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THE SCOPE FOR THE RECONSTRUCTION OF THE GRAZING LIVESTOCK SECTOR OF XINJIANG BASED ON ORGANIC FARMING METHODS

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ABSTRACT

This paper explores the feasibility of developing organic livestock farming in the pastoral
area of Xinjiang, in order to address the problems of grassland degradation and to promote the sustainable development of the grazing livestock sector. Research shows that organic grazing farming may reduce the stocking rate of grassland and relieve the strained relationship between animal and grassland, as well between man and nature. As a result, the value of multifunctional grazing systems may be more widely recognized. As well as including production and economic objectives, cultural, social and environmental implications will also be taken into account. Additionally, herders may also have an improved source of income to poor rural people. The potential markets for organic products are very big and the traditional ruminant livestock husbandry systems in Xinjiang are very close to organic livestock farming. It is considered

necessary to change from a production-oriented approach to farming system research to a wider consideration of the systems and policies needed to support the development of organic grazing livestock alongside consideration of how to fund the relevant research and training and establish the systems of quality guarantee associated with organic production.

Keywords: Livestock, pastoral, organic farming, grassland, Xinjiang,

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INTRODUCTION

Xinjiang, at 1.66 million km^2, is China's largest autonomous region. Its dominant geographic features are three large mountain ranges - the Kunlun Shan in the south, Tien Shan in the centre, and Altay Shan in the north - and two large desert basins - the Tarim in the south and the Junggar in the north. Xinjiang is an arid area. Average annual precipitation ranges from under 10mm at the centre of the deserts to over 500mm in some mountain areas. Rainfall of less than 250mm per annum is typical at the edges of the basins, where human population and agricultural areas are concentrated. The Junggar basin is in the north, which stretches to the southern flanks of Altay Prefecture in Xinjiang. Average temperatures are approximately 23 °C in July and -15.6 °C in January. In the mountain areas, the frost-free period is approximately 90 days.

Xinjiang is one of the major pastoral regions in China. The total grassland area amounts to some 56 million hectares, of which 47 million hectares are useable. Pastures are classified in terms of their seasonal use, as winter, spring-autumn or summer pastures. Winter pastures are located at low altitudes, usually along rivers or in the desert basins. Spring-autumn pastures are located on the plains between the arable land area and the hills and in the lower hills. Nearly half of all the grassland is high altitude summer pasture. Pastoralism has historically been an integral part of the lives of the Kazak, Mongol, and Kirghiz ethnic groups. At present, more than 80 percent of the pastoralists are semi-sedentary and practice a vertical migration system. Different pastures, as far as 150 km or more apart, are used on a seasonal basis.

In the past 50 years, the number of livestock has been increased rapidly and there are more and more people living in pastoral farming areas. However, the sustainable development of grazing livestock has been compromised by grassland degradation caused largely by overstocking and the difficulties faced by farmers seeking a reasonable livelihood.

The problems faced by grazing livestock pastoralists of Xinjiang exist not only in Xinjiang are also found in many other regions of the world. In near eastern countries, small ruminants play an important role in rural livelihoods (Bahhady, 1986; Nygaard and Amir, 1987). During recent decades, the sustainability of these systems has been compromised (Steinfeld et al., 1998). The main reason is the feed shortage caused by the extension of crop production (Hamadeh et al., 2001). In the

Mediterranean basin, a gradual degradation of the mountainous and hilly grazing lands has taken place as a result of overgrazing of some areas and under-grazing of others (Zervas et al., 1996). In North East Africa, research conducted by Abule et al. (2005) in the Middle Awash Valley of Ethiopia shows that the condition of the rangelands is poor, mainly due to overgrazing, droughts and increased pressure from a growing human population.

Some studies have given suggestions as to how to find a way to promote the sustainable development of grazing livestock. These suggestions can be typically categorized as:

(1) Organic livestock farming may contribute to increase sustainability of grazing livestock systems (Ronchi and Nardone, 2003; Chander and Mukherjee, 2005; Lei Hua and Muxiaofeng, 2006). According to their opinions, traditional livestock farming is very close to organic farming, and organic farming is of particular interest for pastoral areas. The application of organic farming may promote more sustainable land use; enhance environmental conservation, and improve animal health and welfare and product quality.

(2) Reform of particular forms of pastoral land tenure may be needed (Abule et al., 2005).

These studies attribute the grassland degradation principally to "the tragedy of commons". They argue that introduction of well-defined individual use rights will give pastoralists the incentive to stock at sustainable rate and invest in rangeland improvement on the land under their control.

(3) There may be scope to take advantage of agro-industrial by-products as a substitute for fodder shortages. Hadjipanayiotou, (1992) and Amin (1997) assert that agro-industrial by-products can fill the gap between supply and demand for conventional feed resource, arising from the loss of some grassland to cropping or increased grazing pressure.

Whilst recognizing the legitimacy of these different arguments, the focus in this study is on the use of organic farming systems as a regenerative strategy.

RESEARCH OBJECTIVE

The aim of this paper is to evaluate the feasibility of the development of organic livestock farming in the pastoral area of Xinjiang under organic production methods. Based on the results of the evaluation, it will offer some information and suggestions for decision-makers on how the problems faced by grazing livestock of Xinjiang might be addressed though an organic adjustment strategy.

MATERIALS AND METHODOLOGY

The research combines both normative analysis and positive analysis. It includes a review of the literature surrounding the improvement of grazing livestock systems in other semi arid parts of the world and a more detailed analysis of the particular conditions in Xinjiang. In order to demonstrate the feasibility of organic grazing farming in Xinjiang, the research builds on two basic assumptions:

- Assumption 1: degradation of rangelands is human-induced, and anthropogenic climate change is part of the explanation;
- Assumption 2: pastoral land tenure systems are not the root cause of grassland degradation in Xinjiang.

The reasons for degradation of rangelands are usually divided into first, climate-triggered and, second, human-induced degradation, (Evans and Geerken, 2004; Geerken and Ilaiwi, 2004; Richardson et al., 2005). In practice, the assertion of anthropogenic climate change would suggest a need to distinguish between local human factors and global human factors. If the first assumption is valid, human activity at global scale should account for the greatest part of grassland degradation. The Projection Pursuit Regression (PPR) (Appendix A) is used to test thes assumption. The relevant index includes the average annual temperature, the average monthly rainfall, the average monthly sunshine hours, cultivated area, and the number of animals. The authors argue that the former three reflect the impacts of climate; and the latter two reflect the influence of human activities through locally determined land management practices. In order to test the assumption, the research takes the Altay grazing region of Xinjiang as an example. This is for two reasons. The first is that Altay is a typical grazing region in Xinjiang; the other is that the data relevant to the construction of the index is easy to obtain. The data mainly come from Xinjiang Meteorological Administration, Xinjiang's Altay 50 years (1955-2005) and other existing studies (Xu Peng, 2005).

The paper divides the local human-induced reason for grassland degradation into two parts: property rights and the production systems practised. If the second assumption is valid, grassland degradation can reasonably be attributed to the particular production models of grazing livestock systems in Xinjiang. This is the premise of the research. Under this circumstance, the paper can focus the problems on how to improve the production model. The research thus enables a comparison between the past standard of organic grazing livestock farming from the EEC-Regulation (1804/99) and the actual conditions of grazing livestock in Xinjiang.

RESULTS OF THE ANALYSIS

The reasons for degradation of rangelands are human-induced, including climate change. The result of PPR show that human activity accounts for 55% of grassland degradation during 1961-2005, and climate change accounts for 45% (Table 1).

Some studies show that the main causes of human-induced degradation are attributable to overpopulation (Kaplan, 1994) and overgrazing and backward farming practices (Cleaver and Donovan, 1995; Cleaver and Schreiber, 1996). In relation to the specific rangeland ecosystem of Xinjiang, the degradation problems are the inevitable result of the demands for animal products far exceeding the availability of supply of natural grazing and the failure of rangeland users to balance stock numbers with available fodder.

(1) The growth of population taking Altay prefecture as example, since 1955, the population has increased greatly the annual growth rate of population has been 3.51% from 1955 to 1975, and growth continues today, albeit at lower rates. Population growth creates two results: one is the increased demand for arable land; the other is the increasing demand for animal products (contingent on an adequate level of wealth needed to acquire those products). The coefficient of correlation between the population and the number of livestock amounts to 0.91. Based on GIS techniques and land use data for Xinjiang between 1990 and 2000, which were interpreted by landsat TM remote sensing images (Hou Xiyong et al., 2004), there are about 52,000 ha of grassland which have been transferred into cultivated land during the ten years from 1990 to 2000. Because of the bottleneck of insufficient water resources, most of them cannot be cropped continuously. They then become ‘black’ or bare fallow. Pressure on land resources tends to stimulate further cultivation and this stimulates a vicious cycle of land degradation.

(2) Economic development has the same influence (and perhaps a greater impact) than population growth. Further, because of the development of secondary industry, especially mining, some grassland has been seriously

damaged. Further, the aggregate regional income has been increased with the development of the mining economy and, predictably, food demand and consumption have also increased. According to our research, with an income increase of 1%, the consumption will rise by 1.23%; price rise 1%, the consumption only drop by 0.529. In a region such as Xinjiang, food demand is price inelastic and income elastic. The results show that consumption has strong relationship with the income, and is not very sensitive to changes in the price.

Table1 Influence of grassland degradation driving factors

Indicator	Keeping the largest volume		The area of arable land		Average annual temperature		Average monthly precipitation		Average monthly sunshine hours	
Influence period	Relative impact	Weight	Relative impact	Weight	Relative impact	Weight	Relative impact	Weight	Relative impact	Weight
1961-1983	0.43	0.14	1.00	0.34	0.54	0.18	0.40	0.13	0.60	0.20
1984-2005	1.00	0.39	0.47	0.18	0.44	0.17	0.41	0.16	0.24	0.09
1961-2005	1.00	0.33	0.69	0.22	0.33	0.11	0.51	0.16	0.54	0.18
Projection indicator	Coefficient S = 0.1 the number of projectors M = 3, MU = 3									

(3) The pursuit of maximum utility by herders. Herders' lifestyles are affected strongly by the production methods of transhumance. As consumers, a basic feature of their livelihoods is a demand for few durable goods and simple foods. Their traditional attitude towards life can be seen as based on a need for subsistence economy with an associated respect for nature. Since they have settled, however, they are stimulated by the expanding opportunities for consumption and the disparity of income between them as herders and other peasants, so that their demand for increased disposable income is increasing rapidly.
An important problem is how to meet these new income aspirations. Theoretically, herders can migrate to another enterprise which offers more income. In fact, thanks to their different language, culture, and the traditional habits, most of them still live on the proceeds of their grazing livestock systems. Their main source of income still comes from breeding and selling animals.

Under these circumstances, they can improve their income by two ways. One is to improve the productivity by the application of appropriate technology (breeding, feeding and productivity). The second is to enlarge the scale of breeding. The former is regarded commonly as the more rational choice. The main manifestation of technological progress relevant to improving herders' incomes should be the reduction of the risk of production and the increase in production and productivity per breeding animal by a variety of means. Table 2 shows the fluctuation of the risk variable (Appendix B) between1991 to 2002. It is obvious that the level of fluctuation has declined. The production per animal has been rising, in which the production of wool and meat per sheep have been raised respectively by 0.2 kg and 0.89 kg. There is no doubt that technological progress has contributed to improve production. However, new technology adoption is so slow that it cannot be relied to improve the herders' incomes significantly. Therefore most herders have chosen the method of enlarging their enterprise scale in order to improve their livelihoods.

Pastoral land tenure is not the root cause of grassland degradation in Xinjiang: There is the common perception among government officials and researchers that the situation in Xinjiang is a classical "tragedy of the commons" problem, an apparently invariable outcome of having privately owned livestock grazing on (unregulated) land occupied under commons regimes. The policy of individualising land tenure is predicated on the assumption that it will improve tenurial security and create the incentives for owners of property rights to adopt more sustainable resource management strategies. Obviously, the idea is on the basis of two economic theories relevant to land tenure. One is Hardin's "tragedy of the commons" (Hardin, 1968); the other is the theory of property rights within an individualistic ownership structure.

A precondition of the Hardin's theory is the assumption of free access to the common land. Indeed, he asserts that freedom of the commons means ruin for all. But open access commons are not consistent with experience in Xinjiang or indeed in many other areas where communal forms of tenure are practiced (Ostrom, 1990). In addition, some research shows that Hardin has overlooked some other factors which prevent the tragedy happening. The power may come from the either the government but may also come from the interaction and choices of local people (Ostrom, 1990; Ouchi, 1980; Bowles and Gintis, 2002) However, none of these solutions can solve the problems completely (Bowles, 2006). Which kind of tenurial form is most appropriate depends on many factors, such as the situation of resource, the differences of factors/stakeholders (their wealth, social status, technical ability.), social capital and social preferences, etc.

Table 2: The change in the Coefficient of Risk in the livestock industry in Xinjiang

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Coefficient of risk	0.0331	0.0542	0.0577	0.0549	0.0473	0.0392	0.0255	0.0166	0.0090	0.0187	0.0004

In practice, for reasons related to both the resource configuration and Kazak culture, it is questionable whether an institutional change based on reallocating property rights would improve resource management and reduce grassland degradation. Firstly, the nature of the resource configuration, particularly the extensive nature of the resource and the seasonality of resource use, makes the definition, monitoring, and enforcement of individual household boundaries difficult and costly. It is simply not practical. Secondly, Kazak pastoral households have long history of co-operation and co-ordination that cuts across more spheres than just land management. They know each other very well, and have established equitable governance mechanisms regarding pasture use. These characteristics make the common property regimes of Xinjiang suitable for a combination of government regulation and community governance (Banks, 2001).

DISCUSSION AND COMMENT

The design of policies for the area needs to be changed radically: In general, governments have two choices to resolve the problems of compromised livelihoods and resource degradation. One is to enhance the carrying capability of the ecological system of grassland by investment to the infrastructure, such as irrigation, fencing or fertilizer application; another is to reduce the people's economic reliance on grassland. In recent years, many measures have been taken by government in Xinjiang to improve the production of grassland, such as planting seeds by airplane, offering to provide irrigation systems, fencing etc. However, because of the complex topography and the shortage of water resource, the beneficial effects are not very obvious. Meanwhile, government has also implemented policies, such as trying to balance grass availability and animal numbers, permanently settling nomadic people and reducing stocking rate of grassland. (Xu Peng, 2005; Hou

Xiyong et al., 2004). There is no doubt that these policies have proved effective to some extent.

However, most of these policies have constrained the herders' mobility. Constriction of mobility is associated with development interventions to settle nomadic pastoralists into ranches, encroachment of rangelands by other forms of land-use such as cultivation and conservation, increasing population densities in rangeland areas, and the proliferation of water points, often accompanied by settlements. Some research shows that the reduction of mobility of herders in semi-arid and arid pastoral systems has increased the risk of degradation because of the way it concentrates grazing pressure on the resource and reduces the opportunities for resting parts of the vegetation (e.g. Coughenour, 1991; Perkins and Thomas, 1993; Oba et al., 2000; Fernandez-Gimenez and Swift, 2003; Kerven et al., 2003). In sparsely populated arid areas, grazing impact is often concentrated in biospheres or 'sacrifice zones' around water points or settlements (Perkins and Thomas, 1993; Sullivan, 1999; Leggett et al., 2003).

From the point of view of sustaining the multifunctionality of montane grazing systems, policy is underpinned by a desire to enhance production, and the technology to also be developed along the ideas of a production-oriented grazing system. The other functions of grazing livestock, such as environmental protection and supporting cultural development, have been given limited attention. To some extent, it can be said that grassland degradation is the inevitable result of ignoring a multifunctional approach.

Of course, the desire to increase production originates in the huge pressure for food demand in China. Under these circumstances, production is the primary objective. However, with the economic development of China, the situation of food security is increasingly being transformed from a quantity issue to one of quality (involving both better choice and food safety), and more and more people hope to improve their quality of life. These changes have created some advantage to explore the new methods of production based on the multifunctionality of traditional extensive grazing livestock systems in delivering watershed management, high biodiversity and landscape values and speciality food for an increasing and increasingly affluent population. The new methods of production should allow that the rangelands continue to support a significant livestock industry, accommodate important watershed protection functions, and provide valuable and biological diverse resource. It also should reflect a diverse cultural landscape (ICIMOD, 2002).

