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Assessment of farmers' management activities on scattered trees on crop fields at Gemechis district, West Hararge Zone, Oromia, Ethiopia

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ABSTRACT

This study was designed to assess farmers' management activities on scattered trees/shrubs on crop fields at Welargi and Hidha Dima kebeles in Gemechis district, West Hararghe Zone. Key informants and household interviews were used. Data collected from key informants and household interviews was analyzed using software SPSS version 20 (statistical package for social science). The analyzed data was summarized in narrative form and presented in descriptive manner. The result showed that, farmers deliberately retained/planted and managed different tree/shrub species. Trees/shrubs scattered on crop fields were identified along their uses. The identified trees/shrubs were seventeen in number and their uses were for soil fertility improvement, animal feed, food, fuelwood, timber, construction and cash income. Management activities they used for managements of different trees/shrubs species were pruning, pollarding and coppicing. Tree-crop based farming system is the most widely distributed agroforestry practice in the study area. Under this practice, the most abundant retained tree species on crop fields by farmers is Croton macrostachyus, under which sorgum and maize were the most dominantly intercropped crops. This study demonstrated that pruning activities is the most dominant management activities for scattered on-farm trees/shrubs in the study area. Farmers' management activities knowledge to be integrated with scientific knowledge to enrich their knowledge and techniques for practice, such as pruning and pollarding time, intensity etc., deserves attention. Study on litter quality (litter decomposition) and nutrient dynamics in the canopy tissues of this tree species should be conducted in order to determine when branches have to be pruned and pollarded for off-site uses or in situ soil conservation activities.

Keywords: Pruning, Pollarding, Coppicing, Gemechis, Scattered trees/shrubs, Hararghe.

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1.0 INTRODUCTION

In many traditional agroforestry systems, trees have always been a key element for sustainability, and farmers often manage high percentage of trees on their lands to control soil erosion and improve the soil fertility (Lakany, 2004). On-farm trees can be found in agricultural landscapes in various forms of spatial and temporal arrangements for different purposes. One of the features of on-farm tree management is that the biological characteristics of trees are often taken into account to determine where it should be grown (Tesfaye, 2005).

Evidence throughout the tropics indicate that trees/shrubs on crop fields contribute to socio-economic (sustain food and wood security), and biophysical sustainability (productivity, environmental services mainly maintenance of soil quality and microbial diversity). Socio-economic benefits include: increase farmers' income and alleviation of poverty, creation of employment opportunity, provision of fuel wood, fodder and construction wood, provision of food, shade provision both for animals and humans medicine. With regard to the latter some of the advantages of the inclusion of compatible and desirable species of woody perennials on farmland are: increasing organic matter content of soil, enhancing efficient nutrient cycling hence maintaining soil fertility, control of soil erosion (Rocheleau *et al.,* 1988; Nair, 1993; Young 1997; Rao *et al.,* 1998).

On-farm tree throughout the tropic has been managed through indigenous knowledge (IK). IK is perceived as knowledge that is unique to a given culture or society. It is embodied in culture and described as an integrated pattern of human knowledge, beliefs and behaviors, ideas, customs, taboos, codes, institutions, tools, techniques, artifacts, rituals, ceremonies and gender. This culture is passed down from one generation to the next generation. It provides a holistic view of how to use natural resources based on traditional ethical perspectives (Atteh, 1991). As on-farm trees and trees outside the natural forests are also important for conservation and social benefit, understanding of farmers' management activities on these resources requires particular attention.

Four factors contribute to a frame of reference: knowledge, experience, values and interests (Boogaard *et al.,* 2006). Experiences is there where traditional management of resources such as on-farm trees and forest has emerged over a century's cultural and biological development and represents accumulated indigenous knowledge of farmers. Recent interest in the value of farmers' indigenous knowledge in developing countries has largely stem from a dissatisfaction with the differentiate and modernization approaches in dealing with poverty, a situation exacerbated by the seeming inability of science and technology to improve the living standards significantly for the majority of people in developing countries (Briggs *et al.,*1998).

Farmers' indigenous knowledge complements scientific knowledge by providing the long practical experience of farmers in managing, living within ecosystems, and responding to the changes of ecosystems. An understanding of the reasons underlying a farmer's management activities can help the researcher to identify the potentially beneficial tree/crop cultivation practices or to stimulate research leading to technical alternatives. So, consideration of farmers' knowledge is important because both farmers and scientific knowledge systems should incorporate each other's ideas and techniques (Den Briggelaar, 1996).

In order to manage tree cover in agricultural landscapes for conservation and production goals, it is important to understand the existing pattern of tree cover, how farmers manage the trees within their farms, and the roles that trees play within production systems. Further more understanding of the roles of the trees on-farms and diversification of the farm in terms of species richness, as well as evenness through increase in number of trees of rare species or through replacement of more common species are the best options for preventing degradation of agroforest ecosystems on-farms (kindt *et al.*, 2005).

2.0 MATERIALS AND METHODS

Descriptions of the study area

Location

The study was conducted in Gemechis district of the West Hararghe zone of the Oromia National Regional State. Gemechis district is one of the fourteen districts in West Hararghe zone, which is located at 343 km east of Addis Ababa and about 17 km south of Chiro, capital town of the zone.The district is situated at the coordinate between $8^{0}40'0''$ and $9^{0}04'0''$ N and $40^{0}50'0''$ and $41^{0}12'0''$ E. It shares borders with Chiro district in the west and north, Oda Bultum district in the south and Mesala district in the east (DOA, 2014) (Fig. 1).

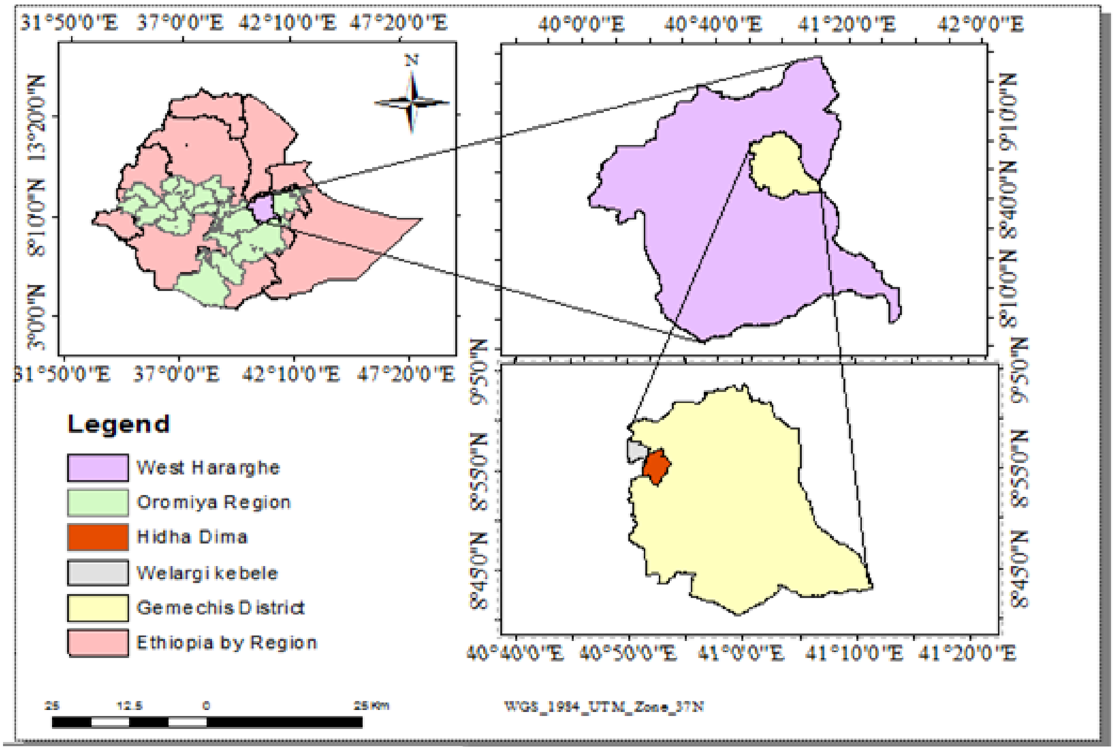

Figure 1. Map of Gemechis district (study area)

Soil and vegetation

The soil of the study area was dominantly loamy soils (moderately fine texture). The vegetation type of the district is characterized by forest, bushes and shrubs. The area of the district covered by forest, bushes and shrubs is 1385ha (DOA, 2014). The most dominant tree species found in the area include; *Croton macrostachyus*, *Cordia africana*, *Olea europaea*, *Vernonia amygdalina*, *Erythrina abyssinica* and many others.

Climate

Agro-ecologically, the district has three climatic zones classified as temperate climatic zone (highland) constituting (15%), warm mild climate (midland) (45%) and lowland climate (40%). The district is found within 1300 to 2400 meters above sea level (m.a.s.l). It receives an average annual rainfall of 850 mm. The district has bi-modal distribution in nature with small rains starting from March/April to May and the main rainy season extending from June to September/ October (DOA, 2014). The average temperature is 20 ^{0}c.

Population

The total population of the district is 184,032 of which 93,659 are males and 90, 373 are females (CSA, 2007). It has thirty-five rural and one urban kebeles. The number of agricultural households in the district is estimated to 38,500 with 32,308 male headed and 6,192 female headed (DOA, 2014). The average family size is estimated to be 6 and 4 per household in rural and urban areas respectively. The district is the first most densely populated district in the zone.

Agricultural activities

The agricultural activities in the district are mainly characterized by the presence of subsistence mixed farming, of both agricultural crop production and livestock. Gemechis district is known for its crop production in West Hararghe zone. There are also households engaged in non/off-farm activities. On-farm trees are the main source of fuelwood demand for the whole communities. The major cereal crops produced in the district are Sorgum and Maize and vegetables (onion, potato, redroot, tomato and cabbage), fruits (banana, pineapple, mango, avocado, papaya), and chat (*Catha edulis*). Minor crops are teff, wheat and barley. The land used for cultivation in the district is 32,994.5ha (DOA, 2014). Based on climatic classification, the farming systems vary in such a way that in low lands one finds livestock dominated type of production system and as one goes up to mid and highlands, crop based mixed production system prevails in the district. Generally, the main sources of income for the local communities are selling of crops and livestock.

Methods

Site selection

Gemechis district was selected based on extensive practice of different trees/shrubs on crop fields and the familiarity of the researcher with the biophysical and socio-economic settings of the study area. In order to have a fair representation of the site, multistage sampling procedure was followed starting from the district, kebele and household levels. Reconnaissance survey was undertaken in the district to select representative scattered tree on crop field practicing kebeles. Of the thirty-five rural Kebele administrative in Gemechis district, Welargi and Hidha Dima were purposefully selected because of extensive practice of scattered trees/shrubs on crop fields. Within the kebeles, random selection procedure was employed for selecting individual households.

Key informants

In order to get data on the scattered trees/shrubs on crop fields, the species type and type of management activities they used; key informants were identified. Key informants are defined as persons who are knowledgeable about soil resources and management, trees and tree cultivation and management, changes in local conditions and have lived for a long time in the respective sites.

To select individual farmers who can identify key informants (KI), snow ball method was carried out. During farm walk, individual farmers were randomly asked to give the name of ten key informants from each kebele. Finally, twenty key informants were selected.

Households

The total numbers of households in both kebeles administrations are 1500. The name of the households living in the village was obtained from the kebeles office and cross-checked by the KIs for its inclusiveness. There are several approaches to determine the sample size. According to Storck *et al*. (1991), the size of the sample depends on the available fund, time and other reasons and not necessarily on the total population. Therefore, this study sampling was representing five percent of the total households for the study site. Finally, eighty households (42 HHs out of 786 in Hidha Dima kebele and 38 HHs out of 714 in Welargi kebele) were randomly selected for interview.

At kebele level, data were collected through both informal interviews with key informants and household questionnaire. Semi-structured questionnaires was prepared to obtain the necessary data about the type of management activities farmers practiced on scattered trees on crop fields, the number and type of trees/shrubs retained/planted on crop lands, crops intercropped with trees/shrubs and other related topics. Beside the interviews, the farms were visited to make observation on the overall condition of the practices.

Data analysis

Data collected from key informants and household interviews was analyzed using software SPSS version 20 (statistical package for social science). The analyzed data was summarized in narrative form and presented in descriptive manner.

3.0 RESULTS AND DISCUSSION

Demographic and socioeconomic characteristics of the respondents

Farmers' settings in different socio-economic situations affect the management of tree/shrub species diversity in their landholdings. In this study, the demographic and socio-economic features of the sampled households were assessed and presented (Table 1).

From the total respondents 93% were male, the remaining were female respondents, and majority of the respondents (84%) were married. However, 9% and 8% of the respondents were divorced and widowed, respectively. This in line with the work of Soyebo *et al.* (2005) that agriculture is very much practiced by married people to make ends meet and cater for their children.

Age is an indicator of experience and accumulation of knowledge in farming activities practically obtained through experience. At the study site, the mean age of the respondents was forty years (Table 1).

Household size represents the total number of individuals living in the same house. Accordingly, the result of the study revealed that 39%, 51% and 10% of respondents constituted a total family size of less than or equal to 5, 6-9 and above 10 members, respectively (Table 1). On the other hand, the mean of family size was six in the study area.

Table 1. Demographic and socio-economic characteristics of the respondents at Welargi and Hidha Dima kebeles in Gemechis district, West Hararghe.

Variables	Frequency and mean of the respondents(n=80)		
	Categories	Frequency	Mean
Sex	Male	74	
	Female	6	
Age(years)	≤30	27	40
	31-64	50	
	≥65	3	
Marital status	Married	67	
	Divorced	7	
	Widowed	6	
House hold size	≤5	31	6
	6-9	41	
	≥10	8	
Educational level	Illiterate	34	
	Primary (1-8)	35	
	Secondary (9-12)	11	
Total Livestock owned in TLU	≤5	51	3.74
	≥6	23	
Farm size(ha)	≤0.5	69	0.4
	≥0.51	11	
Non and off-farm income activity involvement	yes	21	
	no	59	

Educated farmers have more knowledge and capable of recording, documenting and transferring the locally known management activities to the follow farmers and next generation. It also enhances the skill and ability to better use activities practiced in the study area on management of scattered trees/shrubs on crop fields. This survey result indicated that 44% respondents completed primary education followed by illiteracy with 43%and the remaining 14% was achieved secondary education (Table 1).

Land is the component of nature, which has various elements on it, and each element has various uses for humans. In Ethiopia, farmers' livelihood is mainly dominated by agriculture and it forms the backbone of the country's economy. Farm size in this case refers to area under scattered trees/shrubs on crop fields with crop. The result of this study shows that average land holding of household was 0.4 ha. However, majority of them had land holding less than or equal to 0.5 hectare (Table 1).

Farmers in the study area pursued mixed farming in which livestock production was a component. Cattle, Goat, Donkey and poultry were important species of livestock kept by the farmers in the study area. Farmers rear these different types of animals for various purposes such as, source of food (milk and meat), cash income, draft power, means of transport and source of dung for fuel and manure and most importantly as capital asset in time of shocks resulting from crop-failure and other natural hazards. High proportion of the respondents (71%) owned less or equal to five and the rest 29% owned greater or equal to six(Table 2). The mean total livestock owned of the respondents were 3.74 TLU.

Rural household normally diversify their income into a range of farm, non-farm and off-farm activities (Ellis, 2000). According to this study result, from total numbers of respondents 74% farmers involved in on-farm activity, where as the remaining proportion (26%) were based on both non/off-farm activities (Table 1). According to respondents, the main non/off-farm activities that they involved were serving as daily laborer (14%), petty trading (11%) and weaver (1%).

Trees/shrubs scattered on crop fields and their uses

All interviewed farmers had trees/shrubs scattered on their farm lands, but there was variation in the number of trees/shrubs species. Tree/shrub species richness in the studied farmlands was not high. A total of17 trees/shrubs species were recorded over all farms (Figure 2).

