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Influence of Poultry Manure on Growth and Fruit Yield of Selected Pepper Species and Their Qualities after Storage in Various Structures

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The production of pepper is low due to decrease in fertility of soil and inadequate storage structures. The study was aimed at evaluating the growth, yield and storage qualities of selected pepper varieties as influenced by poultry manure and storage structures in Ibadan, Nigeria. A field experiment was carried out at Department of Agronomy, University of Ibadan between November, 2017 and April, 2018 growing season. Two varieties of pepper (*Capsicum annum* and *Capsicum frutescens*) were used, with four treatments consisting of different rates of poultry manure. Controls of 0 g of poultry manure (T1), 12.5 g (T2), 25 g (T3) and 37.5 g (T4) were laid out in a complete randomised design and replicated four times. Storage experiment was carried out in the Department and at Nigeria Stored Products Research Institute (NSPRI), Ibadan in June, 2018. The storage experiment comprised of four treatments with ambient condition (open shelf), wet basket, Evaporative Coolant Structure (ECS/Pot-in-pot), and plastic crates used as storage structures, laid out in a completely randomised design and replicated three times. The physical parameters obtained in days in storage (DIS) included weight loss (%), firmness, freshness, among others. Data observed were subjected to analysis of variance (ANOVA) and means separated using least significant difference (LSD) at $p>0.05$. The result obtained showed that pepper growth was enhanced using *Capsicum frutescens* under 25 g poultry manure application rate which resulted to

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superior pepper yield. The combination of pot-in-pot with sawdust as storage structures enhanced the storage qualities of pepper fruits within the two weeks of storage. Although, the different manure treatments had no significant effect on the postharvest quality of pepper, the ECS can be effectively used in the storage of pepper fruits in order to improve postharvest quality, extend shelf life and enhance affordability of the commodity at all seasons.

Keywords: Capsicum annum; Capsicum frutescens; structures; growth; yield; storage.

1. INTRODUCTION

Pepper (*Capsicum spp*) is an important fruit vegetable in the tropics and the world second most important vegetable after tomatoes [1]. Nigeria is the largest producer of pepper in Africa, producing about 50% of the total African production on approximately 200,000 hectares of farmland annually. Pepper production in Nigeria stood at 695,000 metric tonnes obtained from an area of 77,000 ha, which gives an average yield of 9,026 metric tons per hectare [2].

Pepper is often grown solely or in mixtures with either cereal crops or other vegetables [3]. It is often consumed fresh (green), dried or processed, and along with other fruit vegetables like tomato, onion, among others. It is an important spice crop, highly cherished for its pungent flavour. In one hundred grams of the edible part of sweet pepper; approximately 87% of the total weight of the fruit contains 82 g water, 1.3 g protein, 10.3 g carbohydrate including 1.4 g cellulose 12 mg calcium, 0.8 mg niacin, 0.07 mg thiamine, 0.8 mg riboflavin and 103mg vitamin C and 108 kJ or 26 kcal energy [4]. It is also rich in vitamin A and C [5].

Pepper has increased in popularity, value and importance over a long period, thus making it an indispensable part of the daily diet of millions of Nigerian. One of the major constraints to pepper production is low soil fertility [6]. Therefore, there is need to augment the soil fertility status in order to meet the crop's need and thereby maintain the fertility of the soil. The nutrient status of the soil can be improved either with the use of organic or inorganic fertilizers [7].

Another constraint to the production of vegetables is the lack of adequate information on postharvest technology to improve its shelf-life. Postharvest technology for extending shelf-life of perishable commodities has gained significant importance in recent years [8]. Different structures have been used to store vegetables, which include refrigerator, evaporative coolant structure, wet basket, bricks in bricks, among others. However, there is paucity of information on the response of pepper varieties to different rates of poultry manure, and the storage qualities of pepper under different storage structures.

Therefore, the objective of the study is to assess the growth and yield of pepper varieties under different application rates of poultry manure and storage qualities of pepper under different storage structures.

2. MATERIALS AND METHODS

The experiment was carried out from November, 2017 – April, 2018 at Screen house of the Department of Agronomy, University of Ibadan (Latitude 07° 27' 06.4" N, Longitude: 03° 53' 46.1" E and Altitude 200 m above sea level). Seeds were sourced from National Horticultural Research Institute (NIHORT), Idi-shin, Ibadan and sown into nursery trays containing rich top soil in rows and placed under shade. Varieties used are *Capsicum annum* (V1) ('atarodo') and *Capsicum frutescens* (V2) ('tatase') and treatments combinations used are: Control = 0 g of poultry manure pot^{-1}, 12.5 g of poultry manure pot^{-1}, 25 g of poultry manure pot^{-1} and 37.5 g of poultry manure pot^{-1}. The experiment was laid out in 2 × 4 Factorial experiment in completely randomized design (CRD) with four replications. The soil samples was taken and analysed before the experiment. Data was collected on growth and yield parameters.

Yield parameters measured included number of pepper fruits, fresh fruit weight (g) and fruit length (cm). Number of fruits/plant was counted, fresh fruit weight obtained using an electric scale, and fruit length measured using a metre rule. Harvesting of pepper fruits began at 10 weeks after planting, and was done weekly at mature green stages by carefully turning the fruits while holding the pedicel. This was done at evening (cool period). Soil samples were collected from the experimental plot and routine soil analysis was carried out to determine the nutrient content of the soil. Soil chemical parameters measured are pH, organic carbon, total nitrogen, phosphorus, exchangeable cations, among others. Data were subjected to T-test and analysis of variance at $P \geq 0.05$. Significantly different means were separated using Duncan Multiple Range Test.