Organic livestock farming should benefit the grazing system: Recently, organic livestock farming has developed rapidly, especially in developed countries. Organic farming is substantially different from more intensive conventional production systems, but is less significantly different from extensive grazing practices in some parts of the world. Organic farming focuses on building a harmonious relationship between man and environment and pays more attention to animal health and welfare, to environmental conservation and to food quality and safety (Ronchi and Nardone, 2003; Sundrum, 2001, Prasad, 2005) than many conventional systems of production. Organic farming aims to establish and maintain soil-plant, plant-animal and animal-soil interdependences and to create a sustainable agro-ecological system based on local resources (Nardone et al., 2004). Organic farming principles are consistent with the resolution of the problems of overgrazing which might be solved during the development of organic grazing livestock in Xinjiang, as long as there are no problems in meeting organic specifications with respect to organic feeds and use of fertilizers and pesticides. Specifically, organic livestock farming will bring some benefits in following aspects:

- It will deliver potential environmental benefits. According to the principles of organic livestock farming, the stocking rate should be reduced. It will reduce the grazing pressure on grassland, and relieve the strained relationship between animal and grassland, as well as that between man and nature. As a result, it will also help to increase bio-diversity, improve the animal welfare, enhance the multifunctionality of grazing stock, especially the ecological function, and improve the utilisation of local and renewable resources (Ye Mao et al., 2006).
- It will help to preserve and develop the traditional culture of nomadic ethnic groups in the grazing livestock sector; multifunctional values of grazing systems are widely recognised and, together with production and economic objectives, cultural, social and environmental implications need to be taken into account.
- It will contribute to taking advantage of the existence of a market of organic food as a means by which herders can be compensated for internalising the external benefits that will otherwise be appropriated by wider societal interests. Herders should also have some new source of income, because of the multifunctionality of grazing livestock, such as

subsidies from government, income from off-farm sources, etc. (Padel et al., 2002).
However, these benefits will only arise if the livestock rearers reduce their stocking rate, if organic agriculture can be adequately regulated and if there is a premium price for the product in the market place. It must also be noted that the general requirements of organic husbandry will mean that only a limited amount of conventional feeds should be used, especially when the stock is 'down the slope' on winter pastures and may make use of arable by-products during the winter months.

5.3. The scope for developing organic livestock farming
(1) The traditional husbandry practices are very similar with those of organic livestock systems. Conversion from conventional grazing stock to organic is relatively easy. Of course, the traditional grazing farming is different from organic gazing livestock (Chander and Mukherjee, 2005). In comparison with traditional production methods, organic grazing livestock always is perhaps more dependent on knowledge-intensive production methods (Morgan and Murdoch, 2000), whereas traditional grazing livestock systems of livestock husbandry are more experience-based. However, the difference does not deny that the two production methods have many similarities. That (and the very low levels of use of chemical inputs, is the reason why some researchers think that traditional production methods are very close to organic ones (Chander and Mukherjee, 2005; Nardone et al., 2004), not least because both tend to use few chemical inputs and are reliant on adapting production systems to natural cycles. Table 3 shows the difference between the basic rules of organic animal agriculture in Europe and the actual situation of grazing livestock in Xinjiang. Obviously, it is not too difficult to convert from traditional grazing livestock to organic systems in these areas.

Table3: The difference between the basic rules of organic animal agriculture in Europe and the actual situation of grazing livestock in Xinjiang

	EEC-Regulation(1804/99)	The actual condition of grazing livestock in Xinjiang
Animal feedstuffs	---Up to 25% conventional feed in a daily ration ---Antibiotics and other additives are forbidden in regular feedstuffs as well as the use of hormones and growth promoters	--->80% natural feed; ---Hormones, growth promoters and other additives never be used in raising.
Housing conditions	---Allow farm animal to perform all aspects of their innate behaviour; ---Dry litter for their bedding; ---Tethering of farm animal is forbidden.	---Most of time livestock are fed through grazing on pasture. Their house is big enough for moving freely; ---Application of dry litter for bedding;. ---Generally speaking, sheep are never tethered.
Disease prevention	---Selection of breeds with abilities to resistance to disease, to avoid specific disease or health problems, which prevail in conventional livestock production. ---Livestock should be raised in a manner which suits the requirements of the species and promotes a good resistance against diseases and infections. ---Application of good quality feeds, which together with application of outdoor areas and grazing strengthen the natural immune system of the animal. ---Securing a suitable space allowance in order to prohibit overcrowding and associated health problems.	---In Xinjiang native breeds are well adapted to local situation. being hardy, resistant to diseases; ---Grazing in the natural pasture; It is the best way for native breeds; --- In general, the phenomenon of overcrowding does not exist.
Veterinary treatment	---Non-allopathic medicine should be chosen prior to allopathic medicine; ---Preventive treatments with allopathic medicine are not allowed; ---Keep a log of all veterinary treatment use of disease control agents; ---It is not allowed for an adult animal to receive allopathic medicine more than three times during the year.	In general, the cost of animal medicine is very low in grazing system in Xinjiang. One reason is the native breeds have good natural immune system; the other is that the transhumance has influence on the treatment immediately.

Source: Chander and Mukherjee, 2005; Nardone et al., 2004

(2) Producers have soundly based if traditional ideas of environmental protection. From the point view of the producer, the traditional culture of the nomadic ethnic group establishes a good base for the development of organic livestock farming. Their culture comes from the nomadic production methods based on the traditional (or indigenous) knowledge which respect natural forces. In the dimension of ecological ethics, the core idea of nomadic culture is centred on the respect of life, respect of nature and harmonious co-existence of humans with nature (Gegenguva, Oyunbatu, 2002; Zhang et al., 2007). These value systems will help the producers to accept the idea of organic grazing livestock very easy, as

long as there are no other factors that drive such nomadic herders to desperate measures (such as drought, animal disease etc).
(3) The potential market for organic food is very big in China
China has a very big domestic market with striking trends of growth of demand with respect to various foods. Consumers' ideas have changed significantly. Food safety has been a major concern recently with issues of pesticide contamination to the fore. More and more consumers do not satisfy only their basic need, but begin to pursue a wider diet. There are also clear policy drivers for increasing food safety.

The consciousness of food safety is becoming stronger in Chinese domestic markets. Meanwhile, the levels of green and organic consumption have been increasing with the development of Chinese economy. Consumers have a much more comprehensive understanding of green production processes, compared with pesticide-reduced and organic food, since it is the earliest of the food quality standards adopted in China. The majority of households have positive attitudes towards green foods. According to a survey in Urumqi (Zhou Lili and Chen Tong, 2007), about 87.7 percent of respondents reported that they had bought green food before. Up to 60% of consumers hold the belief that it is reasonable for green food to be a bit more expensive than conventional food.

These arguments suggest that it is important to decide whether the objective should be the production of green 'nearly organic' food or food that is fully certifiable as organic.

The challenges for the development of organic livestock farming in Xinjiang:
(1) How to exploit the market of organic food. The market should be the decisive factor for the development of organic grazing livestock in Xinjiang. Although China has a very big domestic food market, the market for organic food only really commenced as recently as 2000. By the end of 2005, the sale of organic foods was only valued at about 0.3 billion Euro, in which exports (presumably of speciality crop products not red meat) account for nearly 53% of the total, and domestic consumption is no more than 0.15 billion Euros,which only accounts for 0.02% of food consumption in China (Dong Zhengguo, 2006). According to a recent survey (Zhou Lili and Chen Tong, 2007), the market for organic products in Urumqi, which is the capital of Xinjiang

Uygur Autonomous Region, is right at the beginning of its development. About 44.9% of Urumqi consumers had never heard of organic food. Urumqi consumers who know organic food consider organically-grown products as very healthy, of good quality and tasty. However, on average, consumers are not very familiar with the supply of organic food in the market. Over and above the issue of the small established market, building new market networks and separate supply chains is another challenge. While the general principles of livestock systems in the mountain areas are very close to organic and indeed in many cases may be organic, the transaction costs of regulation need to be considered for it will be essential to separate out organic and non-organic produce in food supply chains and this has been a reason for much higher prices to consumers in some countries where duplicate supply chains must be established. Owing to the main market of organic food being in major conurbations such as Beijing and Shanghai, these main markets are far from Xinjiang, There is also a persistent danger that any increases in value of product will be swallowed up in increased costs of regulation and supply chain management, or by benefiting supply chain intermediaries, so how to build the supply chains in ways that support local livelihood enhancement is also a big problem.

(2) How to build the technological system of organic grazing livestock: Modern technologically based livestock production systems focus on and include the breeding, feeding, disease control, management, processing, marketing, of production and use scientific methods to improve performance. Concerns relevant to animal welfare and the environment have historically been associated with these so-called 'productivist' methods, especially in more intensive systems where poor welfare reduces productivity. However, organic farming is more knowledge-intensive, and modern technologies should be developed based on the scientific understanding of organic farming. The main challenges are:

- Awareness about organic production practices is currently inadequate, especially at the level of extension workers and trainers, farmers, and researchers;
- It is necessary to better understand which ideas, standards, and elements of the production system influence disease incidence and welfare, and how to deal with these in ways which are appropriate in the organic standard.

(3) How to guarantee the high quality of organic animal products

Some studies (Yiridoe et al., 2005; TNS, 2003) show that the most important reason why consumers are willing to pay premium price for

organic food is the benefits to health, and the perceived high quality. That is to say, it is very important that consumers believe that organic food is of better quality than conventional food. This relies on the system of quality guarantee.
Generally speaking, there is a quality assurance system in the slaughterhouse to prevent any contaminated diseased meat product entering the market in Xinjiang. It is not enough just to control the quality during breeding, feeding, fattening and transport. The systems need to be in place all along the food supply chain from common pasture to chopstick (or field to fork in Euro-parlance).

CONCLUSIONS

Grassland degradation has adversely influenced not only the sustainable development of grazing livestock systems, but also herders' livelihoods, as well as the condition of the ecological environment of Xinjiang. In essence, grassland degradation in Xinjiang is a reflection of imbalanced relationship between man and nature in the region. The root cause is considered to be an overly production-oriented set of farm policies, as well as the specific production methods that have evolved in the region. The reform of pastoral tenure to individual rights is not seen as appropriate to the resolution of the identified problems.

Organic farming offers a potential strategy to enable the development of more sustainable agriculture. It is obvious that organic farming differs completely from more intensive and narrowly productivist forms of conventional agriculture. According to principles of organic livestock farming, the stocking rate should be reduced. Organic agriculture will reduce the yield of grassland, but reduce pressure on that yield and relieve the strained relationship between the ruminant animal population and the grassland on which it depends, as well the strained relationship between man and nature. By placing a greater premium on the inherent qualities of organic production, organic agriculture can break the cycle of intensification which has been occurring. Further, the important multifunctional dimensions of semi-natural grazing systems will be more widely recognised and, together with production and economic objectives, cultural, social and environmental implications will also be taken into account. Meanwhile, herders may also have new sources of non-pecuniary benefits and potentially income, because of the multifunctionality of the grazing livestock system. The benefits may be reflected in subsidies from government, and increased income from farming.

Although conventional agriculture is often associated with unsustainable farming, practices, especially in areas with significant agri-environmental problems, it should be recognised that food shortages have not been solved completely in China, so conventional agriculture will still exist as mainstream agriculture in China for a long time. Meanwhile organic livestock farming is not a panacea to solve all the problems facing the grazing system of Xinjiang. At present, organic livestock farming still faces some major challenges, such as developing the market of organic food, building the technological systems of organic grazing livestock, guaranteeing the high quality of organic animal products and ensuring cost effective forms of certification and regulation for poor farmers.

In relation to supporting multifunctionality, Western European agriculture has developed significant agri-environmental policy measures since the late 1980s, including organic aid schemes. The environmentally rich grasslands of the hill and mountain lands of west China might benefit from similar schemes where farmers are rewarded for maintaining or enhancing environmental features. As well as supporting organic production, paying farmers for the delivery of particular environmental goods and services which comprise public goods is an alternative strategy that merits attention. However, these may be seen as mature economy policies inappropriate in China at present and may represent long-term aspiration rather than realistic current possibility.

As a form of agricultural development, China should think seriously about developing a twin track strategy with regard to organic livestock farming: one an export-oriented sector which is driven by market imperatives and the demand for quality foods; the other is in places with serious environmental problems, where an organic solution might contribute to economic development and where the reduction of total food production might have no big impacts on overall security of food in China. The grazing livestock systems in the pastoral regions of Xinjiang constitute a potentially suitable case for the development of organic agriculture as an agri-environmental and rural development policy. Moreover, since the traditional technology is very close to organic livestock farming, the adaptive challenge may not be that great. There is though, a need to shift from a predominantly production-oriented state to a more integrated and holistic vision based on quality food and sustainable environmental management. This cannot be done without further market research and action research on how to effect the full transformation to organic agriculture.

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Appendix A

This study used a projection pursuit regression (PPR) which was newly developed in the last 20 years. This is mainly because that PPR can solve the problem of "dimension curse" which may be caused by the non-linear, non-normal data and conventional regression technique. The basic idea of PPR is to project high-dimensional data to low-dimensional space and to look for a meaningful projection direction by computer constantly so that data in these projection directions can show the structural features of the original data. Thus we can study and analyze high-dimensional data by the analysis of the data structure in low-dimension space. PPR model and its implementation are as follows: Let X = ($x_1, x_2, \ldots x_p$) is a p-dimensional random variable, y=f(x) is a one-dimension random variables. To avoid the contradiction that linear regression does not reflect the actual nonlinear situation, PPR takes the sum of a series of Ridge functions of Gm (Z) to approach the regression function.

$$f(x) \sim \sum_{m=1}^{M} \beta m Gm(Zm) = \sum_{m=1}^{M} \beta m Gm(\alpha_m \cdot X)$$

of which, GM (Zm) is the m Ridge function $Z_m = \alpha_m x_1 + \alpha_{m2} x_2 + \ldots + \alpha_{mp} x_p$ is Ridge function variables, it represents the projection of p-dimensional vector X in the direction of α_m . α_m is also a p-dimensional vector in a certain direction. m is the number of the Ridge function β_m is the weight coefficient of the m Ridge function's contribution to f(x).

the key is the ultimate model of the estimated coefficients α mj and β_m in the formula, Gm Ridge function and the optimization number Mu. The discriminant of the minimum of the model still use least-squares criteria, that is to say, we should select appropriate parameters of α mj and β_m Gm(z) and combination to satisfy the following formula:

$$L_2 = E[y - \sum_{m=1}^{Mu} \beta_m G_m \left(\sum_{j=1}^{p} \alpha mjxj \right)]^2 = \min$$

The specific practice is to divide the whole parameters into several groups, with the exception of one group, give an initial set, and then optimize the parameters of the group left. The results obtained, set the extreme point as the initial value, and ten optimize another group of parameters in this initial value, repeated until the convergence of parameters. That is to say, $\alpha mj, j = 1,2 \wedge, p; \beta_m, G_m$ can be induced in one group, m=1,2,…, M; There are total M groups. Fix one M-1 for a group, only optimize α_{mj}, β_m *and* $Gm(z)$ is the group. Now divide it into three sub-groups to optimize again, and then repeat this process until L2 no longer decrease.