Most of the respondents (91%) in the study area used seedlings from natural regeneration to replace old trees in their crop fields, including trees such as *Croton macrostachyus*, *Cordia africana*, *Olea europaea*, *Vernonia amygdalina* and *Erythrina abyssinica*. For scattered trees/shrubs on crop fields, (Rocheleau *et al*, 1988) agree that it is better to protect young natural stands than to plant nursery stock. The practice of protecting the existing natural regeneration, rather than raising seedlings in nurseries and then replanting them, has many advantages, such as labor and cost reduction and they reported that trees in crop fields originate mainly from natural regeneration. However, few of the respondents (9%) used both natural regeneration and seedlings from other sources like from government nursery to replace old trees scattered on their crop fields.

Among scattered trees/shrubs species on crop fields in the study area,*Croton macrostachyus*(90%) was the most frequently encountered species which was retained or planted as on-farm tree and it occurred almost in all visited fields; *Cordia africana* (79%) was the second abundant species; followed by *Olea europaea*(36%), *Vernonia amygdalina* (29%), *Erythrina abyssinica* (16%),*Ehretia cymosa*(15%) and *Casuarina equisetifolia* (15%) with a decreasing order of frequency(Figure 2). These commonly existing species are indigenous. According to the respondents, these indigenous are preferred for two main reasons: first, farmers already have experience as how to manage them and secondly, indigenous trees are better adapted to the local environment.

Farmers and KIs in the study area indicated that, they do not plant species which is not previously known in that area on crop fields. Based on their experience they are well knew which species are suitable for crop production through facilitation. So, farmers give primarily attention for soil fertility improvement rather than other purposes for those trees/shrubs scattered on crop fields and they remove species which is competing with crops.

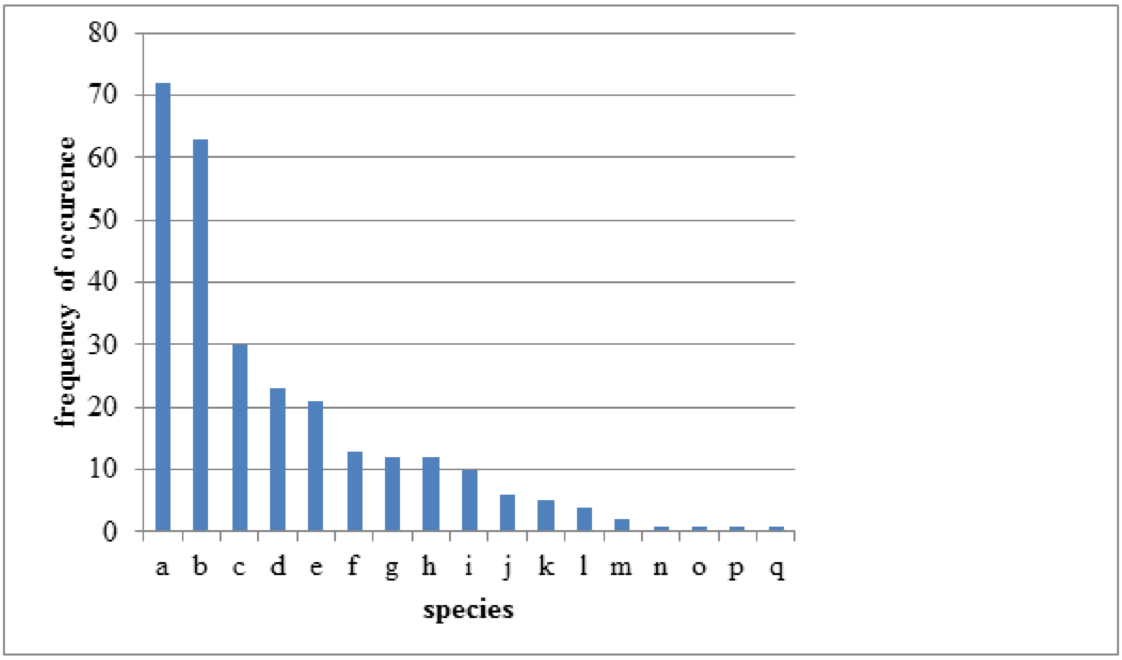

Figure 2. Frequency occurrence of scattered trees/shrubs on crop fields at Welargi and Hidha Dima kebeles in Gemechis district, West Hararghe.

Where: a=*Croton macrostachyus* b=*Cordia africana* c=*Olea europaea* d=*Vernonia amygdalina* e=*Erythrina abyssinica* f=*Casuarina equisetifolia* g=*Ehretia cymosa* h=*Acacia abyssinica* i=*Psidium guajava* j=*Casimora edulis* k=*Anona reticulate* l=*Ricinus communis* m=*Mangifera indica* n= *Persea Americana* o=*Prunus persica* p= *Podocarpus falcatus* q= *Sesbania sesban*

There exists accumulated knowledge that helps farmers to manage trees for various uses. Trees/shrubs that are best for soil fertility improvement, fuelwood, animal feed, food, cash income and other purposes are well known by farmers in the study area and they indicated multipurpose nature of trees. Although a number of trees can be used for the same purpose, preferences of farmers for selecting them depend upon several factors, such as fast growth, ease of management, ease of decomposition and good market demand.

The interviewed respondents indicated that from scattered tree species on their crop fields, *Cordia africana* was mainly maintained for its wood products (timber and fuel wood) and soil fertility. However, *Croton macrostachyus* was mainly for soil fertility improvement. Similarly, from fruit trees Mango (*Mangifera indica* L.), Avocado (*Persea americana*), Bullok's heart*(Anona reticulate L)*, Guava (*Psidium guajava),* White sapota (*Casimora edulis* La Llave & Lex.) andPeach (*Prunus persica* (L.) Batsch) were maintained for food and cash income (Table 2).

Table 2. Percentage of respondents identifying uses of trees/shrubs scattered on their crop fields at Welargi and Hidha Dima kebeles in Gemechis district, West Hararghe.

Trees/shrubs	Percent of respondents (n=80)							
	SF	AF	FW	FT	F	SD	TCW	CI
Crotonmacrostachyus	90	12.5	87.5	-	-	75	37.5	-
Cordia africana	78.8	62.5	75	50	-	68.7	78.8	67.5
Erythrina abyssinica	16.3	16.3	-	-	-	12.5	-	-
Olea europaea	25	37.5	12.5	-	-	5	3.8	-
Casuarina equisetifolia	12.5	8.8	10	-	-	15	7.5	-
Acacia abyssinica	12.5	12.5	6.3	-	-	12.5	-	-
Ehretia cymosa	7.5	15	10	15	-	15	11.3	-
Vernonia amygdalina	7.5	28.7	5	-	-	-	-	-
Persea americana	1.3	-	-	-	1.3	1.3	-	1.3
Podocarpus falcatus	-	-	-	1.3	-	1.3	1.3	1.3
Sesbania sesban	1.3	1.3	-	-	-	-	-	-
Mangifera indica	-	-	-	-	2.5	-	-	2.5
Psidium guajava	-	-	-	-	1.3	-	-	1.3
Prunus persica	-	-	-	-	1.3	-	-	1.3
Casimora edulis	-	-	-	-	6.3	-	-	3.9
Anona reticulata	-	-	-	-	2.5	-	-	1.3
Ricinus communis	2.5	-	-	-	-	-	-	2.5

Key: SF=soil fertility, AF=animal feed, FW=fuelwood, FT=farm tools, F=food, SD=shade, TCW=timber and construction wood, CI=cash income.

Tree-crop based farming was the most widely distributed agroforestry practice in the studied area. Under this practice the most commonly retained and planted tree species by farmers was *Croton macrostachyus* under which Maize (*Zea mays*),Sorgum(*Sorghum bicolor* (L.) Moench*)* were the most dominantly intercropped crops, whereas Barley(*Hordium vulgare)*,Wheat(*Triticum aestivum*), Chat (*Chata edulis)* and Haricot bean (*Phaseolus vulgaris)* were also the intercropped crops. All of the interviewed farmers incorporated annual crops with trees into their farmlands.

Farmers' management activities on scattered trees/shrubs on crop fields

The result of this study indicated that farmers managed different trees/shrubs species on their crop fields. All the interviewed farmers and key informants (KI) indicated that, managing scattered trees/shrubs on crop fields is important for many purposes, such as for soil fertility improvement, animal feed and for other tree products. Farmers used different management activities for managing different scattered trees/shrubs species on their croplands in the study area. These management activities include pruning, pollarding and coppicing.

Farmers in the study area also indicated that managing trees/shrubs on their crop fields by using different management activities were used not only to extract output but also to shape the growth of the tree (through pruning/pollarding). They also indicate that pollarding is used to initiate the preferred stem growth.

Management of scattered trees/shrubs on crop field by pruning was used for better crop-tree interaction, which is commonly practiced by farmers in the study area. Similarly, pollarding practice was also an established management activity for management of scattered trees/shrubs on crop fields in the study area. However, coppicing practiced mainly for harvesting of trees for various purpose (Table 3).

Farmers in the study area not only have profound management activities of which tree species are capable of pruning, pollarding and coppicing, but also the time these activities accomplished. They also indicated that time of pruning; pollarding and coppicing are determined by the need of the trees/shrubs products they wanted. All of the respondents and KIs in the study area indicated that the suitable time for pruning and pollarding was during entry of wet season. In addition, they indicated that those trees that are pruned and pollarded during wet season were used mainly for soil fertility improvement (for example, *Croton macrostachyus* and *Cordia africana).* Respondents mentioned that the trees pruned and pollarded in dry season cannot properly sprout and not easily decomposed. However, pruned branches with leaves practiced during dry season, is used for animal feed (e.g. *Erythrina abyssinica, Olea europaea* and *Acacia abyssinica*).

In the study area, farmers have practiced branch and shoot pruning activities largely for *Croton macrostachyus* and *Cordia africana* for the purpose of soil fertility improvement through transfering the biomass to the crop fields by applying their leaves as a mulch and makes nutrient available to the crops, besides reducing the competition of the trees for water and light and for other purposes, such as for fuelwood.

Similarly, they also prune branch and shoot of *Olea europaea*,*Vernonia amygdalina*, *Erythrina abyssinica*, *Ehretia cymosa* and *Acacia abyssinica* and *Sesbania sesban* and use their leaves, pods, twigs and bark as a source of animal feed, fuel wood, construction and also apply it as a mulch to improve soil fetility. In addition, they also prune *Podocarpus falcatus* for the purose of fuel wood,construction as well as for soil fertility improvement(Table 3).

Table 3. Percentage of respondents practicing management activities on scattered trees/shrubs species on crop fields at Welargi and Hidha Dima kebeles in Gemechis district, West Hararghe.

Species	Percent of respondents(n=80)		
	Pruning	Pollarding	Coppicing
Croton macrostachyus	90	37.5	25
Cordia africana	83.3	50	62.5
Olea europaea	37.5	31.3	12.5
Vernonia amygdalina	28.7	-	10
Erythrina abyssinica	16.3	16.3	7.5
Casuarina equisetifolia	-	10	6.3
Ehretia cymosa	12.5	6.3	7.5
Acacia abyssinica	12.5	7.5	5
Sesbania sesban	1.3	-	-
Podocarpus falcatus	1.3	-	-

The farmers practicing pruning activities for scattered trees/shrubs on crop fields in the study area is in consistent with study made in Awi zone by Workineh (2002), where he reported that pruning by farmers of trees on croplands was common, and was intended to reduce competition with crops for nutrients and water and to obtain fuel wood and construction wood. Similarly in Hararghe, Eastern Ethiopia, Poschen (1988) record that 83% of the respondents pruned *Faidherbia albida* and use for animal feed. As Poschen mentioned, the extent of tree pruning and removal of trees is mainly determined by the need for the tree products.

Based on their experience of cultivating various crops under trees retained on crop lands farmers in the study area practice pollarding for *Croton macrostachyus*,*Cordia africana*, *Olea europaea*, *Erythrina abyssinica*,*Casuarina equisetifolia*,*Acacia abyssinica* and *Ehretia cymosa* for the purpose of reducing shade effect,soil fertility improvement, fuel wood, animal feed and construction.In line with this study, FAO(1985) reported that in the highlands of Kenya, the pollarding of Grevillia robusta growing on agricultural lands is common. Similarly in Lay-Gayint district, south Gonder zone, Abebaw (2006) reported pollarding of *Acacia abyssinica*,*Olea africana*,*Croton macrostachyus* and *Cordia africana* growing on agricultural lands.

The other management activities mentioned at study area was coppicing. Similar to other activities farmers in the study area also practiced coppice activities for *Cordia africana*, *Croton macrostachyus*,*Olea europaea*, *Vernonia amygdalina*, *Casuarina equisetifolia*, *Acacia abyssinica*,*Erythrina abyssinica* and *Ehretia cymosa* mainly for the purpose of harvesting tree for various use(Table 3). Farmers used the harvest part for timber, firewood, charcoal and other tree products. Respondents and KI noticed that coppicing avoids the need to replant trees after harvesting if appropriate time for cutting and method of cutting applied correctly. All respondents and KIs indicated that, the appropriate time for coppicing was after the rainy season. They indicate that cutting of trees during rainy season cause stump of tree. This agrees with study made in Lay-Gayint district by Abebaw (2006), who reported that cutting of trees in the rainy season cause stump decay. They also preffered to cut trees at near the ground at a height of one shoe mainly to protect the sprouts from splitting by wind.

In general, the farmers' view on management of scattered on-farm trees by different management activities is in line with farmers' view of Dhillion and Gustad (2004) who reported different activities are known and locally applied in order to protect and maintain trees successfully in the farm fields for future human benefit. Tree management practices can be applied to meet a variety of specific outcomes; pruning for example can be applied for sanitation, production of specific shapes and rejuvenation.

Scattered trees/shrubs on crop land and soil fertility management

This study indicated that the tree-crop based farming system have both production and protection roles. The production role includes food, feed, timber and fuelwood, which are directly obtained from scattered on-farm trees, whereas the protection role is mainly related to soil fertility improvement and conservation. According to the KI, soil fertility management is predominantly accomplished through using animal manure. They know that soil fertility management using trees depends on the type of tree species, their arrangement and management practices.

Farmers in the study area identify fertile soil by colour; they said that fertile soil is black in colour, while infertile soil is red. All respondents and KI agreed that a decrease in crop yield is the indicator of decrease of soil fertility status. This is consistent with a study made in Zimbabwe by Chuma *et al.* (2002), stated that farmers have expressed that soil fertility has declined to such an extent that no yield can be obtained without applying fertilizers.

Farmers have developed various techniques to improve or maintain soil fertility (Reijntjes *et al.*, 1992). The interviewed farmers have a considerable knowledge on soil fertility management. They select trees/shrubs that maintain soil fertility and recognize which parts of their decompose faster and change to soil. Respondents mentioned leaves as fast decomposing tree parts. Similarly, study in Kindo Koisha district of Wollaita by Eyasu (2000), showed that there were a wide use of leaf litter by resource poor groups of farmers to manipulate soil fertility. In the study area,*Croton macrostachyus* was highly preferred by farmers as soil fertility improvement, due to the reason that; faster decomposition of its leaf. The farmers' response on faster decomposition of *Croton macrostachyus* leaf was in line with Gindaba *et al.* (2004) who reported that trees such as *Croton macrostachyus* whose leaves decompose rapidly could supply nutrients in the short term for uptake by crops.

All respondents replied that soil fertility is better under tree canopy than outside areas because of litter addition under tree canopies.With regard to soil fertility and the role of tree species, interviewed households had similar view with KI. The farmers' view on the role of tree species in improving soil fertility is in line with the farmers' view reported by (Kamara and Haque (1992),Abebe *et al.* (2001); Tadesse *et al.* (2001) for *Militia ferruginea* and by Zebene and Agren (2007) for *Millettia* and *Cordia* grown on enset fields and by Zebene and Agren (2007) for Millettia-enset-coffee and Cordia-enset-coffee agroforestry practices managed by Sidama traditions.

4.0 CONCLUSION AND RECOMMENDATIONS

In Gemechis district at Welargi and Hidha kebeles, trees/shrubs are retained/planted on crop lands in an intimate association mostly with annual and rarely with perennial crops. The total number of trees/shrubs scattered on crop fields were seventeen and their uses were for soil fertility improvement, animal feed, fuelwood, food, shade, cash income, construction and timber. The most dominant crop intercropped with trees/shrubs was maize and sorgum. The activities farmers used on managements of different trees/ shrubs species scattered on their crop fields were pruning, pollarding and coppicing. The management of scattered trees/shrubs by different management activities, which is currently being practiced in the area, could significantly improve livelihood of the people. Hence, their integration in the farming system is worthy and should be encouraged.

