. Whereas increased extension contact culminated in increasing the level of awareness of organic fish farming practices.. The study therefore recommends that training on organic fish production practices should be emphasized in extension activities in the study area. Socio-economic variables of education, sex, marital status, household size, farmers association, farming experience, income and religion were not significantly related to awareness of organic farming practices and as such should be discountenanced in decision making and policy implementation.

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Is Organic Farm Challenges by Profitability an Interdisciplinary Approach in Nature? A Review

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ABSTRACT

This paper outlines whether organic farming profitability research is an interdisciplinary approach. It draws inspiration from the relevant literature and disciplines surrounding this topic (Public health, Environmental studies, Economic/Finance). It focusses on the complex nature of organic farming in terms of profitability and how it affects all parties involved (policymakers, farmers, and consumers). This report argues that through an examination of the relevant literature surrounding this research area, the current topic has been developed and reviewed from various disciplines and foci points (Public health, Environmental studies, Economic/Finance). Organic farming research associated with a broader range of interdependent factors, and it is more likely to rely on a more significant component of value judgement or intuition. Research methods for studying organic farming and profitability depend on an acceptance of complexity as an essential part of the research process. Employing this perspective aids the consideration of organic agriculture and profitability because each discipline used to explore this topic has its strength, weakness, and also examined this topic from a particular vantage. Therefore, an interdisciplinary approach is a means of opening up a more meaningful account of this process.

Keywords: Organic farms, Profitability, disciplinary, Interdisciplinary, sub-disciplines, Environment, Health, Economic

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INTRODUCTION

Organic farming is a holistic approach to production management, which promotes and enhances agro-ecosystem health and avoids the use of synthetic materials to fulfill any specific function within the system (Codex Alimentarius 1999). According to the International Federation of Organic Agriculture Movements (IFOAM 2007), organic farming includes all agricultural policies that promote environmentally, socially and economically sound production of food and fibers (Suutari 2007). Recycling nutrients and strengthening natural processes helps to maintain soil fertility and ensure successful production (Codex Alimentarius 1999, IFOAM 2007). By respecting the natural capacity of plants, animals, and the landscape, it aims to optimize quality in all aspects of agriculture and the environment. Organic farming dramatically reduces external inputs by refraining from the use of synthetic fertilizers and pesticides, in that diseases/pests are controlled with naturally occurring means and substances by traditional as well as modern scientific knowledge, increasing both agricultural yields and disease resistance (Mahmoudi et al., 2009). This paper seeks to advance this line of inquiry in an attempt to understand better how organic agriculture adheres to globally accepted principles implemented within local socio-economic, climatic, and cultural settings. The gaps in the research surrounding organic farming and profitability related to the lack of studies advocating for a more holistic approach and the utilization of reductionist techniques to organic research (Woodward, 2019). More recently, there have been calls for secure integration of interdisciplinary perspectives and for the development of diverse methodologies to assess new research targets and existing research surrounding organic farming (Keatinge and Rasmussen, 1999). This line of investigation intertwines with various fields of academic inquiry. Presumably, organic food/farming itself is an inherently interdisciplinary endeavor, encompassing a wide range of research areas, including economic/commerce, public health, environmental studies, and much more. Following the review of the literature, the paper attempts to answer the overarching research question on the profitability of Ontario farms and its implications on this field of study. The research question comprised of interrelated segments such as organic farming, farmland, agriculture, labour cost, production, sale, distribution, profitability, and challenges associated with organic farms (Klaus Ammann, 2008; Langemeier el at., 2014).

MATERIALS AND METHODS

This paper describes and analyses the incentives of using the interdisciplinary methodology research concept concerning the organic farms' profitability context to capture and understand the essence of the issues of this research methodology. It focuses on the review of journals, websites, and other related and reliable sources collected under the Preferred Reporting Items for Systematic Reviews and Meta-Analyses) convention from 2010 to 2017. The data will be both private and public, as Cheng and Phillip (2014) recommend. Several environmental, health, public health, and economic databases from government, non-profit agencies, and research organizations would help this report to access a wide range of information on organic farming and its probability. The secondary collection of data would be befitting for this kind of study, is that it would require an analysis of the existing linkages between various disciplines to establish a review of the profitability of organic farming. This method maximizes, as Cheng and Phillips (2014) explain, outputs of data collection that exist from existing primary research. Often, initial researchers do not expansively conceptualize the implications that their data has on the fields of study.

Additionally, restrictions such as time and resources may inhibit the research (Logan, 2020). Using this data as part of other research papers allows optimization of the data. Secondary reviewers may have more comprehensive insights. This research will have a question and a data-driven approach. This report has its prior hypothesis on the profitability of organic farming in Ontario via the exploration of an interdisciplinary approach. This theory helps in establishing the primary datasets that would apply to the scope of the research. Under the data-driven method, the researcher will look at the available variables within the identified datasets to determine which can address the concerns of the report (Cheng and Philips, 2014). This report has to incorporate an analytical plan that will specify variables. Secondly, the researcher will look at the strengths and weaknesses of the datasets using the PRIMA method. Again, there will be operational definitions of variables that will assist in crosstabulations of the factors that will feature in the principal analysis (Cheng and Phillips, 2014). Lastly, the emerging themes will help in the re-coding of the data.

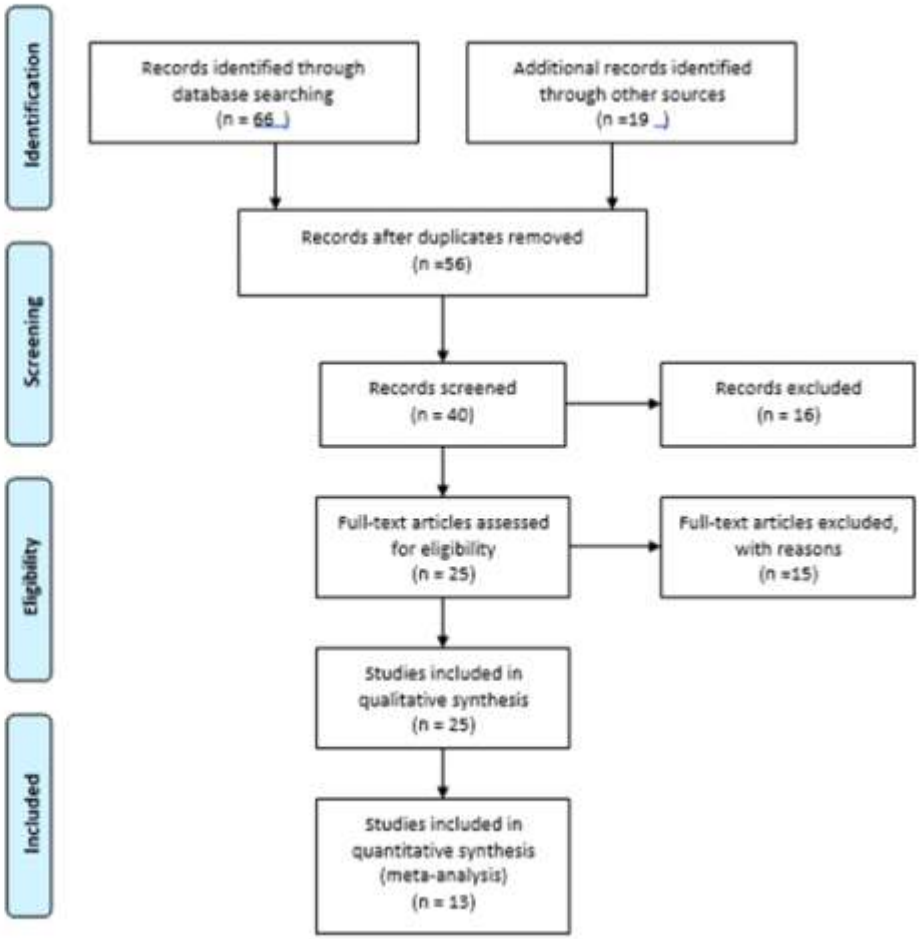


Image 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Model for the Study. (Source: Liberat, el at., 2009)

Organic Farming and Public Health

Public health is a discipline within science that focuses on protecting the safety and improving the health of communities and individuals in society through education, policy-making, and research for disease and injury prevention (Andresen and DeFries-Bouldin 2010; Joyce 2009). For thousands of years, individuals have been concerned with sanitation, housing, the provision of safe, clean food and water, and the control and

treatment of diseases. Public health evolved to address these concerns and issues in society. It is an area of study that focuses on providing interdisciplinary efforts that can address the multiple determinants of health, such as: the biological, behavioral, environmental, cultural, social, living, and working conditions and populations at risk for disease and injury (Fertman and Allensworth, 2016). Research in this field describes how public health has evolved in both practices and as an academic discipline through the bacteriological period, the sanitary period, and the social reform movement and through the excellent society era forward to the current landscape of health reform (Erwin and Brownson, 2016). In essence, the definition, goals, and organization of public health as a discipline has changed over the last 170 years with social reform. Through this evolution, the roles and responsibilities of those working in public health professionals have been influenced and tested by various other disciplines. Public health has five core disciplines in which practitioners train in epidemiology, biostatistics, social and behavioral sciences, environmental health, and health management (Andresen and De-Fries-Bouldin 2010). Professionals in different fields work together in solving problems that benefit from the application of more than one set of skills. The hallmark of public health is the philosophy of social justice and a focus on populations and a focus on prevention.

Rohr et al., (2005) argue that research on public health and organic foods may align with a consumer's need to be physically fit and improve their quality of life. The public health discipline may also focus on an aversion to the kinds of food safety issues that are associated with highly processed foods. As such, scholars and researchers must examine the motivation and the acculturate needs of organic food consumers thoroughly. Additionally, academics seek to appreciate better the motivation and needs of persons who do not consume these foods. This understanding can help to explain why specific consumers choose to eat organic, while others prefer to eat conventional foods (Hjelmar 2011). Economics plays a significant role in food choice, but there may be other factors that are as of yet unknown (Aertsens et al. 2009). Therefore, it is necessary to study other factors that play a role in food choice and why consumers exhibit various health habits in regards to food irrespective of illness patterns and frequencies for both physical and mental conditions. Furthermore, research would refocus on the

psychosocial dispositions that influence purchase and consumption strategies (Gittelsohn et al., 2010).

Organic Farming and Environmental Studies

Environmental studies are a multidisciplinary discipline that systematically focuses on studying human interaction with the environment in the interest of solving complex societal problems/issues (Montello and Sutton, 2012). This area of study provides a broadly integrated understanding of the social, political, and historical facets of our environmental challenges with a focus on policy, law, and social aspects of these challenges (Bissonnette and Contento, 2001; Tobler, Visschers and Siegrist, 2011). The scope and meaning of environmental studies include social sciences and the following disciplines in conjunction with one another (i.e., biology, chemistry, physics, geology, meteorology, agriculture, economics).

While the environment has been the subject of numerous studies, only recently (the early 1960s) has it become an active mainstream scientific investigation and discipline. Due to growing public awareness of environmental issues and a need for action is one factor in the growth of ecological studies to what it is today. This broad interdisciplinary research approach examines human interaction with environmental processes, from different natural and social science disciplinary viewpoints. From its beginning, environmental studies have always been an academic field that embraces a philosophy of advocacy, in which research promotes particular values such as the ethical value of environmental conservation (Montello and Sutton, 2012). Understanding both ecological and social sciences is necessary for the understanding of the complexity and multidimensionality of ecological issues and problems, including organic farming and profitability.

Belon et al. (2016) argue that it is essential to study the various environmental factors associated with organic farming and profitability, such as farmers, suppliers, and consumers concerning conventional and organic foods. The conventional food supply system, especially the food commodity chain, can lead to extreme forms of environmental degradation or conservation (Ahearn, Armbruster and Young, 2016). However, the

economic costs of participating in conventional food production may outweigh the environmental costs associated with organic farming. Researchers argue that ecological management strategies that can promote economic and environmental sustainability concerning food production will be achieved only through a coalition of the willing, in which environmental sustainability receives considerable analysis as profitability (Sazvar, Rahmani and Govindan, 2018). By assessing the basic economic concepts behind pollution, environmental management, and emissions targets, there is demonstrable connectivity with the social cost of pollution that consists of all environmental damages. These social implications include health costs and reduced enjoyment from consumer locations, as well as direct financial accruals by farmer and supplier companies that need consideration as food resources decrease (Zander and Hamm, 2010).

Organic Farming and Economic/Finance

Finance is a discipline or subject area that describes how individuals, governments, and corporate organizations manage the flows of money through an organization (Chang 2005; Mayo, 2011). In essence, finance enables us to understand better how people make decisions about the collection and allocation of resources in organizations. Although finance is a separate academic discipline, its roots are in accounting and economics. In many ways, finance is a sub-discipline of economics, and many financial principles are rooted in economic theory. The development of empirical tools further augmented financial analysis, as statistics became a means to verify economic theory as it applies to finance (Mayo, 2011). The ability to test economic and financial hypotheses further enriched the field of finance. Popov (2018) explains that finance was a branch of economics until the closure of the 19th century that it witnessed significant developments and shifts with regards to scientific rigor. The academic discipline of finance includes the following specialized areas in its scope (i.e., public finance, institutional finance, securities and investment, international finance, financial management). Approaching finance from more than one perspective is fundamental, especially in organic farming and profitability. An interdisciplinary approach can fuse knowledge and insights from other disciplines within an economic framework of analysis to form a more

inclusive means of examining the research questions, thereby fostering a more detailed and productive description of the issue/problem.

This paper draws inspiration from a wide range of literature associated with organic farming and profitability from the discipline of finance, despite being circumscribed technical fields, finance, and accounting touch on a vast number of areas (Popov, 2018). Finance seeks to capture the essence of the relationship between a company and its stakeholders, a relationship that has legal, financial, managerial, and cultural dimensions. As such, finance is not a discrete discipline, but rather as a cornerstone of business theory, management, and economics (Kavussanos and Visvikis, 2016). The primary focus/core of this research is on issues related to the profitability of Canadian organic farming, staying in business to contribute to environmental sustainability and farming social responsibility.

Another specific research agenda of great importance to the researcher is how to frame the cost-benefit analysis of organic food used by Canadian organic farming, since in the absence of profitability; organic farming cannot achieve pro-social and pro-environmental goals (Bergendahl, Sarkis and Timko, 2018). With these considerations, it is fundamental to examine organic profitability and agriculture from an interdisciplinary vantage point, leading to new insights that would have been undiscovered if a discipline-specific approach was adopted to understand this phenomenon.

Integrating these disciplines and sub-disciplines

As evident from the review of literature, a significant number of researchers have tried to understand the links between corporate financial performance and benefits for the development of human society, specifically those associated with health and the environment. However, there are gaps in this body of research surrounding organic farming and profitability. The author is particularly interested in some of these gaps as outlets for this journey of scholarly work at the interdisciplinary research level. The research questions above reflect on significant holes within the literature and knowledge/disciplines. The report intends to allow integration from the specific perspective of organic food use in society. To date, only a few studies have examined how to support sustainable, healthy, and organic food systems and its link to social responsibility. However, this has not

generated scholarly answers to the research questions mentioned in the literature.

More importantly, existing methodologies and empirical approaches can allow the exploration of the research questions. For example, brand premiums and customer engagement have experimentally, pseudo-experimentally, or correlational measurements. Additionally, accounting methods based on the use of secondary data can measure the profitability of organic food and the utilization of organic food by significant companies (Flora, 2018). Although we have considered this research topic to be novel and worthwhile, the author needs additional research practice and sophistication to answer these questions within the current study more empirically. In academia, working across disciplinary boundaries helps scholars to avoid silo thinking, which in turn creates alternative perspectives to viewing an issue, resulting in a better reflection of real-world complexities (Augsburg and Henry 2009; Chandler 2009; Morin 2008; Repko 2012; Shailer 2005). Due to the contributions from the various disciplinary perspectives and modes of thinking, organic farming can is, therefore, a complex interdisciplinary research domain.