Experiment 2: Storage qualities of pepper under different storage structures

The aim of the experiment was to evaluate the effects of poultry manure on the storability of pepper fruits kept under different storage structures, which are: ambient condition (open shelf), wet basket, evaporative coolant structure (ECS/Pot-in-pot) and plastic crates. The experiment was conducted at the Horticulture Laboratory of the Department of Agronomy University of Ibadan and Nigeria Stored Products Research Institute (NSPRI) Onireke, Ibadan. The fruits were left in storage for 14 days. Peppers were stored on open shelf under ambient condition in the laboratory. The evaporative coolant structure (ECS) used was a portable model described by [9]. The ECS is a pot-in-pot having two pots placed one in the other, and the space in between the pots is filled with river sand and wetted constantly. One was filled with ash (2 m deep overlay and cover the fruits lightly), the other was filled with smooth sawdust (2 m deep overlay and cover the fruits lightly). The ECS was kept under shade to allow for free flow of air to prevent direct sunlight and rainfall. Wet basket used was made from cane tree and stitched from inside to outside with jute bag which was sprayed or sprinkled with water when dried (excess will leak out). One was filled with ash (2 m deep overlay and cover the fruits lightly), the other was filled with smooth sawdust (2 m deep overlay and covered the fruits lightly). Plastic crates used were well ventilated, one was filled with ash (2 m deep overlay and covered the fruits lightly), and the other was filled with smooth sawdust (2 m deep overlay and covered the fruits lightly). Mature green pepper fruits obtained from the treatments were harvested at cool times of the day by carefully turning the fruits while holding the pedicel. Fruits harvested were sorted to obtain dark green, bruise-free and disease free fruits. Infected fruits (ones with red patches) were discarded. Transparent polythene bags (0.04 mm thick) perforated well was used to package the pepper fruits. Grams of pepper fruits were packaged in the transparent polyethylene bags and sealed. The bagged pepper fruits were kept under different structures with relative humidity ranging from 77% - 98% and temperature ranging from 18^0C - 29^0C.

Treatments used in experiment 2 are as follows: Open shelf or ambient condition, Plastic crates + ash, Plastic crates + sawdust, Pot in pot + ash, Pot in pot + sawdust, Wet basket + ash, and Wet basket + sawdust. The experiment was carried out in a completely randomized design and replicated three times. Harvested fruits were rinsed (to remove soil particles and dirt), air dried and kept in storage.

Data collected on physical parameters included weight loss (%), firmness, disease incidence and decay level.

- **Weight loss (%):** Fruits in each replicate were weighed at the beginning of the experiment using an electronic balance and subsequently at three days interval during the period of storage. The percentage change in weight was calculated thus:

Loss in weight X 100% original weight (1)

- **Decay level:** This was obtained through visual observation for noticeable mould growth at three days intervals to determine the level of decay using a subjective scale of 1-4 (4= wholesome, 3= very slight decay, 2= moderately decay, 1= highly decayed) [10].
- **Firmness:** Observation was made by hand felt at three days interval to determine the level of firmness of pepper fruits. This was rated using the firmness scale 1-4 (4 = very firm, 3= firm, 2= slightly firm, 1= not firm) [10].
- **Freshness:** Visual observation was made for noticeable shrivelling at three days interval to determine the level of freshness of pepper fruits. This was rated using the subjective scale of 0-4 (0= poor, 1=unacceptable, 2= acceptable, 3= good, 4= excellent) [11].
- **Disease incidence:** Visual observation of pepper fruits for skin defect or blemishes was carried out at three days interval using a subjective scale of 1-4 (1= wholesome, 2= slightly infected, 3 = moderately infected, 4= highly infected) [10].

Proximate analysis was carried out in the laboratory. Pepper fruits obtained from the treatments were subjected to laboratory analysis to determine the nutrient composition using the standard method of [12]. Chemical parameters measured include crude protein (%), crude fibre

(%), ash (%), dry matter (%), nitrogen (%), phosphorus (%), potassium (%), calcium (%), magnesium (mg/kg), sodium (mg/kg), iron (mg/kg), zinc (mg/kg), and vitamin C (mg/100g). Data were subjected to analysis of variance (ANOVA) and means separated using least significant difference (LSD) at p>0.05.

3. RESULTS AND DISCUSSION

The soil analysis of the experimental site prior to cropping was slightly acidic sandy loam soil, which was low in total nitrogen, exchangeable magnesium and available phosphorus (Table 1). The chemical analysis of the poultry manure (Table 1) showed that it was high in phosphorus and had more manganese and calcium than potassium and nitrogen. The low nitrogen and potassium of the soil are expected to benefit from the application of poultry manure.

The result obtained for effects of poultry manure on plant height (cm) of pepper is presented in Table 2. Plant height (cm) increased from 2 – 12 WAT across all treatments. Furthermore, 12.5 g of poultry manure for variety 2 (*Capsicum frutescens*) were significantly taller than those of the control at 12 WAT. The result of the effects of poultry manure on number of leaves of pepper is shown in Table 3. There was an increase in the number of leaves from 2 – 12 WAT for all treatments and 12.5 g of poultry manure variety 2 (*Capsicum frutescens*) resulted with higher number of leaves from 2 – 8 WAT, but control (no poultry manure) had significantly higher number of leaves at 10 WAT. The effects of poultry manure on number of branches of pepper are shown in Table 4. Number of branches increased from 2 – 12 WAT for all treatments. However, number of branches of pepper was significantly affected by the treatment with 12.5 g of poultry manure from 2 – 12 WAT, thereby producing higher value of number of branches for all treatments.

The results on the effects of poultry manure on weight, length and number of fruits of pepper (Table 5) shows a significant increase in fresh fruit weight and fruit length of pepper.