Based on these findings the following points are recommended:

- Integration of farmers' management activities knowledge with scientific knowledge to enrich their knowledge and techniques for practice, such as pruning and pollarding time, intensity etc., deserves attention.
- Study on litter quality (litter decomposition) and nutrient dynamics in the canopy tissues of this tree species should be conducted in order to determine when branches have to be pruned and pollarded for off-site uses or *in situ* soil conservation activities.

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Effect of organic amendments on soil nematode community composition, nematode infectivity and plant growth

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ABSTRACT

The effect of organic amendments on soil nematode community composition and pathogenicity on *S.melongena* L.was evaluated by comparing the nematode faunal composition in an amended soil with non-amended soil. Prior to soil enrichment, the undisturbed plot was assessed to determine the endemic nematode community composition. Organic amendment was administered to the undisturbed plot and nematode population dynamics was determined. Planting was done 14 days after application of organic amendment after which soil samples were collected from the experimental plot at 30, 60 and 90 days intervals. Root samples of the *S. melongena* L. were also collected at the same interval. The modified Bearmann's extraction technique was used to determine the soil and endophytic population of nematodes. Soil samples were collected from two different depths, 0-5cm and 6-10cm depths. There was variability in depth related occurrence of nematode genera and species, with abundance and species diversity declining as depth increased prior to amendment ($p>0.05$). This variability was replicated in the experimental plots after amendment ($p<0.05$). The study revealed that the soil enrichment strategies have a great influence on the spatial and temporal distribution of nematode community composition. In this study, the application of organic amendments stimulated trophic affiliation of nematodes such that the fungivores; *Aphelenchoides* spp., *Aphelenchus* spp., *Tylenchusi spp. and Ditylenchus* spp. were common at 0-5cm depth along with the specialist plant feeders (parasitic nematodes). The presence of *K*-strategists such as *Xiphinema* spp. indicated maturity and stability of the environment.

Keywords: Soil enrichment, abundance and species diversity, trophic affiliations, spatial and temporal distribution.

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1.0 INTRODUCTION

Eggplant, *S.melongena* L. is a species of the Nightshade plants known by various names such as Brinjal, Melongene, Guinea squash orAubergines. It is one of the most delicious and nutritive vegetable crops globally (Karmani *et al*., 2011). The eggplant is ranked fourth amongst the universally economically important vegetables after tomato, pepper and potato. The crop is a delicate, tropical perennial often cultivated as atender or half-hardy annual in temperate climates (Sasanelli*et al*., 2009). It grows 40-150cm tall, with large, coarsely lobed leaves that are 10-20 cm long and 5-10 cm broad during fruit bearing (Bohme., 2006; George, 2006 and Mumtaz, 2006). Eggplant suffers from different types of infections howeverplant parasitic nematodes stand out as economically important etiologic agents. Various species of plant parasitic nematodes such as *Meloidogyne*spp., *Pratylenchus*spp., *Rotylenchus*spp., *Tylenchorynchus*spp., *Xiphinema*spp., *Longidorus*spp., *Tylenchus*spp. *and Tylodorus*spp. decline yields in cultivation(Banglapedia, 2006 andKarmani *et al*., 2011).

Nematodes are known to damage the root system of plants thereby hampering the vascular functions of crops. Beside nematode pests, other pests of economic importance of eggplant include;*Empoascaflavencesns* (leaf hopper), *Leucinodesorbaralis* (fruit and shoot borer), *Heliothisarmigera* (army worms), *Trialeurodesvaporariorum* (white fly), *Cercospora* spp. (leaf spot), bacterial wilt, vascular wilt and leaf viral (Gangopaday*etal*., 2009). Pests attack lead to damage in root system and vascular system distortion which affects water and mineral uptake resulting in serious yield reduction (Karmani *et al*., 2011).

The use of synthetic nematicidehave proved to be effective in managing and controlling plant parasitic nematodes, however, their utility is now limited due to environmental unfriendliness, non-availability, costliness, residual effect, bio-accumulation and impact on non-targetorganisms(Ranganatha, 2001). These numerous problems posed by synthetic nematicides to the environment and human health have discouraged their usage world over (Nzeako *et al*., 2013). Organic soil amendments had been a cultural practice for improving the physical and chemical properties of the soil as well as the soils'nutrients. A variety of organic amendments ranging from animal and green manure, undecomposed or decomposed materials are variously used in the agro-ecosystem world over(Vannacci & Gulino, 2000; Atungwu, 2005; Riga, 2011). Incorporation of organic materials to the soil helps to restructure the soils' microflora and microfauna including soil nematodes. Nematodes, are the most ample and diverse group of soil fauna (Vannacci & Gulino, 2000; Riga, 2011). They are ubiquitous in all terrestrialhabitats and soil types with soaring population densities (Atungwu, 2005; Riga, 2011). The changes in the soil physicochemical properties can results in increase in the number of beneficial nematodes such as the bacteriovores and fungivores and the suppression of economically important plant parasitic nematodes. The enrichment of the soil with organic amendments supplies nutrients to the crop, impacts communities of soil organisms, seldom stimulate organisms that are antagonistic to nematodes and suppressive on plant parasitic nematodes (Orisajo *et al*., 2007 and Orisajo *et al*., 2008). This research work is aimed at determining the effects of organic amendments on the soil nematode population dynamics, growth of eggplant, *S. melongena* and their pathogenicity on the eggplant.

2.0 MATERIALS AND METHODS

Study Location

The experiment was carried out in a 15x30 meters plot of land laying between (Lat. 4.895993°N and Long. 7.017002°E) in Port Harcourt, Rivers State, Nigeria. Port Harcourt city falls within the rainforest zone with a short dry season. The area experiences an average annual rainfall range of 1500mm to 3000mm and with average temperature range of 24°C to 28°C. The annual relative humidity ranges between 60-90%. The region has two seasons; dry season from November to March and wet season from March to October. The soil is a loamy sand soil (70.2% sand, 11.2% silt and 18.6% clay, pH 6.16, total organic content (TOC) 2.01, total organic matter (TOM) 3.46 and total hydrocarbon content (THC) 0.005) (Black, 1965).

Experimental Design

The experimental design adopted for the study was the Complete Randomized Block Design (CRBD) of five treatments and five replicates.

Land Preparation and Soil Sterilization Procedures

Pre-planting Collection of Soil Samples

Forty (40) soil samples were randomly collected with the use of a modified soil auger at 0-5cm and 5-10cm depths of a designated undisturbed land. Collected soil samples were put in properly labeled polythene bags and transported to the University of Port Harcourt Parasitology laboratory to determine the initial nematode population in the soil.

Determination of Physicochemical Properties the Soil.

The soil particle size was evaluated using the Bouyoucos Hydrometer Method by Bouyoucos (1951), pH of the soil was determine using the electronic method by Black (1965)while the Total Organic Matter (TOC) was according to the method proposed by Anderson and Ingram, (1989), Total Nitrogen (TN) was according to Linder and Harley(1942), Total Hydrocarbon Content (THC) was according to Anderson and Ingram(1989). The Oil and Grease (O and G) component of the sampled soil was in line with Bouyoucos(1951), Electric Conductivity according to Day(1953), Total Organic Matter (TOM) was in line with Davidson(1953). However, Sulphate (SO_4^{2-}) ion determination was according to Black(1965), Nitrate (NO^3) ion according to Jackson(1962), Phosphate (PO_4^{3-}) ion was according to Jackson(1962), Chloride (Cl^-) ion by Jackson(1962), Available Phosphorus (AP) was by Jackson(1962) method, sodium (Na^+) ion according to Black(1934) and Potassium (K^+) ion was according to Black(1934).

Removal of Natural Vegetation and Preparation of Beds

The primary vegetation of the planting plot (Experimental plot) was removed with local implements such as cutlass and hoes.The experimental land (30m x 15m) was partitioned into five plots. These were labeled plots A-E. In each plot, five beds were made with a dimension of 5m length by 50cm breadth by 60cm height. Furrows were 90cm apart and served as drainages for water as well as walk way for the researcher.

Compost Preparation

Poultry dung, dry leaves and fresh leaves were used to prepare the compost. To enhance composting, leaves were chopped into small pieces. These were piled in layers and stored in 200litre container with perforated sides to increase aeration in the container.

Planting

Source of Seed

Eggplant seeds were sourced from Songhai farm at Bunu, Tai Local Government Area of Rivers State, Nigeria.

Sterilization of Soil for Nursery

Garden soil were collected at depths of 1-10cm, sieved with a 2mm aperture sieve and sterilized with steam at a temperature of 40-50°C for a period of 50 minutes and air cooled. The sterilized soil was used in building the nursery on perforated plastic troughs.

Raising eedlings in the Nursery

The seeds were planted by broadcasting on the sterilized soil in the nursery chamber and observed for three weeks before transplanting. The seedlings were thinned in the nursery to avoid overcrowding. The watering can was used to water the seedlings twice daily.

Transplanting

Seedlings were transplanted three weeks after germination with the hand trowel. 80cm planting distance was observed, with each bed havinga total of 20 plants. The plants were watered at 12 hour intervals while weeding was done on daily basis (hand picking).

Application of Organic Amendment (Compost)

All the plots were amended with organic fertilizer except plot D as control and E (standard). Plot D has no organic amendment while Plot E was treated with inorganic fertilizer. Organic amendment was applied as surface mulch using the hand fork at the rates of 50kg, 37.5kg and 25kg for A, B, and C respectively. These were left to mineralize for a period of two (2) weeks transplanting. The control was not amended with Organic materials while the artificial fertilizers served as a standard control (Abolusoro*et al.*, 2013).

Post-planting Soil Sampling

Soil samples were collected 30, 60 and 90 days after planting from each bed at the depths of 5cm and 10cm making a total of 50 samples. Soil samples were collected randomly close to the rhizosphere of the eggplants, put in a designated sterile polythene bags and transported to the laboratory for nematode assay.

Extraction of Nematodes from Root and Identification

The root bioassay was carried out at intervals of 30, 60 and 90 days to determine the endophytic nematode population according to Nzeako *et al.*, (2011). The Light compound microscope was used to identify the worms according to Golden (1985) and Goodey and Goodey(1963).

Determination of Gall Index and Egg mass Index

Gall index was determined using the method by Hertmann and Sasser, (1987)

Analysis of Plant Parameters

Assessment of growth parameters and plant yield was done using the methods proposed by Harish (2009), Vijaya and Seethalakshmi (2011) and Habib *et al.*, (2012)

Diversity Index and Evenness Indices

The Shannon Weirmers' diversity (H'), Evenness' index (E), Simpsons Index (S), Species Index and Dominance Index were used to evaluate the rhizosphere nematode population.

Weed and pest control

Hand picking was adopted as the weed control strategy. Physical barriers were created around the perimeter of the experimental plot while the soluble fractions of goat dung were used as aerosol on the plants to repel insects.

Chemical fertilizer

Statistical Analysis

The data obtained from the study were analyzed using Analysis of Variance (ANOVA) to evaluate the effect of compost on eggplant as well as the spatial and temporal distribution of nematode in the soil along with aforementioned population dynamics indices.

3.0 RESULTS

Nematode population in the undisturbed site.

A total of 504 nematodes made up of 14 genera were recovered from the sampled sites. Out of this population, 327(64.9%) were obtained from the 0-5cm depth while 177(35.1%) were obtained from 6-10cm depth (Table 1).Amongst the individual genera of nematodes, *Tylenchus* spp. had the highest prevalence of 81 (16.1%), followed by *Ditylenchus* spp. with a prevalence of 77(15.3%) and *Meloidogyne* spp. 66(13.1%). Others were *Pratylenchus* spp. recording 47(9.4%), *Hemicycliophora* spp. with 40(8.0%), *Aphelenchoides* spp. had 31(6.2%), *Longidorus* spp. had 31(6.2%), *Paratylenchus* spp. had 25(5.0%), *Xiphinema* spp. with 24(4.8%), *Helicotylenchus* spp. with 22(4.4%) and *Aphelenchus* spp. having 18(3.6%). Others were*Gracilacus* spp. with 16(3.2%), *Hemicriconemoides* spp. recording 14(2.8%) and *Rotylenchus* spp. having 10(2.0%). There was great variability in the distribution of nematode species in the undisturbed site, *Rotylenchus* spp. 10(2.0%) had the least prevalence while *Tylenchus* spp. 77(15.3%) had the highest prevalence (Table 1).

At the 0-5cm depth, 327 nematodes recovered comprising 18(5.5%) for *Aphelenchoides*spp., 10(3.1%) for*Aphelenchus*spp., 64(19.6%) for*Ditylenchus*spp., 9(2.8%) for*Gracilacus*spp. *and* 14(4.3%) for*Helicotylenchus* spp. 8 (2.4%) was recorded for*Hemicriconemoides* spp., and 24(7.3%) was for*Hemicycliophora*spp.,. Others were 24(7.3%) for*Longidorus*spp., 38(11.6%) for*Meloidogyne*spp., 15(4.6%) for*Paratylenchus*spp., 31(9.5%) wasfor *Pratylenchus*spp., 4(1.2%) for *Rotylenchus*spp., 56(17.1%) was for *Tylenchus*spp., and12(3.7%) was recorded for *Xiphinema*spp. (Table 1).

At the 6-10cm depth, a total of 177 nematodes were recovered. However, there was variability in the occurrence of nematodes at this depth, of which 13(7.3%); belonged to the *Aphelenchoides* spp., *Aphelenchus* spp. had 8(4.5%);*Ditylenchus* spp. had 13(4.0); *Gracilacus* spp. had 7(4.0%); *Helicotylenchus* spp. had 8(4.5%); *Hemicriconemoides* spp. had 6(3.4%); *Hemicycliophora* spp.,had16(9.0%); *Longidorus* spp. had 9(5.1%); *Meloidogyne* spp. had 28(5.8%); *Paratylenchus* spp. had 10(5.6%); *Pratylenchus* spp. had 16 (9.0%); *Rotylenchus* spp. had 6(3.4%); *Tylenchus* spp. had 25(14.1%);while *Xiphinema* spp. had 12 (6.8%). *Tyelnchus* spp. 25(14.1%) had the highest prevalence and the lowest was *Rotylenchus* spp. with 6(3.4%) (Table, 1.).

The trophic affiliation of the nematodes showed no occurrence of bacteriovores, omnivores and predaceous nematodes however, 23(14.3%) of the nematodes recovered were fungivores and 12(85.7%) were plant parasitic. The fungivorous ones were *Aphelenchoides* spp., and *Ditylenchus* spp, while the herbivores also known as plant parasitic were *Gracilacus* spp *Helicotylenchus* spp., *Hemicriconemoides* spp., *Hemicycliophora* spp., *Longidorus* spp., *Meloidogyne* spp., *Paratylenchus* spp. *Pratylenchus* spp., *Rotylenchus* spp., *Tylenchus* spp., and *Xiphinema* spp. (Table 4.1).The c-p value of the 14 genera and species were identified into three groups, *Aphelenchoides* spp., *Aphelenchus* spp.,*Ditylenchus* spp.,*Gracilacus* spp.,*Paratylenchus* spp. and *Tylenchus* spp. had a c-p value of 2, *Helicotylenchus* spp., *Hemicriconemoides* spp., *Hemicycliophora* spp., *Meloidogyne* spp., *Pratylenchus* spp. and *Rotylenchus* spp. had a c-p value of 3 while *Longidorus* spp. and *Xiphinema* spp. had a c-p value of 5 (Table 1).

Data Showed that there was a significant difference ($p<0.5$) between the populations of nematodes recovered from different soil depths. However, there was no significant difference ($p>0.05$) on the depth related biodiversity in the study (Table 1).

Pre-planting nematode population after application of organic amendment (PAOA).