It is important to note that the researcher's approach to understanding organic farming is diverse and calls attention to a breadth of various interests. The researcher believes that different educational backgrounds (i.e., accounting and commerce) and personal connection to the topic stimulated a desire to frame the current study around the tenets of interdisciplinary research. This insight results in opportunities for conceptualizing relationships with other parallel disciplines. Organic farming and organic food utilization present a unique opportunity to understand a system of interconnected profitability, sustainability, and operational concerns shared by individuals in society. As a cornerstone of knowledge production, organic farming, and profitability require an interdisciplinary approach to comprehend the various facets associated with this phenomenon. This research topic covers broad areas of science, including natural, humanistic, social, and economic/commerce. The critical aspect studied in the current study is the profitability of organic farmers. If they are to survive in a competitive market, then they will be a benefit to society, including in the domains of health and the environment. Therefore, one can argue that organic food is fundamentally an interdisciplinary

subject. As such, this study intends to demonstrate how these interdisciplinary and innovative facets can undergo the integration of multiple perspectives.

According to MacRae (1993) and McLaughlin and Clow (2008), in terms of food production, farmers, customers, and companies ethically react in the sense of acceptable ways within a particular ecological, economic, and social fact.

Research originating from this area of the study describes research methodologies in organic farming that clearly distinguish between organic and conventional food research methodologies and indicates the different blend characteristics (Keatinge and Rasmussen, 1999).

Organic farming research associates with a broader range of interdependent factors (Gallin and Ferguson, 2019). It likely relies on a more significant component of value judgment or intuition.

The table below demonstrates how organic farming embodies this integrated outlook as compared to conventional agriculture. The section below highlights the various disciplines and sub-disciplines (i.e., public health, environmental studies, and economic/finance) integrated into understanding organic farming and profitability better.

Table 1. Generalized characteristics of organic and conventional experiments (Keatinge and Rasmussen, 1999)

Organic	Conventional
Inter (multi) disciplinary	Discipline-based
Interdependence of activities	Singularity of activities
Role of value judgment/ intuition	Objectivity
Longer-term	Short-term
Environmental interaction	Environmental control
Greater range of parameter studies	Fewer parameters evaluated
Based on farmer goals	Involve 'commercial' goals
Applied	Fundamental

(Source: Keatinge and Rasmussen, 1999)

Research methods for studying organic farming and profitability focus on acceptance of complexity as an essential part of the research process. Furthermore, conducting interdisciplinary research is far from an easy task. According to Francis and Hildebrand (1989), holistic and multidisciplinary approaches focus on the total systems. Farming Systems Research and Extension (FSR/E) takes into account the multiple goals of the farm family as well as the economic and resource situation such as profitability, sustainability, organic food, and operational concerns in which the farm operates (Poats, 2019).

Additionally, when considering the time dimension within which families make decisions and plans for the future, the long-term sustainability of production and profit become central to system design (Francis and Hildebrand 1989). A systems methodology (i.e., real-world activities and systems thinking about the real world) suggests interdisciplinary efforts in research and education. This kind of research necessitates not only a consideration of various disciplines, including farmers, farmworkers, consumers, and policymakers, but also profitability, sustainability, organic food, operations, and others (Poats, Schmink and Spring, 2019).

This paper integrates the knowledge, concepts, theories, and methods from these diverse disciplines on organic farming by drawing inspiration from Repko's (2008) conceptualization of how to conduct interdisciplinary research. Repko (2008) identified ten steps to help guide the multidisciplinary researcher. First, state the problem or question, justify using an interdisciplinary approach, identify relevant disciplines, and conduct the literature search. Then develop adequacy in each related subject, analyze the problem, and evaluate each insight into it. Again, identify conflicts between each idea, establish common ground, and integrate insights. Finally, produce an interdisciplinary understanding (Jones et al., 2019).

Similarly, Szostak (2003) employs a similar approach to conducting interdisciplinary research. The researcher explores these ten guidelines suggested by Repko (2008) to encourage quality work instead of superficial multidisciplinary research and practice. These guidelines allow flexibility for researchers to revisit earlier steps as they perform later stages, alter the

questions as one discovers new information, embrace new theories and methods as the limits of the first ones chosen to become apparent.

CONCLUSION

This paper seeks to advance the understanding of the organic farming and profitability in the province of Ontario through the integration of two or more disciplinary perspectives, leading to a deeper, richer and broader understanding of this issue than is typically possible through a single disciplinary approach (Frodeman et al., 2012; Moran, 2010; Newell, 2013; Shailer, 2005; Szostak, 2007). Employing an interdisciplinary perspective to understanding organic farming and profitability is essential because each discipline that explore this topic previously had their strengths, weakness, and also examined this topic from a particular vantage. Therefore this approach can be seen as a means of opening up a new meaningful research ground. The secondary review of data is appropriate in its capacity to look at existing data and repurpose and contextualize it within other fields of study. This report aspires to create a paradigm shift in the analysis of the profitability of organic farming.

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Performance of Indian Spinach (*Basella alba* L.) as Affected by Water Stress and Different Sources of Plant Nutrients

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ABSTRACT

Indian Spinach (*Basella alba* L.) is an important leafy vegetable of enormous nutritional and economic benefits but it is underutilized in Nigeria partly because it has received very little research attention. This work aimed to determine the effects of different sources of plant nutrients and water stress on the performance of the crop. The treatments consisted of 4 water stress levels (daily, 2, 4 and 6 days watering intervals) and 4 nutrient sources (control, NPK 20-10-10, poultry manure and sapropel). These were arranged in Completely Randomized Design (CRD) in four replicates. Growth and yield parameters were recorded. The results revealed that water stress significantly reduced the number of leaves, vine length, stem diameter and biomass yield. Water stress up to 4 days reduced the biomass yield by 82% in NPK treated plants and 26% in poultry manure treated plants but there was no significant difference between the biomass yield of daily and 2 days interval watered plants. NPK fertilizer and poultry manure significantly increased all the growth and yield parameters measured compared to sapropel treated plants which had statistical similar performances with the control plants. Application of NPK fertilizer and poultry manure significantly increased the shoot fresh yield by 137% and 82% respectively while application of sapropel only increased the yield by 6%. In the control and sapropel treated plants, water stress did not significantly affect the biomass yield up to 6 days watering interval. It can therefore be concluded that application of organic or inorganic fertilizer is needed for optimum performance of *B. alba*. Use of sapropel alone may not be a viable alternative to chemical fertilizer in the cultivation of the crop unlike poultry manure. Water stress sets in after 2 days watering interval causing significant reduction in growth and yield. Indian spinach can tolerate up to 6 days watering interval, but when there is improved soil nutrition leading to better growth, watering at two days interval is optimum.

Key words: Indian spinach, water stress, water use efficiency, sapropel, poultry manure, NPK fertilizer.

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INTRODUCTION

Indian spinach or Malabar spinach (*Basella alba* L.) is a leafy green vegetable that belongs to the *Basellaceae* family. This vegetable is popular in tropical and sub-tropical areas, where young stems and tips are used in cooking and making salad. The matured fruit and root are also useful (Kumar *et al*., 2013). The water rich leaves have a mild flavor and slightly mucilaginous making it a good alternative to water leaf. It is reported to be low in calories and fat but very high in vitamins, minerals and antioxidant (Kumar *et al*., 2015). It's anti-inflammatory and anti-bacteria properties was also reported (Azad *et al*., 2013), thus, it has been described as functional food that lower the risk of various diseases (Kumar *et al*., 2015). It is widely used in traditional medicine to treat ulcer, fever, hormonal imbalance, constipation, inflammation, wound and neutralize poison (Kumar *et al*., 2013). Basella species are endowed with various industrially important chemicals such as acacetin, anthraquinone, basellasaponins A, B, C and D, betacyanin, ferulic acid (Kumar *et al*., 2013).

There are more than twenty leafy vegetables consumed in Nigeria but fewer than six are actually grown for commercial purpose, while others such as *B. alba* are underutilized plant with great potential (Olgorite, 2006). These underutilized vegetable which offer good domestic marketing opportunities and are often adapted to our tropical environment are yet to receive the desired research attention. Research on vegetable crops tends to be limited to a small number of crops for which there is an assured market, such as tomato, pepper, cabbage, onion, beans, and cucumber (UNCTAD, 2003). *B. alba* is not usually cultivated conventionally but grows spontaneously in non-hygienic places in Nigeria. It is commonly grown close to drains from lavatories or other house liquid waste. This is to ensure constant water supply as it is believed that the plant requires relatively high amount of water. This may be the reason why it is called 'flowing water vegetable'. It is often found in wet localities (Abukutsa-Onyango, 2004). To attain food security in developing countries, it is important to maximize the potential of these vegetables.

Global warming and associated climate change have already negatively impacted the availability of critical natural resources; there is increasing scarcity of irrigation water (Zhang *et al*., 2014). It is therefore

important to practice climate smart agriculture in which just the adequate amount of water is made available to the plant. Adoption of a suitable irrigation water management practice is necessary to reduce cost of production and eliminate many associated problems.

Successful commercial vegetable production cannot be achieved without fertilizer application in the tropics as tropical soils are deficient in major nutrient element (Kostov, 2016). Chemical fertilizer though effective for vegetable growth, has posed lots of environmental pollution and health risk due to excessive use. With the advocate for organic farming, it is imperative to test alternative organic fertilizers which are more environmental-friendly. Use of animal manure has been reported to improve the productivity of crop among which poultry manure has been reported to be effective by many researchers (Al-gaadi *et al*., 2019). Use of sapropel as bio-fertilizer is a relatively new technology for growing vegetables in Nigeria. Sapropels are subaqueous layers formed at the bottom of nutrient rich water under anaerobic condition (Ismail-Meyer *et al*., 2018). It is a clean and ecological-friendly natural material obtained from remains of plankton, water plants and other water dwelling organism used as biofertilizers and in soil conditioning (Marunga *et al*., 2020). Considering the bulkiness and lack of hygiene associated with use of animal dung, sapropel could be a better alternative. Hence, this work was conducted to compare the effect of chemical fertilizer, poultry manure and sapropel on *B. alba* under different water stress levels.

MATERIALS AND METHODS

The experiment was conducted at the screen house of Federal University of Technology, Minna, Nigeria. It was a 4 x 4 factorial experiment comprising 4 water stress levels (daily watering, 2, 4 and 6 days watering intervals) and 4 nutrient sources (control, NPK 20-10-10, poultry manure and sapropel biofertilizer). These were arranged in Completely Randomized Design (CRD) with four replicates. Four seeds were sown per pot filled with 3.5 kg of top soil at a depth of 5 cm. The seedlings were thinned to two stands per pot at two weeks after sowing. The water stress schedule was introduced at 3 weeks after sowing following the treatments. At each watering day, the soil was watered to field capacity with 40 cl of water per pot.

NPK 20-10-10, sapropel and poultry manure were applied at the rate of 625 kg ha^{-1}, 1580 kg ha^{-1} and 3 ton ha^{-1} according to the recommendations of Pujari (2017), Salami and Babajide (2015). The sapropel used (Emerald fertilizer sapropel) contained 7.91% N, 17.37 mg/kg phosphate and 7.76 mg/kg potassium.

Data were collected on vine length, number of leaves and branches, stem diameter (cm) and leaf area (cm^2). At 9 WAS, the shoots were harvested and weighed on a Mettler balance to obtain the fresh weight. These were oven dried at 70°C until constant weight was obtained to get the dry weight. The roots were severed and weighed on a Mettler balance to obtain the below ground biomass (g/plant). All the data collected were subjected to analysis of variance (ANOVA) using Statistical Analytical System (SAS). Means were separated using Least Significant Difference (LSD) test at P>0.05. Where significant interaction exists, results of main effect are not presented.

RESULTS

Effect of water stress on the performance of *Basella alba*

Number of leaves, vine length, stem diameter, shoot fresh yield and above ground biomass were significantly affected by water stress (P<0.05) (Table 1). Plants that received daily and two days watering interval had statistical similar vine lengths which were significantly higher than the vine length of plants watered at 4 and 6 days interval which were also at par. Water stress of 4 and 6 days significantly reduced the vine length of *B. alba* by 42 and 37% respectively compared to daily watering (Fig 1).

Plants watered daily and those watered at two days interval had similar stem diameter which were significantly higher than stem diameter of plants watered at 6 days interval which had the least value (Fig 2). Plants that received daily and two days watering interval had statistical similar shoot fresh yield which were significantly higher than the shoot fresh yield of plants watered at 4 and 6 days interval which were at par. Water stress of 4 and 6 days reduced the shoot fresh yield by 22 and 21% respectively (Fig 3).

Effect of nutrient sources on the performance of *Basella alba*

All the parameters measured were highly significantly affected by nutrient sources (P<0.01). Application of NPK fertilizer significantly

increased the leaf area by 128% over the control (unfertilized) plants. This was statistically similar to the increase of 101% recorded in poultry manure treated plants. Application of sapropel only increased leaf area by 6% which was not significantly different from the value recorded in the control plants (Fig. 4).

Application of NPK and poultry manure significantly increased the vine length by 74% and 67% respectively over the control plants but there was no significant difference between the vine length of the sapropel treated and control plants (Fig. 5). Similar trend was recorded for number of branches (Fig. 6).

Plants fertilized with NPK had significantly thickest stem followed by the stem of plants fertilized with poultry manure. Sapropel treated and control plants had similar stem diameter that were significantly thinner than the stem of poultry manure and NPK treated plants (Fig 7). Application of NPK produced plants with significantly highest shoot fresh yield with 137% increase over the control plants. This was followed by plant treated with poultry manure which had 82% over the control plants. Application of sapropel only increased the shoot fresh yield by 6% which was not significantly different from the yield of the control plant (Fig 8). Similar trend was recorded for root weight (Fig 9).

Interaction effect of Water Stress and Nutrient sources on the performance of *Basella alba*

Number of leaves and above ground biomass was significantly affected by water stress, nutrient sources and interaction between the two ($P<0.05$) (Table 1). The highest number of leaves was obtained in NPK fertilized plants watered daily. This was however statistically similar to the number recorded in poultry manure treated plants watered daily. When plants were fertilized with NPK, the number of leaves obtained in daily watered plants was significantly higher than in plants watered at two days interval. In poultry manure fertilized plants however, there was no significant difference between the number of leaves of daily and two days interval watered plants. The lowest numbers of leaves were recorded in sapropel treated and control plants irrespective of the watering interval (Table 2).

The highest above ground biomass yield (24.40g/plant) was obtained

in NPK fertilized plants watered at 2 days interval similar to NPK fertilized plants watered daily (21.33 g/plant), The least value (7.22 g/plant) was recorded in the control plants watered at 6 days interval. When plants were fertilized with NPK, the highest biomass weight was obtained at 2 days watering interval which was similar to the value recorded in the daily watered plants. In poultry manure treated plants however, the highest biomass yield was recorded in daily watered plants. The value was however similar to those recorded in 2 and 4 days interval watered plants. Water stress up to 4 days reduced the biomass yield by up to 82% in NPK treated plants compared to the two days interval. In poultry manure treated plants, water stress of up to 4 days reduced the biomass by 26% compared to the two days interval. For the Sapropel treated and control plants, though the least biomass yield was obtained at 6 days watering interval plants, there was no significant difference between the biomass yield of the different watering schedule (Table 3).

Table 1: Mean square values for response of *Basella alba* L. to water stress and plant

Source of variation	Number of leaves	Leaf area (cm^2)	Vine length (cm)	Number of branches	Stem diameter (cm)	Shoot fresh yield (g/plant)	Above ground biomass (g/plant)	Below ground biom
Water stress	185.72*	724.51	4930.74***	18.52	0.12*	3806.77***	74.20**	0.30
Nutrient	1311.10	15492.37***	17372.23***	150.39*	0.39**	40977.64*	369.70**	1.44**
W x N	57.52*	536.45	815.51	11.88	0.02	875.72	27.01*	0.11
Error	24.71	370.06	535.95	7.32	0.01	535.18	12.49	0.13

*, **, ***- significant at 5, 1 and 0.1% respectively

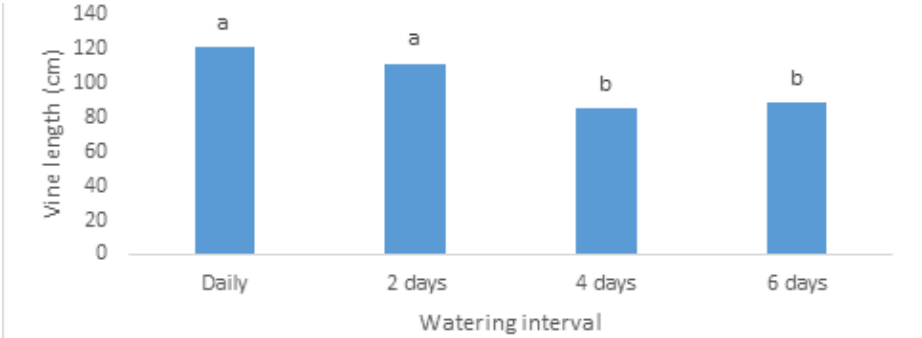


Fig. 1. Effect of water stress on vine length of Basella alba L.