Among the treatments, 12.5 g of poultry manure of varieties 1 & 2 resulted in fruit weight compared to maximum with 25 g of poultry manure for varieties 1 & 2. Similar to weight, higher values was produced in fruit length and number of fruits with the application of 25 g of poultry manure pot^{-1} for varieties 1 & 2. The least value for fruit weight, fruit length and number of fruits were obtained among treatments with no fertilizer or control.

Table 1. Chemical properties, particle size of experimental soil and Poultry Manure

Properties	Soil	Poultry manure
pH (1:1, H_2O)	5.6	
Organic Carbon (g/kg)	10.3	
Total Nitrogen (g/kg)	0.7	2.8
Available Phosphorus (mg/kg)	2.0	17
Exchangeable Cations (cmol/kg)		
Potassium	0.3	1.9
Magnesium	0.3	
Sodium	0.2	
Calcium	1.9	8.5
Exchangeable Acidity	2.8	
Exchangeable Micro Nutrients (mg/kg)		
Iron	93	
Manganese	28	58
Copper	5.0	
Zinc	1.0	
Particle Size Distribution (g/kg)		
Sand	782	
Clay	138	
Silt	80	
Textural class	Sandy loam	

Table 2. Effects of poultry manure on plant height (cm) of pepper

Treatments	Weeks After Planting					
	2	4	6	8	10	12
0 g PM (control) + V1	16.1	21.3	25.2	27.6	31.4	36.0
0 g PM (control) + V2	15.4	20.9	23.8	30.9	38.2	40.1
12.5 g PM + V1	18.5	24.4	29.8	32.2	39.6	44.6
12.5 g PM + V2	22.9	27.7	38.1	44.0	49.1	52.9
25 g PM + V1	21.5	26.8	30.8	31.8	34.2	42.1
25 g PM + V2	21.6	25.0	27.7	30.6	31.6	32.6
37.5 g PM + V1	20.9	25.9	30.6	33.8	37.4	39.6
37.5 g PM + V2	21.7	25.5	27.4	29.1	32.9	35.8
LSD $_{(0.05)}$	9.52	12.31	16.56	16.59	18.49	22.02

PM: Poultry Manure V1: Capsicum annum V2: Capsicum frutescens

Table 3. Effects of poultry manure on number of leaves of pepper

Treatments	Weeks after planting					
	2	4	6	8	10	12
0 g PM (control) + V1	11.2	16.2	20.5	33.5	32.8	25.0
0 g PM (control) + V2	10.0	20.0	28.2	45.0	73.8	33.8
12.5 g PM + V1	13.5	20.5	29.8	39.0	39.2	38.5
12.5 g PM + V2	27.8	37.8	37.2	54.5	60.2	49.2
25 g PM + V1	22.8	26.2	34.5	30.0	23.8	26.8
25 g PM + V2	34.5	26.5	31.8	44.8	38.0	34.8
37.5 g PM + V1	12.2	25.9	28.0	33.5	38.5	27.5
37.5 g PM + V2	26.0	38.2	49.2	36.8	37.0	34.2
LSD $_{(0.05)}$	27.58	32.10	29.01	38.50	38.38	28.09

PM: Poultry Manure V1: Capsicum annum V2: Capsicum frutescens

Table 4. Effects of poultry manure on number of branches of pepper

Treatments	Weeks after planting					
	2	4	6	8	10	12
0 g PM (control) + V1	2.00	4.50	6.2	7.8	11.2	12.0
0 g PM (control) + V2	2.00	4.75	7.8	11.5	14.5	15.5
12.5 g PM + V1	2.25	5.00	9.5	13.2	15.0	16.2
12.5 g PM + V2	2..25	9.00	13.2	17.0	19.8	20.2
25 g PM + V1	3.25	6.00	8.8	11.2	12.5	13.5
25 g PM + V2	2.75	7.75	12.0	15.2	16.8	17.8
37.5 g PM + V1	2.50	7.25	9.5	11.5	13.8	14.8
37.5 g PM + V2	2.50	9.25	12.2	13.5	15.0	16.5
LSD $_{(0.05)}$	1.074	7.477	8.33	10.20	11.02	11.27

PM: Poultry Manure V1: Capsicum annum V2: Capsicum frutescens

3.1 Effects of Poultry Manure on Storability of Pepper Fruits

With effect to manure treatment during storage (Table 6), there was significant increase in weight loss in pepper fruits with no fertilizer or control. As the duration of storage period increased, pepper fruits with higher poultry manure application showed higher weight loss. However, the storage structures had a significant effect on decrease in weight loss of pepper fruits and pepper fruits left under ambient condition had significantly higher weight loss (5.04) compared to fruits stored in the ECS (2.08) and those in the wet basket (2.07) and plastic crates (4.02).

Firmness The storage structures significantly influenced the firmness of pepper across the days in storage (Fig. 1). A general decline was observed in all the storage structures after 4 days. Wet basket, plastic crate and ECS overlaid with saw dust had better firmness rating (about scale 3) than others which are below the firmness rating scale of 2. The same trend was observed subsequently until the 14th day in storage when the ECS had the optimum firmness score followed by the wet basket and plastic crates, while the lowest score was observed under the ambient condition.

Freshness: Fruit freshness reduced significantly with respect to all the storage structures as the duration changes in number of days (Fig. 2). Significant influence was observed with the storage structures at 7th day as pepper fruits kept in the ECS stored significantly better compared to fruits kept in the wet basket, plastic crates and open shelf. On the 14th day in storage, ECS had the highest firmness score followed by the wet basket and plastic crates, while the lowest score was observed under the ambient condition.