A total of 453 nematodes made up of 13 genera and species were recovered from soil prior to planting. Out of this population, 228(50.3%) were obtained from the 0-5cm depth while 225(49.7%) were obtained from the 6-10cm depth. Amongst the individual genera of nematodes, *Xiphinema* spp. had the highest prevalence of 113(24.9%), followed by *Longidorus* spp. with a prevalence of 90(19.9%) and *Hemicycliophora* spp. 52(11.5%) while *Aphelenchoides* spp.,

Paratylenchus spp. and *Tylenchorynchus* spp. had the least prevalence of 13(2.9%), 10(2.2%) and 10(2.2%) respectively. The prevalence of the others are; *Crypthodera* spp. 32(7.1%), *Ditylenchus* spp. 30(6.6%), *Pratylenchus* spp. 30(6.6%), *Tetylenchus* spp. 25(5.5%), *Meloidogyne* spp. 18(4.0%), *Dorylaimus* spp. 15(3.3%) and *Tylenchus* spp. 15(3.3%) (Table, 2.).

At the 0-5cm depth, a total of 228 nematodes were recovered belonging to 13 genera and species. Out of which 13(5.7%) belonged to the *Aphelenchodes* spp., 17(7.5%) were *Crythodera* spp., 10(4.4%) were *Ditylenchus* spp., 5(2.2%) were *Dorylaimus* spp., 20(8.8%) were *Hemicycliophora* spp., 35(15.4%) were *Longidorus*spp.,10(4.4%) were *Paratylenchus* spp., 25(11.0%) were *Pratylenchus* spp., 10(4.4%) were *Tylenchorynchus* spp., 15(6.6%) were *Tylenchus* spp. and 68(29.8%) were *Xiphinema* spp.,. There was great variability in terms of distribution of the nematode species in the site 14 days PAOA. *Xiphinema* spp. had the highest prevalence of 68(29.8%) while *Dorylaimus* spp. had the least prevalence of 5 (2.2%) at this depth (Table 2).

Furthermore, a total of 225 nematodes were recovered from the 6-10cm depth belonging to 13 genera and species. Out of these 15(6.7%) belonged to the *Crypthodera* spp., 20(8.9%) were *Ditylenchus* spp., 10(4.4%) were *Dorylaimus* spp. and 32(14.2%) were *Hemicycliophora* spp., while 55(24.4%) were *Longidorus* spp.,18(8.0%) were *Meloidogyne* spp., 5(2.2%) were *Pratylenchus* spp.,25(11.1) were *Tetylenchus* spp., and 45(20.0%) were *Xiphinema* spp., Out of all these, *Longidorus* spp. had the highest prevalence of 55 (24.4%), followed by *Xiphinema* with a prevalence of 45(20.0%) while *Pratylenchus* spp. had the least prevalence of 5(2.2%) (Table 2).

The 13 genera of nematode recovered were identified into 3 trophic groups namely fungivorous, herbivorous (plant parasitic) and omnivorous-predaceous. Of which 2 (15.4%) were fungi feeders (*Aphelenchoides* spp. and *Ditylenchus* spp.), 10 (76.9) were plant feeders (*Crythodera* spp., *Hemicycliophora* spp., *Longidorus* spp., *Meloidogyne* spp., *Paratylenchus* spp., *Pratylenchus* spp., *Tetylenchus* spp., *Tylenchorynchus* spp., *Tylenchus* spp.and *Xiphinema* spp. while 1(7.7%) were omnivorous-predaceous (*Dorylaimus* spp.) (Table2).The 13 genera were identified into four c-p values. *Longidorus* spp. and *Xiphinema* spp. were identified into c-p value of 5, *Crypthodera* spp. and *Dorylaimus* spp. had a c-p value of 4, *Meloidogyne* spp., *Paratylenchus* spp., *Pratylenchus* spp., and *Tylenchus* spp. were identified into c-p value of 3 while *Aphelenchoides* spp., *Ditylenchus* spp., *Tetylenchus* spp. and *Tylenchorynchus* spp. were identified into c-p value of 2 (Table 2).

Data showed that there was no significant difference between the number of nematodes populations recovered from 0-5cm depth and 6-10cm depth at the significance level of ($p>0.05$), however, there was a significant difference in terms of occurrence, biodiversity and variability. In overall, data showed that there was no significant difference ($p>0.05$) on the depth related biodiversity and depth variability in the study (Table 2).

Response of nematodes to organic amendment.

A total of 176 nematodes in 1ml of aliquot were recovered from the roots of *S. melongena* after 30 days of transplanting. Data showed that in all the three treatment levels; 42 (23.9%), 38 (21.7%) and 36 (20.4%) nematodes were extracted while the non-amended (NOA) and fertilizer (IOF)plots were 36 (20.4) and 24 (13.6) respectively. After 60 days, a total of 810 nematodes were recovered from the amended plots and they are follows 232 (28.6), 154 (19.0) and 160 (19.8) while 156 (19.3) and 108 (13.3) were recovered from the NOA and IOF sets respectively. At 90 days, total of 744, nematodes recovered of which 174 (23.4), 170 (22.9) and 128 (17.2) were recovered from the amended levels while 132 (17.7) and 140 (18.8) were recovered from the NOA and the IOF sets respectively (Table 3).

Data showed that 50kg treatment level encouraged the multiplication of nematodes with multiplication peaking at the 60 days interval. However, there was a significant different ($p<0.05$) between the amended sets and the NOA and IOF sets in the study (Table 3)

Response of eggplant to organic amendment

At 30 days post application of organic amendment (PAOA), the mean stem height (MSH) of the amended crops were 22.4cm, 15.0cm and 18.2cm at 50kg, 37.5kg and 25kg treatment levels respectively.

However, the control sets of NOA recorded 12.6cm and IOF had MSH of 12.6cm. The mean leaf length (MLL) of the amended crops at 50kg, 37.5kg, 25kg, were 17.6cm, 18.8cm, and 18.2 cm respectively while the NOA and IOF were 12.2 cm and 14.3cm respectively. The mean plant girth (MPG) obtained from the amended crops were 0.27 cm, 0.26cm and 0.20cm at 50kg, 37.5kg and 25kg respectively while 0.17cm and 0.19cm were recorded for the NOA and IOF respectively. Also, the mean number of leaves (MNL) for the crops was 6 in all treatment levels. The mean branch number (MBN) was 1 for all the treatment levels.

At 60 days PAOA mean stem height (MSH) at treatment levels of 50kg, 37.5kg and 25kg were 100cm, 98cm and 92cm respectively while (MSH) for the NOA and IOF were 80 and 80 respectively. The Mean leaf lengths (MLL) of the crops at the three treatments were 42, 43 and

41respectively while that for NOA and IOF were 33 and 33 respectively. Also, the Mean leaf numbers (MLN) of the crops at the three treatment levels were 46, 54 and 51 respectively, while that of the NOA and IOF were 32 and 40 respectively. Plant branch (MPB) at all treatment levels were 8, 11 and 11 while that for the NOA and IOF were 6 and 8 respectively. The mean plant weight (MPW) of the crops at three treatment levels were 389.7g, 253.7g and 297.6g respectively while that of NOA and IOF were 25kg 91.1g and 127.7g respectively. The mean plant girths (MPG) of the crops at all treatment levels were 0.6, 0.5 and 0.44 while that of NOA and IOF were 0.37 and 0.38 respectively. The Mean root weight (MRW) of the plants at the three treatment levels were 89g, 70g and 78g while that of the NOA and IOF were 49g and 58g respectively.

At 90 days PAOA, the mean stem height (MSH) at treatment levels of 50kg, 37.5kg and 25kg were 171cm, 167cm and 148cm while for NOA and IOF were 132 and 158 respectively. The mean leaf lengths (MLL) were 41, 35 and 31 for treatment levels of 50kg, 37.5kg and 25kg respectively while 20cm and 37cm were for NOA and IOF respectively. The mean plant girths (MPG) for treatment levels of 50kg, 37.5kg and 25kg were 4cm, 3.4cm and 3.6cm while 1.4cm and 2.1cm were for NOA and IOF respectively. The mean leaf number (MLN) were 142cm, 124cm and 115cm for treatment levels of 50kg, 37.5kg and 25kg respectively while 88cm and 102cm were for NOA and IOF respectively. Furthermore, the mean plant branch (MPB) for treatment levels of 50kg, 37.5kg and 25kg were 26, 29 and 21, while 18 and 19 were MPB for NOA and IOF respectively. The mean plant weight (MPW) were 1580g, 1360g and 1500g for treatment levels of 50kg, 37.5kg and 25kg respectively while 675g and 814g were MPW for NOA and IOF respectively. The mean root weight (MRW) were 214g, 166g and 208g for treatment levels of 50kg, 37.5kg and 25kg respectively while 56g and 116g were MRW for NOA and IOF respectively. Furthermore, the mean fruit number (MFN) for treatment levels of 50kg, 37.5kg and 25kg were 108, 82 and 125 while 17 and 34 were MFN for NOA and IOF respectively. The mean fruit weight (MFW) in grams for treatment levels of 50kg, 37.5kg and

25kg were 37, 37 and 39 while 30 and 33 were MFW in grams for NOA and IOF respectively.

Data showed that there was significance difference ($p>0.05$) in plant growth and nematode population in relation to organic amendment. At 30 days PAOA, the mean stem height (cm), mean leaf length (cm), mean plant girth (cm), mean wet plant weight (g) and mean wet root weight (g) were significantly increased in the case soil amended with varied dosages of organic manures as compared to the subsets without organic manure or synthetic fertilizers. However, more nematodes were extracted from the roots of plants grown in 50kg dosage than others. Although, the population nematode recovered were not significant at this period. At 60 days PAOA, the mean stem height (cm), mean leaf length (cm), mean plant girth (cm), mean plant branch number, mean leaf number, mean wet plant weight (g) and mean wet root weight (g) were significantly increased in the case soil amended with varied dosages of organic manures as compared to the set without organic manure or synthetic fertilizers.

The number of nematodes recovered from the root were significantly higher at $p>0.05$ in all concentrations compared to those without amendment soil.

At 90 days PAOA, the mean stem height (cm), mean leaf length (cm), mean plant girth (cm), mean plant branch number, mean leaf number, mean wet plant weight (g), mean wet root weight (g), mean fruit number, mean fruit girth (g), and mean fruit weight (g) were significantly increased in the case soil amended with varied dosages of organic manures as compared to those without organic manure or synthetic fertilizers. Furthermore, nematode population in the roots were significantly increased (Table 1). This increment is specifically due to high organic amendment applied rather than diversity of the vegetation.

Discussion and conclusions

Discussion

This study showed that the diversity and abundance of nematodes in the undisturbed site was more than in the amended soil. Depth related occurrence of nematodes in the study declined as depth increased which was in conformity with Nzeako *et al*., (2014, 2015 and 2016). However, this trend was not consistent in the amended soil where there was homogeneity in diversity and species abundance. The homogeneity observed in the study was strongly due to the tilling of the soil and addition of organic amendment which enhanced availability of nutrients (table 2).The nematode species abundance at the 0-5cm depth in the undisturbed (pre planting) was associated to humus litter deposits on the soil surface. Nematodes such as *Ditylenchus* spp. accounted for 19.6% of recovered nematodes where litter were broken down and mineralize (table 1). *Tylenchus* spp.; a specialist feeder and strong biotroph assemblage occurred at this depth accounting for 17.1% of the recovered nematodes (table 1). However, at the 6-10cm depth, the population of these two nematodes were not statistically significant (p>0.0). (table 1).

In this study it was observed that the population of the dagger nematode, *Xiphinema* spp increased greatly after the application of organic amendment in 0-5cm and 6-10 cm depths respectively (Table 2). The population theses nematode genera and species decreased after AOA, due to the increased temperature of the soil environment owning to the organic amendment and removal of natural vegetation. It was also observed that 14 day after incorporation of organic amendment some genera of nematodes were delineated while new ones such as *Dorylaimus* spp., *Tetylenchus* spp. and *Tylenchorynchus* spp. emerged (Table 2) owing to succession pull occasion by variability in physicochemical and biological characteristics of the soil (Nzeako, 2013, Nzeako, 2016).The variability in spatial and temporal distribution of nematodes in the study was attributed to organic matter concentration on the surface of the soil. Agricultural practices such as tilling and constant weeding as well as physic-chemical parameters in the terrestrial environment (Bulluck III *et al*., 2002 and Karmani *et al*., 2011) a factors stated to influence the population dynamics of soil meiofauna.

The disparity in the nematode species richness in the study site reveals the impact of anthropogenic influence on flora and fauna integrity in the habitat (Ruston *et al*., 2004; Breure *et al*., 2005).Muldera (2005) opined that nematode species usually display increased ecosystem stability in conditions of poor ecosystem management. Ferris *et al*. (2001), stated that the enrichment opportunist nematodes usually respond positively to disturbances in environment irrespective of the health integrity of the environment thereby making them very important indicators of soil fertility and not of pollution (Muldera 2005).

Growth parameters such stem height (cm), leaf length (cm), mean plant girth (cm), wet plant weight (g), wet root weight (g), plant branch number, leaf number, fruit number, fruit girth (cm), and fruit weight (g) were significantly influenced at the various levels of amendment 30, 60 and 90 days PAOA compared to the control (No organic amendment and synthetic fertilizer). This agrees with El-Zawahry (2000) and Umar and Jada (2000) reported that organic amendment resulted to increase in plant growth and reduction in nematode population. However, Ibrahim and Ibrahim (2000) observed that organic amendments of the soil with farmyard mixed with poultry manure resulted in plant vigor and reduced penetration of the roots by plant parasitic nematodes. BulluckIII *etal*., (2002) reported that soil amendments had a large impact on nematode community structure and diversity. This was buttressed by Devi and Hassan (2000) who showed a 100% improvement on the growth attributes of crops planted in soils enriched with farmyard and poultry manure.Karmani*et al*., (2011) reported that organic amendment in all doses significantly increased the shoot and root weight, increased in soil nematodes but suppressed parasitic in the roots.

Conclusion

The variability of nematode species, abundance and diversity in relation to depth as well as to disturbances is associated with nutritional availability, the degree of anthropogenic inferences, physiological characteristics of the parasites (i.e. hydrobiosis), physico-chemical parameters of a

Specific area in the study sites. Enrichment of the agro-ecosystem with organic soil amendment influenced nematode trophic dynamics and nematode community structure.

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Table 1 Initial nematode population in the undisturbed site

Genera/Species	C-P Scale	Trophic Group	Depth related occurrence (%) 0-5cm	6-10cm	Overall Occurrence (%)
Aphelenchoides spp.	2	FF	18 (5.5)	13 (7.3)	31 (6.2)
Aphelenchus spp.	2	FF	10 (3.1)	8 (4.5)	18 (3.6)
Ditylenchus spp.	2	FF	64 (19.6)	13 (7.3)	77 (15.3)
Gracilacus spp.	2	FF	9 (2.8)	7 (4.0)	16 (3.2)
Helicotylenchus spp.	3	PF	14 (4.3)	8 (4.5)	22 (4.4)
Hemicriconemoides spp.	3	PF	8 (2.4)	6 (3.4)	14 (2.8)
Hemicycliophora spp.	3	PF	24 (7.3)	16 (9.0)	40 (8.0)
Longidorus spp.	5	PF	24 (7.3)	9 (5.1)	31 (6.2)
Meloidogyne spp.	3	PF	38 (11.6)	28 (15.8)	66 (13.1)
Paratylenchus spp.	2	FF	15 (4.6)	10 (5.6)	25 (5.0)
Pratylenchus spp.	3	PF	31 (9.5)	16 (9.0)	47 (9.4)
Rotylenchus spp.	3	PF	4 (1.2)	6 (3.4)	10 (2.0)
Tylenchus spp.	2	PF	56 (17.1)	25 (14.1)	81 (16.1)
Xiphinema spp.	5	PF	12 (3.7)	12 (6.8)	24 (4.8)
Total (%)			327 (64.9)	177 (35.1)	504

Key: FF: Fungi feeders. PF: Plant feeders, C-P Scale: colonizer-persister Scale

Table 2 Pre-planting nematode population after application of organic amendment

Genera/species	C-P Scale	Trophic Groups	Depth related occurrence (%) 0-5cm	6-10cm	Overall occurrence (%)
Aphelenchoides spp	2	FF	13 (5.7)	0 (0.0)	13 (2.9)
Crythodera spp.	4	PF	17 (7.5)	15 (6.7)	32 (7.1)
Ditylenchus spp.	2	FF	10 (4.4)	20 (8.9)	30 (6.6)
Dorylaimus spp.	4	OM/PR	5 (2.2)	10 (4.4)	15 (3.3)
Hemicycliophora spp	3	PF	20 (8.8)	32 (14.2)	52 (11.5)
Longidorus spp.	5	PF	35 (15.4)	55 (24.4)	90 (19.9)
Meloidogyne spp	3	PF	0 (0.0)	18 (8.0)	18 (4.0)
Paratylenchus spp	2	PF	10 (4.4)	0 (0.0)	10 (2.2)
Pratylencus spp.	3	PF	25 (11.0)	5 (2.2)	30 (6.6)
Tetylenchus spp.	2	PF	0 (0.0)	25 (11.1)	25 (5.5)
Tylenchorynchus spp	2	PF	10 (4.4)	0 (0.0)	10 (2.2)
Tylenchus spp.	3	PF	15 (6.6)	0 (0.0)	15 (3.3)
Xiphinema spp.	5	PF	68 (29.8)	45 (20.0)	113 (24.9)
Total (%)			228 (50.3)	225 (49.7)	453

Key; FF: Fungi feeders, PF: Plant feeders, OM/PR: Omnivores or predaceous ,C-P Scale: colonizer-persister scale

Table 3 Response of nematodes to organic amendment

	Nematodes in eggplant root					
Days/OAC	**50kg**	**37.5kg**	**25kg**	**NOA**	**IOF**	**TOTAL**
30 days	42 (23.9)	38 (21.7)	36 (20.4)	36 (20.4)	24 (13.6)	**176**
60 days	232 (28.6)	154 (19.0)	160 (19.8)	156 (19.3)	108 (13.3)	**810**
90 days	174 (23.4)	170 (22.9)	128 (17.2)	132 (17.7)	140 (18.8)	**744**

Table 4 Response of *S.melongena* to organic amendments at 30, 60 and 90 days intervals.