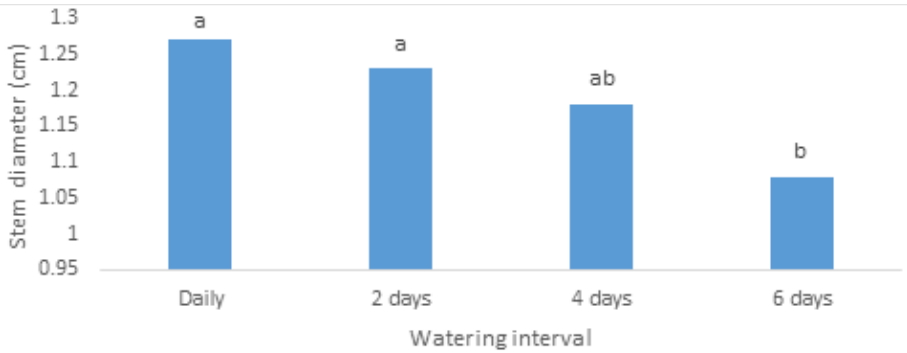


Fig. 2. Effect of water stress on stem diameter of Basella alba L.

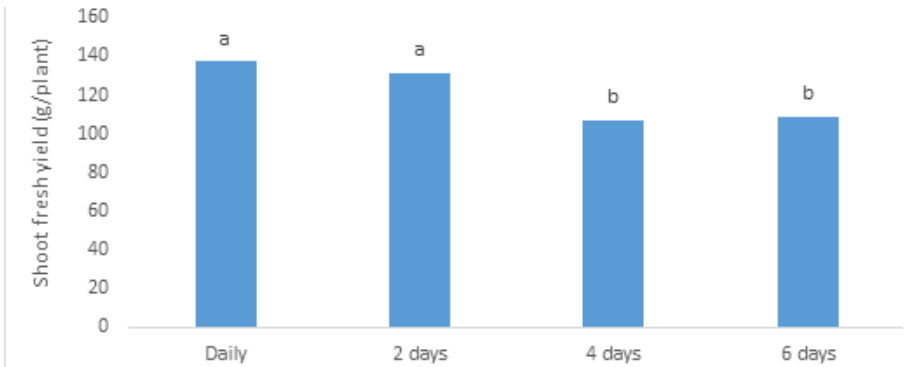


Fig. 3. Effect of water stress on shoot fresh yield of Basella alba L.

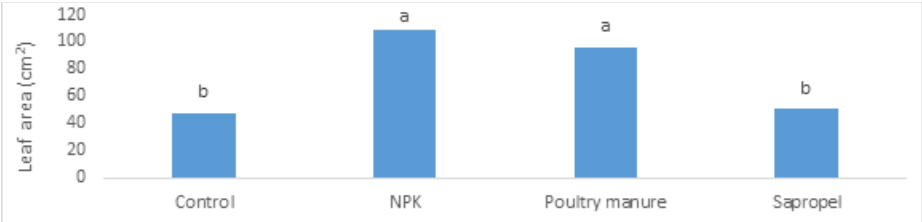


Fig. 4. Effect of nutrient sources on leaf area of Basella alba L.

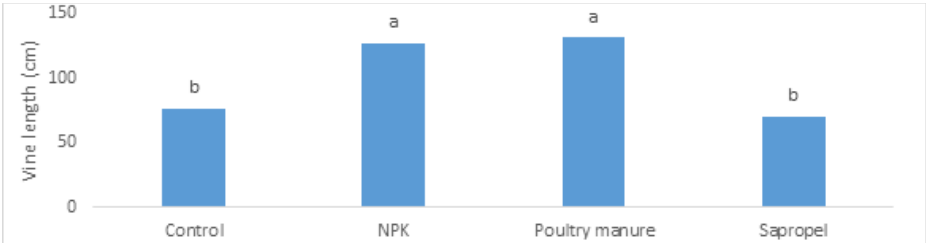


Fig. 5. Effect of nutrient sources on vine length of Basella alba L.

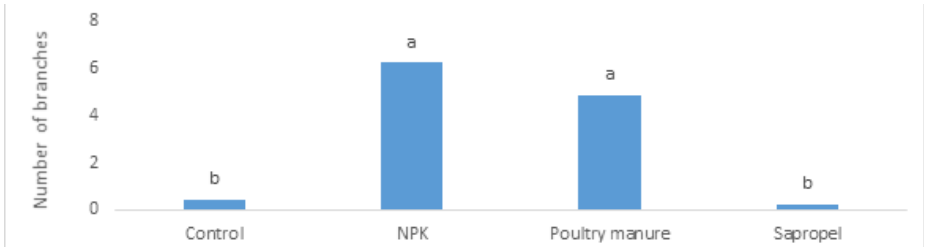


Fig. 6. Effect of nutrient sources on number of branches of Basella alba L.

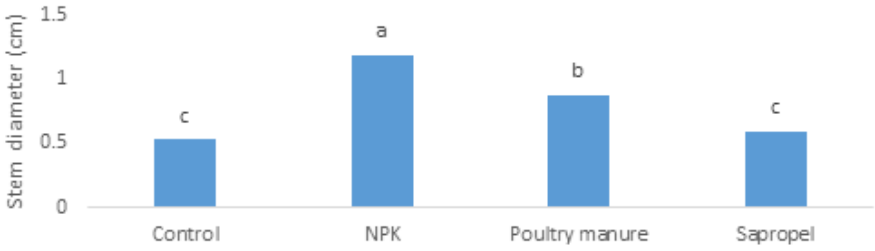


Fig. 7. Effect of nutrient sources on stem diameter of Basella alba L.

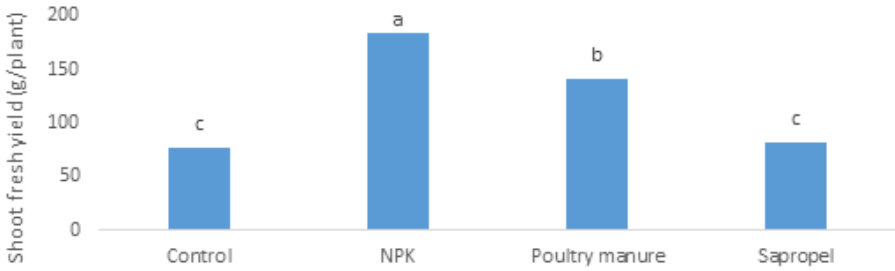


Fig 8. Effect of nutrient sources on shoot fresh yield of Basella alba L.

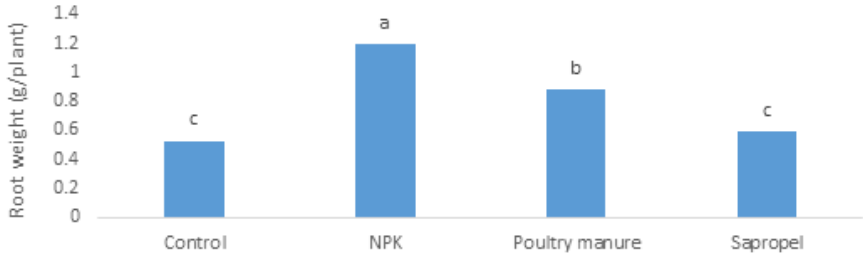


Fig 9. Effect of nutrient sources on below ground biomass of Basella alba L.

Table 2. Interaction effect of water stress and nutrient sources on the number of leaves of *Basella alba L.*

		Nutrient sources			
		Control	NPK	Poultry	Sapropel
Water stress					
Daily		18.25f	46.25a	39.75ab	21.00ef
2	days	21.25ef	32.75bcd	36.75bc	18.75f
4	days	16.50f	27.50de	31.50cd	18.50f
6	days	18.25f	30.25cd	32.25cd	19.25f
SE ±			2.49		

Means having similar alphabets are not significantly different; SE- standard error of the mean

Table 3. Interaction effect of water stress and nutrient sources on the above ground biomass yield of *Basella alba L.*

	Nutrient sources			
	Control	NPK	Poultry	Sapropel
Water stress				
Daily watering	8.89e-h	21.33ab	17.12bc	8.86e-h
2 days interval	8.42fgh	24.40a	15.80cd	9.38e-h
4 days interval	8.05gh	13.37c-f	12.56c-g	8.38fgh
6 days interval	7.22h	13.45cde	11.85d-h	7.69gh
SE ±		1.77		

Means having similar alphabets are not significantly different; SE- standard error of the mean

DISCUSSION

Application of NPK and poultry manure remarkably improved *B. alba* performance in this study. Abukutsa-Onyango (2004) similarly reported that Basella can grow under moderate soil fertility but its production is enhanced with application of NPK or organic fertilizer. The increased growth and yield recorded in this study as a result of NPK and poultry manure application is in line with the findings of Salami and Babajide (2015) who reported that *B. alba* is highly responsive to improved soil nutrition. Quader (2007) similarly reported that *B. alba* requires proper supply of plant nutrient.

The relatively better performance recorded in NPK than poultry manure treated plants may be attributed to the fact that NPK being a chemical fertilizer, has higher concentration of N, P and K in relatively equal proportions unlike organic manure. N, P and K are the primary essential nutrients required by plants. Poultry manure contains an average of 3-5% N, 1.5-3.5% P, and 1.5-3.0 K (Amanullah *et al*., 2010) compared to the 20% N, 10% P and 10% K in the NPK fertilizer. Furthermore, the nutrients in chemical fertilizers are readily available for plant growth than organic fertilizer which releases their nutrients slowly. Most of the nitrogen (75-80%) in poultry manure is in the organic form and need time to mineralize before becoming available to plant. The full benefit of organic manure may not be reaped in just one season of cropping. Quader, 2007 similarly reported that *B. alba* plants that received NPK produced higher vine length, number of leaves and dry matter than poultry manure treated plants. Similar result was

reported by Oyedeji *et al*. (2014). In this study, sapropel only increased the shoot yield by 6%. This is close to the 9% yield increase reported by Aganofora *et al.* (2015). The nutrients in the sapropel fertilizer may not also be readily available for plant immediate use. Aganofora *et al.* (2015) further reported that sapropel's positive effect is manifested in subsequent years of crop cultivation. This may suggest that when using sapropel as the nutrient source, little quantity of chemical fertilizer need to be added to the soil especially in the first season for short-lived crops. At the long run, it may cut down on the quantity of chemical fertilizer used. The fresh shoot yield values obtained in NPK fertilized and poultry manured plants in this study (183.61 and 141.13 g/plant respectively) is within the range of the highest value (177.40 g/plant) reported by Salami and Babajide (2015) when they applied poultry manure.

Contrary to the daily irrigation recommended by Abukutsa-Onyango (2004), there was no significant difference between the performance of daily and 2 days watering interval in this study. The NPK and poultry manure treated plants had the highest above ground biomass at 2 days watering interval though statistically similar to daily watering. Furthermore, plants that received 6 days watering interval did not reach permanent wilting point in this study. This may be an indication of good water use efficiency in the plant which is an important crop quality under water deficit. This contradicts the general believe that the plant requires constant supply of water and indicates that the crop could tolerate short period of drought. In this study, the significant reduction in the growth and yield of NPK and poultry manure treated plants from 4 days watering interval indicates that moisture stress sets in after 2 days watering interval. Water stress affects growth and yield by inhibiting nutrient uptake and reducing photosynthesis. At initial stages, the plant try to cope with adverse water stress condition by altering (increasing) abscisic acid (ABA) and proline content, enzymatic and non-enzymatic antioxidants (Deshmukh and Gaikwad, 2016). Water stress induces a decrease in leaf water potential and in stomatal opening, leading to down-regulation of photosynthesis-related genes and reduced availability of CO_2 for carbon fixation during photosynthesis. Osakabe *et al.* (2014) reported that in response to water stress, ion- and water-transport systems across membranes function to control turgor pressure changes in guard cells and stimulate stomatal

closure. Endogenous ABA is rapidly produced during drought, triggering a cascade of physiological responses, including stomatal closure, which is regulated by a signal transduction network.

In this study, water stress up to 4 days reduced the biomass yield by 82% in NPK treated plants while it reduced by 26% in poultry manure treated plants. The wide disparity may be attributed to the fact that poultry manure increases the water holding capacity of the soil being rich in organic matter. The reduced growth of sapropel treated and control plants may be responsible for the non-significant water stress recorded in them at 4 and 6 days watering interval. They produced shorter plants, fewer number of leaves and branches and slimmer stem, hence the water demand in these plants will be lesser than their NPK and poultry manure treated counterpart which will need more water due to increased transpiration rate as a result of larger surface area and maintenance of balance.

CONCLUSION

Application of organic or inorganic fertilizer is needed for optimum performance of *B. alba*. Use of sapropel alone as soil amendment may not be a viable alternative to chemical fertilizer in the cultivation of the crop unlike poultry manure. Water stress sets in after 2 days watering interval causing significant reduction in growth and yield. Though the plant can tolerate up to 6 days watering interval but when there is improved soil nutrition leading better growth, watering at two days interval is recommended.

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Organ Weights and Testicular Histology Of Heat-stressed Cockerels Given Lycopene and *Tetracarpidium conophorum* Leaf Extract

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ABSTRACT

This study was conducted to assess the relative organ weight and testes histopathology of heat-stressed cockerels given &lycopene and African walnut (*Tetracarpidium conophorum* Mull. Arg. Hutch & Dalziel.) leaf extract (TCLE). Thirty week (30-week) old cockerels (n=54), were used for this experiment. They were randomly grouped into nine treatments containing: 0 ml of extract / 250 ml of water (control) (T1), 7.5 ml of lycopene / 250 ml of water (T2), 15 ml of lycopene / 250 ml of water (T3), 7.5 ml of TCLE / 250 ml of water (T4), 15 ml of TCLE / 250 ml of water (T5), 7.5 ml of lycopene + 7.5 ml of TCLE / 250 ml of water (T6), 15 ml of lycopene + 15 ml of TCLE / 250 ml of water (T7), Vitamin C 0.1 g per 250 ml of water (T8), Cold temperature + Cold water (5-7^{O}C) (T9). The result showed that there was non-significant effect ($P>0.05$) of lycopene and TCLE on all the relative organs weight values recorded. Testes of the cockerels given the control treatment (T8) had abnormal widening of interstitial spaces and degeneration of interstitial cells and lumen. For cockerels on T2 diets, there was an increase in both the interstitial spaces and intracellular spaces of the seminiferous tubules. Cockerels given T7 showed appreciable normal histomorphology with increased interstitial spaces and intracellular spaces of the seminiferous tubules. Cockerels under T8, given Vitamin C, showed abnormal widening of interstitial spaces and degeneration of interstitial cells of the seminiferous tubules. Normal appearance without abnormal widening of interstitial spaces and degeneration of interstitial cells in cockerel given T9. In conclusion, 15 ml of lycopene + 15 ml of TCLE / 250 ml of water (T7) can be administered to cockerels in a cool environment, with an addition of cold water (T9), to give a better testicular structure, and 15 ml of lycopene / 250 ml for improved internal organ weight.

Keywords: Heat stress, Cockerel, testis, histology, lycopene, Organ weight

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INTRODUCTION

Heat stress causes depressed bodyweight gain, feed efficiency among others (Deyhim *et al.,* 1995). Oxidative stress delineates the existence of products known as free radicals and reactive oxygen species (ROS) which results into DNA damage in exposed animals. Although ROS are produced under normal physiological conditions, but become pernicious when not being eliminated (Chanda and Dave, 2009). However, some natural antioxidants have been employed to ameliorate oxidative stress to enhance overall performance of animals despite the consistent climatic change. A few of such antioxidants are lycopene and *Tetracarpidium conophorum* (Mull. Arg. Hutch & Dalziel.) leaf (TCL). A study conducted by Sahin *et al.* (2008) showed that lycopene-rich tomato powder improved feed intake, weight gain, and reduced concentration of malondialdehyde (MDA) in muscles, liver, and serum of Japanese quail raised under heat stress

Also a study conducted by Nwaoguikpe *et al. (*2012A) on *Tetracarpidium conophorum* has revealed that ingestion of its seeds improves protection against proliferous diseases, and the leave extract promotes fertility. advancing spermatozoa count in male animals. However, there is limited information on the effect of different concentrations of plant extracts on tissue structure, despite the outward improved performance shown by the animal models used for different experiments. That is why this study is designed to determine the effect of different concentrations of lycopene and TCLE on the organ weights and testis histology of experimental animals.