Disease incidence: Fig. 3 reveals the effect of storage structures on disease incidence of pepper fruits observed for the period of time in storage. The earliest and highest level of disease incidence was observed in open shelf. This incidence maintained a sharp positive slope against the number of days in storage. Wet basket storage overlaid with ash expressed an increase in disease incidence after 4 days in storage but was stable from the 7th day till the 14th day. Pepper fruits kept in the wet basket and ECS stored better compared to fruits kept in the plastic crates and open shelf. This was also observed until the 14th day in storage when the wet basket had the optimum firmness score followed by the ECS and plastic crates, while the lowest score was observed under the ambient condition.

Table 5. Pepper yield characteristics as influenced by varietal differences and poultry manure application rates in Ibadan

Treatment	Number of fruits $Plant^{-1}$	Fruit weight g $plant^{-1}$	Fruit length cm $fruit^{-1}$ $plant^{-1}$
Variety (V)			
V1	10.38	17.64	3.1
V2	10.88	26.55	10.3
$S.E.D_{(0.05)}$	Ns	1.258	0.140
Poultry manure (PM)			
0 g of PM (control)	6.3c	11.90c	6.4b
12.5 g of PM	10.3b	21.87b	6.9a
25 g of PM	15.9a	33.90a	7.0a
37.5 g of PM	10.1b	20.72b	6.7ab
$S.E.D_{(0.05)}$	1.186	1.779	0.200
$S.E.D_{(0.05)}$ (V × PM)	Ns	2.516	Ns

Table 6. Effects of poultry manure on weight loss of pepper fruits during storage

	Days in storage				
Treatments	**1**	**4**	**7**	**10**	**14**
Poultry Manure					
Control	3.71	2.93	3.64	3.32	3.96
12.5 g	3.68	3.02	2.57	3.81	3.98
25 g	3.51	3.01	2.48	3.76	3.99
37.5 g	3.12	3.04	2.35	3.61	4.13
$LSD_{(0.05)}$	2.50	1.60	4.15	5.72	10.81
	Ns	Ns	Ns	Ns	Ns
Storage					
Open shelf	5.04	5.76	4.32	5.42	9.40
PC + Ash	4.02	4.12	3.84	3.82	4.78
PC + sawdust	4.01	4.05	3.65	3.60	4.21
ECS + Ash	2.15	1.19	1.87	2.43	2.85
ECS + Sawdust	2.08	1.14	1.39	2.32	2.73
W.B + Ash	3.13	2.06	1.62	2.40	2.84
W.B + Sawdust	2.07	1.12	1.84	2.31	2.74
$L.S.D_{(0.05)}$	2.50	1.60	4.15	5.72	10.81
PM x S	ns	Ns	Ns	Ns	Ns

PC: Plastic Crate, Pot-in-Pot: Evaporative Coolant Structure, W.B: Wet basket, Open shelf: Ambient condition PM: Poultry Manure