30 days post application of organic amendment					
Organic amendment concentration (OAC)	50kg	37.5kg	25kg	NOA	IOF
Stem height (cm)	22.4	15.0	18.2	12.6	12.6
Leaf length (cm)	17.6	18.8	18.2	12.2	14.3
Plant girth (cm)	0.27	0.26	0.20	0.17	0.19
Leaf number	6	6	6	6	6
Plant branch number	1	1	1	1	1
60 days post application of organic amendment					
Organic amendment concentration (OAC)	50kg	37.5kg	25kg	NOA	IOF
Stem height (cm)	100	98	92	58	80
Leaf length (cm)	42	43	41	33	33
Plant girth (cm)	0.6	0.5	0.44	0.34	0.38
Leaf number	46	54	51	32	40
Plant branch number	10	11	11	6	8
Plant weight (g)	389.6	253.7	298	91	128
Root weight (g)	87	70	78	49	58
90day post application of organic amendment					
Organic amendment concentration (OAC)	50kg	37.5kg	25kg	NOA	IOF
Stem height (cm)	171	167	148	132	158
Leaf length (cm)	41	35	31	20	37
Plant girth (cm)	4	3	3	1.4	2.1
Leaf number	142	124	115	88	102
Plant branch number	26	29	21	18	19
Plant weight (g)	1580	1360	1500	675	814
Root weight (g)	214	166	208	56	116
Number of fruits	108	82	125	17	34
Fruit weight (g)	37	37	39	30	33
Fruit girth (cm)	5	5	5	3	4

Nematode in Root and soil = Population of nematodes in 1ml of aliquot, F = flower, OAC = Organic Amendment Concentration in (kg), NOA = No organic amendment, IOF = Inorganic fertilizer

Effects Of Pinching Time On Growth And Fruit Yield Of Three Tomato Varieties (*Lycopersicon Lycopersicum* Mill) In The Southern Guinea Savanna Zone Of Nigeria

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ABSTRACT

Field experiment was conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso and Niger State College of Agriculture, Mokwa, in 2012 cropping season to examine the effects of pinching on growth and fruit yield of tomato. The experiment had twelve treatments of three varieties (Ogbomoso Local, Mokwa Local and UC82B) of tomato and four pinching times (0, 2, 4 and 6) weeks after transplanting (WAT) replicated three times. The experiment was laid out in Randomized Complete Block Design (RCBD) and data were collected on plant height, number of leaves, number of flowers, number of fruits and total fruit yield. Data was analysed using analysis of variance (ANOVA) SAS package and treatment means compared using least significant difference (LSD) at 5% probability level. The results showed that un-pinched plants gave the highest plant height (39.5 cm) while pinching at 2 WAT gave the least (33.7 cm). UC82B gave the highest fruit yield (23.10 t ha^{-1}) while Mokwa Local recorded the least (12.00 t ha^{-1}). Plants pinched at 4 WAT gave the highest fruit yield (19.60 t ha^{-1}) and the least (12.5 t ha^{-1}) was obtained from un-pinched plants. Based on the findings, UC82B and pinching time of 4 WAT may be recommended for the farmers within the study areas.

Key words: Tomato, pinching time, variety, growth, yield.

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1.0 INTRODUCTION

Tomato (*Lycopersicon lycopersicum*) belongs to the solanaceae family. It originated in Peru and Mexico, in the present day Central and South America from where it spread to other parts of the world (Zeidan, 2005). Tomato reached Europe from Mexico in the 16th century, and was initially used as ornamental plant. Its cultivation for edible fruits started at the end of the 18th century. Tomato was introduced to West Africa and Nigeria in particular, at the end of the 19th century (Villareal, 1980). It is currently considered to be one of the main vegetable crops in the world, and constitutes an economic force that influences the income of many growers in the world (Omar, 2005). In Nigeria tomato also finds its way into almost every kitchen. Tomato crop is very important in terms of diet and economy in Nigeria both during the rainy season (rain fed) and dry season using irrigation facilities. It is used as a condiment in stews and soup or eaten raw in salads. Industrially, the crop is made into puree, sauce, paste and powder (Balarabe, 2012).

Pinching is an horticultural operation in which the terminal growing end of a plant is removed (George, 2004). Pinching consists of removing side shoots when they are 5 cm long by gently breaking off shoot between finger and thumb. This can be done up to one meter or full height of the plant. Pinching makes the control of diseases particularly during wet periods easier. When plants with apical dominance are pinched, lateral buds are encouraged to grow, resulting in full rather than tall, narrow plants (single stem) (Anon, 2006). Pinched plants produce multiple terminal growths that bear flowers and hence increase fruit formation. The side shoots should be removed by pinching them out with the fingers. If allowed to grow they will produce mass foliage but few tomatoes (Guildford, 2009). Pinching and staking increase earliness of fruiting at the expense of yield. Pinching of determinate varieties should be avoided or kept to minimum (Jeffrey, 2004). Pruning tomato plants should begin during early stages of growth, when the plant reaches a height around 30.5 – 45.7 cm. Waiting to prune later on in the development could cause it to go into shock, reducing production. These can occur if you prune a lot of branches at one time (Williams, 2010).

Once tomato plant has developed six or seven trusses it should be stopped by breaking out the growing tip as this would encourage the plant to produce good quality tomatoes rather than an abundance of low quality late-maturing fruit (Michele, 2009). It is necessary to pinch off the growing tip or tips so that the remaining fruits have a chance to ripen. The fruit that is formed on unpinched plant are generally smaller than and not as flavourful as that of a pruned tomato plant, although more fruits are produced. Although pinching can be a tedious chore, it is immensely satisfying to harvest a large crop of juicy, healthy tomatoes all season long (Tonya, 2006).

Despite the popularity of the crop, there is paucity information on the response of tomato to pinching. Many farmers in Nigeria do not practice it for tomato production. This study aimed at determining the appropriate pinching time for tomato production.

2.0 MATERIALS AND METHODS

The experiments were conducted at two locations; Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso (8°10¹N; 4°10¹E) and Niger State College of Agriculture, Mokwa (9° 18¹N and 5° 04¹E), during 2012 cropping season. The experimental plot was ploughed and harrowed after which lining out was carried out. There were 36 plots with three replications. Each replicate consisted of 12 plots. Each treatment was in a plot size of 2.5 m x 2.0 m (5.0 m^2). A plot contained 30 plants. The total experimental area was 378.00 m^2 (0.038 ha^{-1}). The alley way between replicates plots was 1.0 m and within replicates was 1.0 m. Tomato seedlings were transplanted at a spacing of 50 cm x 50 cm. The treatments consisted of four pinching times; 0 (no pinching) 2, 4 and 6 weeks after transplanting (WAT) and three tomato varieties (Ogbomoso Local, Mokwa Local and UC82B). The treatments were 4 x 3 factorial experiment and fitted into a Randomized Complete Block Design (RCBD), replicated three times.

The seeds were sourced from the Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, Ogbomoso and from the Department of Agricultural Technology, Niger State College of Agriculture, Mokwa. The tomato seeds were sown on nursery beds containing pulverized soil and the seedlings were raised for four weeks before transplanting to the field at the two locations. Watering in the nursery was done as at when needed. Healthy and vigorous seedlings were transplanted into the field in order to ensure uniformity. Watering was done using watering - can to supplement rainfall. Pesticide in form of cypermethrin was applied at the dosage of 25 ml per 15 litres of knapsack sprayer fortnightly to check caterpillars, worms and grasshoppers. Manual weeding was also carried out using hoe at three weeks interval starting from 2 WAT to reduce competition between weeds and plants.

Data were collected on growth and fruit yield from six selected plants per plot. Data collected were subjected to Analysis of Variance (ANOVA) using SAS statistical package. Treatment means were separated using the least significant difference (LSD) at 5% probability level.

3.0 RESULTS

The plant heights of the tomato varieties were not significantly ($P \leq 0.05$) different at 2 and 4 WAT but at 6 WAT variety UC82B was significantly shorter than Ogbomoso Local and Mokwa Local which were not significantly different from each other (Table 1). The plants pinched at 2 weeks were significantly shorter (13.0 cm) than the plants from the un-pinched plants and pinched plants at 6 weeks. The un-pinched plants recorded the highest mean value of 39.5 cm at 6 WAT. But the value obtained from un-pinched was not significantly different from the mean value (37.1 cm) obtained from the plants pinched at 6 weeks. The trend was the same at 2, 4 and 6 WAT. The interaction effect of variety and pinching time had no significant ($P \geq 0.05$) effect on the plant height of tomato at all the sampling periods. The mean number of leaves of tomato varieties were not significantly ($P \geq 0.05$) different at 2, 4 and 6 WAT (Table 2). The number of leaves of the three tomato varieties were significantly ($P \leq 0.05$) influenced by pinching time at 2 and 6 WAT. The plants pinched at 2 weeks with the mean value of 76.8 significantly produced higher number of leaves than the un-pinched plants at 6 WAT but plants pinched at 4 and 6 weeks had similar number of leaves with the mean values of 71.1 and 68.5, respectively. The interaction effect of variety and pinching time was not significant ($P \geq 0.05$).

The number of flowers of UC82B (30.3) was significantly ($P \leq 0.05$) more than that of Ogbomoso Local (22.3) which was not more than that of Mokwa Local (21.3). The mean number of flowers of three tomato varieties were significantly ($P \leq 0.05$) increased by the pinching time in both locations. The plants pinched at 4 WAT recorded the highest mean value of 31.6, followed by the pinched plants at 6 WAT with the mean value of 26.0 which was not significantly different from the plants pinched at 2 WAT (22.3) while the least mean value of 18.7 was obtained from the control plot. But there was no significant difference between the plants pinched at 2 WAT and the control plots (Table 3).

The number of fruits of UC82B (30.5) was significantly higher than that of Ogbomoso Local (22.3) while the varieties of Ogbomoso Local and Mokwa Local had similar number of fruits (Table 4). The number of fruits was significantly ($P \leq 0.05$) increased by pinching time. The plants pinched at 4 WAT recorded the highest mean value of 31.8 which was significantly higher than the mean value of 26.0 obtained at 6 WAT. But there was no significant difference between the mean values received at 6 WAT from the plants pinched at 2 weeks and the control plot. The interaction effect between the variety and pinching time was not significant ($P \geq 0.05$).

The three tomato varieties was significantly ($P \leq 0.05$) different in the total fruit yield (Table 5). The highest fruit yield of 23.10 t ha^{-1} was obtained from UC82B, followed by the mean value of 14.60 t ha^{-1} received from Ogbomoso Local which was not significantly different from the least mean value of 12.00 t ha^{-1} obtained from Mokwa Local. But UC82B significantly performed better than the values obtained from Ogbomoso Local and Mokwa Local varieties, respectively. Pinching time had significant ($P \leq 0.05$) influence on the total fruit yield of tomato. The total fruit yield increased as the pinching time weeks increased with the highest mean value of 19.60 t ha^{-1} recorded from the plants pinched at 4 WAT. This was closely followed by the plants pinched at 6 WAT with the mean value of 18.00 t ha^{-1}. The plants pinched at 4 WAT significantly recorded a higher yield than the plants pinched at 2 WAT and the un-pinched, respectively. Also, the plants pinched at 2 WAT with the mean value of 16.10 t ha^{-1} significantly gave better yield than that of the control plot which had the least mean value of 12.50 t ha^{-1}. The interactive effect of variety and pinching time was not significant ($P \geq 0.05$).

4.0 DISCUSSION

The increased in growth parameters as the plant aged might be due to the increase in the cell number and size. This result is similar to the report of Olaniyi and Akanbi (2008) who reported that there was increase in the plant height and number of leaves of cabbage as the plant aged. The significant reduction in plant height following pinching time as recorded in the current study agrees with the report of Stacey (1983) in which apical bud removal resulted in decreased tomato plant height. The results of the current study revealed that plants in which pinching time of 2 and 4 WAT were done had decreased plant height.

This is in agreement with the findings of the above author. Findings in this study also agrees with those of Levent and Sozer (2001) who stated that pinching of the lateral branches and the tips cause reduction in the production of a mass foliage which must have led to plant height reduction observed in the presents study. This is contrary to the reports of Uddin *et al.* (1997) and Ara *et al.* (2007) working in Bangladesh who obtained the shortest heights from unpruned tomato plants. The disagreement might have arisen from varietal and climatic differences. Olasantan (2001) also reported that treatment enhanced in branch production increased young leaf production in okra. According to Williams (2010), pruning tomato plants should begin during early stages of growth, when the plant reaches a height of about 30.5 to 45.7 cm waiting to prune later on in the development could cause it to go into shock, reducing production. This result is in line with Anon. (2006) who reported that when tomato plants with apical dominance are pinched, lateral buds are encouraged to grow, resulting into full rather than tall, narrow plants (single stem).

The superiority of UC82B over the other two varieties in respect of the number of flowers and total fruit yield agrees with the findings of Olaniyi (2009) who stated that tomato varieties differ in flowering ability due to differences in genetic make-up. This view is also in line with that of Olaniyi and Fagbayide (1999). The significant increase in number of flowers is as a result of more lateral buds that were encouraged to develop when plants tip were pinched. This agrees with George (2004) who revealed that pinched plants produced multiple terminal growths that bore flowers and hence, increased fruit formation and size. Stopping of tomato plants above six or seven trusses is a practice that encourages flowering (Michele, 2009). However, result obtained from this study in which about 30.3 flowers was obtained for UC82B, agrees with Anon. (2008) and Tswanya *et al.* (2012) who stated that average number of tomato flowers ranged between 20 - 35 under normal practice. In okra, work carried out by Olasantan and Salau (2007) also revealed that pruning significantly increased number of pods per plant.

Olaniyi *et al.* (2010) reported that fruit yield per plant and total fruit yield significantly differed among varieties due to genetic differences. The results of the current study showed that UC82B significantly gave the highest total fruit yield of 23.10 t ha^{-1} which falls to the upper value of a range of 26.29 t ha^{-1} of the world as per FAO (2003) and 20 to 30 t ha^{-1} with good management as reported by Uguru (2011). Furthermore, the highest total fruit yield of 19.60 t ha^{-1} and 18.00 t ha^{-1} was recorded when plants were pinched at 4 WAT than the values obtained from the un-pinched plants, which was very close to 20 to 30 t ha^{-1} total tomato yield reported by Uguru (2011). The yield obtained from this study current study agrees with the findings of Tswanya *et al.* (2012) who revealed that plants pinched produces higher fruit yield than the un-pinched plants.