MATERIALS AND METHODS

Study Area

This study was carried out at the Broiler Unit of Teaching and Research Farm of the Faculty of Agriculture, Kwara State University Malete, Moro Local Government Area, Kwara State, Nigeria located within Guinea Savannah ecological zone with average day time temperature of 30-38°C in the dry season and relative humidity of 55-75% with latitude 8.7082N and longitude 4.4723E.

Experimental Animal, Management and Design

Reproductively matured cockerels, aged 30 weeks old (n=54) were used for this experiment. The birds were procured from a reputable farmer within

Kwara State. The birds were individually wing-tagged for identification purpose and housed accordingly. The birds were given feed *ad-libitum* with commercial breeder mash containing 17.5% crude protein and 2700kcal metabolizable energy. Clean water was supplied *ad- libitum*. Medications and vaccinations were done as required. The cockerels were given a 2-week period to acclimatize physiologically to the environment before commencement of data collection. There were nine (9) treatments with each treatment replicated 3 times with 2 birds per replicate in a complete randomized design. Birds in treatments 1-8 (T1-T8) were subjected to an external heat source through the use of wooden charcoal after grouping them in treatments and partition the cubicle to achieve an average temperature of the pen (38±2^{O}C), while birds in T9 was given a source of temperature coolant to enhance a reduced temperature of about 25±2^{O}C as well as cold water of about 5-7^{O}C both from 08.00 hours till 02.00 hours throughout the period of the experiment.

The treatments include the following;
T1: 0 ml of extract / 250 ml of water, T2: 7.5 ml of lycopene / 250 ml of water
T3: 15 ml of lycopene / 250 ml of water, T4: 7.5 ml of TCLE / 250 ml of water
T5: 15 ml of TCLE / 250 ml of water, T6: 7.5 ml of lycopene + 7.5 ml of TCLE / 250 ml of water, T7: 15 ml of lycopene + 15 ml of TCLE / 250 ml of water, T8: Vitamin C 0.1 g per 250 ml of water (control), T9: Cold temperature + Cold water (5-7^{o}C).

Sample procurement and preparation

Bright red tomatoes (*Solanum lycoperisicum*. L) were purchased from Ipata market, Ilorin, Kwara State. The tomatoes were washed under running stream of water to remove dirt, dust and foreign materials. De-heading and trimming of the tomatoes were carried out manually using a knife. These were processed into tomato paste following the protocols described by Daugthy (1995). Tomato paste was cooked for several hours and reduced to a thick, red concentrate. Likewise, fresh sample of *Tetracarpidium conophorum* leaves were obtained from the environs of Ore in Ondo State, Nigeria. The leaves were cleaned and air dried and pulverized for subsequent usage.

Extraction of lycopene

This involved the simple application of N-hexane and acetone to the tomato paste samples for lycopene extraction as adopted by Roldan-Gutierrez *et al.* (2007). The tomato paste was properly homogenized for efficient extraction of lycopene. 20g of each sample was taken in the 250mL of the conical flask. Samples were extracted overnight in the orbital shaker with the solvent mixture of 200mL of hexane and acetone in the ratio of 75:25 respectively at room temperature. The extract from each flask was filtered with Whatman No. 1 filter paper. The solvent from extract was separated at 50°C in a rotary vacuum evaporator (EYELA, N-N series, Japan) leaving behind crude extract only. The crude extract of each sample was stored at 4°C until use.

Preparation of Extract from TCLE

The freshly collected *Tetracarpidium conophorum* leaves were separated, air dried, and milled into powder using a hammer mill. 542.6 g powdered plant material is added to 2713 ml of ethanol and kept in conical flask, the mouth of the conical flask was covered with aluminum foil and kept in a reciprocating shaker for 24 hours for continuous agitation at using rotatory mechanical shaker with 150 rev/min for thorough mixing and also complete elucidation of active materials to dissolve in the respective solvent. Then extract was filtered by using muslin cloth followed by Whatman filter paper. The solvent from the extract was removed using rotary evaporator at 75^{0}C and placed in the water bath of 50^{o}C. finally the residue was collected and used for the experiments.

Organ weight Determinations

Cockerels were selected per treatment for histopathological investigation. The dissection was carried out as described by Byanet *et al.* (2008). All animals were anaesthetized with formalin solution. An incision was made from the first cervical region up to the pelvic region. The specimens' liver, kidney, lung, heart, and spleen, both left and right testes were carefully removed, weighed of bird was obtained using a digital weighing balance various measurements of weight were taken. Sections were immediately fixed in neutral buffered formalin for further investigation.

Histopathological examination

Histopathological examination was carried out using the method of Aliyu *et al*. (2007).

HPLC Quantification/Analysis of Lycopene

Lycopene was analysed using reversed-phase high performance liquid chromatography using isocratic elution and UV detection at 472 nm (Waters, Zellik, Belgium).

Total lycopene was quantified by summing the peak area of all lycopene and the Z isomers and based on the standard curve of all lycopene (Lee and Chen, 2001).

Statistical Analysis

Trt	Liver (g)	Kidney (g)	Spleen (g)	Heart (g)	Testis vol. (ml)	L/T (g)	R/T (g)	Repro(g)	LUNG (g)
1	1.07±0.24	0.30±0.06	0.10±0.00	0.43±0.06	1.01±0.11	0.50±0.03	0.46±0.08	1.00±0.09	0.44±0.13
2	1.41±0.32	0.37±0.02	0.12±0.03	0.30±0.17	1.10±0.77	0.49±0.38	0.47±0.36	1.05±0.80	0.54±0.05
3	1.27±0.20	0.58±0.38	0.11±0.02	0.55±0.04	1.37±0.13	0.64±0.06	0.67±0.14	1.31±0.22	0.49±0.19
4	1.12±0.19	0.29±0.04	0.10±0.02	0.41±0.09	1.02±0.07	0.51±0.03	0.490.05	1.05±0.10	0.42±0.08
5	1.29±0.07	0.36±0.05	0.10±0.03	0.46±0.09	1.29±0.20	0.56±0.06	0.54±0.07	1.18±0.15	0.50±0.10
6	1.34±0.34	0.34±0.08	0.09±0.01	0.43±0.11	1.26±0.44	0.54±0.37	0.54±0.30	1.20±0.58	0.55±0.17
7	1.08±0.07	0.33±0.07	0.10±0.01	0.51±0.17	1.42±0.34	0.61±0.16	0.67±0.26	1.39±0.41	0.64±0.15
8	1.17±0.18	0.25±0.01	0.10±0.03	0.38±0.08	0.96±0.18	0.45±0.07	0.43±0.09	1.03±0.18	0.39±0.09
9	1.04±0.21	0.35±0.11	0.08±0.03	0.43±0.08	0.97±0.07	0.49±0.03	0.44±0.01	1.04±0.11	0.49±0.07
	NS	NS	NS	NS	NS	NS	NS	NS	NS

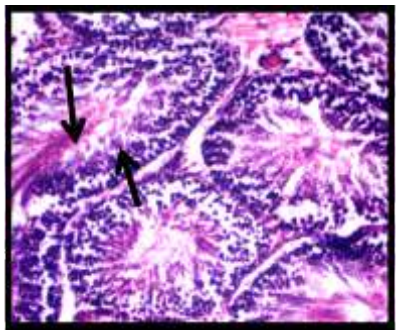
NS =not significant, Trt = Treatment, R/T = Right testis, L/T= Left testis, Repro= Reproductive system, T1=0ml of extract / 250ml of water, T2= 7.5ml ml of lycopene / 250ml of water, T3=15ml of lycopene / 250ml of water, T4= 7.5mlin of TCLE / 250ml of water, T5=15ml of TCLE / 250ml of water, T6=7.5ml of lycopene + 7.5ml of TCLE / 250ml of water, T7=15ml of lycopene + 15ml of TCLE / 250ml of water, T8=Vitamin C 0.1g per250ml of water, T9= Cold temperature + Cold water 5°C

Effect of lycopene and TLCE on the histopathology of heat-stressed cockerels

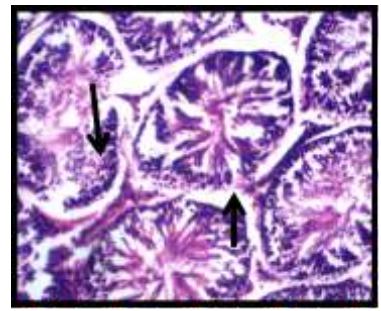
Effect of experimental inclusions on testis histology

The result of the testis histopathology showed that:

In Treatment 1, Plate A, there is normal histomorphology with typical seminiferous tubule containing different types of germ cells; spermatogonia lying on basement membrane (BM) with other cells proliferating in a centripetal direction., the transverse section of testis shows an abnormal widening of interstitial spaces (IS). (H and E x100). However, in Treatment 2, Plate B, the transverse sections testis shows a normal histomorphology with typical seminiferous tubule with an increase of interstitial spaces and increased intracellular spaces of the seminiferous tubules. The transverse section of testis shows a normal histomorphology with typical seminiferous tubule but with intercellular space. (H and E x100)



A Plate A: Photomicrograph of testis of the cockerels given control diet (0 ml of extract / 250 ml of water).



B Plate A: Photomicrograph of testis of the cockerels given control diet (7.5 ml of lycopene / 250 ml of water).

The result of the testis histopathology cockerels in Treatment 3 and 4, represented as Plate C and D respectively showed that the transverse section of testis had abnormal widening of interstitial spaces (IS) with degeneration of interstitial cells and increased intracellular spaces of the seminiferous tubules (H and E x100)

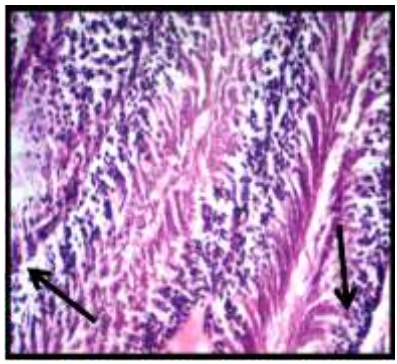


Plate C: Photomicrograph of testis of the cockerels given control diet (15 ml of lycopene / 250 ml of water)

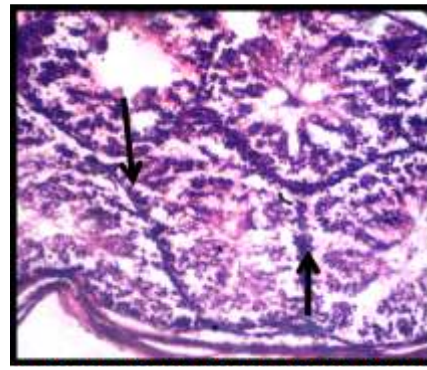


Plate D: Photomicrograph of testis of the cockerels given control diet (7.5 ml of TCLE / 250 ml of water)

The photomicrographs of chickens given 15 mls TCLE (Treatment 5) and 7.5 mls lycopene + 7.5 mls TCLE (Treatment 6), as shown in Plate E and F respectively. Observation shows that there is a normal histomorphology with typical seminiferous tubule with maintained integrity, but with increase of interstitial spaces. containing different types of germ cells; spermatogonia lying on basement membrane with other cells proliferating in a centripetal direction.

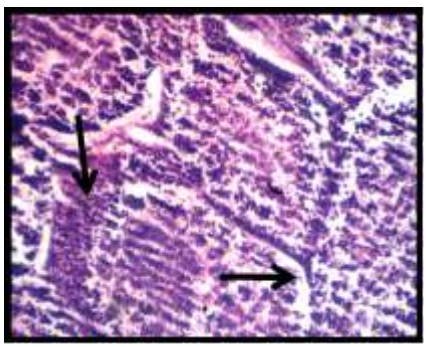


Plate E: Photomicrograph of testis of the cockerels given 15 ml of TCLE / 250 ml of water

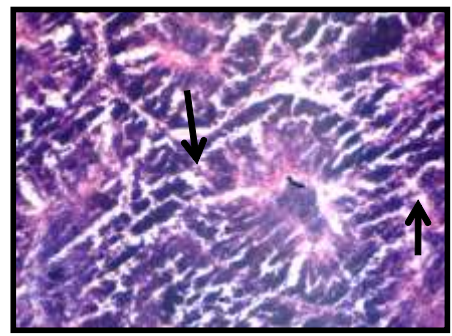


Plate F: Photomicrograph of testis of the cockerels given 7.5 ml of lycopene + 7.5 mls TCLE / 250 ml of water

In Treatment 7, Plate 7G, there is an increased interstitial spaces and intracellular spaces of the seminiferous tubules. However, in Treatment 8,

Plate 8H, an abnormal widening of interstitial spaces (IS) was noticed, with degeneration of interstitial cells with increased intracellular spaces of the seminiferous tubules.

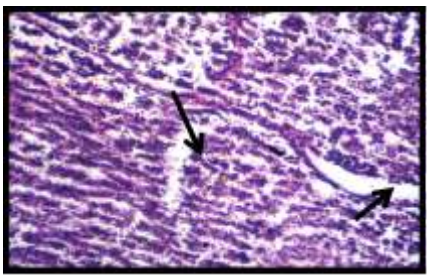


Plate G: Photomicrograph of testis of the cockerels given 15 ml of lycopene + 15 mls TCLE / 250 ml of water

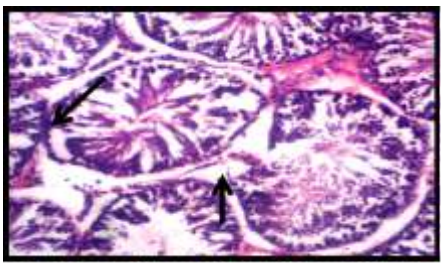


Plate H: Photomicrograph of testis of the cockerels given 0.1 g vitamin C/250 ml of water)

It was recorded in Treatment 9 (Plate I) that there is seminiferous tubule with maintained integrity but with increase of interstitial spaces. Normal histomorphology with typical seminiferous tubule containing different types of germ cells was also noted and spermatogonia lying on basement membrane with other cells proliferating in a centripetal direction was also recorded. (H and E x100)

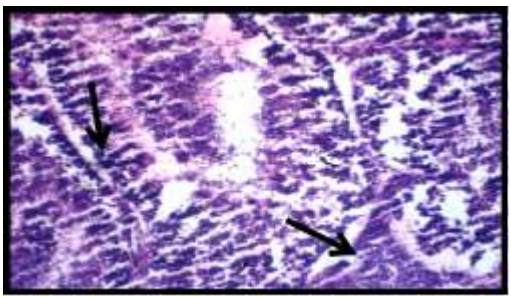


Plate I: Photomicrograph of testis of the cockerels given Cold water +reduced micro environmental temperature

DISCUSSION

The abnormal widening of interstitial spaces and degeneration of interstitial cells and lumen observed in plate A, similar to plate H (Control-Vitamin C treatment) could be an indication of depletion in the spermatogenic cell layers of the seminiferous tubules in the testis which led to larger lumens of the seminiferous tubules and fewer germ cells. The interstitial cells consist of leydig cells, fibroblast, collagenous fibres and reticular fibres, lymphatic vessels and blood vessels. Interstitial cells are responsible for the secretion of testosterone, hence their degeneration could lead to reduced secretion of testosterone by these cockerels and negatively affect their reproductive performance. Testosterone is a reproductive hormone necessary for the development of primary sexual development, testicular descent, spermatogenesis, enlargement of the penis and testes, and increasing libido (Nasar, 2021). A deviation from the normal concentration of this hormone could adversely affect reproduction. The result of this study is in tandem with the findings of Shaugnessy et al. (2008) who treated adult rats with busulfan to remove the germ cell population and ablate leydig cells in the seminiferous tubule, after which he observed a significant depression in the testosterone levels within 24 h of treatment. Also, it can be observed that some spermatozoids were present in the luminal space of seminal tubes. Hence, a degenerated lumen might have caused the death of matured and immature spermatozoa resulting in infertility and low reproductive performance (Ojobor *et al.,* 2017). The result in this study also correspond with the findings of Orji *et al.* (2018) who reported an attenuated testicular damage in rat given Vitamin C.