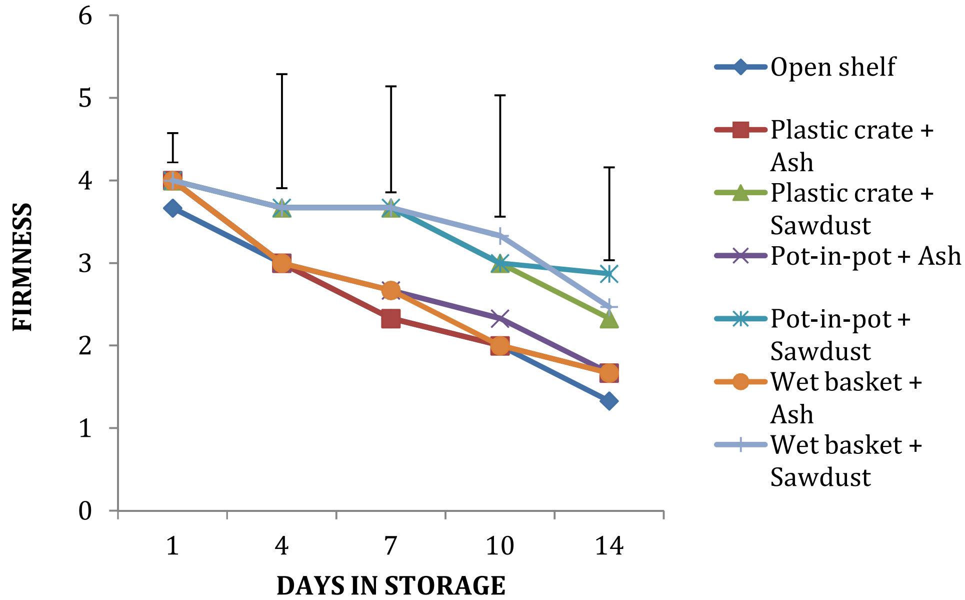

Fig. 1. Firmness of pepper fruits in different structures

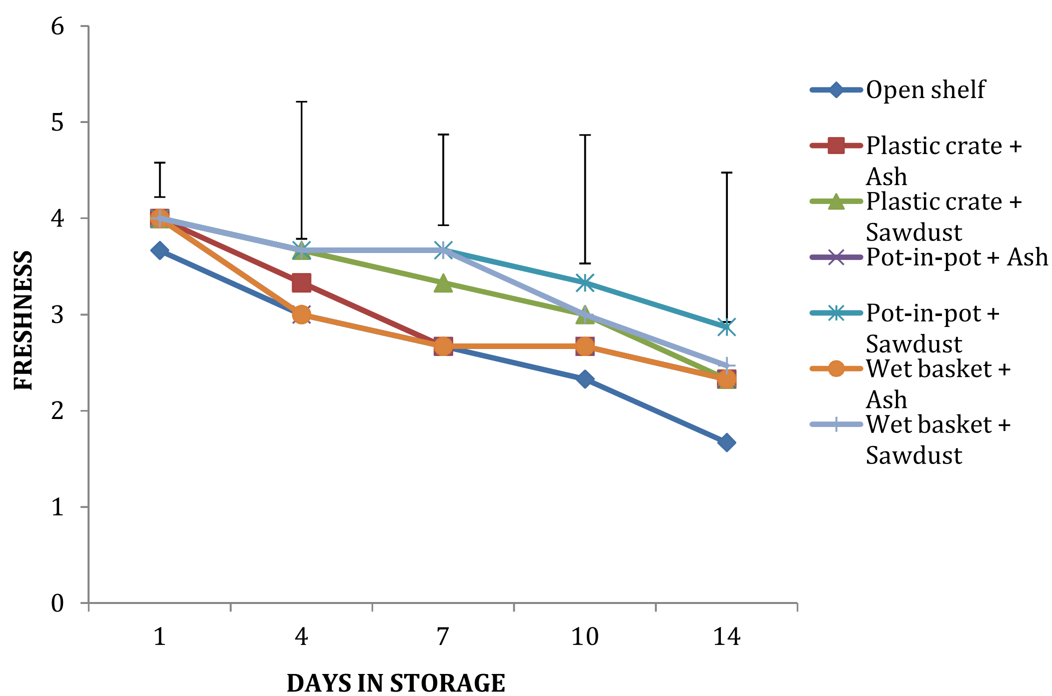

Fig. 2. Freshness of pepper fruits in different structures

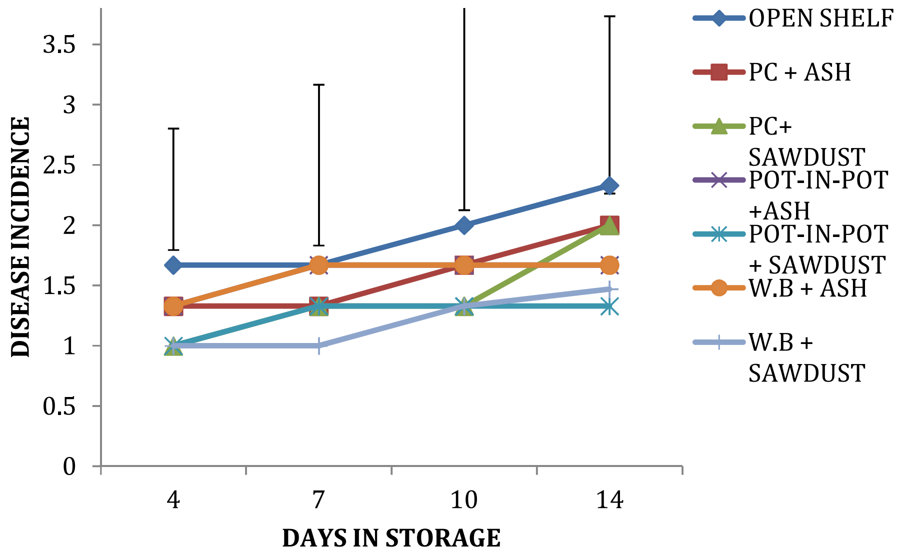

Fig. 3. Disease incidence of pepper fruits in different structures

Decay level: Decay response of pepper fruits are presented in Fig. 4 with respect to the different storage structures used for the number of days in storage. Pepper fruits showed varying decay level with prolonged storage periods. On the 4th day, a slight decay was observed on open shelf, wet basket laid with saw dust and ash, while a higher level of decay was observed for pepper fruits in other storage structures. Generally, from 7 – 14 days in storage, decay level of pepper fruits increased. The decay level increased for wet basket overlaid with ash, open shelf and ECS overlaid with ash, others were stable until the 7th and 10th day where fruits stored in other storage structures showed increased decay level. At the end of the storage period (14th day), wet basket had the lowest decay level followed by the ECS and plastic crates indicating moderate decay, while the lowest score observed under the ambient condition were highly decayed. The highest decay level was observed in pepper fruits stored in open shelf after 14 days.

3.2 Effects of Poultry Manure on Nutrient Composition of Pepper Fruits

The effects of poultry manure on nutrient composition of pepper are shown in Table 7. However, fruits from the manure treatments were higher in crude protein, crude fibre and ash than the control. Fruits from poultry manure treatments (37.5 g of PM) were significantly higher in crude protein and crude fibre content, and ranked the best among the treatments. This was followed by those from 25 g of PM treatment having (10.98 crude proteins and 3.21 crude fibres). Fruits from control had significantly lowest crude protein and crude fibre. The same trend was observed in ash content of pepper fruits across the treatments. Pepper fruits from control were higher in dry matter than fruits from the fertilizer treatments. There was no significant difference in percentage dry matter content of the pepper fruits with respect to the manure treatments.

Table 7. Effects of poultry manure on nutrient composition of pepper fruits

Treatments	Crude protein (%)	Crude fibre (%)	Ash (%)	Dry matter (%)
Control	5.28	2.14	5.13	91.54
12.5 g of P.M	7.41	3.15	5.67	91.47
25 g of P.M	10.98	3.21	6.13	91.33
37.5 g of P.M	12.75	3.57	6.21	91.21
L.S.D $_{(0.05)}$	2.35	1.27	0.23	Ns