4.0 CONCLUSIONS

The appropriate pinching time for tomato in the southern guinea savanna is 4 WAT. Generally, the values observed from un-pinched plots were lower than the pinched plants. Findings from the results showed that UC82B variety had the highest fruit yield and consistently maintained higher values in other parameters evaluated. It is therefore recommended for the farmers within the study areas.

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Table 1: Effect of variety, pinching time and their interaction on plant height of tomato plants in 2012 cropping season

Variety	Plant Height (cm) Pinching Time (WAT) 0	2	4	6	Variety Mean
			2WAT		
OL	16.8	13.8	15.3	15.7	15.4
ML	14.9	12.1	13.5	14.3	14.6
UC82B	15.6	13.2	13.6	14.8	14.5
PT Mean	15.8	13.0	14.1	14.9	
LSD V	ns				
LSD PT	1.21				
V x PT	ns				
			4 WAT		
OL	21.9	19.5	19.8	21.6	20.7
ML	19.8	17.3	18.7	19.4	19.9
UC82B	20.6	17.3	18.7	20.1	19.7
PT Mean	20.8	18.0	19.1	20.4	
LSD V	ns				
LSD PT	1.22				
V x PT	ns				
			6 WAT		
OL	43.0	35.7	38.4	39.9	39.3
ML	39.9	35.4	37.9	38.8	38.7
UC82B	35.6	30.0	31.5	32.5	36.9
PT Mean	39.5	33.7	35.9	37.1	
LSD V	ns				
LSD PT	3.01				
V x PT	ns				

OL = Ogbomoso local, ML = Mokwa local, V = variety, PT = pinching time, NS = not significant (P≤0.05)

Table 2: Effect of variety, pinching time and their interaction on number of leaves per plant of tomato plants in 2012 cropping season

Variety	Number of Leaves Pinching time (WAT) 0	2	4	6	Variety Mean
			2 WAT		
OL	16.7	19.7	17.8	17.0	17.8
ML	15.8	18.4	17.8	16.8	17.5
UC82B	15.5	18.5	18.1	16.2	17.4
PT Mean	16.0	18.9	17.9	16.7	
LSD V	ns				
LSD PT	1.52				
V x PT	ns				
			4 WAT		
OL	38.7	43.1	41.3	40.1	40.8
ML	33.1	38.1	37.2	35.4	38.6
UC82B	34.8	46.4	40.4	39.3	39.1
PT Mean	35.5	42.5	39.6	38.3	
LSD V	ns				
LSD PT	ns				
V x PT	ns				
			6 WAT		
OL	58.4	85.3	74.2	70.0	72.0
ML	56.4	74.5	71.4	69.2	70.2
UC82B	60.7	70.6	69.4	66.2	69.2
PT Mean	58.5	76.8	71.7	68.5	
LSD V	ns				
LSD PT	9.25				
V x PT	ns				

OL = Ogbomoso local, ML = Mokwa local, V = variety, PT = pinching time, ns = not significant (P≤0.05)

Table 3: Effect of variety, pinching time and their interaction on number of flowers per plant of tomato plants in 2012 cropping season

Variety	Pinching time (weeks after transplanting)				Variety mean
	0	2	4	6	
OL	16.6	20.1	31.0	21.4	22.3
ML	13.1	15.1	32.6	24.4	21.3
UC82B	26.6	31.6	31.1	32.2	30.3
Pinching time mean	18.7	22.3	31.6	26.0	
LSD 0.05					
Variety	3.89				
Pinching time	4.49				
V x PT	ns				

OL = Ogbomoso local, ML = Mokwa local, V = variety, PT = pinching time, NS = not significant (P≤0.05)

Table 4: Effect of variety, pinching time and their interaction on number of fruits per plant of tomato plants in 2012 cropping season

Variety	Pinching time (weeks after transplanting)				Variety mean
	0	2	4	6	
OL	16.6	20.1	31.0	21.4	22.3
ML	13.1	15.1	32.6	24.5	21.3
UC82B	26.4	31.6	31.8	32.2	30.5
Pinching time mean	18.7	22.3	31.8	26.0	
LSD 0.05					
Variety	4.04				
Pinching time	4.66				
V x PT	ns				

OL = Ogbomoso local, ML = Mokwa local, V = variety, PT = pinching time, NS = not significant, (P≤0.05)

Table 5: Effect of variety, pinching time and their interaction on total fruit yield (t ha-1) of tomato plants in 2012 cropping season

Variety	Pinching time (weeks after transplanting)				Variety mean
	0	2	4	6	
OL	10.9	14.5	17.6	15.2	14.6
ML	8.3	11.1	15.2	13.4	12.0
UC82B	18.2	22.8	26.1	25.4	23.1
Pinching time mean	12.5	16.1	19.6	18.0	
LSD 0.05					
Variety	2.95				
Pinching time	3.40				
V x PT	ns				

OL = Ogbomoso local, ML = Mokwa local, V = variety, P = pinching time, NS= not significant, (P≤0.05)

Effects of Pre-Storage Treatments on Sprouting and Nutritional Quality of Ginger (*Zingiberofficinale*Rosc) Rhizomes in Different Storage Periods

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ABSTRACT

Ginger rhizomes are highly susceptible to damage during postharvest storage due to soil borne pathogenic disorder. Experiments were conducted to evaluate the effects of pre-storage treatments required for sprouting and maintaining the quality of ginger plant in different storage periods at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso. The rhizomes were treated with four different pre-storage treatments viz.,control, hydrated lime, Mancozeb, and 100ml of *Trichodermaharzianum* solution at different storage periods of one, two and three months. The experiment was arranged in a complete randomized designand laid out in a randomized complete block design with three replicates. Data were collected on percentage sprouting, plant height, number of leaves, leaf area and nutritional quality of ginger rhizomes. Data were subjected to analysis of variance using Statistical Analysis System Software (SAS, 2005). Differences among treatment means were compared using Least Significance Difference (LSD) at 5% probability level. The storage periods significantly ($P \leq 0.05$) influenced the percentage sprouting andgrowth parametersof ginger at various sampling period. Highest growth of 9.05cm was recorded from ginger plant stored for three months while the least value of 6.94cm was obtained from rhizomes stored for one month. The pre-storage treatments significantly ($P \leq 0.05$) influenced the percentage sprouting, weight loss and growth parameters of ginger at various sampling period. Highest percentage sprouting (94.3%) was recorded from rhizomes treated with 100 ml *Trichodermaharzianim* solution followed by rhizomes treated with hydrated lime (88.3 %) while lowest percentage sprouting (61.5 %) were recorded from control. Highest percentage weight loss of 46.3% was recorded from control followed by hydrated lime (35.58 %) while the lowest percentage weight loss of 33.93 % was recorded from 100 ml *Trichodermaharzianim* solution. In conclusion, rhizomes treated with *Trichodermaharzianim* solution for a period of three months before planting produced better sprouting and enhanced the growth quality of ginger on the field.

Key words: Pre-storage treatment, sprouting, nutritional quality, Ginger rhizomes, storage periods.

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1.0 INTRODUCTION

Ginger (*Zingiberofficinale*Rosc) is an important spice crops throughout the world. It requires a tropical or subtropical climate and thrives well up to an altitude of 1500 m above MSL in the Himalayas, the optimum being 300-900 m (Archana *et al.*, 2013). There are yellow ginger (Ug1) and black ginger (Ug2) varieties in Nigeria at present. (NRCRI, 2005). Ginger is used to prevent many ailments such as; asthma, fever and cough. It contains volatile oil, fixed oil, oleoresin, vitamins, starch, proteins and minerals (Sharma *et al.*,1991). From the time of harvesting (December to January) of rhizomes till subsequent planting season (May – June) the rhizomes are to be stored for about 3 -4 month in healthy and viable conditions (Thankamani *et al.*,2002). According to Karuppaiyan *et al.* (2008), harvested rhizomes are highly vulnerable to damage if proper care is not taken during postharvest storage due to soil borne pathogens or pest attack.

Chemical solutions are used to prevent soil borne pathogens or pest, and induce sprouting after sowing. Treatments of rhizomes with 5g of *Trichodermaharzianum* per kg rhizomes and 0.3% dithane M-45 had been reported to induce early sprouting and improves rhizomes quality (Shadap *et al.*, 2014). However, there is need to improve the indigenous technology of pre-storage treatments in order to obtain more viable and better performance ofginger rhizome. This study is todetermine the appropriatepre-storage treatments and storage periods required for improving the growth quality of ginger on the field.

2.0 MATERIALS AND METHODS

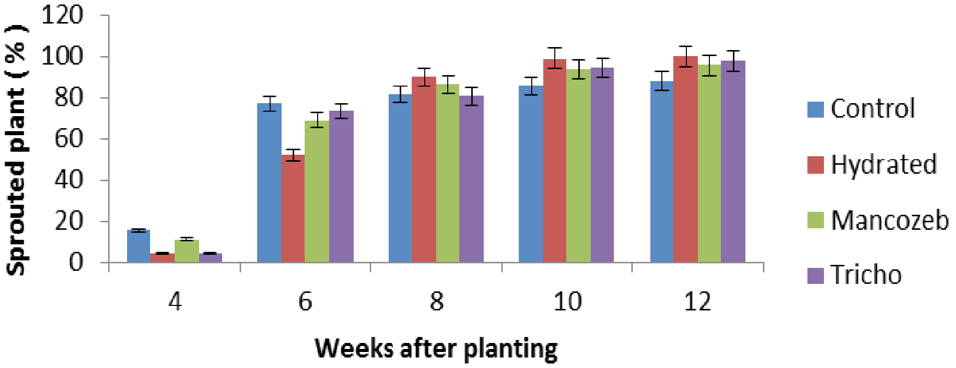
Laboratory and field experiments was carried out during December 2014 –May2015 at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso to determine the effects of pre-storage treatments and storage periods on sprouting and nutritional quality of ginger rhizomes. Fresh, healthy and uniform yellow ginger variety (Ug1) were obtained from Ladoke Akintola University of Technology, Ogbomoso. and used as test crop. The rhizomes were treated in four different pre-storage treatments and stored forthree storage periods. The pre-storage treatments are; Hydrated lime, Mancozeb,100ml of *Trichodermaharzianum* solution and Control. The storage periods are; one month, two months and three months. Each pre-storage treatment was used to treat 1kg of ginger rhizomes for 30minutes.The experimentswasarranged in a complete randomized designand laid out in a randomized complete block design with three replicates.

Land was cleared using cutlasses and tilled thoroughly with hoe to bring the soil to fine tilt .Twelve beds were prepared on the field, each size of 1.2 m x 1.2 m with an inter-space of 0.5 m between beds.After one month interval of storage period,four samples of ginger rhizomes were taken from each pre-storage treatment and planted on each bed.Cultural practices such as mulching, watering, and weeding were carried out for proper crop establishment.Data were collected on percentage weight loss, sprouting date and number of sprouted plant per bed from each treatment combinations at one week interval.Early growth of ginger plant were determined by assessing the plant height, number of leaves and leaf area(using length x breadth x 0.6475).The sprouting percentage was calculated by the number of sprouted rhizomes divided by total number of rhizomes planted on each bed and multiplied with 100. Percentage Ca, Fe, Crude protein, Crude Fibre , moisture Content, fat and ash content was determined using the official method of analysis described by the Association of Official Chemist (AOAC,1990).Data collected were analyzed using Standard Analysis System (SAS, 2005) for analysis of variance (ANOVA). Difference among treatments means were computed using least significance differences (LSD) at 0.05 probability level.

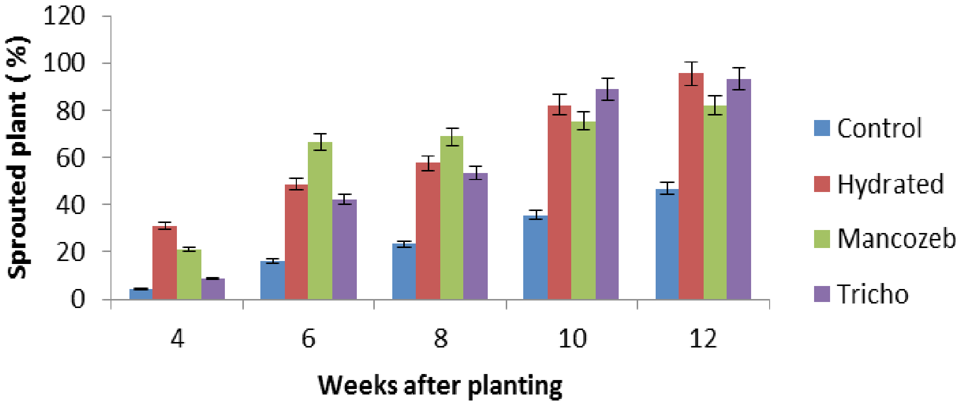
3.0 RESULTS AND DISCUSSION

The pre-storage treatment and storage periodsignificantly ($P \leq 0.05$) influenced the percentagesprouting of ginger plant at various sampling periods as shown in Figure 1. Highest percentage sprouting was recorded from ginger stored for one month while the least growth was obtained from rhizomes stored for three month irrespective of the pre-storage treatments. At one month after storage rhizomes treated with Hydrated lime gave the highest percentage sprouting of (100%) closely followed by rhizomes treated with *Trichodermaharzianum* solution (95.00%) while the control rhizomes recorded the least value of 87.87% at 12 WAP.

One month



Two months



Three months

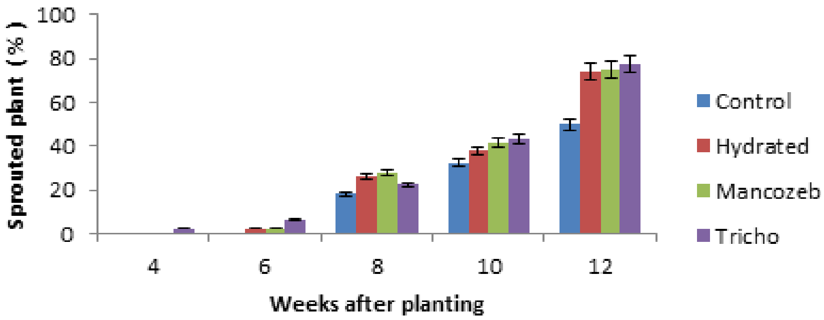


Figure 1: Effects of pre-storage treatments on the percentagesprouting of ginger rhizomes at different storage periods

At two months after storage rhizomes treated with Hydrated lime gave the highest percentage sprouting of 95.6% closely followed by rhizomes treated with *Trichoderma harzianum* solution (93.00%) while the control rhizomes recorded the least value of 46.87% at 12 WAP. At three months after storage rhizomes treated with *Trichodermaharzianum* solution gave the highest percentage sprouting of 95.6% followed by rhizomes treated with Mancozeb (74.93%) while the control rhizomes recorded the least value of 49.8% at 12 WAP.This was in accordance with Shadap *et al.*, (2014) who reported that ginger rhizomes treated with *Trichodermaharzianum* (5g/kg) gave highest percentage sprouting when used as pre-storage treatment which might be due to the favorable effects of the bio-control agent on sprouting.

The pre-storage treatmentand storage period significantly (P≤0.05) influenced the growth parameters of ginger plant at various sampling periods (Table 1). Highest plant height was recorded from ginger stored for three months while the least value was obtained from rhizomes stored for one month irrespective of the pre-storage treatments. This was in accordance with Shadap *et al.*, (2014) who reported that rhizomes stored under healthy condition for 90 days prior to subsequent planting season prevent rhizomes rot and improved viability of ginger rhizomes. At one and two months after storage the highest height 8.63 cm and 10.4cm of ginger plant were recorded from rhizomes treated with *Trichodermaharzianum*at 12 WAP. At three months' storage rhizomes treated with 100 *Trichodermaharzianim* solution recorded the highest sprouted height (9.05cm) followed by control (8.95 cm) while rhizomes treated with hydrated lime recorded the least value (7.71cm) at 12 WAP.