Observation shows that cockerels on T2 (plate B) which received the administration of lycopene at 7.5 ml/250 ml of water led to increase in both the interstitial spaces and intracellular spaces of the seminiferous tubules compared with birds on T8, who recorded abnormal widening of interstitial spaces and degeneration of interstitial cells of the seminiferous tubules. The number and density of spermatozoids cells in the lumen area of the seminal tubes are more in T2 (Plate B). This indicated an increased production of sperm cell and the associated hormone (testosterone). The number of spermatozoids is related to the spermatogenesis process, which is also influenced by the testosterone hormone. Increased testicular interstitial and intracellular space in the cockerel's testis indicated an accelerated blood flow

and the level of testosterone hormone, which resulted in improved spermatogenesis in the testicle and concomitant increase in fertility. It has been reported that lycopene protect cells and tissue damage caused by ROS (Palozza *et al.,* 2011) and has been ranked as more potent in this activity compared to other carotenoids. This finding is in line with the report of Hamzehnezhad *et al.* (2019), Morakinyo *et al.* (2008) and Bordbar *et al.* (2013). Cockerels given T3, (Plate C), T4 (Plate D), T5 (Plate E) and T6 (Plate F) respectively showed a similar form of abnormal widening of interstitial spaces with degeneration of interstitial cells and with increased intracellular spaces of the seminiferous tubules. This is similar to what was obtained in control group (T8 (Plate H). This might be due to increased lycopene content beyond the requirement of the cockerel, thereby affecting the cockerel negatively as it was recorded to lead to degeneration of interstitial cells and widening of interstitial spaces. These changes are consistent with testicular degeneration observed by Foster and Ladds (2007). Cockerels in T7 (plate G) showed appreciable normal histomorphology with increased interstitial spaces and intracellular spaces of the seminiferous tubules, contrary to what was obtained in T8, indicating that the combination of lycopene and TCLE at 15 ml each can be used to improve the reproductive capability of the cockerels as there was no record of abnormality in the testis. This is consistent with the report of Ojobor *et al.* (2017), who observed normal histomorphology of testis with increased interstitial connective tissue and robust seminiferous tubular lumen containing sperm cells in rat after been administered orally with *T. conophorum* leaf extract. It can also be observed that feeding cockerels with Vitamin C (T8) might not improve the sperm cell production capability of the cockerel as it failed to cushion the occurrence of abnormal widening of interstitial spaces and degeneration of interstitial cells of the seminiferous tubules. This suggest that Vitamin C might not be a suitable additive to ensure improved production of quality spermatozoa by the seminiferous tubules of the cockerel's testis. Orji *et al.* (2018) also reported a scanty germinal cells in the epithelium of seminiferous tubules and empty spermatids in some part of seminiferous tubules in rat given Vitamin C. Occurrence of normal appearance without abnormal widening of interstitial spaces and degeneration of interstitial cells in cockerel given T9 (plate I) showed that birds in cool environment and with cold water normally experience less heat stress and are able to perform better than those that are

heat-stressed. This is similar to the report of Hussain *et al.* (2011) who observed normal diameter of seminiferous tubules with no degeneration of interstitial cells but with presence of spermatogonia cells and spermatocytes in broiler subjected to cool and controlled environment with fresh cool water.

CONCLUSION AND RECOMMENDATION

Inclusion of lycopene and TCLE at the experimental dosage levels adopted in this study did not induce any significant cellular damage of the testis in the experimental birds. Hence, the dietary treatments especially at 15 ml of lycopene + 15 ml of / 250 ml of water could be regarded as safe for medicinal use. Also, 15 ml of lycopene / 250 ml of water (T3) can be given to the birds as they gave better testicular structure.

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Growth Pattern and *in vitro* Antibacterial Activity of Some Cultivated Herbs against Fish Pathogenic and Food Poisoning Bacteria

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ABSTRACT

The global concerns on the deleterious effect of synthetic antimicrobials in the production of food animals call for suitable and sustainable natural alternatives, one of which is the use of herbal products. This study aimed to investigate the growth pattern of some herbs of medicinal values and their antibacterial potentials against some fish pathogenic and food poisoning bacteria, compared with Aquamedics (a synthetic antibiotic) using agar well diffusion assay. The results showed that the number of leaves produced in *Euphorbia hirta* was more than the leaves produced in *E. hererophylla*; notwithstanding, *E. heterophylla* was higher than *E. hirta*. *Ocimum gratissimum* showed similar pattern of growth with *E heterophylla* during the first 8 weeks while *Phyllanthus amarus* is characterized with production of higher number leaflets at the early growth stages. All the herbal extracts investigated showed presence of flavonoids and tannins. The ethanol *E. hirta* extract (EHE) and *Jatropha gossypiifolia* extract (JGE) exhibited significantly higher ($P < 0.05$) zone of inhibition against *Pseudomonas aeruginosa* and *P. fluorescens*, compared to other extracts and Aquamedics. The JGE also had higher zone of inhibition against *Aeromonas hydrophila* (26.67mm), and *Streptococcus agalactiae* (25.67mm) compared to Aquamedics (22.33mm) and other extracts while EHE, *E. heterophylla* and *Moringa oleifera* exhibited similar zones of inhibition, 23.67mm, 23.00mm, 21.67mm, respectively, compared with 22.33mm obtained for Aquamedics against *A. hydrophila* . The methanol extracts of JGE, EHE and *P. amarus* extract also exhibited higher zone of inhibition against *P aeruginosa*, compared to other extracts and the synthetic antibiotic. However, the synthetic antibiotic demonstrated

higher zone of inhibition than the aqueous extracts of the herbs, except EHE which had similar inhibitory activity with Aquamedics against *P. fluorescens*. On the over all, the ethanol extracts seemed to have more potent antibacterial activity than other extracts. The present study has demonstrated the moderately inhibitory activities of the ethanol and methanol extracts of *Euphorbia* species, *J. gossypiifolia* and *P. amarus* against the food poisoning *Pseudomonas* species and pathogenic *A. hydrophila* and *S. agalactiae*. These extracts are therefore recommended for utilization and further *in vivo* study as herbal antibacterial agents for fish health management and fish preservation.

Keywords: Growth pattern of herbs, phytochemicals, fish pathogens, zone of inhibition

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INTRODUCTION

The continuous rise in the cost of feed ingredients in the production of farmed terrestrial and aquatic animals is a major concern in animal husbandry as well as losses arising from diseases, most especially bacterial diseases of aquaculture species (Hardi *et al*., 2019). Chemotherapeutic agents are often used as additives for prophylactic, therapeutic measures and to promote production. However, the continuous utilization of these synthetic drugs makes the residues to remain in the tissues of food fish and other animal products, with the resultant deleterious effects such as development of resistant pathogen strains which can be transferred from fish and other animal products to humans resulting in immune suppression, destabilization of helpful bacterial populations as well as the environmental pollution (Sajid *et al*., 2011; Gent *et al*., 2012; Aly and Albutti, 2014; Reverter *et al*., 2017; Santos and Ramus, 2018). Hence research into suitable organic alternatives to the synthetic drugs for sustainable fish production is crucial.

In the recent decades the global scientific communities have focused on the utilization of natural alternatives to the synthetic drugs in the production of fish or livestock meant for consumption; including prebiotics, probiotics, organic acid and phytobiotics (herbal products). Out of these alternatives, herbal products seem to be the best because they are naturally and readily available, accessible, less expensive, easily produced and tend to be more biodegradable compared to synthetic drugs (Olusola *et al*., 2013; Reverter *et al*., 2014). The utilization herbal-based extracts for prophylactic or chemotherapeutic for various fish diseases has been considered to be best alternative for controlling the spread of bacterial infection by increasing the fish immunity and the innate behavior of fish (Reverter *et al*., 2014, Adeniyi et al., 2017; Abdel-Tawwab *et al*., 2018). Earlier studies on the utilization of medicinal plants such as caraway (Ahmad and Abdel-Tawwab, 2011), walnut and onion (Bello *et al*., 2012) *Aloe vera* (Mahdavi *et al*., 2013), Roselle (Adeyemo, 2014), fluted pumpkin (Dada, 2015), cotton leaf (Adeniyi and Lawal, 2017), tamarind (Adeniyi *et al*., 2018a, 2018b), *Garcinia kola* (Nyadjeu *et al*., 2019), lemon (Adeniyi, 2020) have shown that this alternative has growth-promoting and/or immune-stimulating potentials. The availability and accessibility of these plants herbal products at commercial level is crucial for sustainability of organic farming of fishes and terrestrial animals. Although several attempts have been made to investigate both *in vitro* and *in*

vivo antimicrobial potential of herbs on both human and fish pathogens (Oluwafemi and Debiri, 2008; Najiah *et al*., 2011; Panda and Ray, 2012; Pedge and Ahirrao, 2012; Bello *et al*., 2013; Kalsom *et al*., 2013; Adeniyi *et al*., 2017; Adeshina *et al*, 2018; Adeniyi, 2020). *Euphorbia hirta, E. heterophylla, Jatropha gossypiifolia, Ocimum gratissimum, Moringa oleifera, Phyllanthus amarus, Senna alata, Tithonia diversifolia*, and *Vernonia amygdalina* are herbal plants belonging to the families Euphorbiaceae, Lamiaceae, Moringaceae, Phyllanthaceae, Fabaceae, and Asteraceae that are widely utilized owing their significance in ethnomedicine, but with paucity of scientific information on their cultivation and antibacterial effects on aquatic pathogenic microbes. Therefore this study aimed to investigate the *in vitro* antimicrobial potential of *E. hirta, E. heterophylla, J. gossypiifolia, O. gratissimum, M. oleifera, P. amarus, S. alata, T. diversifolia*, and *V. amygdalina* against *Aeromonas hydrophila, A. salmonicida, Pseudomonas aeruginosa, P. fluorescens, Streptococcus agalactiae, Staphylococcus aureus* and *Escherichia coli.*

MATERIALS AND METHODS

Cultivation of herbal plants

The seed / stem of the herbs used for planting were locally sourced around the villages and towns in Kwara State and cultivated on an herbal garden section of an integrated homestead farm in Ilorin, in the Southern Guinea Savannah agro-ecological zone of Nigeria. The land was cleared, beds were manually prepared and hoe weeding was done as at when due. Each plot size measured 5.0 m × 5.0 m with 0.5 m in-between plots and 1.0 m in-between blocks. Poultry manure was applied during land preparation by incorporation into the soil at the rate of 5 tons/ha at two weeks before planting. Herbal plants were planted at their respective plant spacing in a randomized complete block and replicated three times. All the cultivated herbal plants, except *Vernonia amygdalina* were propagated by seed. The *E. hirta*, *E. heterophyla* and *P. amarus* were planted by drilling between rows at 20 cm for *E. hirta* and 30 cm for the other 2 herbs. Details of the planting are presented in Table 1.

Table 1: Details of planting of herbal plants

Herbal plants	Method of propagation	Seed rate	Spacing	Plant population/ha
Euphorbia hirta	Seed	5kg	20 cm	NA
Euphorbia heterophylla	Seed	5kg	30 cm	NA
Ocimum gratissimum	Seed	NA	60 cm × 30 cm (+)	55,555
Phyllanthus amarus	seed	NA	30 cm	NA
Senna alata	Seed	NA	60 cm × 60 cm (+)	27,777
Vernonia amygdalina	Stem	NA	60 cm × 60 cm (+)	27,777

+ = One plant per stand, ++= Two plants per stand, NA = Not applicable

Soil analysis

Composite soil sample at the experimental site at 0-20 cm depth were collected in a zig-zag pattern before planting and taking to the laboratory to determine the physical and chemical properties. Soil particles were analyzed using the hydrometer method (Bouyoucous, 1962 modified by Gee and Bauder, 1986). The soil sample was air-dried in the laboratory and sieved with 2 mm diameter mesh. Soil pH was determined using glass electron pH meter in 1:2 soil / water ratio, hence ten grams (10g) of the soil sample was weighed into 100mL beakers (in duplicate) and 20mL distilled water was added; Each beaker was stirred several times for about 30 minutes. The pH of the samples was measured by immersing the glass electrode pH into the clear solution on to suspension. Care was taken not to stir the suspension before taking the pH measurement. The soil total nitrogen was determined using the Kjeldahl digestion method as described by Bremner and Mulvaney (1982), which involved digestion, distillation and titration: 10g of the air-dried and sieved soil sample was weighed into 250 mL digestion flask and gently mixed with 100 mL HCl was added; the mixture digested at for 1 hour at 420^{o}C using an automated digestor (8 Holes, Foss Tecator digestor, Denmark), allowed to cool for 20 minutes and then Kjeltec auto distillation unit (Kjeltec 8200, Denmark). The distillate was then titrated with standardized hydrochloric acid (HCl) using titrator dispenser (Solarus $^{(R)}$ Hischmann Laborgerate GmbH and Co. KG., Germany). Titre value was also determined for Blank (B) of each batch. The total nitrogen (%) was estimated using the formula below:

Total nitrogen (%) = 100 x [(T – B) x N x 14.007] / W (mg)

Where, T=Titre value of sample, B=Titre value of blank, N=0.1(Normality of acid), and W=Weight of sample

Available P was determined by Bray 1 method (Anderson and Ingram, 1998): 2g of the air-dried and sieved soil sample was weighed into 250 conical flask. 30 mL of $HClO_4$ was added and digested on a hot plate in the fume cardboard at 130°C until solution became clear. As digested was completed, fume $HClO_4$ appeared and soil residue become white, the flask was removed from the hot plate and allowed to cool to room temperature. 50 mL of distilled water was added and filtered into 100 mL standard flask and phosphorus was determined colometrically. Total soil organic carbon was determined using the acid dichromate wet-oxidation procedure described by Walkley and Black (1934), in which 1g of the sample was put into 250mm conical flask, followed by addition of 100mL 0.167M Potassium dichromate (vi) and 20mL concentrated H_2SO_4; the flask was then swirled gently until the soil and reagent were thoroughly mixed and vigorously swirled for one minute and allowed to stand on a sheet of asbestos for about three minutes; 10mL distilled water was then added, followed by three drops of ferroin indicator and titrated with 0.5M Iron (vi) ammonium sulphate. The titre value was recorded when colour changes from green through blue to red moron; the titre value was multiplied by 1.33 to give percentage organic carbon. Exchange bases were extracted with neutral ammonium acetate solution buffered at pH 7.0, using the method of Anderson and Ingram (1998) as described by Adeoye and Agboola (1985): briefly, 10g of the air dried and sieved soil sample was weighed into conical flask, and 100mL ammonia acetate was added, the mixture was put on mechanical shaker for one hour, filtered and made up to 100 ml with ammonium acetate. Exchangeable bases: calcium, magnesium, potassium and sodium were determined from the filtrate by atomic absorption spectrophotometer. The cation exchange capacity of the soil was determined with 1M NH_4OAc (1M ammonium acetate), buffered at pH 7.0 (Rhoades, 1982).

Plants and extraction

The shoots of *E. hirta*, *E. heterophylla*, *and P. amarus* were harvested at 8 weeks to obtain the leaves and seeds while the leaves of *J. gossypiifolia*, *O.*

gratissimum, *M. oleifera*, *S. alata*, *T. diversifolia*, and *V. amygdalina* were harvested at 12 weeks; rinsed with clean water, drained and air-dried under shade in the laboratory for 14 days. Each of the dried herbal materials was blend into uniform powder using a kitchen blender machine and labeled. A known weight of each herbal material was added to the solvents at a ratio of 1:10 (weight/volume), using distilled water, ethanol and methanol (Ghassan *et al*., 2012; Adeniyi *et al*., 2017) to obtain three different extracts for each herb. Each of the blend herbal materials was folded in filter paper, immersed in the solvent and extracted using Soxhlet apparatus for 6 hours. After 6 hours of extraction, each crude extracts were concentrated, using rotary evaporator (IKA® RV10 digital, Artisan Technology Group, Champaign, USA). The resulting concentrated crude extracts of each herb were labeled accordingly and kept in freezer until they are used for the antimicrobial and phytochemical screening.