PM – Poultry Manure ns – not significant

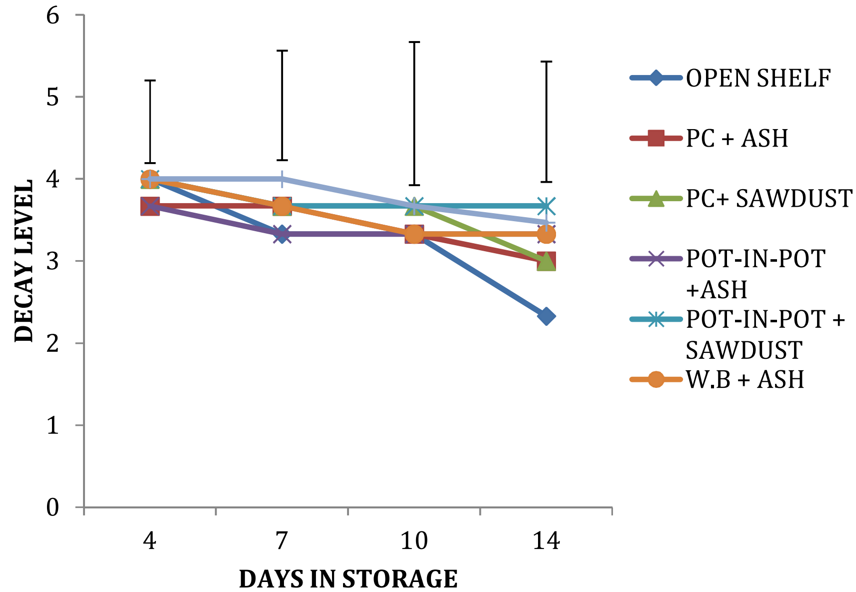

Fig. 4. Decay level of pepper fruits in different structures

3.3 Effects of Poultry Manure on Nutrient Content and Vitamin C Content of Pepper Fruits

Table 8 shows the effects of poultry manure on nutrient elements and Vitamin C content of pepper fruits. There was significant difference in concentration of mineral elements with respects to the fertilizer. However, pepper fruits from poultry manure treatment 37.5 g of PM had significantly higher nitrogen content followed by pepper fruits from 25 g of PM treatment, while the lowest value was observed from control. Pepper fruits from control had significantly higher phosphorus content followed by pepper fruits from 12.5 g of PM treatment, while pepper fruits from poultry manure treatment with 37.5 g of PM had the lowest phosphorus content. The same trend was observed with calcium content of pepper fruits from all the treatments. Pepper fruits from control had the highest calcium content followed by pepper fruits from 12.5 g of PM treatment and the lowest calcium content was observed in fruits from poultry manure treatment 37.5 g of PM. With respect to potassium content, pepper fruits from control had significantly highest value followed by pepper fruits from 12.5 g of PM, while pepper fruits from poultry manure treatment 37.5 g of PM had the lowest value. The same trend was observed for magnesium content of the pepper fruits. Iron content was significantly highest in pepper fruits from poultry manure treatment 37.5 g of PM compared to those from subsequent poultry manure treatment and control. The same trend was observed for zinc content of the pepper fruits and sodium content was higher in pepper fruits from control than the fertilizer treatments. Conversely there was no significant difference in the Vitamin C content of the pepper fruits with respect to all treatments.

Table 8. Effects of poultry manure on nutrient content and Vitamin C content of pepper fruit

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (mg/kg)	Zn (mg/kg)	Vit.C (mg/100g)
Control	1.00	0.34	10.51	0.092	6570	620	420	23	11.72
12.5g P.M	2.04	0.26	8.12	0.079	5430	550	850	30.5	11.97
25 g P.M	2.12	0.18	6.37	0.058	4720	460	1030	32.9	12.83
37.5g P.M	2.19	0.14	6.08	0.047	4290	430	1120	34.3	13.23
L.S.D $_{(0.05)}$	0.04	0.06	1.10	0.005	91.2	13.20	69.30	3.10	Ns

PM – Poultry Manure   ns – not significant Vit. C – Vitamin C

4. DISCUSSION

The main focus of the study was to determine the growth, yield and storage qualities of selected pepper varieties as influenced by poultry manure and storage structures. In general, application of poultry manure increased growth and yield of pepper as indicated by plant height, number of leaves, number of branches, number of fruits and fresh fruit weight. This result is in agreement with [6] who reported that organic fertilizers gave better crop yield with increase in application rate than the use of no fertilizers, and this was as a result of improved availability of nutrients adduced through the application of animal (poultry) manure. [13] also observed that soil amendment contributes to plant growth besides that; maximum benefits are derived from adequate or moderate application of fertilizer or manure to vegetable crops. Moreover, Pepper responded best to 25 g of Poultry Manure application in number of fruits, fruits weight and fruit length. Furthermore, increase in the amount of poultry manure applied reduced the yield observed in pepper. This corroborates the findings of [14] who reported an enhancement in growth and fruit yield of pepper with the use of 10 ton/ha of goat manure.

The evidence from this study showed that application of organic manure gave better performance of pepper. This could be attributed to the fact that organic manure supplies mineral nutrients and organic matter which contributes to improving soil physical and chemical properties [15]. However, poultry manure has been reported to increase supply of phosphorus and potassium to the soil as well as much nitrogen, which gives strong plant growth and fruit yield [16]. This was justified by pot receiving 12.5 g pot^{-1} poultry manure rate which later recorded a higher number of leaves and branches at 8 WAP. Although it was not significantly higher than pot receiving no manure treatment (control) at 10 WAT. This may be assumed to the native nutrient present in the soil, which is marginal to support pepper growth. In terms of yield, pots receiving 25 g poultry manure application rate treatment performed significantly better than other treatments with mean yield (15.9 g) which were significantly higher than control (6.3 g). This support the findings of [17] and [18] who reported that vegetables grown with higher levels of organic manure performed better and resulted in a final higher total yield than those grown with lower amounts or no fertilizers. Also, the application of animal manure especially poultry manure has been reported to enhance yield and marketability of vegetable crops such as okra, amaranthus, among others [19]. Furthermore, animal manure has beneficial effects on soil physical and chemical properties [20], as well as the ability to supply macro and trace elements that are not contained in inorganic fertilizers [21]. The two varieties (*Capsicum annum* and *Capsicum frutescens)* differ in their fruit weight and fruit length but were similar in their number of fruits. *Capsicum frutescens* had heavier and longer fruits than *Capsicum annum*. The interaction of the varieties and poultry manure significantly influenced the fruit weight.