Appendix B

The paper defines risk as a king of uncertainty which bring loss to producer. So that coefficient of risk can be calculated by the formulation as following:

$$r = \frac{\sum \left| yi - \hat{yi} \right|}{\bar{Y}} = \frac{\sum |ei|}{\bar{Y}}$$

Which, r is the coefficient of risk; $\hat{Y}$ is the value of production forecasted; $\bar{Y}$ is the average of sample; $ei = yi - \hat{y} < 0$

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Effectiveness of intercropping and staking in the management of root-knot nematode for rural farmers in intensive mixed vegetable cropping systems in South-western Nigeria

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ABSTRACT

Two-season field trials were conducted between 2004 and 2006 at the vegetable research plots of the National Horticultural Research Institute Ibadan, Oyo state, Nigeria to evaluate the effect of intercropping *Telfairia occidentali*s cv.EN2000-25 with okra cv. NHAe47-4 and pepper NHV1A on the populations of nematode pests of these vegetables. Raised seedlings of root-knot nematode-susceptible *T. occidentalis* and root-knot nematode-tolerant pepper varieties were each nursed and transplanted at 2 and 6 weeks respectively. Okra seeds were sown directly after transplanting *Telfairia* and pepper. The experimental layout was in each case a 4 x 2 factorial fitted into a randomized complete block design with three replications. Sole cropping of *Telfairia* served as the control treatment. The result shows significantly high population of the nematodes in sole *Telfairia* plots, *Telfairia*/okra as well as staked and unstaked *Telfairia*/okra/pepper mixtures. Lower population of the nematodes in the soil and root of plants as well as the number of eggs were observed in *Telfairia*/pepper intercrop. Root- knot rating was also significantly lower. Sole *Telfairia* and *Telfairia*/pepper intercrop recorded the highest shoot yield. Pod weight was heaviest in *Telfairia*/pepper intercrop. Yield of okra was significantly different in staked *Telfairia*/pepper/okra mixtures while the lowest value occurred in unstaked *Telfairia*/okra intercrop. The number and weight of pepper fruits in *Telfairia*/pepper intercrop was superior to the values observed in *Telfairia*/pepper/okra mixture. The interaction between cropping system and staking method indicated that staked *Telfairia*/pepper intercrop exerted the highest suppressive effect on *Meloidogyne incognita* populations while

Telfairia/okra and *Telfairia*/pepper/okra x staking interaction encouraged both soil and root nematode population build-up. The interactive effect of cropping system and staking method showed significantly highest shoot and pod weight values in staked *Telfairia*/pepper intercrop. The land equivalent ratio (LER) and cumulative yield of the crops was significantly highest in staked *Telfairia*/pepper intercrop when compared with other crop mixtures. This study therefore shows that using resistant/tolerant varieties as component crop in *Telfairia* production could be a useful approach in root-knot nematode management under rural and farmer friendly intensive cultivation where these vegetables are mostly preferred.

Key words: Intercropping systems, nematode management, pepper, okra, *Telfairia occidentalis*

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INTRODUCTION

Fluted pumpkin (*Telfairia occidentalis* Hook F), okra (*Abelmoschus esculentus* (L.) Moench. and pepper (*Capsicum frutesence* (L.) are three important vegetables extensively cultivated in southern part of Nigeria. Their production has been on the increase in Nigeria due to increased awareness of their nutritional values. Most rural farmers place emphases on these crops because they believe that they enhance body metabolism. These crops were hitherto regarded as minor compared to traditionally valued crops such as tuber and cereal. This perception is now on the contrary in view of the daily income realized by farmers per unit land area. Information generated from survey of farming communities in parts of Imo state indicated that dry season farming with supplementary irrigation especially for okra, pepper and *Telfairia occidentalis* and in some instances *Solanum* spp. significantly contributed in improving the economic well-being of the rural farmers.

Intercropping is a form of cropping system that involves the planting of two or more crops species together in the same field within one cropping season (Beets, 1978). In addition to its inherent biological checks, it possesses some pest management properties (Idowu, 1988). Each of these systems has sustained the farmer in providing the basic food needs. It is a common practice among the rural farmers to combine two or more vegetables together so as to optimize meager resources for increased output. Plant parasitic nematodes pose a major threat to the production of vegetables. Crop losses of between 20% and 50% have been reported in vegetable crops due to nematode attack. The severity of their attack increases when susceptible crops are planted together or in succession on the same field. Nematicides are expensive and may not be easily affordable by small-scale farmers apparently due to their low-income base. The utility of resistant varieties, though cost-effective and environmentally-friendly, often breaks- down upon continuous cropping especially in heavily infested soils. Consequently, other methods of control should be identified to give the grower a range of options for nematode management. The use of farmer-friendly models with potential for pest control is highly desirable. Extensive investigation is therefore needed to understand the role of mixed cropping in nematode population management on vegetable crop more so since population build-up on favourable host in mixed cropped situation is often comparable with that of monocultures. This work was therefore aimed at evaluating the efficacy of intercropping *Telfairia occidentalis* with okra and pepper in the management of nematode pest.

MATERIALS AND METHODS

The investigation was conducted between 2004 and 2006. The experimental site was the vegetable research plot of the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria lies within Latitude 7° 23′N and Longitude 3° 50′E and with mean altitude of 168m above sea level. Rainfall in the area is bimodal with peaks in June and September. Mean annual precipitation was 103.41 mm in 2004 while in 2005 the value was 121.95mm. Average monthly temperature ranged from a minimum of 22ºC and maximum of 36ºC in 2004. In 2005, a range of 19ºC minimum temperatures and maximum temperatures of 36ºC were recorded. Root-knot nematode susceptible accessions of *Telfairia occidentalis* EN2000-25 obtained from the NIHORT, Ibadan were used for the trials. Using the pie -pan modified tray method, the pre-plant soil nematode population obtained from composited 200cm^3 soil samples were predominantly *M. incognita* (570). In 2005 *M. incognita* predominated with a population of 620, *M. incognita,* was identified using the perineal pattern morphology (Eisenback *et al.,* 1981) and other morphological characteristics (Mai and Lyon, 1975). Two-week-old *T. occidentalis* seedlings earlier raised in moist-sawdust were transplanted 1.0m x 1.0m apart into prepared raised beds in plot of size 3.0m x 4.0m. Raised seedlings of highly tolerant pepper variety (NHV1A) obtained from NIHORT, Ibadan were transplanted 0.75m x 0.75m apart five weeks after emergence in combination with root-knot nematode-susceptible okra (cv. NHAe47-4) and/or *T. occidentalis.* Two staking methods (trellis and zero staking) were employed. The trials were in each case a 4 x 2 factorial experiment replicated three times in a randomized complete block design. Sole planting of *Telfairia* served as the control. The factors included four (4) cropping mixtures and two (2) staking methods. Cultural practices across treatments were maintained. The vines of *T. occidentalis* were trained on the trellis on seven foot-high bamboos. Harvesting for fresh shoot yield of *T. occidentalis* commenced 42 days after establishment. Five harvests were made at 4-week intervals. Harvesting for fresh shoot yield was in each case terminated at the emergence of the female flower. Parameters measured after each harvest included total shoot fresh weight, number of vines, vine length, number of leaf and fresh leaf weight. Five nematode assays were conducted in each plot (using 5 tagged plants) at four-week intervals in each year. Soil nematode population was assessed from composite 200 ml soil samples collected from around the root zone of each individual plant in each plot. Root-nematode populations were determined from replicated 5g weight of root samples using the method described by Byrd *et al*., (1983). The uprooted root systems were also rated for gall development using the method of Barker (1978) viz: 0 = immune; 1 = highly resistance; 2 = resistant; 3 = moderately susceptible; 4 = susceptible; 5 = highly susceptible. The eggs were extracted using the methods of Hussey and Barker (1973) while the eggs were counted in a counting dish using a triple tatty counter. Pods of *T. occidentalis* were harvested at maturity. Yield data form pepper and okra in the trials were recorded. The two-year data were pooled and subjected to analysis of variance (ANOVA) test using the SAS (1985) package.. The means were separated using the Fisher's Least Significant Difference at 5% probability level.

RESULTS AND DISCUSSION

Tables 1a and 1b show the utility value and constraints in the production of *Telfairia occidentalis*. The results showed that greater percentage across the zones of farmers engaged in the production of the crop apparently in view of the premium value placed on it as food and the cash returns it commands. The cropping system being adopted was perhaps informed by constraint of land availability and as such there was the need to maximize the utilization of the insufficient available input per unit area. Source of planting material and cropping system being adopted may support the build-up of soil-borne nematode pests and their confounding effect expressed on plant productivity which explains the apparently sub-optimal yield being experienced by the farmers.

Table 1a: Utility profile of *Telfairia occidentalis* in farming communities in some parts of Imo state.

Loca-tion	Uses % Consumption		Cash	Medicines/ Herb	Fodder	Crop. system	Major intercrop	Source of planting material
Orlu	67.5	83.4	49.6	13.2		Intercrop (83%)	Okra/ Pepper	Previous planting
Okigwe	71.2	76.5	44.8	6.9		Intercrop (80%)	Okra/ Solanum	Previous planting
Owerri	66.8	79.4	57.3	11.5		Intercrop (78%)	Okra/ Pepper	Previous planting

Table 1b: Constraints of *Telfairia occidentalis* production in farming communities in some parts of Imo state.

Location	Constraints			
	Percentage(%)			
	Pest and Disease	Land Availability	Control options in use	Input related options (fertilizer, etc.)
Orlu	74 (Nematodes)	80	10	64
Okigwe	69(Nematodes)	62	0	66
Owerri	78(Nematodes)	86	16	60

On Table 2a, the length of vine and numbers of leaves among the treatments were not statistically at variance. Sole *Telfairia* plots and *Telfairia*/pepper mixture recorded the heaviest shoot weight while the lowest value occurred in *Telfairia*/okra and *Telfairia*/okra/pepper mixture. Total shoot weight and number of pods significantly increased from unstaked to staked intercropping systems compared to sole cropping. These results justify the assertion that vegetative and reproductive growth is enhanced when more leaves are exposed to sunlight especially if such plants are staked (Vandermeer, 1989). Staking provides the plant with opportunity to explore sunlight and enhance assimilation of photosynthates (Vandermeer, 1989, Innis, 1997). This is suggestive that staking confers some advantages to the plant than when the plants were not staked. It is also possible that competition in *Telfairia/*okra under no-staking condition encouraged crowdedness of crops thus limiting aerial advantage and exposure to light intensity, consequently reducing growth and yield performance of *T . occidentalis*

Table 2a: Vegetative and pod yield characteristics of *Telfairia* in *Telfairia*/okra/pepper intercrop

Treatment	Vine length (m)	No of leaf	Fresh shoot wt. (Kg)	No. of Pod	Pod wt. (Kg)
Cropping System					
Sole *Telfairia*	25.88a	224.67a	17.33a	8.17b	29.42b
Telfairia / Pepper	25.89a	265.83a	16.08a	11.00a	53.58a
Telfairia / Okra	24.61a	195.50a	16.22b	6.5c	36.50b
Telfairia / Okra / Pepper	29.10a	264.0a	16.01b	6.17c	38.37b
Staking Method					
Staked	27.55a	228.92a	790.79a	8.76a	20.54a
Unstaked	25.19b	236.08a	714.0b	7.17b	18.44a

Means with the same letter in the column do not differ significantly at 5% probability level.

On table 2b, *Telfairia* and okra used in this study are both susceptible to the root-knot nematode. Their host status encouraged high population build-up thus their effect on plant growth and development translated to suppressed shoot growth and pod yield as opposed to the observation in *Telfairia*/pepper mixture where the tolerant pepper provided some level of protection to the main crop. This observation may also be true for the significant observations made on some parameters in *Telfairia*/pepper intercrop. The low values obtained in most of the parameters as well as the high level of root damaged evidenced by high root-knot rating of *Telfairia*/pepper/okra intercrop presupposes that the intercropping model did not provide any protection for *Telfairia* against infection, This observation suggests that growing *M. incognita* susceptible okra in association with *T. occidentalis* in the field naturally infested with the nematodes has some detrimental consequences for yield of *T. occidentalis.* The decline in growth and yield characters with increasing nematode populations strongly suggests that the reduction in growth and yield attributes of these vegetables resulted from population pressures to which the plants were exposed. The earlier findings of Nwanguma (2002) and Nwanguma *et al.,* (2005) corroborate these findings.

Table 2b: Effect of Cropping Systems and staking method on nematode populations, growth and yield of *Telfairia occidentalis* in *Telfairia*/Okra/Pepper mixtures

Treatment	Soil nematode Pop./200cm^3 soil	Root nematode Pop./5g root	No of eggs/5g root	Root gall rating (1-5)
Cropping System				
Sole *Telfairia*	1667.2b	22b	2497b	2.65c
Telfairia/Pepper	1097.3c	20b	675c	2.77c
Telfairia/Okra	2149.2a	29a	5792a	4.11a
Telfairia/Okra/ Pepper	1953.2ab	27ab	4746a	3.44b
Staking Method				
Staked	1983.3a	18a	2129a	3.10a
Unstaked	2767.5a	22a	2984a	3.88a

Means with the same letter in the column do not differ significantly at 5% probability level.

The interactive effects of cropping system and staking method are presented in Table 3a and 3b. Staking x *Telfairia*/pepper interaction recorded outstanding values (P>0.05) in all the assessed parameters when compared with other interactions (Table 3a). This result was followed by interaction involving okra and pepper. The lowest values were obtained in *Telfairia*/okra interactions. The interactive effects were significantly higher in staked *Telfairia* than the control (zero staking). This observation is in consonance with reports of Innis (1997).

The interaction staked x *Telfairia*/pepper exerted the highest significant (P>0.05) suppression of *M. incognita* populations in terms of soil, root, and number of eggs as well as root-gall rating (Table 3b). Polled effect of the host efficiencies of *T. occidentalis* and okra to the root-knot nematodes culminated in the high populations of the pests observed in the intercrop

Table 3a: Effect of cropping system and staking method on growth and yield of *Telfairia occidentalis* in *Telfairia*/okra/pepper mixture.

Staking Method	Cropping system	Vine length (m)	Fresh shoot wt. (Kg)	Leaf wt (g)	No. of pod	Pod wt. (Kg)
Staked	Sole*Telfairia*	27.14a	27.14a	656.2b	9.66b	9.66b
	Telfairia / pepper	29.06a	29.06a	768.10a	9.66b	9.66b
	Telfairia/ okra	26.64ab	26.64ab	699.42ab	8.33b	8.33b
	Telfairia/pepper/okra	31.33a	31.33a	675.45b	7.33bc	7.33bc
Unstaked	Sole *Telfairia*	28.62a	28.62a	748.00b	6.66c	6.66c
	Telfairia/pepper	22.73b	22.73b	821.20a	12.33a	12.33a
	Telfairia/okra	22.57b	22.57b	554.30b	4.66c	4.66c
	Telfairia/okra/pepper	25.85b	25.85b	734.09a	5.00c	5.00c

Means with the same letter in the column do not differ significantly at 5% probability level

Table 3b: Effect of cropping system and staking method on growth and yield of *Telfairia occidentalis* in *Telfairia*/okra/pepper mixture

Staking Method	Cropping system	No of eggs/5g root	Soil nematode pop./200ml Soil	Root nematode pop./5g root	Root knot rating (1-5)
Staked	Sole *Telfairia*	2046bc	800.00b	17c	3.2b
	Telfairia/ pepper	614c	103.33c	7e	2.4c
	Telfairia / okra	4463b	666.66b	10d	2.7c
	Telfairia/pepper/okra	5560a	1500.00a	25a	4.21a
Unstaked	Sole *Telfairia*	3246b	800.00b	20b	3.18b
	Telfairia/pepper	3260b	553.33c	8de	2.6c
	Telfairia/okra	5027a	1400.00a	22ab	3.81a
	Telfairia/okra/pepper	5667a	1400.00a	23a	3.76a

Means with the same letter in the column do not differ significantly at 5% level of probability

At 50% flowering, okra in staked *Telfairia*/okra intercrop has the highest plant height (36.4cm). Similarly, significantly ($P>0.05$) higher yield values were observed in the intercrop as compared with other treatments (Table 4). These yield values are comparable with yield values obtained in sole okra field trials. This observation thus implies that the intercrop had no negative influence on the growth and yield parameters of okra and as such is compatible.

Table 4: Growth and yield characteristics of okra in Telfairia/okra/pepper intercropping system.