At one month after storage the highest number of leaves (5.0 and 8.63) for ginger plant was recorded from rhizomes treated with *Trichodermaharzianum*at 10 and12 WAP. At two months after storage the highest number of leaves (10.4) for ginger plant was recorded from rhizomes treated with *Trichodermaharzianum* at 12 WAP. At three months storage rhizomes treated with mancozeb recorded the highest number of leaves (8.63 cm) followed by rhizomes treated with 100 ml of *Trichodermaharzianim* solution (10.25 cm) while control recorded the least value (8.33 cm) at 12 WAP.

At one month after storage the highest leaf area for ginger plant (36.31cm^2 and 41.21cm^2) were recorded from rhizomes treated with *Trichodermaharzianum*at (10 and 12 WAP). At two months after storage the highest leaf area for ginger plant (28.58 cm^2 and 43.09 cm^2) were recorded from rhizomes treated with Mancozeb at (10 and 12WAP). At three months storage rhizomes treated with hydrated lime and stored for three months recorded the highest leaf area (62.23 cm^2) followed by rhizomes treated with 100 ml of Trichodermaharzianim solution (61.96 cm^2) while control recorded the least value (49.56 cm^2) at 12 WAP.

Table1: Effects of pre-storage treatments on the plant height (cm) of ginger at different storage periods

	STORAGE PERIOD					
	ONE MONTH		TWO MONTHS		THREE MONTHS	
	WEEKS AFTER PLANTING					
Pre—storage Treatments	10	12	10	12	10	12
Control	3.45	6.91	6.20	7.95	8.13	8.95
Hydrated lime	3.93	8.06	5.95	6.95	6.75	7.71
Mancozeb	4.18	8.25	7.83	9.26	5.75	8.17
Trichoderma	5.59	8.35	5.86	7.37	4.40	9.05
LSD (0.05)	0.50	0.32	0.45	0.51	0.53	00.19

Table 2: Effects of pre-storage treatments on the number of leaves of ginger plant at different storage periods

	STORAGE PERIOD					
	ONE MONTH		TWO MONTHS		THREE MONTHS	
	WEEKS AFTER PLANTING					
Pre-Storage Treatments						
Control	**4.1**	**5.13**	**6.03**	**9.47**	**8.25**	**8.33**
Hydrated lime	**4.4**	**6.81**	**6.03**	**8.8**	**8.41**	**9.05**
Mancozeb	**4.04**	**7.7**	**6.1**	**8.36**	**9.15**	**10.6**
Trichoderma	**5.0**	**8.63**	**7.3**	**10.4**	**9.00**	**10.25**
LSD	**0.45**	**0.52**	**0.5**	**0.55**	**0.49**	**0.51**

Table 3: Effects of pre-storage treatments on the leaf area (cm^2) of ginger at different storage periods

	STORAGE PERIOD					
	ONE MONTH		TWO MONTHS		THREE MONTHS	
	WEEKS AFTER PLANTING					
Pre-storage Treatments	**10**	**12**	**10**	**12**	**10**	**12**
Control	25.90	39.29	28.49	49.56	39.62	49.56
Hydrated lime	27.69	34.60	28.47	62.22	44.17	62.23
Mancozeb	28.39	33.89	28.58	43.09	39.04	43.10
Trichoderma	36.31	41.27	28.48	42.22	47.28	61.96
LSD(0.05)	0.63	1.00	0.15	0.70	1.52	0.71

The pre-storage treatment and storage period significantly (P≤0.05) influenced the percentage weight loss and retained the nutritional quality of ginger rhizomes at various sampling periods as shown in Figure 2, 3. Highest percentage weight loss was recorded from ginger stored for three months while the least percentage weight loss was obtained from rhizomes stored for one month irrespective of the storage methods. This was in line with Bahri and Rashidi (2009) who reported that weight or water loss significantly increased with increased in storage period. At one month storage period percentage weight loss was minimum for rhizomes treated with 100 ml of Trichodermaharzianim solution (13.15 %) followed by mancozeb (15.59%) while percentage weight loss recorded the least for control (23.75%). At two months storage period percentage weight loss was minimum for rhizomes treated with 100 ml of *Trichodermaharzianim* solution (24.46 %) followed by hydrated lime (25.89%) while percentage weight loss recorded the least for control (35.72%). At three months storage period percentage weight loss was minimum for rhizomes treated with 100 ml of *Trichodermaharzianim* solution (24.46 %) followed by hydrated lime (35.58%) while percentage weight loss recorded the least for control (45.30%).

LSD 5%

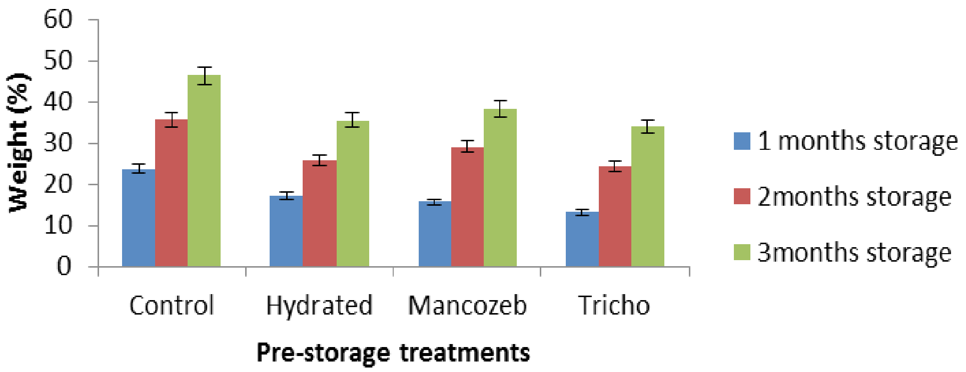


Figure 2: Effects of pre-storage treatments on the percentage weight loss of ginger rhizomes at different storage periods

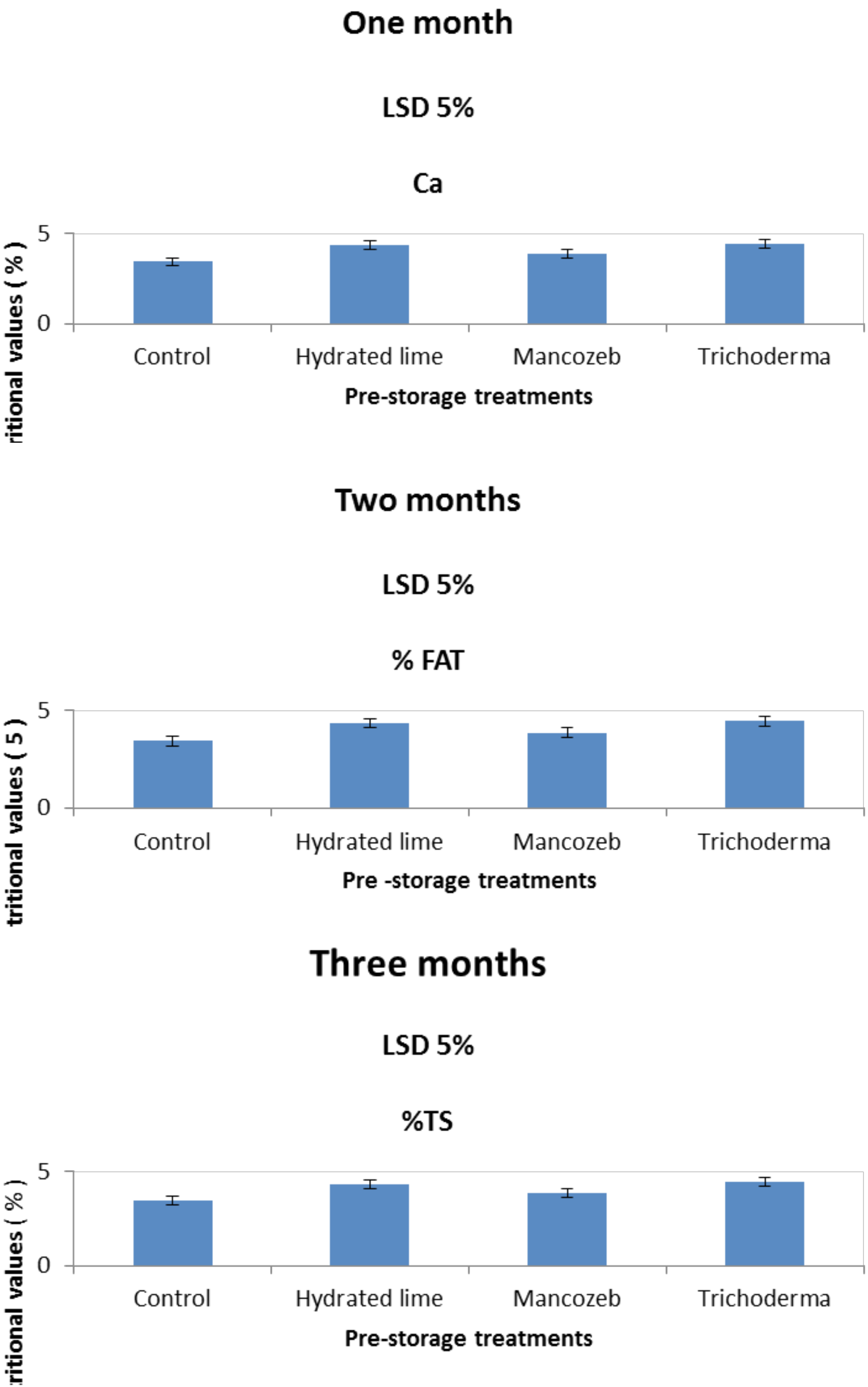


Figure 3: Effects of Pre-storage treatments on the nutritional quality of ginger rhizomes at different storage period

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Effects of Storage Methods on Sprouting and Nutritional Quality of Ginger (*Zingiberofficinale*Rosc) Rhizomes in different Storage Periods

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ABSTRACT

Harvested ginger rhizomes are highly vulnerable to damage during postharvest storage due to soil borne pathogens or pest attack. Experiments were conducted to evaluate the effects of storage methods required for sprouting and maintaining the nutritional quality of ginger rhizomes under different storage periods in the laboratory. The rhizomes were stored inside five different storage methods viz., refrigerator, clay pots, pit lined with sand, pit lined with sawdust and black polythene bag with twelve perforations at three different storage periods of one, two and three months. The experiment was laid out in a complete randomized design and randomized complete block design for laboratory and field experiment respectively, replicated three times. Data were collected on temperature, percentage weight loss of stored rhizomes, percentage sprouting, plant height, number of leaves, leaf area and nutritional quality of ginger rhizomes. Data were subjected to analysis of variance using Statistical Analysis System Software (SAS, 2005). Differences among treatment means were compared using Least Significance Difference (LSD) at 5% probability level. The storage methods significantly ($P \leq 0.05$) influenced the percentage sprouting, weight loss, growth parameters and nutritional quality of ginger at various storage periods. The highest growth parameters were recorded from rhizomes stored for three months while the least value was recorded from rhizomes stored for one month. Highest percentage sprouting (94.90%) was recorded from rhizomes stored inside pit-sawdust followed by polythene (85.25%) while least percentage sprouting (66.28 %) was recorded from refrigerator. Rhizomes stored inside clay pots recorded least percentage weight loss of 27.89% closely followed by pit-sawdust (28.45%) and retained the nutritional quality of ginger at various storage periods while rhizomes stored inside refrigerator recorded highest percentage weight loss of 62.78.%. In conclusion, storage of rhizomes inside pit-sawdust as well as clay pots for a period of three months before planting produced better ginger growth on the field and maintain the quality of stored rhizomes.

Key words: Ginger rhizomes, Pre-storage treatments, Storage methods.

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1.0 INTRODUCTION

Ginger (*Zingiberofficinale* Rosc) is a world grown spice crops and traded in three basic forms which include; green, pickled and dry ginger (Archana *et al*., 2013). There are yellow ginger (Taffingiwa) and black ginger (Yaltsunbiri) varieties in Nigeria at present (NRCRI, 2005). Ginger is used as folk cure for many ailments such as; diabetes, migraine headache and cough. It contains minerals like calcium, nitrogen, phosphorus, potassium and magnesium (Archana *et al*., 2013). It is propagated vegetatively using rhizomes. Nearly 17 -20 percent of the produce is retained and stored for subsequent cropping season. From the time of harvesting (December to January) of rhizomes till subsequent planting season (May – June) the rhizomes are to be stored for about 3 -4 month in healthy and viable conditions (ThankAmani *et al*., 2002). Harvested rhizomes are highly vulnerable to damage during postharvest storage due to soil borne pathogens or pest attack.

In pit storage methods, about 25-30% ginger rhizomes due to rot were recorded useless for sowing (Karuppaiyan *et al*., 2008). Various indigenous and modern storage methods are required to minimize the possible losses and maintain ginger quality during postharvest storage. Kandiannan *et al*. (2009) reported that rhizomes stored with sawdust, sand and 100%-gauge white polythene bags gave better sprouting percentage which may be due to lesser decay and moisture losses. However, there is need to evaluate the indigenous technology of storage methods in order to obtain more viable and better performance of ginger rhizome. The aim of this study is to determine the appropriate storage method and storage period required for sprouting of ginger plant on the field and maintaining the quality of stored rhizomes.

2.0 MATERIALS AND METHODS

Laboratory and field experiments were carried out during December.2014 –May2015 at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso to determine the effects of storage methods and storage periods on sprouting and nutritional quality of ginger rhizomes. Fresh, healthy and uniform sized yellow ginger variety (Ug1) was obtained from Ladoke Akintola University of Technology, Ogbomoso. and used as test crop. The rhizomes were stored inside five storage methods at three different storage periods. The storage methods include; refrigerator, polythene, clay pots, pit lined with sand and Pit lined with sawdust while the storage periods are one month, two months and three months. The experiment was laid out in a complete randomized design and randomized complete block design for laboratory and field experiment respectively, replicated three times. The different storage methods were evaluated to determine their ability to maintain quality, reduced microbial growth and prevent rot of ginger rhizomes during storage.

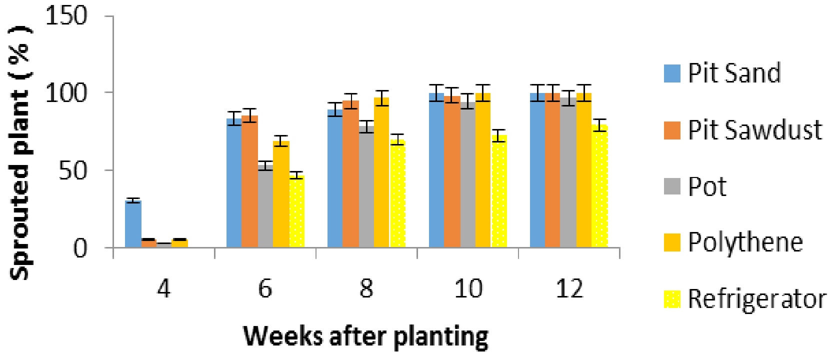
Land was cleared using cutlasses and tilled thoroughly with hoe to bring the soil to fine tilt. Fifteen beds were prepared on the field, each size of 1.2 m x 1.2 m with an inter-space of 0.5 m between beds. Harvested ginger rhizomes were stored in each of the storage method and samples of ginger rhizomes were taken from each storage method at one month interval of storage and planted on raised bed. Cultural practices such as mulching, watering and weeding were carried out for proper crop establishment. Data were collected on percentage rhizome weight loss, temperature in the various storage methods, sprouting date and number of sprouted plants per bed from each treatment combinations at one week interval. Early growth of ginger plant was determined by assessing the plant height, number of leaves and leaf area (using length x breadth x 0.6475). The percentage sprouting was calculated by the number of sprouted rhizomes divided by total number of rhizomes planted on each bed and multiplied with 100.PercentageCa, Fe, Crude protein, Crude Fibre, moisture, fat and ash contents were determined using the official method of analysis described by the Association of Official Chemist (AOAC,1990). Data collected were analyzed using Standard Analysis System (SAS, 2005) for analysis of variance (ANOVA). Difference among treatments means were computed using least significance differences (LSD) at 0.05 probability level.