Qualitative phytochemical screening

The extracts was screened for phytoconstituents such as alkaloids, cardiac glycosides, flavonoids, saponins, steroids, tannins and terpenoids qualitatively, following the description of Trease and Evans (1996) and Sofowora (1993). Concisely, each of the concentrated extracts of the herbs was tested for the following phytochemical as follows:

Test for alkaloids

Two (2) mL of 1% HCl was used to dissolve 0.5g of each extracts and heated gently; Wagner's reagent was added to the mixture. Turbidity of the mixture with reddish brown precipitate revealed presence of alkaloids.

Test for cardiac glycosides

Keller-Kiliani test was used: To 0.5g of each of the extracts diluted to 5 mL in water was added 2 mL of glacial acetic acid, containing one drop of 2% $FeCl_3$ solution: this was underlayed with 1 mL of concentrated H_2SO_4. A brown ring at the interface indicated the presence of cardiac glycosides.

Test for flavonoids

Two (2) mL of 2% of sodium hydroxide (NaOH) was mixed with 0.5g of each extract; thereafter 1 mL of concentrated tetraoxosulphate (VI) acid (H_2SO_4) was added. A yellow colouration indicated the presence of

flavonoids.

Test for saponins

Five (5) mL of distilled water was use to dissolve 0.5g of each extracts in a test tube and mixed vigorously. Three drops of olive oil was added to the frothing and another vigorous mixing was done. The appearance of foam showed the presence of saponins.

Test for steroids

Ten (10) mL anhydrous chloroform was used to dissolve 0.5g of each extracts and filtered. The filtrate was mixed with 1mL of acetic anhydride followed by the addition of 1mL concentrated concentrated tetraoxosulphate (VI) acid (H_2SO_4) down the side of the test tube to form a layer underneath. The test tube was observed for green colouration which indicates presence of steroids.

Test for tannins

0.5g of each extracts was boiled in 10 mL of distilled water in a test tube. One (1) mL of 10% alcoholic iron (III) chloride ($FeCl_3$) was added and observed for brownish green colouration.

Test for terpenoids

Two (2) mL of chloroform was added to 0.5g of each of the concentrated extracts; thereafter c3 mL of concentrated H_2SO_4 was carefully added to form a layer. A reddish brown colouration at the interface indicated the presence of terpenoids.

***In vitro* antibacterial screening**

Organisms

The preserved stocks of pure isolates of *Aeromonas hydrophila*, *A. salmonicida*, *Pseudomonas aeruginosa*, *P. fluorescens*, *Streptococcus agalactiae*, *Staphylococcus aureus* and *Escherichia coli* obtained from the Microbiology Unit of University of Ibadan Teaching Hospital were used for the study

Preparation of isolates

The bacteria were sub-cultured on nutrient agar (Oxoid, Hampshire, England) from the preserved slants and then grown in peptone water

(Oxoid, Hampshire, England) for 24 hour before use. The 24-hour old of each of the test organisms was standardized to 0.5 McFarland standards (1×10^6 CFU/ml) following the description of Clinical and Laboratory Standard Institute (CLSI, 2012).

Preparation of extracts

Each of the concentrated extracts of the herbs was dissolved in the solvents (distilled water, ethanol or methanol) used for extraction to produce the desired concentration of 10mg/mL (extract/solvent) (CLSI, 2012; Adeniyi *et al*., 2017).

Agar well diffusion assay

The zone of inhibition was determined using the description of CLSI (2012) using agar well diffusion assay. Concisely, Mueller-Hinton agar (Oxoid, Hampshire, England) was prepared according to the manufacturer's description, sterilized, allowed to cool to room temperature and poured into plates to about 4mm depth under an aseptic condition and allowed to solidify. Thereafter, about 100µL of each standardized isolate suspensions were spread on the Mueller-Hinton agar plates in triplicates. Three wells were bored on each plate with a sterile 6mm diameter core borer; 100 µL of each of the crude extracts of the herbs at 10mg/mL of the three solvents were introduced into the wells in three replicates, allowed to stand at room temperature for about 30 minutes. Controls were also set up in parallel using the solvent used for extraction as well as synthetic antibiotic (Aquamedics) containing oxytetracycline and erythromycin. The plates were incubated at 37°C for 24 hour and observed for zones of inhibition diameter. The zones of inhibition (mm) of the each of the aqueous, ethanol and methanol extracts of the nine herbs were measured with plastic transparent ruler and recorded.

Statistical analysis

Data obtained on growth pattern were analyzed using descriptive statistics, while the data on antibacterial activity were subjected to one way analysis of variance using SPSS (Statistical package for social sciences IBM SPSS Statistics for Windows, IBM Corp., Version 23, Armonk, NY) software while Duncan multiple range test was used to compare differences among means at 5% probability.

RESULTS

Physicochemical analysis of soil of the experimental sites and poultry manure

The physicochemical components of soil sample from the experimental site and poultry manure is presented in Table 2. The soil reaction is slightly acidic, sandy loam in texture, the percentage nitrogen and phosphorous are low. Poultry manure was on the other hand very strongly alkaline in nature with very high organic matter content and available phosphorus. The soil and poultry manure are low in exchangeable calcium with very low exchangeable magnesium. The values of the physicochemical parameters of the poultry manual were generally higher than that of the experimental soil sample.

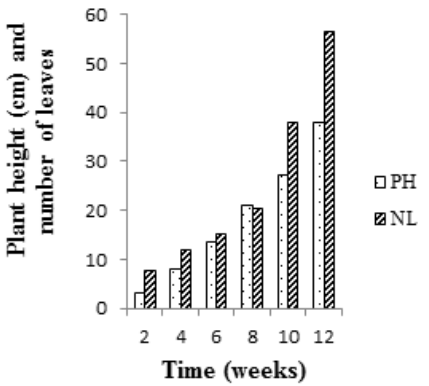
Meteorological conditions during the experimental period

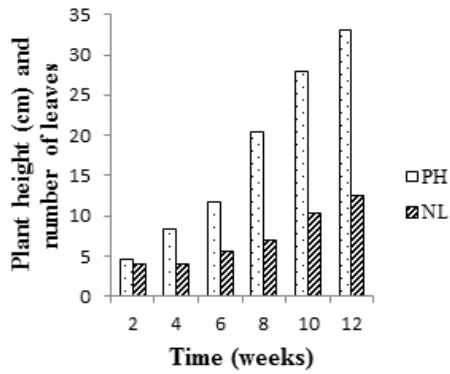
The meteorological information between April and December at the experiment sites is presented in Table 3. The rainfall during the experimental period (June – September) ranged from 40.7-150.2mm. The rainfall was very high in May, but fall drastically between June and August, while the highest was in the month of September and ceased in October. The average air temperature and relative humidity were 24.54 and 76. 03, respectively.

Table 1: Physicochemical analysis of soil and poultry manure of the experimental site

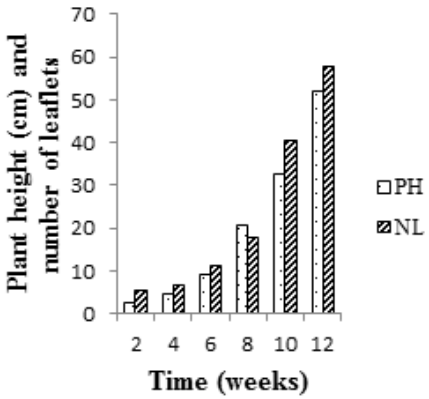
Parameters	Soil	Broiler manure
pH (H_2O)	6.15	10.47
Organic Carbon (%)	1.63	3.48
Organic Matter (%)	2.81	6.01
Textural Class	Sandy loam	-
Nitrogen (%)	0.19	1.26
Available Phosphorus (ppm)	4.85	9.41
Exchangeable Calcium (cmol/Kg)	0.285	0.855
Exchangeable Magnesium (cmol/Kg)	0.085	0.090
Exchangeable Sodium (cmol/Kg)	0.028	0.557
Exchangeable Potassium (cmol/Kg)	0.001	0.026
Exchangeable Acidity (cmol/Kg)	0.152	0.136
CEC (cmol/Kg)	0.551	1.664
Base Saturation (%)	72.41	91.83

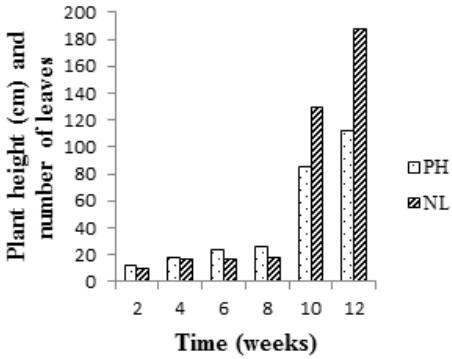
Table 2: Meteorological data for the experimental site





Source: Lower Niger River Basin Development Authority (Hydrological section), Ilorin, Nigeria.





O. gratissimum (Fig. 2b). African basil, *O. gratissimum*, showed slow growth rate at the early growth stages between 2 and 6 weeks after planting, followed by a very sharp growth between 8 and 10 weeks (Fig. 2b). Senna *alata* (Fig. 3a) is characterized with short height but followed normal growth curve, with branching at 6 weeks and numerous broad paripinnate leaves at the older stage. On the other hand, *Vernonia amygdalina* exhibited slow growth rate at 2-8 weeks (Fig. 3b) with considerably higher height but with fewer leaves than *S. alata*. The *S. alata* did not flower while no branching

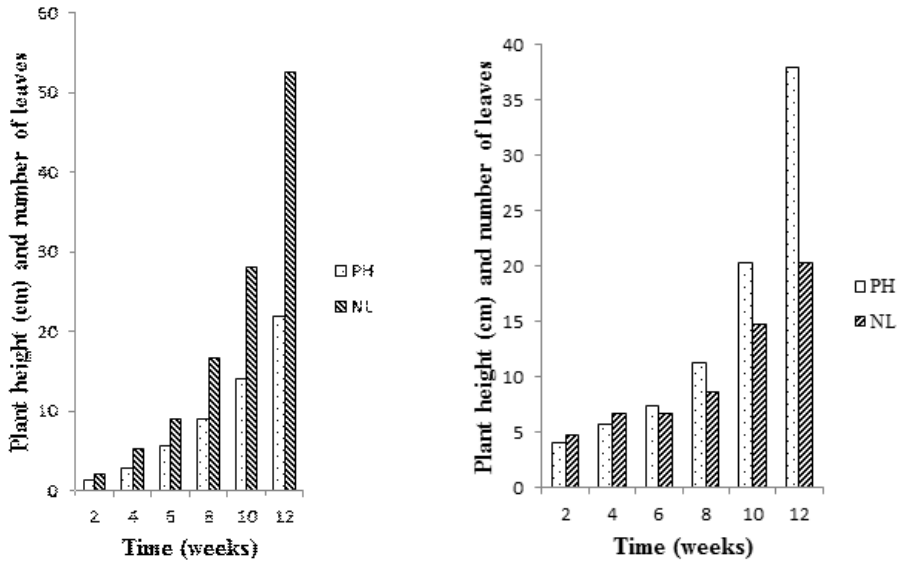


Fig. 3: Plant height (PH) and number of leaves (NL) of *Senna alata* (3a) and *Vernonia amygdalina* (3b) at 2 week's interval after planting

Phytochemical components of the herbs

The phytochemical components of ethanol, methanol and aqueous extracts of the 9 herbs screened in the current study are shown on Table 4. The result showed that saponins, tanins, terpenoids, alkaloids and flavonoids were present in most of various extracts of the herbs. However steroids were absent in *O. gratissimum* and *S. alata* extracts as well as in the ethanol and methanol extracts of *E. hirta*, *E. heterophylla*, *J. gossypiifolia* and *P. amarus*. Alkaloids were also absent in *J. gossypiifolia* extracts and in the aqueous extract of the *Euphorbia* species, while on the other hand, all the extracts contain cardiac glycosides, flavonoids and tannins.

Table 3: Phytochemical components of some herbs using different solvents

Table 3: Phytochemical components of some herbs using different solvents

Herbal plants	Alkaloids			CG			Flavonoids			Saponins			Steroids			Tannins			Terpenoids		
	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A
Euphorbia hirta	−	+	-	+	+	+	+	+	−	+	+	+	-	-	−	+	+	+	+	+	-
E. heterophylla	−	+	-	+	+	+	+	+	−	+	+	+	-	-	−	+	+	+	+	+	+
Jatropha cossuviifolia	-	-	-	+	+	+	+	+	−	+	+	+	-	-	−	+	+	+	+	+	+
Moringa oleifera	−	+	+	+	+	+	+	+	−	+	+	+	+	+	−	+	+	+	+	+	+
Ocimum gratissimum	−	+	+	+	+	+	+	+	−	+	+	+	-	-	-	+	+	+	+	+	+
Phyllanthus amarus	−	+	+	+	+	+	+	+	−	+	+	-	-	-	−	+	+	+	+	+	+
Senna alata	−	+	+	+	+	+	+	+	−	+	+	+	-	-	-	+	+	+	+	+	+
Tithonia diversifolia	−	+	+	+	+	+	+	+	−	+	+	+	+	+	−	+	+	+	+	+	+
Vernonia amygdalina	−	+	-	+	+	+	+	+	−	+	+	+	+	-	−	+	+	+	-	+	+

+ = Present - = Absent CG = Cardiac glycosides E = Ethanol extracts M = Methanol extract A = Aqueous extract

Antibacterial activity of the selected plant extracts

The result of the antibacterial activities of the herbal extracts showing their zones of inhibition against the bacteria in the present study is presented in Tables 5, 6 and 7. Table 5 shows that ethanol *Euphorbia hirta* extract (EHE) and *Jatropha gossypifolia* extract (JGE) exhibited significantly higher ($P < 0.05$) zones of inhibition against *P. aeruginosa*, compared to the synthetic antibiotic. The ethanol extract of JGE also had higher ($P < 0.05$) zone of inhibition against *Aeromonas hydrophila* (26.67mm) and *Streptococcus agalactiae* (25.67mm) compared to 22.33mm obtained for the synthetic antibiotic against both organisms, while EHE, *E. heterophylla* and *M. oleifera* exhibited similar ($P > 0.05$) activities with the synthetic antibiotic against *A. hydrophila*. Also the ethanol extract of *S. alata* seemed to be effective against *A. salmonicida* while JGE, *P. amarus* extract (PAE) and *Vernonia mygdalina* ethanol extracts possess similar ($P > 0.05$) inhibitory effect against *P. fluorescens*, compared to the synthetic antibiotic. On the other hand, higher ($P < 0.05$) zones of inhibitions, 28.67mm and 26.00mm, were obtained from the synthetic antibiotics against *S. aureus* and *E. coli*, respectively, compared to the herbal extracts. The methanol extracts of JGE, EHE and PAE exhibited higher ($P < 0.05$) zone of inhibition against *P aeruginosa*, compared to other extracts and the synthetic antibiotic while on the other hand, EHE and PAE exhibited similar zones of inhibition with the antibiotic against *P. florescens* (Table 6). However, the zones of inhibition of methanol EHE and JGE seemed to be lower than the values exhibited by ethanol extract against the microbes. The aqueous extracts of the herbs exhibited lower ($P < 0.05$) zones of inhibition, except EHE that had similar zone of inhibition with the synthetic antibiotic against *P. fluorescens* (Table 7). On the over all, the ethanol and aqueous extracts showed highest and lowest antimicrobial activity, respectively, against all the microbes with EHE, JGE and PAE as the best 3 extracts with higher antibacterial potential.