Treatments	Plant height (cm) at 50% flowering	Leaf number	Number of fruit	Fruit wt t/ha
Staked *Telfairia*/okra	36.40	9.97	10.30	17.25
Unstaked*Telfairia*/okra	29.97	11.73	6.30	12.31
StakedTelfairia/okra/pepper	35.67	11.37	16.8	22.55
Unstaked*Telfairia*/okra/peper	30.08	10.67	7.00	16.65
Okra sole	36.11	10.00	11.79	24.98
$LSD_{(0.05)}$	2.63	N.S	2.5	1.95

Height of pepper at 50% flowering in staked *Telfairia*/pepper was significantly different (P>0.05) from similar observation in *Telfairia*/pepper/okra intercrops. Superior yield values were observed when compared with other intercrops (Table 5). The yield values in staked *Telfairia*/pepper intercrop compared favourably with yield values obtained in sole pepper previous field trials (Nwanguma *et al.,* 2008; Nwanguma and Idowu-Agida, 2009).

Table 5: Growth and yield characteristics of pepper in *Telfairia*/okra intercropping system.

Treatments	Plant height (cm) at 50% flowering	Leaf number 50% flowering	Number of fruits '000'	Fruits wt t/ha
Staked *Telfairia/* pepper	34.47	51.37	30.8 7	33.17
Unstaked *Telfairia*/ pepper	29.40	39.97	28.36	21.15
Staked *Telfairia*/okra/pepper	29.07	47.73	21.32	30. 07
Unstaked*Telfairia*/okra/pepper	27.96	42.88	32.08	24.99
Sole pepper	30.04	49.00	34.00	33.87
$LSD_{(0.05)}$	3.35	4.82	4.17	5.10

This study thus showed that intercropping susceptible and tolerant vegetable crops is an effective tool in managing *M. incognita* by resource poor farmers in Nigeria. Since the menace of nematode attack was significantly arrested in *Telfairia*/pepper intercrop, it presupposes that the option, in addition, is also capable of minimizing environmental hazards arising from the use of nematicides.

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Assessment of crop rotation and soil fertility building schemes in selected organic farms in England

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ABSTRACT

Crop rotation and soil fertility building schemes were assessed on some organic farms in England between August, 2007 and June, 2008. A total of 20 farmers in Cambridgeshire, Coventry, Leicestershire, Lancashire, Herefordshire, Somerset and Warwickshire were consulted on crop rotation and soil fertility building in organic systems. Crops with different rooting depths were grown in rotation scheme. Major crops on rotation by the organic farmers in the study areas were potato, cabbage, parsnips, leeks, salads, cauliflower, broccoli, sweet corn, wheat, barley, cucurbits, French beans, beets, chards, carrots, onion, spinach and broad bean. The most common novel legume often planted as soil fertility building was red clover; others include sweet clover, subterranean clover, yellow trefoil, crimson clover, lucerne and persian clover. Perennial rye grass was the only grass commonly grown with the novel legumes during the soil fertility period which varies from one to two years. Crop rotation varied widely between farms and was market driven. Farmers with livestock had much longer grass clover leys since the animals that grazed on them provided additional source of income. The medium (6 to 7 years) and long term (12 years) crop rotation schemes were the common practices.

Key words: organic agriculture; crop rotation; leys; soil fertility; nematode management; pest and disease; soil nutrient; nematode management.

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INTRODUCTION

The Soil Association, UK defined organic farming as a system-based form of production designed to produce food of optimum quality and quantity using sustainable management practices to avoid the use of agrochemical inputs and which minimise damage to the environment and wildlife (Soil Association, 2003). The United States Department of Agriculture (USDA), in 1996, defined organic farming as a production system which avoids or largely excludes the use of synthetic compounded fertilisers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming system relies upon crop rotations, crop residues, animal manures, legumes, green manures, off-farming organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests. IFOAM reported that organic agricultural system promotes environmentally, socially and economically sound production of food, fiber, timber etc. In this system, soil fertility is seen as the key to successful production. Working with the natural properties of plants, animals and the landscape, organic farmers aim at optimizing quality in all aspects of agriculture and the environment. Organic agriculture significantly reduces external inputs by avoiding the use of chemo-synthetic fertilisers, pesticides and pharmaceuticals. Instead, it works with nature to increase both agricultural yields and disease resistance. It also includes social considerations in its holistic approach; recognizing that people are as important as the organic system. In addition, it adheres to globally accepted principles which are implemented in specific social, economic, geo-climatic and cultural contexts.

One of the fundamental principles of crop rotation is that crops susceptible to the same diseases or belonging to the same family should not follow one another in rotation. This principle, while it breaks the disease life cycle by alternative host crops, it also ensures healthy, biologically active soil coming as a result of recycling process, which ultimately replenishes organic matter and nutrients removed by crop after harvest. Crop rotation is the oldest and one of the principal control measures against weed, pest and disease in organic farming system worldwide (Lampkin, 2002). Before crop rotation could be effective as a tool against soil borne diseases, farmers should include non-host crops in the rotational schemes and long term rotation programme should be embarked upon in order to avoid pathogenic organisms that can persist in the soil for up to two or three years, even without any suitable host (Guerena, 2006). Inclusion of leguminous crops into crop rotation is very essential for soil fertility building in organic farming system (Nunis and Harlock, 2005).

There were different organic farms with different soil fertility schemes in England. One keeps on wondering why this is so, bearing in mind that these organic farmers have the same aim for practising crop rotation and soil fertility building. This study was therefore designed to (a) check the base line information on crop rotation and soil fertility building schemes being practised (b) to examine the advantages and uniqueness of different crop rotation and soil fertility building schemes at different organic farms (c) to document the lapses (if any) in crop rotation and soil fertility building schemes presently in practice and to make appropriate recommendations.

MATERIALS AND METHODS

Area of study: Twenty organic farms within England were randomly selected and visited between August, 2007 and June, 2008. These include some organic farms in Cambridgeshire, Coventry, Lancashire, Leicestershire, Herefordshire, Somerset and Warwickshire.

Collection of information: The organic farmers were interviewed on crop rotation and soil fertility building scheme. Some of the questions asked: Do you practice crop rotation? If yes, what is the format? How many years crop rotation do you practice? What crops do you grow on your organic farm? Have you had any crop disease outbreak on your farm? If yes, on what crop and how did you control it? How do you build soil fertility on your farm? What legume do you often plant to build the soil fertility on your organic farm? Does your crop show any sign of nutrient deficiency? If yes, how did you solve the problem? Do you apply compost to your crops? Data were collected, collated and analysed using descriptive statistics (non-parametric statistics).

RESULTS

All (100%) the farmers practised crop rotation and engaged in soil fertility building programmes. Up to 21.5% populations of the farmers were apprehensive of the soil borne nematode disease outbreak on their farms. However, none of the farmers had ever encountered any soil borne nematode disease on their farms.

Figure I show the crop rotation and soil fertility building schemes of some organic farmers that were interviewed. Information displayed in Figure I represents 15.3% population of the farmers that were interviewed. It is a 12 years crop rotation system in which red clover, potatoes, cabbage/parsnips, leeks, salads, cauliflower, sweet corn/cucurbits, French beans/green manure, beats/chards, carrots and onions were rotated. The rotation is such that soil fertility building crops, for example, red clover, French beans and green manure were essential part of the crop rotation scheme. The farmers were also mindful of the crop family. Although the rotational scheme, crops in the same family were not allowed to follow one another in rotation.

Figure I: Model rotations from farmers` interviewed (15.3% population of the farmers)

Year 1	Leys (Red clover)
	▼ ▲
Year 2	Potatoes
	▼ ▲
Year 3	White cabbage /Parsnips
	▼ ▲
Year 4	Leeks
	▼ ▲
Year 5	Salads
	▼ ▲
Year 6	Leys (Red clover)
	▼ ▲
Year 7	Cauliflower /Broccoli
	▼ ▲
Year 8	Sweet corn /Cucurbits
	▼ ▲
Year 9	Fresh beans /Green manure
	▼ ▲
Year 10	Beets /Chards
	▼ ▲
Year 11	Carrots
	▼ ▲
Year 12	Onions

Figure II indicates crop rotation and soil fertility building schemes from 21.5% of the farmers` population that were interviewed. It is a 6 years crop rotation scheme. During the fist two years, these farmers grew novel legumes and grass. Main perennial grass was rye, while novel legumes were sweet clover, crimson clover, Lucerne and Persian clover. In the third year (Year 3), the farmers were found growing cash crops (Nitrogen hungry crops) like potato, cabbage, cauliflower and broccoli. In the fourth year, cash crops which demand little nitrogen for their survival were grown. These crops include leek, carrot, salads, cucurbits and spinach. During the fifth year (year 5), nitrogen replenishing crops (beans), such as French beans and broad beans were grown. In the sixth year (Year 6), cereals crops, which were nitrogen depleting crops, were often grown. Examples of these crops were sweet corn, wheat and barley. The farmers are generally mindful of the crop family, degree of nitrogen consumption of different crops and fertility building. In general, crops in the same family were not allowed to follow one another. Crops were selected based on their degree/ level of nitrogen consumption. However, after the first two years of fertility building (Year 1 and 2), cash crops which were nitrogen-hungry cash crops were allowed to be followed by less nitrogen consuming crops (Year 3 and 4), followed by nitrogen replenishing crops (Year 5) and followed by nitrogen depleting crops (Year 6) before the rotation starts again. As earlier mentioned, these farmers (21.5% population) were apprehensive of the nematode disease outbreak on their farms. However, none of the farmers had ever encountered any nematode disease on their farms.

Figure II: Model rotations from farmers` interviewed (21.5%)

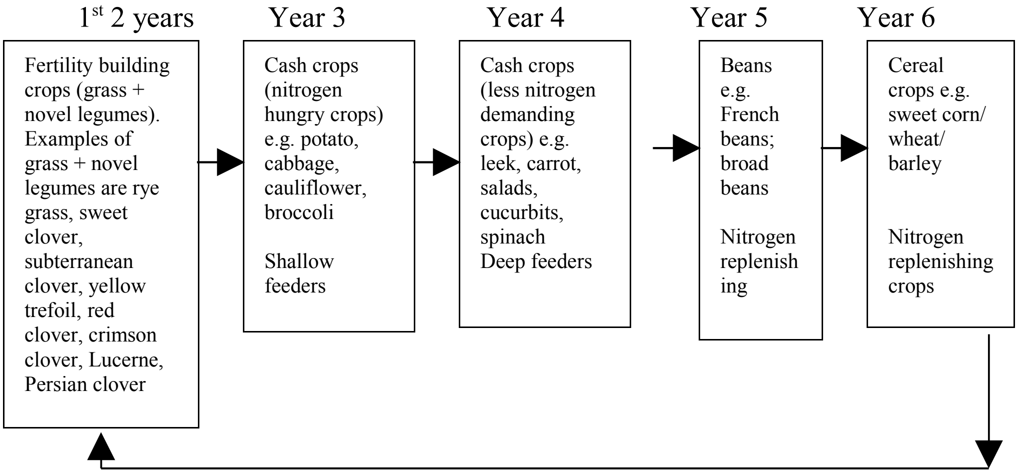

Figure III represents a typical crop rotation and soil fertility building schemes obtained from 32.0% of the population of organic farmers that were interviewed. It is a 7 years crop rotation scheme. The first 2 years of rotation was designed for soil fertility building in which perennial rye grass and novel legumes were planted, this was followed by potato/ broccoli (Year 3) which was followed by carrot/spinach/onion (Year 4) which was followed by salads (Year 5), and followed by beans (French beans/ broad beans) (Year 6), and lastly, followed by cereal crops (barley/wheat) before rotation starts again. These farmers were mindful of the crop family; they did not allow crops that are in the same family to follow each other in rotation.

Figure III: Model rotations from farmers` interviewed (32.0%)

Fertility building with rye grass + novel legumes (2 years) → Potato/Broccoli (1 year) → carrot/spinach/ onion (1 yr) → salads (1 yr) → beans (1 yr) → Cereal crops/(barley/ wheat) (1 yr) → Fertility building with rye grass + novel legumes (2 years)

Figure IV presents model of crop rotation and soil fertility building programmes obtained from 31.2% of the population of organic farmers that were interviewed. It is a six years crop rotation scheme. In the first year, broccoli was planted, by second year, perennial rye grass and clover leys (red clover) were planted. Potato was planted in the third year while leek was grown in the fourth year. Perennial rye grass and clover leys (red clover) were repeated, for soil fertility building purpose, on the fifth and finally in the sixth year, the farmers were fond of planting sweet corn/celery/wheat, before the crop rotation scheme begins again. These farmers were conscious of soil fertility. Therefore, they were fond of building soil fertility at every two year cropping seasons.

Figure IV: Model crop rotation pattern from farmers` interviewed (31.2%)

Broccoli (1 year) → Rye grass + clover leys (1year) → Potato (1 year) → Leeks (1 year) → Rye grass + clover leys (1 year) → Sweet corn / celery /wheat (1 year) → Broccoli (1 year)

Assessment of crop rotation scheme: The results presented in Figure I-IV elicit the crop rotation pattern of different organic farms. Crops grown by the organic farmers in the area visited include potato, cabbage, parsnips, leeks, salads, cauliflower, broccoli, sweet corn, wheat, barley, cucurbits, French beans, beets, chards, carrots, onion, spinach and broad beans. Perennial rye grass was the only grass commonly grown in rotation with novel legumes during the soil fertility building period which varies from one to two years. Novel legumes used as part of trial on the experimental site at Pembridge, Herefordshire and Shropshire, near Ely, Cambridgeshire as fertility building crops included red clover, sweet clover, subterranean clover, yellow trefoil, crimson clover, Lucerne and Persian clover. Red clover was the most grown crop for soil fertility building.

The most common rotation used by the organic crop farmers in England was one to two years fertility building before planting high nitrogen demanding crops (e.g. Brassicas, potatoes) followed by less nitrogen demanding crops (e.g. onions, leeks, carrots) and thereafter, nitrogen replenishing crops (e.g. legumes) and finally by nitrogen removing crops (e.g. cereal), before the rotation starts all over again with ley grass and novel legumes mixture for a period of one to two years. Years of crop rotation scheme by the majority of the farmers were between six and twelve years (Figure I, II, III and IV). Farmers who combined organic livestock with crops grew grass and novel legumes ley for a longer period of time (Figure 1I and III) for period of up to two years as compare to farmers that grew only organic crops and planted mixture of grass and legumes for just one year (Figure 1 and IV).

DISCUSSION

The results showed that all organic farmers consulted engaged in soil fertility building schemes. Maintaining and building soil fertility is crucial in organic crop production system. Generally, soil fertility building is basically through crop rotation. However, to be sustainable and more productive, organic farmers do integrate soil fertility building programmes in their rotation schemes. Inclusion of clover in the fertility building programmes provided N and helped to recycle other basic nutrients like phosphorus and potassium. Rye, in the fertility programme, provides organic carbon required to maintain the microbial biomass needed for mineralization and nutrient recycling in the organic crop production system. Deep rooted crops included in the crop rotation/fertility programme help in extracting nutrients from lower soil depth and returning them to the soil when the plant dies. Although, some of the organic farmers were apprehensive of soil borne nematode diseases on their farms, none of them had ever encountered any soil borne nematode disease on the farms. This is in conformity with Van Bruggen (1995) and Litherick *et al* (2002) who reported that in organic system, pest and disease are not significant problem since it involves holistic approach. Lampkin (2002) stated that pest and disease do not contribute any significant problem in a well established organic system, although certain specific problems do require remedial action. This stems from the fact that a healthy plant, given optimal soil conditions and balanced nutrition, will be better able to resist pest and pathogen. Diseases occur mostly when organism, plant or animal (livestock) is stressed or their environment is unbalanced (Lampkin, 2002).

The medium and long term crop rotation schemes are quite impressive and capable of suppressing the spread and multiplication of soil-borne pathogens. Alternating susceptible and non-host with fallow period of soil fertility building (planting of leys and novel legumes mixture) appeared to be successful, effective and long lasting strategy of breaking the life cycle of the virulent soil borne pathogenic organisms (nematodes, fungi and bacteria). Appropriate crop rotation put in place as reported by all the farmers might disallow the spread and multiplication of the soil inhabiting pathogenic organsms. Welsh *et al*., (2002) reported that crop rotation helps to maintain soil fertility and achieve weed, pest and disease control in organic farming. Guerena (2006) was of the opinion that crop rotation involving non-host crop is often adequate by itself to prevent nematode population from reaching economically damaging levels. Rotating family related crops might not control nematode population, for example rotating pumpkin and cucumber. However, rotating crops which are not in the same family significantly reduced the multiplication rate of soil pathogenic organisms, such as nematodes. For example, pumpkin and bell pepper; or asparagus, corn, onions, garlic, small grains, cahaba white vetch, and nova vetch; or sesame, cotton, peanuts and soybeans are good rotation crops to reduce root knot nematode population below economic level. Crotalaria, velvet beans, and grasses like rye are usually resistant to nematodes especially root knot nematodes (Yepsen, 1984, Peet, 1996, Anonymous, 1997, Wang *et al.,* 2004).