Also, from the study, fertilizer application had no significant effect on weight loss, firmness, freshness, disease incidence and decay level of pepper for the duration of storage. This implies that storability of pepper fruits was not affected by manure treatments. Application of different levels of poultry manure did not affect the weight loss of pepper across the 7th day observed. Similar observation was made in the weight loss of pepper in response to the different storage structures used. With respect to firmness, low temperature and high relative humidity enhanced fruit firmness. Pepper fruits stored in the ECS had significantly higher level of firmness than those stored in the wet basket, plastic crates and under ambient condition. It was observed that pepper fruits stored under ambient condition declined in firmness progressively from 4th day in storage but firmness was retained for fruits in the ECS until 14th day in storage. But pepper fruits stored in wet basket overlaid with sawdust had the best firmness on the 10th day and remained firm on the 14th day compared to ECS. Pot in pot and wet basket overlaid with sawdust was good about freshness scale 3 (score on the 14th day. Other storage structure declined below freshness score 3. 0-4 (0= poor, 1=unacceptable, 2- acceptable, 3= good, 4= excellent) [11]. Pot in pot does not require much watering as compared to wet basket; hence it is a preferred storage structure for pepper freshness.

Decay level of fruits stored in the ECS and wet basket was significantly lower than those in plastic crates and those stored under ambient condition from the 9th day of storage. The best response of pepper to decay was observed in ECS and wet basket overlaid with sawdust followed by ECS and wet basket overlaid with ash, while the highest level of decay was observed in open shelf. Although, lower temperatures storage have been reported to be the best means of maintaining quality and increasing shelf life of pepper. The result of this study may be due to ability of storage structures to regulate/distribute its temperature and relative humidity to suit the storage of produce and the positioning of structures during the duration of storage which resulted in better performance of the ECS and wet basket as against the plastic crates and ambient condition with the treatments combination of ash and sawdust. This is in agreement with [22] who reported that modification (ash or sawdust) of storage structures extends shelf-life of produce. This is also in accordance with [23] who stressed that fruit deterioration is predominantly governed by storage condition and that high temperature hastens the process of deterioration. Increased temperature of the ambient condition was shown to affect the performance of pepper fruits in storage. This is because physiological activities such as respiration, which involves heat emission results in temperature increase and acceleration of metabolic processes and decay incidence [24].

From this study, disease incidence affected storage conditions. However, the trend shows that fruits stored in the ECS and wet basket had the least decay incidence followed by fruits stored in the plastic crates. Early development of disease incidence was observed on pepper fruits stored in open shelf and increased throughout the storage period. Pepper fruits should not be stored in open shelf for a long time as it is unprotected from pathogenic organisms. Pepper fruits stored in wet basket overlaid with sawdust remained wholesome after one week and were slightly infected after 14 days of storage. Similar observation was made for pepper fruits stored in ECS on the 14th day. These ECS and wet basket storage structures are recommended for pepper storage to reduce the incidence of disease. 1-4 (1= wholesome, 2= slightly infected, 3 = moderately infected, 4= highly infected) [10]. Pepper fruits kept under ambient condition had the highest disease incidence because high temperature favours the rapid growth of microbes that cause food deterioration. Moreover, [25] stated that deterioration of fresh commodities may result from physiological breakdown due to ripening, water loss, physical damage or invasion by microorganisms, and all these factors interact and affect temperature and relative humidity of the storage conditions. Observation showed that the ECS performance was better than wet basket, although the temperature in the ECS was lower than that in the wet basket. The trend may be attributed to the positioning of the structure and capillarity/infiltration of water in structures during storage, which led to an alteration in the normal temperature of the structures.

Application of poultry manure also aid chemical properties of pepper fruits as shown in Table 8. An increased value of crude protein, crude fibre, nitrogen and iron was best from the application of poultry manure treatment, while best result of dry matter, potassium, magnesium and sodium was observed from no fertilizer treatment or control application. Although, dry matter and Vitamin C content of pepper fruits increased, there was no significant difference and this is in agreement with the findings of [26]. Moreover, the level of phosphorus, calcium, and sodium content of pepper fruits from control was higher than those of the manure treatment, which may have resulted from the present of native nutrients and the consequent nutrient interaction. Increase in the amount of PM applied significantly improved the crude protein, crude fibre and ash content, but did not influence the dry matter. Poultry Manure did not influence dry matter of pepper for the different levels applied. However, it significantly improved the crude protein, crude fibre and ash content with increased amount of poultry manure. Generally, the results of these findings may be attributed to the activities of the soil microorganism that converted organic nutrients into available mineral form, which complemented nutrient availability and absorption, and enhanced chemical properties and mineral content of pepper in accordance with [27]. Increase in the treatment levels (poultry manure) significantly influenced the nutrient content of pepper except Vitamin C as shown in Table 8. The application of higher levels of Poultry Manure is not advised for pepper fruits grown for the Vitamin C content.