Herbal extracts	PA	PF	Strep	SA	EC	AS	AH
Euphorbia hirta	26.33^{a}	25.00^{a}	22.00^{b}	22.33^{bcd}	21.33^{b}	18.33^{d}	23.67^{b}
E. heterophylla	21.00^{cd}	20.00^{c}	15.67^{de}	18.33^{d}	19.33^{b}	19.33^{d}	21.67^{b}
Jatropha gossypiifolia	25.67^{ab}	24.33^{a}	25.67^{a}	25.00^{b}	23.33^{b}	24.67^{ab}	26.67^{a}
Moringa oleifera	20.00^{cd}	19.67^{c}	18.67^{c}	21.00^{bcd}	19.67^{b}	20.67^{c}	23.00^{b}
Ocimum gratissimum	23.33^{abc}	21.00^{bc}	16.00^{d}	21.33^{bcd}	22.67^{b}	21.00^{c}	12.67^{d}
Phyllanthus amarus	22.33^{bcd}	23.33^{ab}	10.69^{f}	24.00^{bc}	21.67^{b}	19.67^{cd}	13.33^{d}
Senna alata	20.00^{cd}	20.00^{c}	16.00^{d}	19.00^{d}	19.33^{b}	26.67^{a}	15.33^{d}
Tithonia diversifolia	19.33^{d}	19.00^{c}	15.33^{de}	24.00^{bc}	21.67^{b}	20.33^{c}	18.33^{c}
Vernonia mygdalina	22.67^{bcd}	24.67^{a}	13.00^{e}	24.00^{bc}	21.67^{b}	20.00^{cd}	15.00^{d}
Antibiotic	19.33^{d}	23.67^{ab}	22.33^{b}	28.67^{a}	26.00^{a}	25.00^{ab}	22.33^{b}

^{a,b,c} Means within a column with different superscript are significantly different ($P < 0.05$).

PA = *Pseudomonas aeruginosa* PF = *Pseudomonas fluorescens* Strep = *Streptococcus agalactiae* SA = *Staphylococcus aureus* EC = *Escherichia coli* AS = *Aeromonas salmonicida* AH = *Aeromonas hydrophila*

Table 6: Zone of inhibition (mm) of herbal methanol extracts (mg/mL) against some fish pathogenic and food poisoning bacteria

Herbal extracts	PA	PF	Strep	SA	EC	AS	AH
Euphorbia hirta	20.67^{a}	21.00^{ab}	20.67^{a}	23.67^{b}	19.67^{b}	19.67^{b}	22.00^{b}
E. heterophylla	14.67^{c}	18.00^{c}	16.67^{bc}	21.33^{b}	14.33^{b}	17.00^{b}	15.67^{de}
Jatropha gossypiifolia	23.00^{a}	19.33^{bc}	23.00^{a}	24.00^{b}	22.67^{a}	23.00^{b}	25.67^{a}
Moringa oleifera	14.67^{c}	17.00^{c}	20.33^{ab}	15.67^{c}	13.00^{b}	13.67^{cd}	18.67^{c}
Ocimum gratissimum	12.67^{c}	13.00^{d}	12.67^{de}	14.33^{cd}	11.33^{b}	16.33^{c}	14.67^{de}
Phyllanthus amarus	21.00^{a}	21.33^{ab}	21.00^{a}	22.33^{b}	19.67^{b}	19.67^{b}	10.67^{f}
Senna alata	14.00^{c}	14.00^{d}	12.67^{c}	14.00^{cd}	12.00^{b}	14.33^{def}	16.67^{d}
Tithonia diversifolia	12.33^{c}	13.00^{d}	11.67^{de}	12.33^{d}	11.00^{b}	14.00^{ef}	13.33^{de}
Vernonia amygdalina	12.00^{c}	12.67^{d}	12.00^{c}	13.33^{cd}	13.33	11.67^{d}	13.67^{ef}
Antibiotic	19.33^{b}	23.67^{a}	22.33^{a}	28.67^{a}	26.00^{a}	22.67^{a}	22.33^{b}

^{a,b,c} Means within a column with different superscript are significantly different (P 0.05).

PA = *Pseudomonas aeruginosa* PF = *Pseudomonas fluorescens* Strep = *Streptococcus agalactiae* SA = *Staphylococcus aureus* EC = *Escherichia coli* AS = *Aeromonas salmonicida* AH = *Aeromonas hydrophila*

Table 7: Zone of inhibition (mm) of herbal aqueous extracts (mg/mL) against some fish pathogenic and food poisoning bacteria

Herbal extracts	PA	PF	Strep	SA	EC	AS	AH
Euphorbia hirta	16.00^{cd}	25.00^{a}	13.33^{b}	14.67^{b}	17.00^{b}	12.33^{c}	13.00^{c}
E. heterophylla	18.00^{bcd}	14.00^{c}	12.33^{bcd}	15.00^{b}	14.00^{c}	10.33^{e}	12.00^{cd}
Jatropha gossypiifolia	18.33^{bc}	17.00^{b}	13.33^{b}	15.33^{b}	15.00^{bc}	14.67^{b}	15.67^{b}
Moringa oleifera	20.33^{ab}	12.00^{d}	11.33^{cde}	13.33^{bc}	13.67^{cd}	10.67^{de}	10.33^{ef}
Ocimum gratissimum	12.67^{e}	10.67^{e}	10.33^{e}	12.33^{c}	10.67^{e}	10.33^{e}	10.00^{f}
Phyllanthus amarus	18.33^{b}	16.00^{b}	12.67^{bc}	16.33^{b}	14.00^{c}	13.33^{bc}	11.67^{cde}
Senna alata	12.00^{e}	10.33^{e}	10.67^{e}	10.33^{c}	10.67^{e}	10.33^{e}	10.00^{f}
Tithonia diversifolia	15.33^{d}	10.33^{e}	11.33^{cde}	12.33^{c}	11.33^{d}	10.33^{e}	10.33^{ef}
Vernonia mygdalina	13.00^{e}	10.67^{e}	13.33^{b}	10.33^{c}	10.33^{e}	10.33^{e}	10.33^{ef}
Antibiotic	19.33^{b}	23.67^{a}	22.33^{a}	28.67^{a}	26.00^{a}	22.67^{a}	22.33^{a}

^{a,b,c} Means within a column with different superscript are significantly different (P 0.05).

PA = *Pseudomonas aeruginosa* PF = *Pseudomonas fluorescens* Strep = *Streptococcus agalactiae* SA = *Staphylococcus aureus* EC = *Escherichia coli* AS = *Aeromonas salmonicida* AH = *Aeromonas hydrophila*

DISCUSSION

The higher percentage nitrogen, alkalinity and the available phosphorus contents observed in the current study was similar to the previous studies (Enwezor *et al*., 1989; Olowoake and Ojo, 2014; Alabi et al (2017); Fasakin et al., 2019). The soil is also very low in exchangeable sodium, potassium and cation exchangeable capacity (USDA–SCS, 1974) but the quantity is moderate in poultry manure. Our observation on low soil exchangeable sodium and potassium, when compared to poultry manure is similar to the

report of Ogunleye *et al*. (2019). The low nitrogen contents of the soils could be attributed to the characteristic nature of tropical soils and nutrient uptake from the previous crop. Medium to low content of organic matter content may be attributed to the nature of vegetative cover. The relatively low to very low content of exchangeable bases may be due to the nature of parent materials from which soils are formed or due to climatic conditions location, the more the erosion, the more weathering and the more loss of these exchangeable bases. Low rainfalls were experienced from June to August with peak in September during the study. The highest rainfall observed in September during the study coincided with the observation in a previous study (Ogunleye et al., 2019) in which the peak of rainfall was September, even in the Rainforest region of Nigeria while the cessation of rainfall in October is similar to previous report (Fasakin *et al*., 2019) at the experimental site. Although the scientific information on the growth pattern of herbal plants is very scarce, the current study has shown that the plants cultivated in this study could be grown on moderately fertile soil within three months for utilization as organic antibacterial agents and hence it is possible to have 3 cycles per year, especially with irrigation in off rain seasons and could be much more sustainable when integrated with organic aquaculture.

Aeromonas and Pseudomonas species are opportunistic pathogenic bacteria, which are naturally present in aquatic habitat with devastating effects on cultured freshwater fishes, owning to the stressful condition of the semi-intensive or intensive culture systems with acute to chronic clinical signs causing significant morbidity, mortality and enormous economic losses (Noga 2012; Hardi *et al*., 2016). Streptococcosis is a zoonotic disease of global concern caused *Streptococcus* species, including *Streptococus agalatiae*, *S. dysgalactiae* and *S. iniae*, affecting man, freshwater and saltwater fish species worldwide (Gent *et al*., 2012; Abdelsalam *et al*., 2013; Li *et al*., 2014; Li *et al*., 2015; Assis *et al*., 2016; Iregui *et al*., 2016; Delannoy *et al*., 2016; Mengmeng *et al*. 2019. The *E. coli* and *S. aureus* have also been identified as resistant food-borne bacterial pathogens associated with aquatic products and microbial food poisoning which threatens public health (Onmaz *et al*., 2015; Saharan *et al*, 2019).The rise in global concern on the adverse effects of uncontrolled utilization of synthetic antibiotics to control infectious diseases in the production of food fish necessitates search for alternative natural products, including herbal additives in aquaculture.

The present study has demonstrated the antibacterial activities of *E. hirta*, *E. heterophylla*, *J. gossypiifolia*, *O. gratissimum*, *M. oleifera*, *P. amarus*, *S. alata*, *T. diversifolia*, and *V. amygdalina* extracts, in which the ethanol extract showed the highest inhibitory effect. The antibacterial activity shows that the herbal products could be utilized as natural/organic antimicrobial and food preservative agents against the selected pathogens. The findings in the present study affirm the earlier reports on the antibacterial activities of *Euphorbia* species (Ogbulie *et al.* 2007; Saravanan *et al.,* 2012; Oyedun, 2017), *M. oleifera* (Onsare *et al*, 2013; Abubakar and Usman, 2016; Isitua *et al*., 2016; Abubakar and Usman, 2016; Ervianingsih *et al*., 2019), *V. mygdalina* (Adetunji *et al*., 2013), *T. diversifolia* and *J. gossypiifolia* (Okiti and Osuntokun, 2020). The observed antimicrobial effect could be associated with the presence of bioactive compounds like alkaloids, tannins, terpenoids and flavonoid in the herbal extracts. The phytochemicals observed in the current study coincided with previous observations on *Phyllanthus* species (Samali *et al*., 2012; Sen and Batra, 2013), *E. hirta* (Essiett and Okoko, 2013), *M. oleifera* (Saini *et al*., 2016), and *T. diversifolia* (Okiti and Osuntokun, 2020). The antibacterial activities of plant-based antimicrobials have been ascribed to the presence of bioactive phytochemicals, including secondary metabolites such as alkaloid, saponin, tannin, terpenoids and phenolic compounds which have been associated with antimicrobial activities of herbal extracts and thus formed the basis for the ethnomedical uses of these plants as organic therapeutics (Zablotowicz *et al*., 1996; Lewis and Ausubel, 2006; Falodun *et al*., 2012; Olushola *et al*., 2013; Apiamu *et al*., 2013; Ahmad *et al*., 2017) for the culture of aquatic animals and livestock meant for human consumption in other to mitigate the aforementioned deleterious effects of synthetic antibiotics.

In conclusion, the present study has shown the antibacterial potentials of some cultivated herbs against varieties of pathogenic (*A. hydrophila*, *A. salmonicida*, *P. aeruginosa*, *P. fluorescens*, *S. agalactiae*) and food poisoning bacteria (*Pseudomonas* species, *S. aureus* and *Escherichia coli*) of aquaculture species and products. Moderate inhibitory activity was exhibited by ethanol extracts of *Euphorbia* species, *Jatropha gossypiifolia* and *Phyllanthus amarus* against all the microbes.

Further investigations on the *in vivo* antibacterial of these herbal extracts to determine their efficacy as prophylactic, therapeutic and preservative

agents in fish health management and preservation is recommended.

ACKNOWLEDGMENTS

The authors acknowledge the financial support received from TETFUND (Tertiary Education Trust Fund) through Kwara State University, Malete, Nigeria

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A Discourse Regarding the Application Cost Accounting System in Agriculture Farms

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Abstract

The practice of cost accounting is essential for business professionals due to its ability to determine the degree to which resources are being exploited most efficiently. Cost accounting may differentiate between industries and sectors; hence, the importance of reviewing pieces of literature based on their comparisons had been the prime focus of this particular research. Agriculture represents an important aspect of any economy. However, certain crucial factors make the accounting procedure in a sustainable agricultural firm much undeveloped in nature, which need to be addressed from the base level to generate favorable outcomes in the future. The paper is based on a Systematic Literature Review (SLR) by levying utmost attention on gathering secondary data only. The overall findings being gathered for this particular research clearly deciphered that the application of cost accounting system in agricultural firms is somewhat distinct from others due to its strong focus on certain crucial factors. A few of these factors were identified as overhead allocation, availability of livestock, and production sizes among others. Specifically, as per the findings being retrieved from the literature review, it certainly became apparent that Activity-Based Costing (ABC) activities in agriculture included significant and unique differences from the practices of other industries, but there are similarities as well. One of these similarities included maximizing huge profits by making suitable expenses at the end of every fiscal year. In terms of recommendation, accounting staff working in rural areas should be prepared enough for making effective application of cost accounting mechanism in diverse agricultural firms to generate favorable or positive outcomes.

Keywords: Cost Accounting System, Agriculture Farms, Manufacturing Firm, Activity Based Costing System, Production Cost

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INTRODUCTION

Cost accounting is a complex approach to accounting practice. It supports a business organization to evaluate its fixed as well as variable expenses being incurred during the operations properly. Accurate cost appraisal along with distribution to specific activities is viewed to be one of the primary objectives of the cost accounting approach within a business or an organizational context (Barg and Swanson, 2004). This kind of practice is often exercised to determine where there exists any cost inefficiency and evaluate the ways through which an organization can reduce its operating expenses as per the desired level (Fisher, 2012). It is worth mentioning that the cost accounting system or practice is applicable in agriculture as well. Taylor (1923) in this context discussed the objectives of agricultural cost accounting that include maintaining equilibrium amid the receipts and the payments within the production procedures and maximizing profits from the growing execution of fertilizers among others. According to King (1927), cost accounting is regarded as an activity or a tool, which facilitates the determination of efficiency in the production level and attracts the potential farmers to generate huge profits from the same. Black (1955) further noted the importance of approaching cost analysis in agricultural farms from the standpoint of measuring costs similar to that of other industries. There often persists a difference in the degree of difficulty and the approaches taken to cost accounting practice because of the variations being witnessed in the production level and inappropriate services being rendered to the end-users (Black, 1955).

There are several challenges of the cost accounting system, specifically in the agricultural farms, that are identified to be unique from other operational segments including manufacturing and merchandising. Such challenges eventually portray that there still exists an undeveloped accounting approach within a sustainable agriculture system. One such challenge can be recognized as the inability of allocating expenses concerning time credits. The reduction of expenses and the conduct of proper accounting of costs in agriculture were the main focus of DeBoe and Stephenson (2016), who discussed the issue of enlarging nutrient business in an agricultural setting. Their research eventually raised the scope of ecological economics and the issue of costs related to term credits. In

agriculture, commonly, some credits are made available to agriculture professionals, which will come back to the respective farms. Nevertheless, estimation of these credits for any specific farm creates a complex cost accounting problem, wherein transaction costs are not known. Determining these costs certainly becomes difficult for the cost accountants (Fisher, 2012). The issue concerning "Value" can be regarded as the other challenge, which depicts that an undeveloped nature of the accounting system duly persists in a sustainable agriculture mechanism. This issue arises from an invalid assumption being made that it is justified enough to ask someone about how much he/she is keen to pay for protecting the underlying environment (Barg and Swanson, 2004). The agriculture industry is important to the economies and the societal developments of varied nations across the globe because the community members mainly rely on the products to be produced by any means such as farming for basic survival. On one hand, agriculture is essential for the monetary advancement of the nations and their underlying societies and on the other hand, cost accounting in agriculture is complex as well as difficult for several reasons (Fisher, 2012). A few of these reasons comprised commercialization or privatization of farming and inappropriate maintenance of ecosystem services among others (Rundgren, 2017). The research aimed at reviewing some scholarly literature to find out why the accounting system is still undeveloped in the agriculture system, specifically within the context of organic farming. Considering this aim, the objectives of the study are evaluating the practices of cost accounting in agriculture as well as other industries and determining the roles along with the implications of ABC accounting in the domain of agriculture.