Crops with a high nutrient demand, such as potatoes and cabbage, are placed immediately after a fertility-building period, with less nutrient-demanding crops, such as carrots and onions, placed later in the rotation in the fertility-depleting phase. Careful selection of crops, combined with the effective use of cover crops in winter, allows the maximum exploitation of soil nitrogen, while supplementary nutrients, in the form of manure, compost and fertilizer can be added at any point in the rotation (Gosling and Rayns, 2005). Moreover, Rosenfeld *et al*. (2005) reported that nitrogen-fixing plants are commonly grown in combination with nitrogen-lifting plants in an intensive vegetable rotation involving fertility building (1^{st} 2 years), brassicas/potatoes (3^{rd} year), carrots\onions/leeks (4^{th} year), and beans/sweet corn (5^{th} year). Crops with high demand for nitrogen, such as brassicas or potatoes, are normally grown in the first year after fertility building. In the second year, crops with a lower demand for nitrogen, such as carrots, onions, leeks or celery, are grown. A third year of vegetable cropping may include beans or sweet corn. It was reported further that organic farming systems rely on natural nutrient-cycles to provide crop nutrition and more natural, preventative methods of pest, disease and weed management.

Gosling and Rayns (2005) reported that the use of rotation is a fundamental part of organic farming. It was further reported that apart from the fact that rotation is important in managing soil fertility, they are also vital for the control of pests, diseases and weeds. It was stressed that organic rotations consist of fertility-building phases, when legumes are used to increase soil nitrogen, fertility-depleting phases, when cash crops utilize the accumulated nitrogen. Crops with different rooting depths are grown in rotation scheme. Gosling and Rayns (2005) classified cauliflower, celery, lettuce, leeks, onions, peas, spinach as shallow rooted crops; broccoli, Brussels sprouts, cabbage, carrots, potatoes, spring cereals, squash, sweet corn, vetch, white clover are medium rooted crops, while beetroot, fodder rape, parsnips, red clover and winter cereals are deep rooted crops.

Yearly or seasonal rotation of crops that are in the same family with those in different family would reduce the building up of the population of soil borne disease organisms. This might be because crops that are in the same family are host to related species and types of soil borne pathogens. Bridge (1996) opined that farmers who practiced rotation of seedbed areas at each season (summer, winter, autumn and spring) or every year experienced fewer nematode problems on their crops as compared to farmers who retained the same seedbed sites year-in year-out. For the control of nematode and soil borne pathogens, Trivedi and Barker (1986) recommended alternating poor host, non-host, tolerant, or resistant crops with susceptible crops, with long term interval. Moreover, Ingham (1996) reported that best rotation to control the Columbia root knot nematode potatoes involves planting a summer non-host crop, followed by a winter cover crop incorporated as a green manure. Non-host crop were identified as super sweet corn (crisp and sweet 710/711, pepper, lima beans, turnip, cowpea, musk melon, water melon, squash, rapeseed, canola, mustard and sudan grass (trudan 8 and sordan 79). For root lesion nematode (*Pratylenchus* species) control on potatoes, Ball-Coelho *et al,* 2003, recommended that forage pearl millet (Canadian hybrid 101) and marigold (crakerjack) should be rotated with potatoes. Potato cyst nematodes, wireworms, club-root, cereal cyst nematode, take-all and blackleg in cereals are all examples of diseases that could be effectively controlled through well planned crop rotation design. Bridge and Page (1982) suggested the inclusion of Pitpit, *Setaria palmaefolia* (which is a non-host for vegetable root knot nematode) in the crop rotation scheme. Moreover, Rahman (1990) reported that population of rice root knot nematode, *Meloidogyne graminicola*, was significantly reduced by a relatively slight modification of the traditional cropping sequence. Also, planting of mixed or relaying cropping of field crops that are poor host to the plant parasitic nematodes, such as maize, groundnut, rice, sorghum, millet and cassava with cowpea significantly reduced the infection of root knot nematode (Amosu, 1982).

Starr and Black (1995) suggested inclusion of sesame in rotation with other crops because it might help to suppress the field population of peanut root knot nematode (*Meloidogyne arenaria*) and southern root knot nematode (*M. incognita*). Poultry litter/tillage (year 1) and fallow (year 2) had been reported to be effective in managing the lesion nematode (*Pratylenchus* species) population (Kratochvil *et al*., 2004). The brassicas (rapeseed, mustard, oilseed radish) have a nematode-suppressive effect that benefits the following crop in a rotation (Guerena, 2006); Oil radish, when applied as green manure, has reduced stubby root nematode (*Trichodorus* spp.) and root lesion nematode (*Pratylenchus* species) in Idaho potato fields (Anonymous, 2001); rape or mustard inclusion on rotation scheme with strawberries have checkmate rapid population increase of some nematodes (Brown and Morra, 1997). Therefore, Bridge (1996) suggested that crop rotation should involve the sequential planting of field crops with green manure, cover and trap crops, antagonistic plants and grass.

Our investigation revealed that there was soil fertility building period in the entire crop rotation schemes in England. Incorporation of novel legumes as leys by the farmers would restore soil fertility and also make the soil healthy, which is an added advantage to the field crops. This corroborates earlier findings of Lampkin (2002) and Stockdale *et al.*, (2002) who reported that the presence of leys in the crop rotation scheme allows soil fertility to be restored, particularly in term of organic matter and nitrogen. Soil fertility enhances crop growth and development, and also makes crop to be resistant to disease conditions.

CONCLUSION

The organic farmers rely on the planting of legume for building the soil fertility. All the farmers practiced crop rotation scheme within the range of 6 to 12 years. Most farmer included red clover and perennial rye grain in their crop rotation. Few organic farmers (21.5%) were apprehensive of nematode problem on the field crops, but none of the farmers that were interviewed had ever encountered any nematode problem. The crop rotation schemes were carefully planned and structured to avoid outbreak of any soil borne disease. A fairly long range of 6 to 12 years crop rotation scheme in operation is an added advantage in the control of any soil borne disease organism. In organic agriculture therefore, long term crop rotation and soil fertility building programmes are very essential for the control of soil inhabiting pathogen and also for augmenting soil nutrient (soil fertility building).

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Effects of neem extract on insect pest complex of grapevine (*Vitis vinifera* L.)

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ABSTRACT

The neem tree, *Azadirachta indica* A. Juss, belongs to the family Meliaceae. In Nigeria, the plant is popularly called "Dogonyaro". An on-farm study on the efficacy of the Neem extract, as a potential organic source for the management/ control of the insect pest complex and yield of the grapevine *(Vitis vinifera* L.*)* was carried out at the Institute of Agricultural Research, Ahmadu Bello University, Samaru, Zaria, (11˚, 11' N', 07˚, 38' E and 686m above sea level). Zaria falls within northern guinea savannah agro-ecology zone of Nigeria. The treatments were neem seed extract (NSE), neem leaf suspension (NLS), combination of neem seed and leaf (NSE + NLS) and control. The experiment was replicated three times and laid out in a completely randomized design (CRD). Results indicated that the combination neem seed and leaf (NSE + NLS) was significantly ($p = 0.05$) most effective in the control of the insect pests complex of grapevine production. The effects of NSE and NLS on insect pests of grapevine were not statistically different. Neem seed and leaf extracts, singly and in combination, significantly ($p = 0.05$) controlled insect pests of grapevine. There were rapid multiplication of insects and much insect damage on grapevine fruits that were not treated (control). The results also show that there were improved grapevine growth and yield as compared with retarded growth and low yield of grapevine in the control. The treatment combinations of NSE and NLS recorded a 79% higher fruit yield (kg plant^{-1}) over the control; and 48% and 68% respectively over those treated with NSE and NLS. The neem seed and leaf combination (NSE + NLS) was concluded to be most effective in controlling the various insect pest complexes of the grapevine; resulting in better crop growth and fruit yield.

Keywords: Neem seed, neem leaf, grapevine, insect pests, organic

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INTRODUCTION

The neem tree, *Azadirachta indica* A Juss, belongs to the family Meliaceae. In Nigeria, the plant is popularly called “Dogonyaro” (Scott, 1977) and Indian Lilac in India. The tree plant originated from Assam and Burma and now it is widespread in India, the Central and South America, Australia and the Sahel region of Africa (Rao, 1987). Neem tree was introduced to Ghana in 1919 and later to Nigeria in 1928. In Nigeria, it was fully established in the Borno province and several thousands of seedlings from the first plantation were replanted in Sokoto, Katsina and Kano provinces in the1930s (FAO, 1991). The neem tree is now grown on a large commercial magnitude in countries such as Australia, Hawaii, Florida and both Central and South America for research and industrial purposes (Ronald, 1998).

Neem tree is an evergreen plant with abundant and luxuriant canopy all year round. It is reported to grow any where in the lowland tropics. However, it performs best in regions with an annual rainfall of 300 - 1,800 mm and temperature range of 6˚- 40˚ C. It can survive under the hottest conditions, where maximum shade temperatures may soar past 50˚ C; but it would not withstand freezing or extended cold. It does very well at different elevations; at sea level or perhaps 1,000 m near the equator. It may not survive if planted where the ground water is lower than 5m, which would make the root system of the seedlings inaccessible to water within the first years of planting. On the other hand, the neem tree cannot stand too much water and quickly dies if the site becomes waterlogged (Roland, 1998; Neem, 1992).

The neem tree plant is renowned for good growth on dry, infertile sites. It is reported to perform better than most trees where the soils are sterile, stony and shallow or where there is a hardpan near the surface and acidic soil. In some African countries such as Nigeria, Congo and Zambia, it might or has proved suitable for the slowing down of desert encroachment in the sahel and sudan regions of Nigeria; and reclamation of mine dumps in the Congo and Zambia (Ronald, 1998). Though, the neem tree is easily established, as it grows on deep well drained sandy soil, however, it often fails on silty or micaceous loam and silty clays; in depressions with slow drainage and in soils with high or seasonally fluctuating water tables (Neem, 1992).

The neem oil extract had been reported to repel or control insect pest species, but curiously seem to leave humans, animals and beneficial insects unharmed. In India, it had been reported that the farmers had known that the neem tree withstood the periodic attacks of locusts. Consequently, the Indian scientists took up neem research as way back as 1920's, but their work was little appreciated elsewhere until 1959 when a German scientist noticed a locust plague in the Sudan. During this onslaught of billions of winged marauders, he noticed that the neem tree was the only green plant left standing. On closer investigation he observed that although the locust settled on the trees in swarms, they always left without feeding on the neem tree. Since then, entomologists have discovered that the neem plant extract can affect more than 200 species of insects as well as mites, nematodes, fungi, bacteria and even some viruses (FAO, 1991; Sofowara, 1982; Neem, 1992).

Neem oil has been reportedly used to protect stored corn, sorghum, beans and other stored grains or foods against pest for up to ten months in certain controlled experiments and field trails. For instance, in one such trial in which one-half of several soybean leaves were sprayed with neem oil extracts and placed in a container with Japanese beetles, the treated half remained untouched, but within 48 hours, the other half were consumed right down to their woody veins. In another similar test in the U.S.A, soybean sprayed with neem oil stayed unaffected for up to 14 days, while the untreated plant in the same field were chewed to shreds by various insect species overnight. They attributed this observed phenomenon to the substance *azadirichtin,* which was responsible for stopping the many insect species from even touching their most favorable plants. This substance found in the neem oil extracts, they noted, is a very powerful repellant (Neem, 1992; Yusuf, 1998).

Spridhar *et al.,* (2002) reported on the great potentials of the neem for controlling whiteflies, thrips, aphids and grasshoppers in tomato; when they diluted neem leaf extract in water and soap. Also, Singh and Singh (2000) successfully reportedly controlled whiteflies, diamond black moth and aphids using neem seed powder mixed with water and soap.

From the foregone, it is indeed true that prior to the advent of synthetic chemicals, man from ancient time was documented to have used plant parts (organic botanicals) and other local materials in an attempt to protect his food from pest invasion. Most of these methods have received little attention in the past; they are nonetheless being explored in the present.

But, it is also regrettable that since the introduction of the neem plant to Nigeria and many African countries by missionaries and colonial administrators, very little work has been done and documented to assist farmers in the knowledge of the numerous useful applications of the neem. However, with the recent resurgence of resistance to the present chemical control measures in place and the growing concern about the sustainability of current pest control practices involving the use of highly toxic chemicals with all the attendant implications; the versatile and resilient neem tree offers organic great potential and hope for the protection against the insect pest complex of grapevines and other fruit tree crops; thus enhancing crop productivity. No doubt, the plant kingdom is a source of potentially, organically powerful agents in pest control management. The objective of this research is therefore to assess the effects of neem extracts on the insect pests of grapevine.

MATERIALS AND METHODS

An on-farm experiment was conducted to explore the efficacy of neem extract as a potential organic extract source for the management and control of the various insect pest complexes of the grapevine. The research was carried out at the Institute of Agricultural Research, Ahamdu Bello University, Samaru, Zaria, Nigeria, (11º, 11'N, 07º, 38'E and 686m above sea level); which lies in the Northern Guinea Savannah agro-ecological zone of Nigeria (Kaey, 1959) during the 2004 - 2005 dry season. The total annual rainfall ranges between 883 – 1019mm, with an average of 203.8. The dry season starts at about mid-October and extends to the end of April. Details of the meteorological observations of the experimental site were given in Table 1.

The leaves and seeds of matured kernels of neem, 100gm each were macerated respectively using glass mortar and pestle, and extracted with 300 ml warm water. The extract was then passed through a muslin cloth and the final volume made up to 1 liter to obtain 50% extract concentration.

The treatment comprised of one each of neem seed extract (NSE), neem leaves suspension (NLS), combination of both the NSE and NLS and the control (containing neither the NSE nor the NLS). These were repeated three times using a complete randomized design (CRD). The grapevine trees have a spacing was 4 x 4 m. The treatments were sprayed on the individual plant. Fertilizer and manure were applied according to specified recommendations (Okutu, 2004).

In all, three sprays were applied beginning from flower initiation stage in late October, after the attainment of “economic threshold level”

(3 – 5 grasshoppers, scarabid beetles, mealy bugs and spiraling whitefly per grapevine). Subsequently, sprays were made at 14 days interval for 2 months. Pre-treatment observations were made 24 hours before spraying and post-treatment observations taken up to 7 and 14 days after spraying. Larval, nymph count and percent infestations were taken on each vine plant and recorded. The collected data was compiled, tabulated and analyzed statistically using the analysis of variance as described by Snedecor and Cochran (1969). The means were compared using the Least Significant Difference (LSD) Test.

RESULTS AND DISCUSSION

Table 1 elicits information on the rainfall, air temperature, humidity, and sunshine hours during the research period. The total recorded rainfall was 1019.0 mm; with 6 – 7 hours of sunshine; and an air temperature ranged between 22º - 33ºC. These conditions are quite favorable for the growth of the neem tree which has been reported to perform best in regions with an annual rainfall of 300 – 1,800 mm and with air temperature ranging between 6º - 40ºC; and open sunshine. In fact, the Neem tree is known to grow well in dry sites and is reported to survive under the hottest conditions where maximum shade temperature could soar past 50ºC (Ronald, 1998; Neem 1992).