3.0 RESULTS AND DISCUSSION

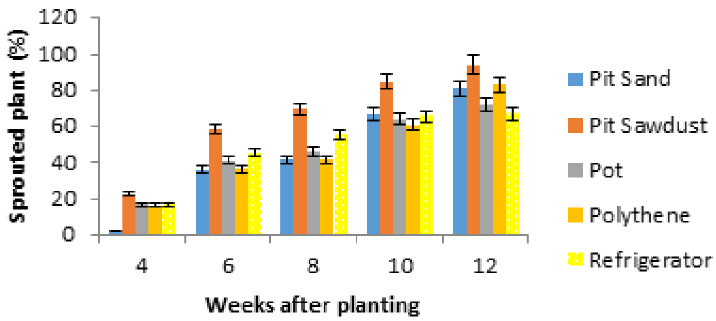
The storage method significantly ($P \leq 0.05$) influenced the percentage sprouting of ginger at various storage periods as shown in Figure 1. Highest percentage sprouting was recorded from ginger rhizomes stored for one month while the least growth was obtained from rhizomes stored for three month irrespective of the storage methods. At one month storage period rhizomes stored inside pit-sawdust (100%) gave highest percentage sprouting closely followed by clay pots (97.00%) while rhizomes stored inside refrigerator recorded the least value of 79.25 % at 12WAP.

At two months' storage period rhizomes stored inside pit-sawdust (94.33%) gave highest percentage sprouting closely followed by polythene (97.00 %) while rhizomes stored inside refrigerator recorded the least value of 66.83 % at 12 WAP. At three months storage period rhizomes stored inside pit-sawdust (90.50%) gave highest percentage sprouting followed by polythene (72.5 %) while rhizomes stored inside refrigerator recorded the least value of 52.75 % at 12 WAP. This was in line with Thankamani *et al.* (2002) on turmeric that pit-sawdust gave highest percentage sprouting due to reduced rhizome rot and low temperature environment provided during storage.

One month



Two months



Three months

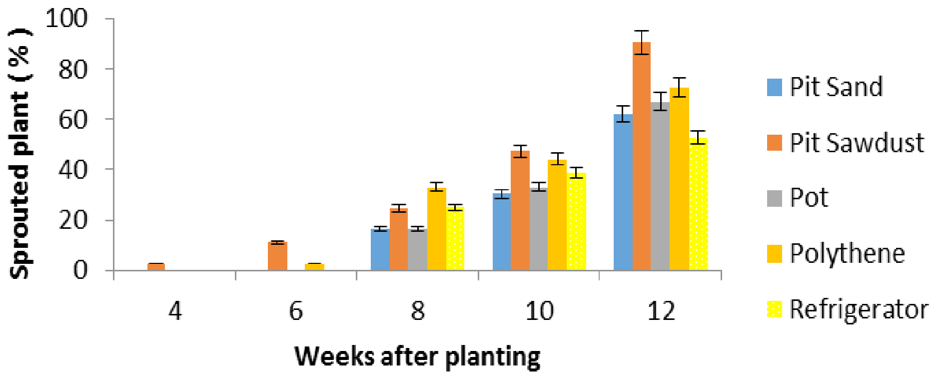


Figure 1: Effects of storage methods on the percentage sprouting of ginger rhizomes at different storage periods

The storage method significantly (P≤0.05) increased the height of ginger plant at various storage periods (Table 1). The highest height of ginger plant was recorded from ginger stored for three months while the least plant height was obtained from rhizomes stored for one month irrespective of the storage methods. At one month after storage the highest height (8.84cm) of ginger plant was recorded from rhizomes stored inside Pit-sawdust at 12 WAP. At two months after storage the highest height (9.96cm) of ginger plant was recorded from rhizomes stored inside clay pots at 12 WAP. At three months after storage, rhizomes stored inside clay pots gave the highest plant height of 9.74cm closely followed by rhizomes inside pit-sawdust (8.96cm) while rhizomes inside refrigerator recorded the least value (5.53cm) at 12WAP. This was in accordance with Shadap *et al*., (2014) who reported that rhizomes stored under healthy condition for 90 days prior to subsequent planting season prevent rhizomes rot and improved viability of ginger rhizomes.

The storage methods significantly (P≤0.05) increased the number of leaves of ginger plant at various storage periods (Table 2). At one month after storage the highest number of leaves (9) of ginger plant was recorded from rhizomes stored inside Pit-sawdust at 12 WAP. At two months after storage highest number of leaves (12.24) of ginger plant were recorded from rhizomes stored inside Pit-sawdust at 12 WAP. At three months after storage rhizomes stored inside Pit-sand gave the highest number of leaves of (11.75) closely followed by rhizomes inside pit-sawdust (10.75) while the rhizomes inside refrigerator recorded the least value of (7.25) at 12 WAP. The storage method significantly (P≤0.05) increased the leaf area of ginger plants at various storage periods as shown in Table 3. At one and two months after storage the highest leaf area of ginger plant (49.44cm^2 and 60.56cm^2) were recorded from rhizomes stored inside Pit-sawdust at 12 WAP. At three months after storage, rhizomes stored inside Pit-sawdust gave the highest leaf area of (60.56cm^2) closely followed by rhizomes inside polythene (53.33cm^2) while the rhizomes inside refrigerator recorded the least value of 42.88cm^2 at 12WAP.The growth character of ginger plant was highest in the rhizomes stored inside pit-sawdust which may be due to the favorable effects of the storage method in minimizing moisture loss and controlling the temperature of the storage environment.(Thankamani *et al*.,2002)

Table 1: Effects of storage methods on plant height(cm)of ginger at different storage periods

	STORAGE PERIODS					
	ONE MONTH		TWO MONTHS		THREE MONTHS	
	WEEKS AFTER PLANTING					
Storage Methods	10	12	10	12	10	12
Pit Sand	8.5	9.35	4.38	7.56	6.09	7.25
Pit Sawdust	8.74	11.16	3.29	9.21	6.98	8.96
Clay pot	6.2	8.84	6.75	9.96	8.64	9.74
Polythene	6.34	7.59	3.78	7.43	6.48	7.94
Refrigerator	2.76	5.41	3.24	5.31	4.13	5.53
LSD(0.05)	0.59	0.21	0.56	0.36	0.5	0.57

Table 2: Effects of storage methods on the number of leaves of ginger plant at different storage periods

	STORAGE PERIODS					
	ONE MONTH		TWO MONTHS		THREE MONTHS	
	WEEKS AFTER PLANTING					
Storage Method						
Pit Sand	4.88	7.54	6.50	9.00	10.25	11.75
Pit Sawdust	6.00	9.00	8.38	12.24	9.70	10.75
Clay pot	4.50	8.25	7.67	9.54	9.55	9.64
Polythene	3.63	6.50	6.92	10.88	8.25	9.00
Refrigerator	2.93	4.05	2.38	4.63	6.10	7.25
LSD(0.005)	0.51	0.59	0.57	0.62	0.53	0.57

Table 3: Effects of storage methods on the leaf area(cm^2) of ginger at different storage periods

STORAGE PERIODS						
	ONE MONTH		TWO MONTHS		THREE MONTHS	
	WEEKS AFTER PLANTING					
Storage methods						
Pit Sand	21.32	36.69	28.57	47.37	33.52	47.37
Pit Sawdust	44.68	49.44	28.46	60.56	49.9	60.56
Pot	29.54	38.55	28.43	49.61	49.61	49.89
Polythene	35.07	38.42	28.55	53.33	36.44	53.33
Refrigerator	19.27	21.98	28.53	35.50	35.51	42.88
LSD (0.05)	0.71	1.12	0.17	0.79	1.69	0.09

The storage methods significantly (P≤0.05) influenced the percentage weight loss of ginger rhizomes at different storage periods as shown in Figure 2. The highest percentage weight loss was recorded from ginger rhizomes stored for three months while the least percentage weight loss was obtained from rhizomes stored for one month irrespective of the storage methods. At one month storage period, the least percentage (11.91 %) weight loss was recorded from rhizomes stored inside pots followed by rhizomes stored inside pit-sawdust (12.25%) while highest percentage weight loss was obtained from rhizomes stored inside the refrigerator (21.2%). At two months storage periods least percentage weight loss (15.26 %) was recorded from rhizomes stored inside clay pots followed by rhizomes stored inside pit-sawdust (12.25%) while highest percentage weight loss (16.13%) was obtained from rhizomes inside the refrigerator. At three months of storage periods least percentage weight loss (27.89 %) was recorded from rhizomes stored inside clay- pots followed by rhizomes stored inside pit-sawdust (28.35%) while percentage weight loss (62.78%) was obtained from rhizomes inside the refrigerator. This was in line with Bahri and Rashidi (2009) who reported that water loss significantly increased with increased in storage period. The storage methods retained the nutritional of ginger rhizomes at different storage periods as shown in Figure 3. This support the work of Thankamani *et al.* (2002) on turmeric, that quality of stored rhizomes is retained due to low temperature provided by the storage environment.

.LSD 5 %

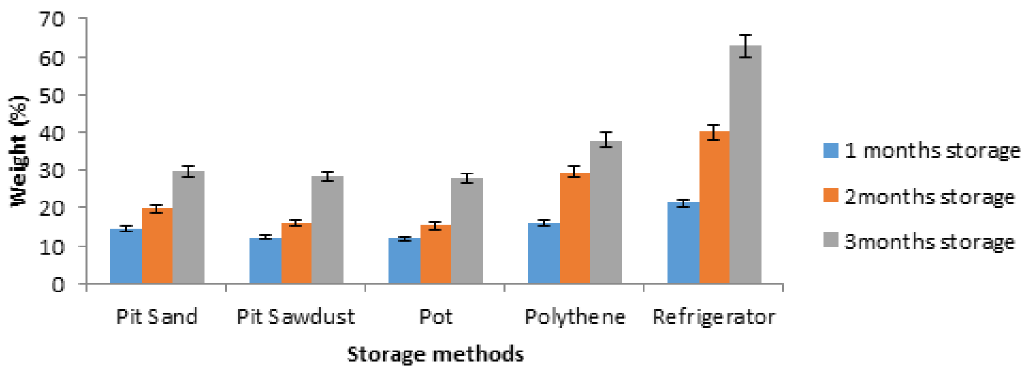
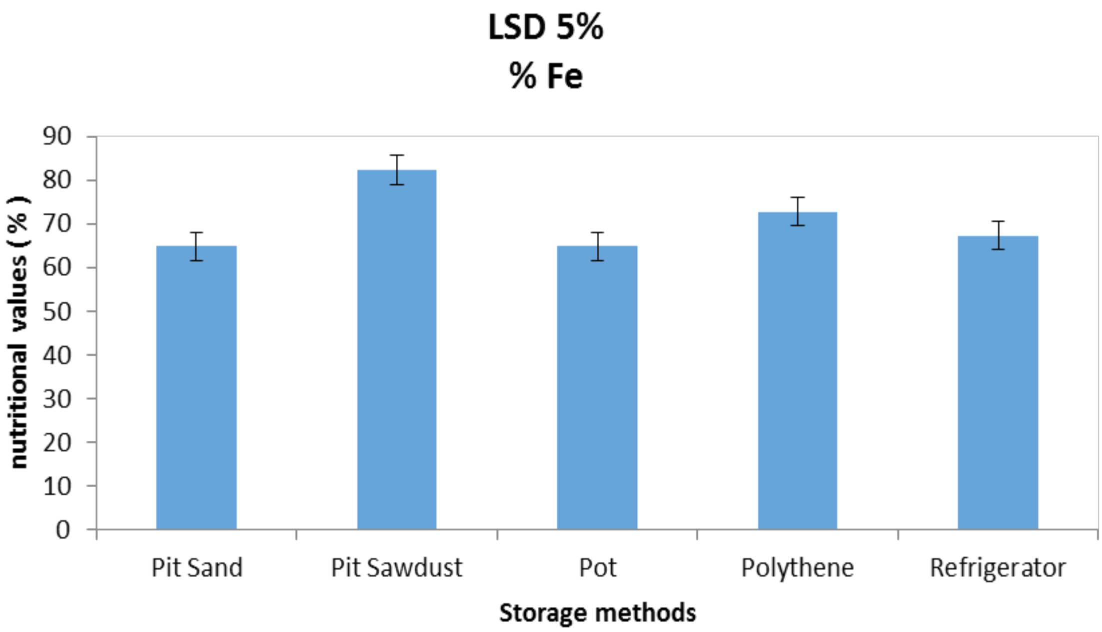
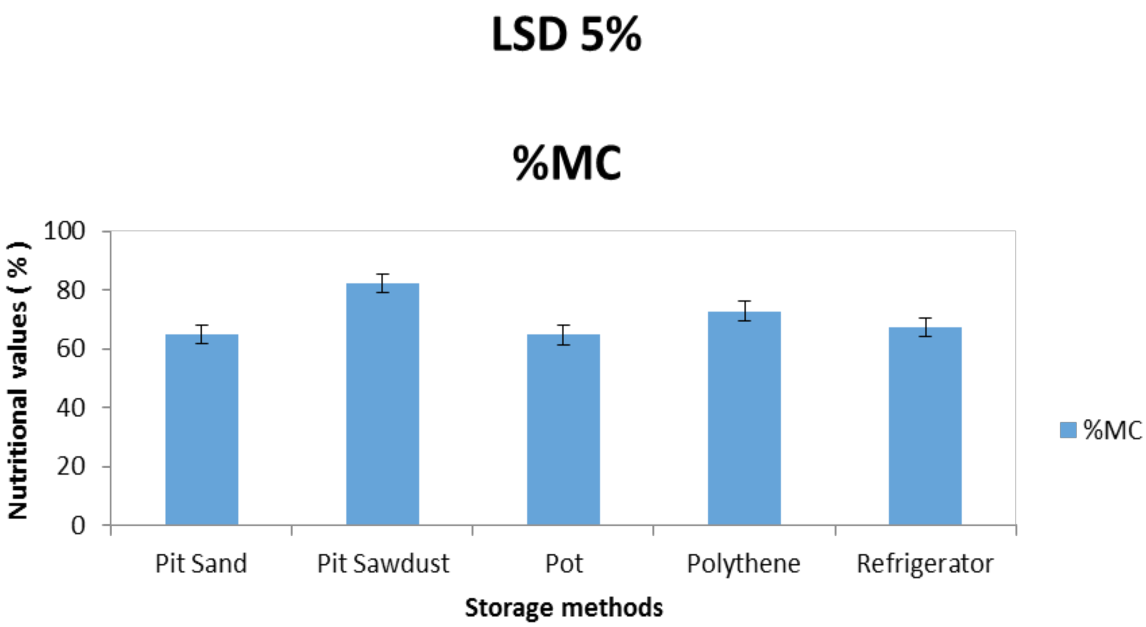


Figure 2: Effects of storage methods on the percentage weight loss of ginger rhizomes at different storage periods

One month



Two months



Three months

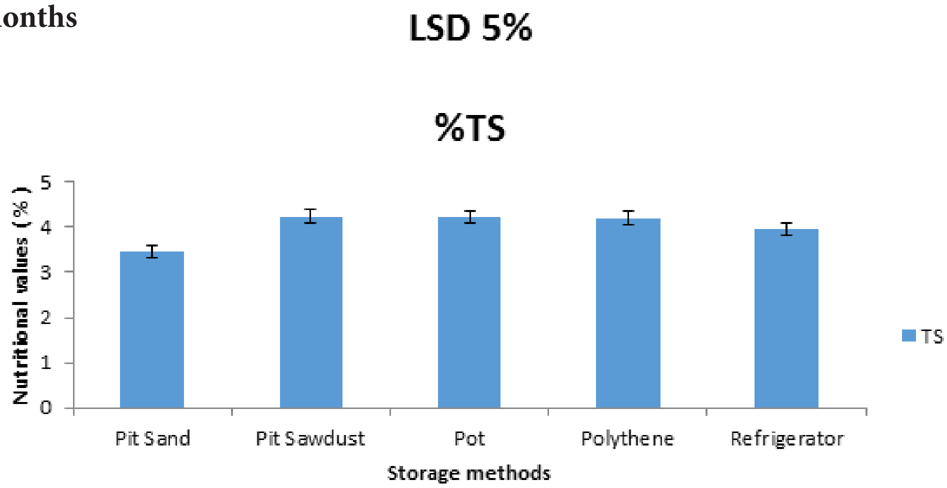


Figure 3: Effects of storage methods on the nutritional quality of ginger rhizomes at different storage periods

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