Cost Accounting in Agriculture and Other Industries

Agricultural activities are similar to that of manufacturing ones, wherein a specific form of raw material is duly converted into an end product efficiently. However, in most agricultural activities, the process is performed through biological mechanisms, wherein the farmers seek to facilitate optimum efficiency in the operations. In this regard, the finished products are duly considered to be commodities with the help of which fair market value is easily determined. Unlike manufacturing firms, wherein, the historical cost is deemed as the basis for evaluation, Lewis and Jones

(1980) asserted that a current cost accounting method must be employed. This is because in the case of agricultural farms, there lays the requirement of examining accurate current costs to maintain a balance amid receipts and payments. This is also supported by financial reporting standards just outside the range of cost accounting (Lewis and Jones, 1980). Marsh and Fischer (2013) further discussed the issue of accounting for agricultural products in GAAP, wherein Accounting Statement Codification 905 along with non-GAAP guidelines are used. The issue of accounting recognition and valuation variances is significant, as the differences between the accounting practices of historical cost and fair value are highly concerned. Table 1 illustrates the PricewaterhouseCoopers' (2009) hierarchy of fair value in agriculture. In the hierarchy, it is found that the highest value for biological agricultural assets is placed on the asset price based on an active market. Herein, an active market can be related to the commodities market. Concerning the study findings of Marsh and Fischer (2013), the nature of USGAAP reporting standards is noticed to be somewhat different from the IFRS method, wherein less information is given to the decision-makers when USGAAP is in use. Therefore, unlike other industries where decision-makers consider financial data to be reported following USGAAP as sufficiently conservative and informative, in agriculture, the current paradigm relies on historical costs for further analysis. These findings further support the practice of cost accounting in the agricultural industry, particularly in the domain of organic farming (Marsh and Fischer, 2013).

Table 1: Fair market value hierarchy

Hierarchy	Type
Highest	Price for the asset on an active market
Second	Recent transaction price
Third	The market price for a similar asset
Fourth	Sector benchmark
Lowest	The present value of future cash flows

Source: PricewaterhouseCoopers, 2009

Based on the above-portrayed Table 1, it is evident that the financial statement computation of fair market value follows a hierarchical chain from the price, which is being measured on an active market to the value of

cash flows into the future. This reflects a higher degree of value being placed on the market when determining the valuation. Valuation, in this regard, is deemed important in cost accounting. This is because it is regarded as the method by which costs may be determined either to single products or a pool of products, wherein percentages are used for cost allocation. There are different theories related to how cost computation should be approached in agriculture. Under this circumstance, Bavita et al. (2010) discussed the issue of allocation, wherein the authors mentioned that when a nutrition unit is used, the equivalence indices method is the best approach to consider for generating favorable results. Herein, this specific method seems to be beneficial because of the complications that are created as well as solved through intercropping and better allocation of production costs being related to nutrition units. In this particular method, the total expenses incurred are measured against secondary production at Net Realizable Value and then divided among the products (Bavita et al., 2010).

In addition to the use of equivalent indexes, other methods of cost accounting are suggested for use in agriculture. These methods include the remaining value method and the method of quantitative equivalence (Bavita et al., 2010). In general, the remaining value method involves the deduction of the value of a secondary product. In this method, several products are obtained from a crop. Crops may be used for several purposes such as the development of cereals or base products. Since different approaches are taken into concern for production, costs are often considered into different lines under distinct measurement methods (Bavita et al., 2010). On the other hand, the method of quantitative equivalence is applied in the situation when there is a secondary product being coupled with the main product. The computation of costs in this particular method generally involves the expenses that are incurred during the production, which are then recorded and grouped for operative accounts on the respective agricultural firms (Bavita et al., 2010).

Another important factor related to the use of cost accounting in agriculture is the issue of external costs associated with agricultural production. These external costs represent the expenses that are not directly incurred by the agricultural firms. Tegtmeier and Duffy (2004) discussed some of these external costs as livestock production and damages are done

to the underlying ecosystems through croplands among others that have an impact on environmental and human health at large. It has been apparent that the entire exterior expenses of agricultural production in the US are projected to fall between the level of $5.7 and $16.9 billion every year (Tegtmeier and Duffy, 2004). In the context of cost accounting for the agri-businesses, Tegtmeier and Duffy (2004) stated that the estimations of the identified external costs are important for determining whether the contribution of such businesses to the economy is neutral or better than the impacts being imposed over the environment. Furthermore, this agricultural cost accounting assessment is important because it posits the potential stakeholders with the ability to measure the impact of agricultural activities on the underlying communities (Tegtmeier and Duffy, 2004). Thus, agricultural cost accounting methods are useful for both businesses and interested stakeholders in agricultural firms.

From a historical perspective, cost accounting activities have been the focus of accounting and agriculture researchers for over a century aimed at describing ways in which accounting systems could be designed to allocate costs of production accurately. Contextually, one of the first scholars to contribute to the progression of accounting in agriculture was Arthur Young (Juchau, 2002). Juchau (2002) discussed the early history of agricultural accounting in the context of how it became relevant during industrialization. Based on the observation made by Juchau (2002), determining the degree of efficiency and benchmarking certainly became an important activity in the late 19th century and is followed throughout the 20th century within agricultural schools. It was evident that questionnaires along with surveys were utilized as the methods to validate the evaluation of crops, harvests, yields, and the costs associated with production (Boss, 1945). Boss (1945) also noted that these tie with the importance of cost accounting in agricultural farms have been supporting them to compare their business activities as a quantitative measurement against the performance of competitors and point out areas of development.

Dogan et al. (2013) also discussed the historical advancement in agricultural accounting. In this regard, the authors mentioned that the unique nature of costs and assets in agriculture, wherein products are treated as commodities with values in a constant state of change, influences

the consideration of different systems for accounting to conduct agricultural activities efficiently. Lewis and Jones (1980) further asserted that the application of a current cost accounting system would be rational for agricultural farm businesses because valuations of crops and livestock rely on historical costs. These facets eventually get linked with cost accounting practices in agriculture, wherein historical elements support the importance of valuations that are deemed as different from other service providers and industries.

Roles and Implications of ABC Accounting in Agriculture

It is argued that traditional and generalized cost accounting practices to agriculture create greater financial stress on the respective operating firms. Barry and Lee (1983) discussed in this regard that the issue of financial stress in agriculture from the standpoint of how lenders make decisions to invest and thereby maximize huge profits. Concerning the study findings of Barry and Lee (1983), financial markets have been hostile to farmers in the past, and thereby obtaining credit proved to be difficult because of valuation in cost accounting, about volatility risk. This issue eventually suggests that an undeveloped accounting system still exists in a sustainable agriculture system. Similar aspects have been highlighted by Pawlowska-Tyszko and Soliwoda (2016; p. 171), wherein it has been stated that "'agribusiness clients operated larger farms'" tend to be more likely to use farm cash/accrual financial record systems. Accountants view some limitation for usefulness in 'present financial reports provided to farmers'". These facts determine that an undeveloped accounting system persists within the sustainable agriculture mechanism. Kapronczai and Tomka (1991) noted that through the use of specific cost accounting practices, it is possible to determine areas where both large and small agricultural firms may attain a superior level of competitive position and thereby ensure long-term sustainability in the respective markets or industries wherein, they operate.

METHODOLOGY

The research is a "systematic literature review" (SLR), wherein a greater focus has been levied on retrieving secondary data only. Google Scholar was mainly utilized as the search engine, wherein a total of 20 articles were searched initially after providing the main keywords of the

research that included Agriculture Farms, Production Cost, Cost Accounting System, Manufacturing Firm, and Activity Based Costing System. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach had been duly followed in terms of methodology for the given research paper. For instance, as per PRISMA, only 10 articles were selected for screening, out of 22 articles being appeared in Google Scholar initially. Amongst these, only 4 articles were selected to analyze the issue identified for this specific research and 6 articles had been rejected after following certain exclusion criteria. The mentioned exclusion criteria were based on the following aspects:

- Articles not relevant to the topic and the identified issue i.e., Discourse Regarding the Cost Accounting System in Agriculture Farms
- Articles published beyond the period of 50 years from the current date (2020)
- Articles that do not involve the discussion about cost accounting practices in agriculture farms

Findings

Authors' Names	Name of the Articles	Methodologies Used	Findings/Discussions
Fatah and Mat-Zin (2013)	Literature Review of the Practice of Cost Accounting System in the Agricultural Firms	Literature Review	Usage of the Cost Accounting System in the agricultural firms is somewhat found to be less than that of manufacturing as well as service organizations. This may be due to the reason of the variations being witnessed in the agricultural business setting on a global basis over the preceding few years. Agricultural firms can boost their profit margins via the execution of the Cost Accounting System in their operations by evading unprofitable actions or tasks and controlling distinct variable costs most efficiently.
Dumitru et al. (2011)	Computing the Cost of the Agricultural Products: A Case Study	Literature Review, Descriptive Analysis and Case Study	Cost computing of the agricultural products of distinct is usually made under a natural-material setting, wherein main calculations are being made based on the categories of the crops harvested and the animals used in the overall production procedure. The bookkeeping of the production expenses is also duly considered under the cost computing mechanism of the agricultural products within varied firms.
Fisher (2012)	Cost Accounting Applied to Farming in Southwest Michigan	Descriptive and secondary data analysis	"Cost accounting allows farmers to see their farm as more than "x" amount of acres that cost "x" amount of dollars to produce "x" amount of bushels. Cost accounting allows the farmer to see the farming operation broken into incomes and expenses based on acres and yield units. This is possible because these grain farmers have a unit of production, grain (Fisher, 2012: p. 19).

Bavila et al. (2010)	Cost Computation for the Agricultural Products within the Vegetal Farms	Qualitative with inductive approach	Cost computation seems to be difficult for agricultural firms in comparison with manufacturing or servicing organizations because of having a divergence chance amid resource consumption and the time when the production is acquired. However, this adverse condition can be addressed and mitigated in certain ways. A few of these ways typically encompassed executing the Remaining Value as well as the Equivalent indexes procedures and focusing on valuation techniques. To reap future benefits in terms of profits, agricultural firms need to levy the utmost attention on controlling variable costs, in particular.
Carli et al. (2014)	Introducing Activity-Based Costing in Farm Management: The Design of the FarmBO System	Secondary with descriptive data analysis	In farm management, Activity-Based Costing is mainly used to determine the expenses incurred and measure the performance of the actions being performed to generate favorable or positive outcomes. This particular method or approach in agricultural firms is typically based on the advancement of final products by making sure fuller execution of the accessible resources.
Iuchau (2002)	Early Cost Accounting Ideas in Agriculture: The Contributions of Arthur Young	Qualitative with focus on secondary and descriptive data	Cost accounting and its methods in agricultural firms have certain similarities with that of manufacturing-based corporations. One of these similarities was recognized as controlling variable costs in a way so that optimum production level is maintained to the maximum possible degree for obtaining significant profits. Another similarity was the crucial function of such accounting practice in finding out the valuation of any agricultural firm-related product such as livestock. This valuation is likely to enhance the business performance of the agricultural firms by

			generating greater returns to the involved potential stakeholders.
Lewis and Jones (1980)	Current Cost Accounting and Farming Businesses	Qualitative with a secondary method of data collection	The method or the practice of cost accounting in agricultural farming businesses has gained acceptance in its usage due to the fluctuations being witnessed in the inflation rates in this present-day context. Similar to manufacturing and servicing firms, business organizations operating in the agricultural industry are inclined towards applying cost accounting into their respective operational functions because the profitability levels are determined based on the current values instead of any historic cost. Since the agricultural industry of business is becoming quite competitive, the operating firms often execute cost accounting mechanisms so that more earnings can be maximized and the involved stakeholders are provided with greater returns at the end of every fiscal year.
Barg and Swanson (2004)	Full Cost Accounting for Agriculture	Qualitative research with secondary and descriptive data	The "Value" problem does exist in the approaches of financial valuation, making the accounting system in the sustainable agriculture domain quite undeveloped in nature.
Pawłowska-Tyszko and Soliwoda (2016)	Agricultural Accounting Systems Supporting Farm Financial Management – The Case Of Polish Farm	Qualitative research with secondary and descriptive information	More reliance on the implementation of farm cash/accrual monetary record systems and limitations of the accountants in presenting apt financial reports to the farmers eventually make the accounting technique in a sustainable agriculture system undeveloped.

Dugan et al. (2015)	Historical Development Of Agricultural Accounting And Difficulties Encountered In The Implementation Of Agricultural Accounting	Qualitative research with a focus on secondary data	The farmers and the agricultural enterprises are likely to obtain precise and suitable information about realistic accounting costs via successful usage of "Agricultural Activities Standards 41" and "Farm Accountancy Data Network".
Schnitkey et al. (1991)	Farm Accounting Systems and Information Usage	Qualitative research and secondary method of data collection	The various factors that have a strong influence on the accounting system election within the modern agricultural firms are features of these firms, the number of transactions being made, and determination of the completeness of the reporting requirements.

ANALYSIS AND DISCUSSION

Juchau (2002) and Lewis and Jones (1980) elaborated on the history of agricultural cost accounting, which is deemed as vibrant and unique from other forms of accounting. Nevertheless, there exist some similarities between agricultural cost accounting and manufacturing. In this regard, Bavita et al., (2010) discussed some unique points of cost computation for agricultural products with a focus on vegetation. A few of these points included the allocation of overhead, which is created across different cycles and can be distributed to specific productive activities. The allocation itself can be done in several different ways; however, when it is done following nutritional units, the equivalence indices method should be used (Bavita et al., 2010). On the other hand, with regards to the study outcomes presented by Carli et al. (2014) and Dumitru et al. (2011), cost computation for agricultural products can also be made possible by the incorporation of the Activity-Based Costing method and the determination of production expenses concerning livestock and others. As per the observation made by Schnitkey et al. (1991), agricultural cost accounting systems represent a novel approach to business management for the owners of distinct agricultural firms, wherein they can assess the current performance of their firms and determine what needs to be done to improve their performance as well as increase the efficiency level as per the desired standards.

The qualitative study outcomes of Fisher (2012) highlighted the fact that cost accounting and its varied techniques are largely applied in agricultural firms with the prime intents of allocating production costs successfully and maintaining an optimum equilibrium amid the expenses being incurred during the conduct of operations and the profits obtained at the end of every fiscal year. Based on these outcomes, it is quite apparent that cost accounting in agricultural firms is determined based on certain significant aspects. A few of these aspects typically embraced yield units, production sizes, and the products being produced at the finish of the financial years (Fisher, 2012). Concerning the study findings of Dogan et al. (2015), the agricultural sector has gone through significant transformations over the previous few years. One of such transformations could be witnessed in the traditional system of cost accounting, wherein utmost importance is placed over-controlling as well as maintaining stocks to the maximum possible degree and ensuring optimum execution of the available

resources among others (Dogan et al., 2015). Barg and Swanson (2004) pointed out the fact that the problem concerning Value being inherited within the economic valuation system makes the accounting procedure in a sustainable agriculture process quite undeveloped. This, in turn, eventually poses threats to the financial conditions of the respective agricultural firms at large. Moreover, in this context, Pawlowska-Tyszko and Soliwoda (2016) inferred that the undeveloped nature of the accounting system in a sustainable agriculture mechanism can be determined from having limitations in the financial reports being delivered to the farmers and ensuring more execution of farm cash/accrual methods.

Fatah and Mat-Zin (2013) asserted that manufacturing and service firms receive far greater attention than agricultural firms in terms of cost accounting structure development. The researchers also pointed out that there are distinct differences and there must be a greater focus placed on agricultural accounting systems. The reason for the lack of attention could be the assumption that agriculture is sufficiently close enough to manufacturing, wherein manufacturing cost accounting principles are sufficient enough to undermine the costs being involved in the production procedures. Researches, thus, should be focused on developing new ways in which cost accounting could be performed in the agricultural setting. This could also include accounting for externalities such as those suggested by Tegtmeier and Duffy (2004) to gain a sufficient understanding of how cost accounting works to measure the true costs incurred by the agricultural farms and enable them to safeguard the underlying environment.

CONCLUSION

Based on the above discussion, the use of cost accounting in agriculture must be delineated in terms of its approaches and processes. It is similar to that of manufacturing; however, some factors make the cost accounting mechanism in the domain of agriculture different from the procedure being followed in other industries. The fact cannot be ignored that utilization of cost accounting systems, specifically within the agricultural firms, is increasing thereby intending to earn more profits by controlling variable expenses being incurred during the making of any definite product. The outcomes being retrieved from this research indicated

that cost accounting in agriculture is similar to that of manufacturing because there lays a method through which raw materials can be converted into ultimate products. Nevertheless, there still exists an undeveloped accounting method in a sustainable agriculture system due to the problem having in Value and limitations towards presenting monetary reports to the farmers among others. To conclude, in the agriculture domain, the execution of cost accounting is dissimilar and can be complex when the costs are analyzed from a valuation standpoint.

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