Table 1: Meteorological data of rainfall, temperature, relative humidity and sunshine hours at Samaru in 2004 rainy season

	Rainfall	**Air Temperature (°C)**			**Relative Humidity (%)**			**Sunshine**
Month	**(mm)**	**Max**	**Min**	**Mean**	**10:00a.m**	**4:00p.m**	**Mean**	**Hours**
Jan.	NA	NA	NA	NA	NA	NA	NA	NA
Feb.	NA	NA	NA	NA	NA	NA	NA	NA
Mar.	NA	NA	NA	NA	NA	NA	NA	NA
Apr.	NA	NA	NA	NA	NA	NA	NA	NA
May	NA	NA	NA	NA	NA	NA	NA	NA
June	54.2	32.2	33.4	27.9	80.8	73.4	76.6	7.5
Jul.	243.1	30.3	22.4	26.4	81.3	69.3	75.3	NA
Aug.	427.1	29.5	22.2	25.9	83.9	72.9	78.4	NA
Sept.	219.5	30.7	23.2	26.9	79.7	63.9	71.8	NA
Oct.	65.1	32.6	22.2	27.4	71.7	49.7	60.4	6.1
Nov.	NA	NA	NA	NA	NA	NA	NA	NA
Dec.	NA	NA	NA	NA	NA	NA	NA	NA
Total:	1019.0	155.3	123.4	134.5	397.4	329.2	362.5	

NA= Not Available

The physico-chemical characteristics of the study area are presented in Table 2. The soil of the study site is classified as sandy-loam with a pH range of 6.0 – 6.2 (slightly acidic). The Soil-Organic Carbon (SOC), total-Nitrogen (N) and available phosphorous (P) were all low. However, the exchangeable – K was medium ranged. Despite this low nutrient status of the soil of the soil study site, the general growth of the neem tree was not adversely affected. neem tree has been reported to be capable of good growth on infertile soil sites. This is not surprising because the neem tree has been noted to perform better than most other trees where soils are sterile, stony and shallow or where hard pans exist near the soil surface. It is recorded to grow well on some acid soils.

Table 2: Physico-chemical properties of the composite soil sample taken from 0 – 30cm dept at the study site; during the 2005-cropping season at Samaru, Zaria, Nigeria.

Physical Composition	
% Sand	50
% Silt	30
% Clay	20
Textural class	Sandy loam.
Chemical Composition	
pH in H2O (1:2.5)	6.20
pH in 0.01 CaCl2 (1:2.5)	6.00
Organic Carbon (%)	0.25
Total Nitrogen (%)	0.05
Available Phosphorous (mg kg^{1})	4.29
Exchangeable bases (Cmol kg^{-1})	
Ca	0.53
Mg	0.36
K	0.31
Na	0.44
CEC	5.00
H+Al	0.40

Consequently, as a result of its good performance on degraded soils, it is used in land reclamation in the sahel and sudan savannah regions of Africa. Notwithstanding the fact that the neem tree is capable of thriving on nutrient depleted soils; potassium and zinc deficiencies have been noted to affect its growth and vigor (Roland, 1998; Neem, 1992). Therefore, it could be said that the medium K-status of the soil of the study site was instrumental to the observed sustained good growth of the neem tree. This is supportive of the reasons why the neem tree is seen to thrive well in the dry, hot, infertile soils of the semi-arid (desert) regions of Africa and the world generally.

Table 3 shows result on the efficacy of the neem tree extract on the control and preponderance of insect pest complex of the grapevine. There was no difference between the control and other treatment (singly and combination) in the pre-treatment observations of the preponderance of insect pests on the grapevine.

Table 3: Efficacy of Neem tree extracts on the control of the preponderance of insect pest complex on the grapevine at Samaru, Zaria, Nigeria; in 2004 – 2005.

Treatment	**Pre-treatment observation**	**Post treatment observation at 7 DAS**	**Post treatment observation at 14 DAS**
Control	8.0	6.33a	6.33a
NSE	7.3	3.00b	2.00b
NLS	7.6	3.00b	2.67b
NSE+NLS	7.3	1.33c	1.33c
Significance	NS	**	**
LSD (0.05)		0.15	0.39
C.V (%)		3.02	4.06

Means followed by the same letter(s) in column of any set of treatment are not significantly different at 5% level of probability using the Least Significant Difference (LSD) Test.

DAS = Days After Spraying NSE = Neem Seed Extract
NS = Not Significant NLS = Neem Leaves Suspension
** = Highly Significant
NSE+NLS = Combination of both treatments
Control = No treatment applied

Table 4: Efficacy of the Neem tree extract on the foliage damage caused by the insect pest complex on the grapevine at Samaru, Zaria, Nigeria; in 2004 – 2005

Treatment	**Foliage Damage Caused by Insect Pest**	
	7 DAS	**14 DAS**
Control	6.33a	5.33a
NSE	2.67b	1.33 c
NLS	3.33b	2.00b
NSE+NLS	1.66c	1.00d
Significance	**	**
LDS (0.05)	1.29	0.15
C.V (%)	6.51	0.43

Means followed by the same letter(s) in column of any set of treatment are not significantly different at 5% level of probability using the least significant difference (LSD) Test.
DAS = Days After Spraying NSE = Neem Seed Extract
NS = Not Significant NLS = Neem Leaves Suspension
** = Highly Significant
NSE+NLS = Combination of both treatments
Control = No treatment applied

The post treatment observations however, showed that at both 7 and 14 days to spraying (DAS), there was a significantly higher (p=0.05) number of the insect pests on the control trees of the grapevine compared to those treated with the NSE and NLS extracts and their combination (NSE + NLS). However, the trees of the grapevine treated with the combination (NSE + NLS) of neem tree extract had a significantly lower (p = 0.05) preponderance of insect pest complex than the single treatment of NSE and NLS, which were statistically at par. A similar result trend was recorded when the efficacy of the various neem tree extract treatments on the foliage damage cause by the insect pest on the grapevine tree where compared; except that at 14 DAS, the foliage damage on the grapevine trees treated with NSE was significantly lower (p=0.05) than the NLS treatment. The findings of this study corroborate earlier research works that reported neem extract repel and control insect pests both in the field and on storage crops. Neem extract has been reported to control more than 200 species of insects, nematodes, fungi, bacteria and even some viruses. (FAO, 1991; Sofowara, 1982; Burkiu, 1985; Neem, 1992).

In the present study, the combination of NSE + NLS performed better than either of the individual doses of the treatment and the control of the damage caused by the insect pest complex on the grapevine crop. This resulted in the better growth and vigor of the grapevine crop as reflected in the significantly higher (p = 0.05) yield recorded with the combination of NSE+NLS (42 kg plant $^{-1}$) compared to the individual treatment of each NSE (22 kg plant $^{-1}$) and NLS (15 kg plant $^{-1}$); which were statistically the same, but inturn significantly higher (p=0.05) than the control (9.0 kg plant $^{-1}$). The treatment combination of NSE + NLS recorded 4% fruit damage compared to 20% with the control. The treatment combination of NSE + NLS recorded 79% higher fruit yield over the control; and 48% and 58% over the grapevine tree crops treated with NSE and NLS respectively (Table 5).

Table 5: Effect of the neem tree extract on control of insect pests complex and the yield of the grapevine at Samaru, Zaria, Nigeria; in 2004 – 2005.

Treatment	**Yield (Kg plant^1)**
Control	8.67c
NSE	22.00b
NLS	15.00b
NSE+NLS	42.00a
Significance	**
LSD (0.05)	9.52
C.V (%)	9.49

Means followed by the same letter(s) in the same column of any set of treatment are not significantly different at 5% level of probability using the least significant difference (LSD) Test.

DAS = Days After Spraying NSE = Neem Seed Extract
NS = Not Significant NLS = Neem Leaf Suspension
** = Highly Significant Control = No treatment applied
NSE+NLS = Combination of both treatments

On-farm trials (Okutu, 2004) have corroborated the findings of this study who reported that neem-based extract containing *azadirachtin* as active ingredient significantly reduced the incidences of grasshoppers, various chewing beetles, mealy bugs and spirally whitefly population, growth and their damage on fruits; particularly on the foliage in grapevine resulting in higher fruit yield and health of the crop plant.

Toxic chemicals (synthetic insecticides) have been recommended for the control of various insect pests complex (Rao, *et al.,* 1987; Armes, *et al.,* 1992). The increasing global concern for the environment, has underscored the present emergent trend towards conservation agriculture; and organic farming has driven the search for effective and eco-friendly natural organically based alternatives.

Consequently, the utilization of naturally available and cost effective products in an Integrated Pest Management (IPM) system in viticulture is of great benefit to grapevine farmers in bringing about a drastic reduction in the seasonal large scale application of highly toxic chemicals and the high cost implication to these resource poor farmers; coupled with the reduction in the harmful effects on both human and animal health (as the chemical gets invariably passed through the food chain); and the reduction in environmental pollution, thus helping to create an environmentally friendly ecosystem for healthy human and crop plants cohabitation.

CONCLUSION

From the findings of this study, it can be deduced that the sole application of neem seed extract (NSE) and neeem leaf suspension (NLS) was found to be effective in managing the spiraling whitefly and mealy bugs and also deterred the activity of grasshoppers and scarabid beetles on grapevine. However, the combination of NSE and NLS was observed to have an effective impact in managing the various insect pest problems in grapevine production, with resultant enhanced crop growth and fruit yield. This offers an easily affordable, organically based option for the control of insect pests on grapevine. This could also have concomitant effect on the growth and yield enhancement; sustainable eco-friendly environment for healthier foods consumption and “safe to eat crop production”.

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Response of Cassava and Soyabean grown sole and intercropped to inoculation of Rhizobium and Arbuscular Mycorrhiza Fungi

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ABSTRACT

Indigenous Arbuscular Mycorrhizal Fungi (AMF) and rhizobia (Rh) have the potential to supplement soil phosphorus and nitrogen respectively, thereby reducing the reliance on chemical fertilizer. This study investigated the soil amendment potential of indigenous AMF with or without *Bradyrhizobium* species for production of cassava (TMS 30572) and soyabean (TGx 1448-2E) grown sole or intercropped. AMF + Rh gave significant higher plant height (47.8cm), number of leaf (17.8/plant), leaf area (36.5cm^2), and number of pod (16.5/plant) in soyabean Similarly, AMF + Rh significantly increased cassava plant height (96.60cm), number of leaf (67.66/plant), leaf area (84.11cm^2), and fresh tuber weight (945.22g/plant). Application of VAMF (*Glomus etunicatum* and *Glomus mossae*) with *Bradyrhizobium japonicum to* soils has potential to increase production of soybean and cassava

Key words: *Glomus etunicatum*, *Glomus mossae, Bradyrhizobium japonicum*, Cassava, Soyabean, Intercropping.

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INTRODUCTION

In many countries, especially developing ones like Nigeria, farmers intercrop legumes such as cowpea with millet, sorghum, maize and cassava because of their capability to restore back soil fertility or include them in the crop rotational cycle to restore back soil fertility. This occurs mainly through nodule nitrogen fixation with little or no application of other fertilizer nutrients such as phosphorus (Benjamin, 1994). Supplementation of this agronomic practice with other soil and crop management practices such as timely weeding and application of basal plant nutrients to crops always geared towards yield improvement. Manjunath and Bagyaray 1984, submitted that application of basal phosphorus to pigeon pea and cowpea improved their yield.

Rhizobia and Arbuscular Mycorrhizal fungi are important biofertilizers that pose no ecological threats and have long lasting effect on crops when managed properly (Mahdi and Atabani, 1992). Mycorrhizal fungi form symbiotic association between plant and fungi that colonise the cortical tissues of roots during period of active plant growth (Harley and Smith, 1983). The benefits afforded plants is to increase their growth and yield potentials. Rhizobia are gram negative rod and obligate aerobes. They do not form spores and are motile with either one polar or sub-polar flagella or between two and six peritrichous flagella (Jordan, 1984). They are able to form nodules on host plants.

Cassava (*Manihot esculenta* Cranzt) is a root crop. Its cultivation is by stem and it can tolerate wide range of soils (Hahn and Keyser, 1985). It serves as a fodder for livestock and as industrial raw materials for industries. Soybean (*Glycine max* (L) Merril) is an important oil seed crop in the world. Its seeds contained forty percent protein and twenty percent oil (Foreign Agricultural Service, 1985, IITA, 1983).

Synergistic effects of dual colonization of roots with VAM fungi and Rhizobia on growth, nutrient uptake and nitrogen fixation of soybean (Bethlrnfalvay *et al*., 1990), chiken (Champawat, 1990), and cowpea (Islam *et al*., 1990) have been reported. However work on dual inoculation using AMF and Rhizobium on the intercropping of cassava with soybean have not been reported hence, the aim of this study was to determine the efficacy of AMF and Rhizobium inoculation on performance of cassava and soybean grown sole or intercropped because intercropping is an aged agriculture practice in the humid and sub-humid tropics (Olasantan, 1997; Olukemi and Agboola 2002). Among the reason for the continuous existence of this practice is that higher gross returns and dietary requirements are achieved under intercropping (Andrews and Kassam, 1976; Okigbo and Greenland, 1976).

MATERIALS AND METHODS

The inoculants were Rhizobium and Arbuscular mycorrhizal fungi. The Rhizobium used in this study was *Bradyrhizobium japonicum*. It was isolated from the root nodule of soybean plant according to Weaver and Fredrick (1982).Identification of *Brandy. japonicum* was based on morphological, cultural and biochemical characterisation according to Bergey's manual of determinative bacteriology (Breed et al., 1987). Indigenous mycorrhiza fungi (*Glomus mosseae*) used was isolated from soil collected from Teaching and Research Farm of the University of Agriculture, Abeokuta, Ogun State. Mycorrhiza fungi was identified based on spore size, hypae, colour, reaction to Melzer's solution, different walls types as described by Walker (1991). The fungi was multiplied and propagated on maize plant in a green house pot culture.

The test crops were cassava (*Manihot esculenta* Crantz) TMS 30572 and soybean (*Glycine max* (L) Mer.) variety TG_X 1448-2E. Experimental design was 3x5 factorial fitted into a complete randomized design replicated three times and repeated twice. The three cropping systems were cassava sole, soybean sole and cassava x soybean intercropped. Five soil amendments were mycorrhizal fungi (MF), Rhizobium (RH), Mycorrhizal fungi and Rhizobium (MFxRH), 100% recommended rates of nitrogen (Urea) and phosphorus (single super phosphate) fertilizer for cassava and soyabean and control.

In crop mixtures, nitrogen requirement for individual crop in the mixture are soyabean-15 kg N/ha, cassava-100 kg N/ha. While phosphorus (for the two crops) cassava x soyabean mixture is -30.2kg P/ha. In sole cropping, cassava and soyabean requirement are Nitrogen -80kg N/ha, Phosphorus-11kg P/ha, soyabean Nitrogen -15 kg N/ha Phosphorus-13 kg P/ha. A total of 15 (3x5 factorial) experimental pots were established to constitute a unit experiment. This was replicated three times to give total of 45 experimental buckets in the green house.

Mycorrhiza fungi inoculation was done by placing 50g of *G.mosseae* at a depth of 5cm before planting. Seeds of soybean were surface sterilised by soaking in 70% (V/V) ethanol for a second and washed several times with sterile distilled water (Chabot et al., 1996). Yeast mannitol broth (YMB) was inoculated with 1ml of $10X10^7$

Brandyrhizobium japonicum at room temperature. 20mls of inoculated YMB was mixed with 25g of sterile charcoal powder, seeds of soybean were then coated with the inoculated sterile charcoal powder (Subba *et al*., 1982). Coated seeds were air dried at room temperature.

Uninoculated seeds was used as a control. Ten coated seeds were place in a hole inside the planting buckets. Cassava cuttings were mopped with cotton wool soaked in 70% (V/V) ethanol and washed several times with sterile distilled water before planting.

The crops were planted inside 15litre plastic buckets that contained 10kg sterile soil. They were treated with the soil amendments. The experiment was run concurrently with 100% recommended nitrogen and phosphorus fertilizer for the sole crops and intercropped with a control.

Agronomic measurement

The following agronomic measurements were taken, Plant height (cm) were measured from 10cm from the base of the plant with a meter rule, number of leaf, and leaf area (cm^2). Leaf area were calculated according to Hammer (1980) and modified by Lutalado (1986) for cassava. For soybean, the following parameters were determined: Pod dry weight (g), number of pods, husk dry weight (g), leaf area, seed dry weight, number of seeds and 100 seed weight (g) while on cassava, stem girth cm), tuber number and tuber weight (g) were measured. Statistical analysis were done on the data collected using the SAS version 6 (SAS institute 1990), means were separated using an LSD at $P \leq 0.05$.