5. CONCLUSION

It was evident that pepper benefited from the plant nutrients supplied in the manure. A higher level of poultry manure had the best performance in terms of growth and yield of pepper. Also, variety two, *Capsicum frutescens* responded better and fast to poultry manure application rate in all results obtained compared to variety one *Capsicum annum*. It was also observed from the result of the study that out of the four storage structures (Ambient, Wet basket, Evaporative Coolant Structure and Plastic crates) used, the Evaporative Coolant Structure (ECS) had the best performance. ECS is effective and can be used in place of other storage structures.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Olaniyi JO, Ojetayo AE. The effect of organomineral and inorganic fertilizers on the growth, fruit yield and quality of pepper (*Capsicum frutescence*). Journal of Animal and Plant Sciences. 2010;8(3):1070-1076.
2. FAO, Food and Agriculture organization of the United Nations. Fertilizer and their use. FAO, Rome Italy; 2008.
3. Ado SG. Evaluation of Capsicum in Nigeria- Quantitative Characteristics of pepper. Paper presented at the 12th Annual Conference – Horticultal Society of Nigeria. 1998;16-17.
4. Norman JC. Tropical vegetable crops. Arthur H Stockwell Ltd. Elms; 1992.
5. Yayock JY, Lombin G, Owonubi JJ. Crop science and production in warm climates. Macmillan Publishers, London. 1998; 307.
6. Adesina JM, Sanni KO, Afolabi LA, Eleduma AF. Effect of variable rate of poultry manure on the growth and yield of pepper (*Capsicum annum*) in South Western Nigeria. Academia Arena. 2014;6(1):9-13.
7. Dauda SN, Ajayi FA, Ndor E. Growth and yield of water melon (*Citrullus lanatus*) as affected by poultry manure application. Journal of Agriculture and Social Sciences. 2008;4:121–124.
8. Banaras M, Bosland PW, Lownds NK. Effects of harvest time and growth conditions on storage and post-storage quality of fresh peppers (*Capsicum annuum* L.). Pakistan Journal of Botany. 2005;37:337-344.
9. Babarinsa FA, Nwagwa SC. Development of an evaporative coolant structure for low cost storage of fruits and vegetables. Nigeria Stored Product Research Institute Technical Report No 8; 1984.
10. Babatola LA, Adebayo OB, Lawal OI. Effect of different rates of poultry manure and NPK fertilizer on performance of *Celocia argentina*. Proceedings 16th Annual Conference of Horticultural Society of Nigeria. 2002;55.
11. International Institute of Tropical Agriculture (IITA). IITA Medium Term plan, 1999-2003. IITA Ibadan, Nigeria; 1998.
12. Association of official Analytical Chemists {AOAC). Official Methods of Analysis. l6th. Edition. William S. (ed.) Published by Association of Official Analytical Chemists. CD rom. Washington, D.C., USA; 1998.
13. Baiyeri KP, Otitoju GT, Abu NE, Umeh S. Poultry manure influenced growth, yield and nutritional quality of containerized aromatic pepper (*Capsicum annuum* L.var 'Nsukka Yellow'). African Journal of Agricultural Research, 2016;11(23):2013-2023.
14. Awodun MA, Omonijo LI, Ojeniyi SO. Effect of goat dung and NPK fertilizer on soil and leaf nutrient content, growth and yield of pepper. International Journal of Soil Science. 2007;2(2): 142-147.
15. Olasantan FO. Fertilizer use in vegetable production in Nigeria. Outlook on Agriculture. 1994; 23(3):213-222.
16. Ghoname, A., Shafeek, M. R. Growth and productivity of sweet pepper (*Capsicum annum* L.) grown in plastic house as affected by organic, mineral and Bio-N fertilizers. Journal of Agronomy. 2005;4(4): 369-372.
17. Xu HL, Wang R, Xu RY, Mridha MAU, Goyal S. Yield and quality of leafy vegetables grown with organic fertilizations. Acta Horticulturae. 2005;627:25-33.
18. Ekpo EN, Abiola IO, Adams AB. Growth and yield response of sweet pepper (*Capsicum annuum*) to organic and inorganic fertilizer A.O Olufolaji and V.C Umeh (ed). Proceedings of the 25th National Conference of Horticultural Society of Nigeria (HORTSON), Ibadan; 2007.
19. Ghorbani R, Koocheki A, Jahan M, Asadi GA. Impact of organic amendments and compost extracts on tomato production and storability in agroecological systems. Agronomy for Sustainable Development Journal. 2008;28:307-311.
20. Aliyu L. The effects of organic and mineral fertilizer on growth, yield and composition of pepper. Biological Agriculture and Horticulture. 2000;18:29-36.
21. Mbagwu JSC, Ekwealor GC. Agronomic potential of brewers spent grains. Biological Wastes. 1990;34:335-347.
22. Akomolafe OM, Aborishade AT. Effects of simulated rural storage conditions on the quality of plantain (*Musa paradisciaca*) Fruits. International Journal of Agricultural Research. 2007;2(12): 1037-1042.

23. Sanchez T, Chavez AL, Ceballos H, Rodriguez-Amaya DB, Nestel P, Ishitani M. Reduction or delay of post-harvest physiological deterioration in cassava roots with higher carotenoid content. Journal of the Science of Food and Agriculture. 2006;86:634-639.
24. Sánchez-Mata, M. C., Cámara, M., Díez-Marqués, C. Extending shelf-life and nutritive value of green beans (Phaseolus vulgaris L.) by controlled atmosphere storage: Macronutrients. Food Chemistry. 2003;80(3):309-315.
25. Wilson LG, Boyette MD, Estes EA. Postharvest Handling and Cooling of Fruits, Vegetables and Flowers for Small Farms, Part I. In: Quality Maintenance, Wilson, L.G., M.D. Boyette and E.A. Estes (Eds.). NCCES, USA. 1995;4.
26. Ndubuaku UM, Nwankwo VU, Baiyeri KP, Ukonze J. Influence of poultry manure application on vitamin content, proximate and chemical properties of moringa (*Moringa oleifera lam*) leaves. African Journal of Biotechnology. 2014;14(32): 2501-2509.
27. Ani JU, Baiyeri KP. Impact of poultry manure and harvest season on juice quality of yellow passion fruit (Passiflora edulis var. Flavicarpa Deg.) in the sub-humid zone of Nigeria Fruits. 2008;63(4): 239-247.

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