RESULTS

The soil physicochemical parameters before planting are shown in Table 1. Table 2 contained data on the effect of the different cropping systems and soil amendments on some growth parameters of Glycine max. (L) Merr. There was significant difference in the number of leaf between sole and mixed cropping systems at $P<0.05$. Treatment NP fertilizer gave the highest yield of plant height, number of leaf and leaf area followed by treatments MBRH, MB, RH and control in decreasing order. Interaction effects between the cropping systems and treatments showed that the plant height, number of leaves and leaf area were significantly improved in mixed cropping system than sole cropping system and treatment NP significantly enhanced the plant height, number of leaves and leaf area both in mixed and sole cropping systems at P<0.05.

TABLE 1: Some properties of the soil of the experimental site used

pH (water)	6.63
N %	0.12
C %	1.31
Exchangeable base ($Cmolkg^{-1}$)	
Ca	1.32
Mg	2.22
Na	0.08
H+	0.13
C.E.C	4.02
Av. P ($mg\ kg^{-1}$)	6.35
Mn ($mg\ kg^{-1}$)	3.67
Soil series	IWO
USDA (Taxonomy)	Ultisol

The pod dry weight, number of pod and husk dry weight of soybean were increased in sole cropping system and the treatment NP fertilizer gave the highest husk dry weight. The interaction effect on the pod dry weight and number of pod was best in NP treatment both in mixed and sole cropping systems, while the husk dry weight was best in the dual inoculation (MBRH) both sole and mixed cropping systems (Table 3).

The sole cropping system increased the seed dry weight and number of seeds while the mixed cropping system increased the 100 seed weight. Treatment NP fertilizer significantly (P<0.05) improved the seed dry weight, number of seed and 100 seed weight when compared with the other treatments. In the interaction effect NP fertilizer increased the grain yield parameters when compared with other treatments (Table 4)

The plant height and leaf area of cassava were better improved in mixed cropping system while the number of leaf was better enhanced in sole cropping system. The treatment effect was also increased in NP fertilizer and least in control in the growth parameters studied. Plant height, number of leaves and leaf area were best in treatments NP in the interactions effects (Table 5)

Table 2: Effect of different cropping system and soil amendment on some growth parameters of Soybean.

Treatment		Plant height (cm)	Number of Leaf	Leaf area/plant (cm^2)
Cropping system				
Mixed		49.68	29.34	18.33
Sole		48.46	31.83	17.73
LSD (P= 0.05)		3.52	0.75	1.43
SE (DF)		0.85(18)	0.17 (18)	0.41 (20)
Treatment				
NP		59.10	38.76	22.00
MBRH		47.88	36.52	17.83
MB		46.50	34.02	17.16
RH		46.45	27.41	16.66
ZERO		45.43	16.22	16.50
LSD		3.57	0.75	1.23
SE (DF)		0.53 (18)	0.11 (18)	0.26 (20)
Cropping X Treatment				
Mixed	MB	47.70	32.33	17.67
	MBRH	48.70	35.84	18.33
	NP	58.46	37.33	21.67
	RH	46.80	25.94	17.00
	ZERO	46.73	15.25	16.32
Sole	MB	45.30	35.71	16.67
	MBRH	47.06	37.19	17.33
	NP	59.73	40.19	22.33
	RH	46.10	28.88	16.33
	ZERO	44.13	17.20	15.40
LSD (P=0.05)		3.57	0.75	1.73
SE (DF)		0.53 (18)	0.11 (18)	0.26 (20.)

The effect of different cropping systems and soil amendments on some yield parameters of cassava is shown in Table 6. The stem girth and tuber weight were improved in sole cropping system and NP treatment. The least weight was recorded in the control. In all the parameters taken, the bio-fertilizer treatment (MBRH) was second best in the trials.

Table 3: Effect of different cropping system and soil amendment on some yield parameters of Soybean

Treatment		Pod dry wt/ plant (g)	Number of pod/plant	Husk dry wt/plant(g)
Cropping System				
Mixed		7.31	13.66	2.60
Sole		7.84	15.00	2.84
LSD(0.05)		0.52	2.83	0.18
SE (DF)		0.10 (20)	0.67 (20)	0.04 (20)
Treatment				
NP		12.03	17.33	3.85
MBRH		10.37	15.83	4.65
MB		7.94	14.50	2.26
RH		5.30	12.83	1.95
ZERO		2.23	11.16	0.89
LSD(0.05)		0.42	2.83	0.18
SE (DF)		0.06 (20)	0.42 (20)	0.02 (20)
Cropping x Treatment				
Mixed	MB	7.61	13.67	2.17
	MBRH	9.94	15.00	4.44
	NP	11.59	16.67	3.72
	RH	4.99	12.33	1.84
	ZERO	2.41	10.67	0.84
Sole	MB	8.28	15.33	2.36
	MBRH	10.81	16.67	4.86
	NP	12.47	18.00	4.00
	RH	5.62	13.33	2.07
	ZERO	2.05	11.67	0.95
LSD (P=0.05)		0.42	2.83	0.18
	SE (DF)	0.06 (20)	0.42 (20)	0.02 (20.)

Table 4: Effect of different cropping system and soil amendment on some grain yield and yield attributes of soybean

Treatment		Seed dry weight	Number of seed/plant	100 seed weight (g)
Cropping system				
Mixed		4.64	28.46	15.50
Sole		5.13	29.86	14.70
LSD		0.31	2.34	0.31
SE (DF)		0.025 (20)	0.56 (20)	0.07 (20)
Treatment				
NP		8.08	39.33	20.04
MBRH		5.70	35.50	15.63
MB		5.54	33.66	15.35
RH		3.44	22.50	13.64
ZERO		1.67	14.83	10.83
LSD (0.05)		0.31	2.34	0.31
SE (DF)		0.047 (20)	0.355 (20)	0.048 (20)
Cropping x Treatment				
Mixed	MB	5.32	33.00	15.19
	MBRH	5.46	35.00	15.46
	NP	7.64	37.67	19.31
	RH	3.24	22.00	12.85
	ZERO	1.57	10.67	10.70
Sole	MB	5.78	34.33	15.52
	MBRH	5.94	36.00	15.80
	NP	8.54	41.00	20.77
	RH	3.64	23.00	14.44
	ZERO	1.77	15.00	10.97
LSD (P=0.05)		0.31	2.34	0.31
	SE (DF)	0.047 (20)	0.355 (20)	0.048 (20.)

Table 5: Effect of different cropping systems and soil amendments on some growth yield parameter of Cassava

Trt		Plant height (cm)	Number of Leaf	Leaf area (cm^2)
Cropping System				
Mixed		81.77	60.06	67.30
Sole		90.38	68.27	70.01
L&D (P=0.05)		9.59	6.19	4.88
S.E (DF=20)		2.28	1.49	1.15
Treatment				
NP		108.36	76.83	84.11
MBRH		96.60	67.66	73.72
MB		94.11	65.00	66.82
RH		70.36	59.50	61.19
Zero		60.95	51.83	57.42
LSD (P=0.05)		9.59	6.19	4.85
SE (DF=20)		1.44	0.93	0.73
Cropping x Treatment				
Mixed	MB	91.03	60.33	66.59
	MBRH	90.76	61.32	70.35
	NP	104.16	75.00	83.09
	RH	67.10	53.66	60.68
	Zero	55.80	50.00	55.80
Sole	MB	97.20	69.66	67.05
	MBRH	102.43	74.00	77.09
	NP	112.56	78.66	85.12
	RH	73.63	65.33	61.70
	Zero	66.10	53.66	59.05
	LSD (P=0.05)	9.59	6.19	4.88
	SE (20)	1.44	0.93	0.73

Table 6: Effect of different cropping systems and soil amendments on some yield parameter of Manihot esculenta (Crantz)

Treatment		Stem girth (cm)	Tuber weight (g)	Tuber Number
Cropping System				
Mixed		1.68	484.00	3.80
Sole		1.81	608.93	3.66
LSD		0.14	36.71	0.70
S.E (DF=20)		0.034	8.79	0.18
Treatment				
NP		2.06	737.10	4.33
MBRH		1.86	662.73	4.16
MB		1.76	618.57	3.83
RH		1.53	368.25	3.33
Zero		1.50	345.68	3.00
LSD		0.14	36.71	0.76
SE (20)		0.02	5.56	0.11
Cropping x Treatment				
Mixed	MB	1.75	620.63	3.83
	MBRH	2.07	647.47	4.17
	NP	2.22	715.35	4.17
	RH	1.45	404.65	3.50
	Zero	1.42	337.60	3.00
Sole	MB	2.02	791.03	3.83
	MBRH	2.18	864.95	48.27
	NP	2.53	966.97	4.33
	RH	1.58	435.78	3.17
	Zero	1.53	415.57	3.00
	LSD	0.14	36.71	0.76
	SE (DF=20)	0.02	5.56	0.11

DISCUSSION

In most intercropping experiments, emphasis is usually not placed on the effect of intercropping on morphological parameters such as plant height, leaf area, number of leaf, and number of branches. This is surprising because such morphological parameters have been found to affect the yield of crops (Silwana & Lucas, 2002). Intercropping have been found to reduced morphological parameters like number of branches, number of leaves and leaf area per plant in melon. The reduction in these parameters affected the yield of in the intercropped (Wahua, 1985). Application of nitrogen fertilizer and biofertilizer (mycorrhizal fungi and Rhizobium) had beneficial effects on morphological parameters such as plant height, leaf number and leaf area of soybean when grown sole or intercropped. NP fertilizer applied on soybean gave higher significant effect on yield of plant height, number of leaves and leaf area respectively than any other treatment irrespective of cropping system adopted. However, dual inoculation of indigenous mycorrhizal fungi and rhizobium gave second best significant yield of the above parameters than individual soil amendment (sole AMF or sole Rhizobium) in the trials.

The higher yield recorded in NP fertilizer over the inoculated treatments for the benefit of soybean crop may be due to immediate release of nitrogen nutrient from urea fertilizer applied which gave the plant immediate benefit of nitrogen advantage over other treatments that were investigated to support the growth of the plant in early life of the crop . The effect of soil amendment on pod dry weight, number of pods and husk dry weight of soybean showed significant effect on both NP fertilizer and biofertilizer treated buckets. Higher significant yield is recorded in NP fertilizer while second best yield is recorded in unit that received dual inoculation (MBRH). Ichir &Ismaili (2003) observed similar trend in nitrogen fertilization on wheat crop system based on fact that 33% nitrogen is of immediate benefit to the crop in legume – cereal mixture while 66% is fixed between 0-80 cm soil depth and the remaining 1% were lost due to denitrification process.

Intercropping soybean in this experiment was found to increase the plant height, leaf area, number of leaf but lower the seed yield of soybean in mixed cropping system compared with soybean grown in sole system. Silwana et al. (2007) reported that when assessing the effect of intercropping, the main emphasis is usually placed on the yields of crop with little on the components that made up the yield and these components that made up the yield had been found to influence yield.

The yield components pod dry weight, number of pods and husk dry weight of soybean in the mixed cropping system were reduced relative to the components in sole cropping system and these were the components which had major contribution on the final of these study. Yield components were directly related to yield (Silwana et al., 2002). It can therefore be deduced that lower grain yield of soybean under intercropping with cassava can be attributed to reduced values of the yield components of the crops under sole condition. This finding highlighted the important of fertilizer whether chemical or biofertilizers in the intercropping system involving soybean and cassava whether grown sole or intercropped. The crops gave the lowest yield when no fertilizer was applied. Similar results on the importance of fertilizer in intercropping had been reported for maize/mungbean, maize/bean intercrop and cassava/maize (Dhingra et al., 1991, Fininsa, 1997 and Olasantan et al., 1997). In the crop mixture, soybean and cassava were planted at the same time, hence soybean was fully established and matured before cassava in the mixture was fully established.

CONCLUSION

From the results obtained in this study, it can be concluded that biofertilizer (indigenous mycorrhizal fungi and Rhizobium) has potential to improve yields of small holder farmers who cannot afford to buy inorganic fertilizer. These microorganisms are environmental friendly.

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Evaluation of the agronomic characters of Sweet potato varieties grown at varying levels of organic and inorganic fertilizers

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ABSTRACT

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INTRODUCTION

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RESULTS AND DISCUSSION

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Phytohormone and growth response of Soybean to indigenous *Glomus* sp. inoculation in sterile and unsterile soil conditions

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ABSTRACT

A green house experiment was conducted to investigate the influence of an Arbuscular Mycorrhizal fungal (*Glomus* sp.) on the phytohormone and growth response of Soybean (*Glycine max* L. Merr) in sterile and unsterile soil conditions. Randomized complete block design with three replications was used for the green house experiments. The volume of phytohormone obtained were significantly higher (7.05-70.43mg/100ml) in sterilised soil than unsterilised (6.77-52.73mg/100ml). *Glomus* (7.51-55.68mg/100ml) inoculated soil gave higher phytohormone than uninoculated (5.18-37.73mg/100ml) soil. Auxin level was highest in all treatment 63.64mg/100ml, followed by Absciscic acid 60.55mg/100ml and Gibberellins 7.75mg/100ml was the lowest. Leaf area, leaf number, plant height, root length, number of nodules dry matter of root, dry matter of stem and dry matter of leaf increased significantly ($P<0.05$) in *Glomus* inoculated soil than non inoculated soil and also in unsterilised soil than sterilised soil. All parameters increased with days of planting.

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INTRODUCTION

Plant development is influenced by several internal and environmental factors (Marschner, 1995). The environmental factor includes mycorrhizae, a symbiotic association between soil fungi and the roots of most plants. Arbuscular mycorrhizal influenced plant development. The best known effect of arbuscular mycorrhizal fungi is the enhanced growth of plant in infertile soils, due to more efficient absorption of low mobile minerals mainly phosphorus (Smith and Gianinazzi-Pearson, 1988). Abscular mycorrhizal are able to mordify host root development in relation to root size and architecture and change the level of plant hormones since they mediate internal and environmental signals in plant development (Davies, 1995).

This work was aimed to ascertain the role played by the arbuscular mycorrhizal (*Glomus* sp.) on host root hormones in relation to plant growth in sterilised and unsterilised soil. The objective of this study was to determine the effect of mycorrhizal fungi (Glomus sp.)on the phytohormone, root colonization and growth of soybean in sterile and unsterile soils.

MATERIALS AND METHODS

The soybean seed used in this experiment was TGx-1448 collected from International Institute of Tropical Agriculture, Ibadan, Nigeria. The *Glomus* sp. was isolated from sandy loamy soil collected from the Teaching and Research farm University of Agriculture, Abeokuta, Ogun State, Nigeria. The soil pH was 5.94. The soil was sieved by passing through a 2mm sieve to remove coarse stones and extraneous materials. Soils collected were divided into two batches. A batch of the soil was steam sterilized for 2h at 120°C and left for 2 days before being planted with soybean seeds in 10 kg soil in 15litre bucket. Another portion was not sterilized. This was done to mimic and represent soil field condition. Each pot is sown with 15 seeds that had been surface sterilized with 70% ethanol. After germination the plants were thinned to 10 plants per pot. All plants were grown under well watered conditions for 26 weeks outside, under a maximum photosynthetically active radiation of 1500umol m 25^{-1} and average day/night temperature of 25-35^{0}C. Sixteen pots were used, 8 pots contained sterilized soils while other 8 pots contained unsterilised soil. Half of each set of pots were inoculated with 100 g each stock of *Glomus* sp. (1542 spores /100g of soil) and the other half were uninoculated (control). Randomized complete block design with three replications was used for the green house experiments.

Quantification of percentage VAM root length colonization

VAM root colonization was assessed using the magnified intersections method (McGonigle *et al*., 1990). For each sample, fifty one centimeter root segments were mounted on a glass slide and observed under dissecting microscope at the magnification of 40X, 200X and 400X of a compound microscope equipped with a cross hair eyepiece graticule. The slide was scanned methodically until one axis of the graticule aligned with the long axis of each root encountered. Percentage of root length colonized by mycorrhizal endophyte. Colonization (% RLC) scores presence or absence of arbuscular endophyte touched by the graticule axis which crosses the root each time a root is encountered were recorded. At a single intersection between each root segment and the eyepiece cross-hair, the presence/absence of VAM hyphae was also noted. VAM colonization was calculated as the percentage of 50 root segment intersections at which hyphae were present.

$$RLC = \frac{100 \text{ x Number of intersection with VAM hyphae}}{\text{Total number of intersection counted.}}$$

Experimental measurement

Plant height (cm), leaf area (cm^2), root length (cm), root weight (g) number of nodules, dry matter of leaf, stem and root were determined at 21, 42, 63, 84 & 105 days after planting. Stem root and leaf dry weight were oven dried to constant weight at 70^{0}C for 24h. The following hormones, auxin, gibberellins and abscicic acid were determined by the method Hogan and Scott, (1991). Twenty one day old fresh roots were used for the hormone bio-assay.

Preparation of growth regulators for stock solution

Ten milligram of growth regulator was weighed and place in a 100ml beaker. A few drop of 0.5N HCL and 20-30ml of 90% ethanol were added. This was mixed till completely dissolved. Some quantity of double distilled water (DDW) was added and the content poured into a

100ml volumetric flask. The DDW was used to rinse the beaker and this was made up to 100ml. The flask was covered, sealed with paraffin wax and mixed well. The flask was labeled indicating the name of the growth regulator, concentration and date of preparation. The stock solution would give 0.1ml of growth regulator for each ml that would be pipette.

Determination of Auxin (IAA)

One gram of fresh weight 21 days old root sample was weighed into a 100ml beaker, 10ml of chloroform and 10ml methanol was added. The mixture was allowed to stand for 1 hour and later filtered through a Whatmann NO.2 filter paper into another 100ml beaker. The filtrate was transferred into 250ml separating funnel and 10ml glacial acetic acid and 20ml warm distilled water was added to remove any aqueous contaminants. The mixture was properly shaken until two layers separated out. The organic layer was carefully siphoned out into a 30ml centrifuge tube. This was corked until ready for reading on the spectrophotometer. Concentrations of auxin ranging from 0-5ppm were prepared from 100ppm standard auxin stock solution. One milliliter of Williams reagent was added to sample extract and standards to develop colour. A blank was also prepared. The absorbance of standards and those of samples was measured on the spectrophotometer at a wavelength of 510nm. The concentration of auxin in mg/100g was obtained using the formula.

$$\frac{\text{Absorbance of sample x concentration of standard x dilution factor}}{\text{Absorbance of standard of auxin in mg/100g}}$$

Determination of Gibberellins

One gram of fresh weight 21 days old root sample was weighed in a 100ml beaker, 10ml methanol and 20ml of 8% HCL in glacial acetic acid were added and their mixture allowed to stand for 1 hour after which it was filtered through a Whatmann NO. 2 filter paper into a 100ml beaker. The filtrate was transferred into a 250ml separating funnel and 20ml of propanol was added to totally remove the organic extract. Twenty milliliter of warm distilled water was added to remove any aqueous contaminant. The organic layer was carefully siphoned out into a 30ml centrifuge tube and made ready for reading on a spectrophotometer. One to five ppm (1:5ppm) of gibberellins was prepared from 100ppm standard stock solution. A blank was also prepared as well. The absorbance of the standards and those of the samples were measured on the spectrophotometer at a wavelength of 470nm while the concentration of gibberellins was obtained using the formula.

$$\frac{\text{Absorbance of sample x concentration of gibberellins x dilution factor}}{\text{Absorbance of gradient in mg/100g}}$$

Determination of Abscicic Acid

One gram of fresh weight 21 days old root sample was finely grounded weighed into 100ml beaker. Twenty milliliter of 50% propanol was added and stirred with a glass rod. Twenty milliliter of warm DDW was added to dissolve out any aqueous contaminants and allowed to stand for 1 hour. The extract was quantitatively filtered through a Whatmann NO.1 filter paper into a 100ml volumetric flask using 50% propanol to rinse. This was made up to mark with distilled water. One milliliter of sample extract was pipette into a 30ml centrifuge tube, 5ml methanol, 5ml of 0.5N NaOH and 5% butanol were added and thoroughly mixed. The mixture was allowed to stand for 10 minutes to develop colour for reading on a spectrophotometer. Standard abscicic acid of concentration 1-10ppm were prepared and treated similarly as samples were measured on a spectrophotometer at a wavelength of 500nm. Concentration of Abscicic acid in Mg/100g was calculated using the formula

$$\frac{\text{Absorbance of sample x average gradient of samples standard x Dilution factor}}{\text{NT sample x 10}}$$

Statistical Analysis

The data collected were subjected to analysis of variance(ANOVA) using SAS version 6.08 (SAS Institute,1990).The treatment means were separated using LSD at $P<0.05$

RESULTS

Phytohormone in soybean root showed that there were significant differences among the different soil conditions. The roots of soybean in sterilised soil gave significant higher phytohormone than those from the unsterilised soil. In sterilised soil auxin volume were highest followed by abscicic acid and gibberellins while in the unsterilized soil absci cic acid was highest followed by auxin and gibberellins as the least. The interaction between inoculation and soil condition showed that all inoculated root produced significant higher volumes of auxin and gibberellins than control while control was significantly higher than all inoculated in absciscic acid Table 1.

Table 1: Effect of soil treatment on the production of phytohormones in the fresh root weight of soybean at 21 days after planting

Soil Type	Treatments	IAA(mg/100ml)	GA3(mg/100ml)	ABA(mg/100ml)
Sterilize soil	*G.mossea*	68.18	7.76	30.60
	Control	63.64	5.45	87.44
Unsterilised	*G.mossea*	43.18	6.05	41.53
	Control	11.82	4.36	65.58
	LSD(0.05)	0.59	0.56	0.87

The unsterilised soils significantly improve the root length, plant height, leaf area, leaf number, number of nodules, and dry matter of root, stem and leaf than sterilized soil at 21days after planting. The interaction between inoculation and soil condition in all the parameters were significantly higher than control in sterilized soil except plant height where control was higher than treatment. But in unsterilised soil all the parameters were improved in inoculated soil than control Table 2.

Table 2: Effect of treatment on the growth response and percentage root colonisation of soybean in sterile and unsterile soil condition at 21 days after planting.

Soil Type	Treatment	Root Length (cm)	Plant height (cm)	Leaf area (cm^2)	Number of leaves	Number of nodules	Percentage root colonization
Sterilized	*G. mossea*	8.12	13.45	23.04	0.75	8.12	26.47
	Control	6.7	14.90	19.70	0.85	6.7	12.75
Unsterilised	*G.mossea*	7.75	19.54	38.76	1.25	7.75	8.41
	Control	5.5	17.00	30.95	0.25	5.5	7.09
	LSD(0.05)	0.10	1.00	0.46	0.07	0.56	0.76

At 63 days after planting, significant increase in the values of all the parameters in both sterilized and unsterilised soil were recorded, even though the values of the unsterilised soil were significantly higher than sterilized soil in all the parameters. The interaction between inoculation and soil treatments in both soil condition showed that all the parameters in the inoculated treatments were significantly enhanced than control except dry matter of roots and stem where control was slightly higher than inoculated treatment Table 4

Table 3: Effect of treatment on the growth response and percentage root colonisation of soybean in sterile and unsterile soil condition at 42 days after planting.

Soil type	Treatment	Root Length (cm)	Plant height (cm)	Leaf area (cm^2)	Number of leaves	Number of nodules	Percentage root colonization
Sterile	*G. mossea*	8.87	16.57	41.36	18.75	3.50	55.8
	Control	7.12	14.97	25.52	15.50	1.75	33.61
Unsterile	*G.mossea*	10.50	26.00	43.97	17.75	9.00	29.17
	Control	9.25	23.27	37.41	14.75	5.00	18.8
	LSD(0.05)	0.14	0.52	1.57	0.95	0.29	1.18

Table 4: Effect of treatment on the growth response and percentage root colonisation of soybean in sterile and unsterile soil condition at 63 days after planting

Soil type	Treatment	Root Length (cm)	Plant height (cm)	Leaf area (cm^2)	Number of leaves	Number of nodules	Percentage root colonization
Sterile	*G. mossea*	12.32	28.50	43.69	25.00	7.50	58.38
	Control	9.27	19.62	34.55	22.50	2.75	43.81
Unsterile	*G.mossea*	11.80	28.75	48.97	24.50	10.75	37.51
	Control	9.75	22.25	41.92	15.56	6.00	26.87
	LSD(0.05)	0.73	1.45	1.55	1.53	1.14	1.45

There was decrease in values at 105days in the dry matter of leaf, root and stem, leaf area and number of leaf in sterilized soil while the values in all the parameters were increased significantly. The root length, number of leaf, dry matter of root, stem and leaf were higher in sterilised and unsterilised soil while leaf area, plant height, number of nodules were higher in unsterilised soil. The interaction between inoculation and soil treatments at 105 days showed that the inoculated treatments were significantly higher than control in all the parameters in sterilized and unsterilised soil except dry matter of stem where the control was higher in inoculated treatment in sterilized and dry matter of root in unsterilised soil Table 5.

Table 5: Effect of treatment on the growth response and percentage root colonisation of soybean in sterile and unsterile soil condition at 105 days after planting.

Soil Type	Treatment	Root Length (cm)	Plant height (cm)	Leaf area (cm^2)	Number of leaves	Number of nodules	Percentage root colonization
Sterile	*G. mossea*	15.25	36.50	37.39	16.75	8.75	59.66
	Control	12.25	26.75	20.16	14.25	4.75	43.21
Unsterile	*G.mossea*	10.80	37.25	47.24	15.50	11.75	36.43
	Control	10.02	31.50	43.19	13.05	7.00	27.05
	LSD(0.05)	0.64	1.44	0.26	0.55	0.63	0.75

There was a positive relationship between root colonization and phytohormone production at 21 days after planting. VAM root colonization ranged between 7.09 and 59.66. Highest percentage VAM colonization was recorded in sterile soil while lowest root colonization was recorded in unsterile soil irrespective of days after planting.

DISCUSSION

The results in this finding showed that Glomus inoculation and soil condition had significant effect on plant development and phytohormones.There was also growth promotion during the early stages of root colonization by Glomus. Phytohormones auxin, gibberellins and abscicic acid were produced more in sterile than unsterile soil. This probable may be because the soil organisms in the unsterile soil had metabolized the hormones (Strzelczgk *et al*.., 1973).

The inoculated soil recorded the higher auxin and gibberellins than non inoculated soil (control) while non inoculated soil recorded the highest abscisic acid. This shows that Glomus is able to produce auxin and gibberellins more and less of abscisic acid. The auxin and gibberellins produced in non inoculated sterile soil could be from the Glomus. Increased auxin may (i) lengthen the mitotic cycle in the root apical meristem, leading to the decreased of individual adventitious root length, since auxin is involved in the control of cell division cycle

(Dudits et al., 1993). (ii) Increase in adventitious root number as new root production may be related to the inactivation or elimination of existing apices (Torrey, 1986). (iii) Enhanced lateral root production a well known auxin effect (Charlton, 1996).

Arbscular mycorrhiza fungal (AMF) increased auxin and gibberellins level in the early stages of growth of soybean. This finding did not agree with Danneberg et.al., (1992), Luding-Muller et al., (1997) who did not find changes in auxin levels in maize inoculated with arbuscular mycorrhiza fungi, though indole butyric acid increased in the early stages of infection. However, plants of different species or groups display differences even contrasting morphogenetic response to arbuscuar mycorrhiza infection. Cytokinin content is increased in AM plants (Danneberg et al., 1992). There are indications that AM fungi produce hormones (Berea and Azcon-Aguilair, 1982, Esch et al., 1994).
The percentage root colonization in this study was wide compared with the observation of Khanam et al., (2006) whereb37-43% and 39-45% of mycorrhizal fungi root colonization was reported in agricultural crops grown under different edaphic factors in Bangladesh. The wide range that was observed may be probably due to physiological and biochemical activities of the plants (Giananazzi – Pearson and Gianinazzi, 1983) and environmental condition (Singh, 2005).

Throughout the growth period soybean plant performed best in unsterile than sterile soil and in inoculated soil than uninoculated soil. This agrees with Torelli *et al* (2000) who reported increased in growth of Leek plants when inoculated with G. mossaee. The improved growth of soybean in unsterile soil could be the presence of other soil microorganisms which supported the growth of soybean. The result of number of nodules confirmed the finding of Torelli *et al* (2000). There was more number of nodules in unsterile soil. Better performance in inoculated plant can be attributed to better transpiration coefficient hence, higher dry matter per unit of water when compared to the uninocuated plants (Allen and Allen, 1986). Although, there is no information on the nutrient uptake, there are reasons to deduce that enhanced uptake by inoculated soybean must have played a great role in improved growth (Atayese *et al*., 1997; Osonubi *et al*., 1991).

CONCLUSION

This investigation shows the importance of mycorrhiza infection for the growth of soybean plant confirming other reports of favourable legume response to AM fungi inoculation, whether under sterile or unsterile soil (Daft and El-Giahmi, 1970, Manjunath and Bagyaraj, 1984).
AM inoculation stimulated increase in root length, leaf area, number of leaves, number of nodules, plant height and phytohormones of soybean both under sterile and unsterile soil even though the effect is much under sterile condition. This confirm the report of Ahiabor and Hirata (1994), who reported increase in root and shoot dry weight of cowpea and pigeon pea in both sterile and unsterile soil.

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Effect of substituting Fish meal with Taro leaf meal on growth and blood profile of African Catfish (*Clarias gariepinus* Burchell)

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ABSTRACT

A 14-week feeding trial was conducted to evaluate the potential of Taro (*Colocasia esculenta* (L.) Schutt) leaf supplementary meal as dietary protein source in the African catfish (*Clarias gariepinus* Burchell) fingerlings at the Fishery Section of the Teaching and Research Farms, Ladoke Akintola University of Technology Ogbomoso, Nigeria. There are five treatments (five diets) of 40% crude protein, formulated to contain 0, 5, 10, 15 and 20% Taro leaf meal (TLM) and used partially to replace fish meal in the diets of African catfish. A total of 225 *Clarias gariepinus* fingerlings were randomly distributed into five treatments. 15 fingerlings were stocked in 50litres circular plastic bowl replicated thrice. Results showed that mean weight gain (MWG), average daily weight gain (ADWG), feed conversion ratio (FCR) and protein efficiency ratio (PER) did not differ significantly ($P>0.05$) while the total feed intake(TFI) and total protein intake (TPI) significantly decreased ($P>0.05$) as the inclusion level of Taro leaf meal increased. Significant difference was observed in the values of white blood cells (WBC). The values of WBC for diets A, D and E (0, 15 and 20 % TLM) were similar and significantly higher ($P<0.05$) compared with diets B and C (5 and 10% TLM) . Red blood cells, Heamoglobin concentration, Packed cells volume, Mean corpuscular volume, Mean corpuscular heamoglobin concentration and Total blood protein (TBP) were similar among the treatments. Carcass composition showed significant dissimilarity ($P<0.05$) between the initial analysis and the test fish in terms of crude fibre, ash and nitrogen free extract contents while dry matter content was similar (P>0.05). However, crude protein and fat content were consistently patterned. Therefore, it can be concluded that fish meal can be replaced with up to 20% Taro leaf meal in the diet of African catfish (*Clarias gariepinus).*

Key words: Taro leaf meal, African catfish, growth performance, blood profile and replacement value

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INTRODUCTION

Feed is the most expensive item in fish farming operation, accounting for over two – third of the operation cost (Lovell, 1981). A general view of fish farming in Nigeria shows that 86% of fish farmers do not make use of standard supplementary feeds because of high cost (Eyo, 1995). The success of fish farming operation depends largely on the provision of suitable and economical fish feed. Protein is the most needed and expensive of all the feed ingredients for Fish feed, particularly the fish meal. Therefore, alternative protein source should be considered (Olaniyi, 2008). Aquaculturists are in the quest for alternative protein source from both plant and animal origin, which can replace fish meal and nutrition and also increase the growth performance with good survival rate of the fish. Thus, meeting the existing demand for fish at a lesser production price and also enhances profit to the fish farmers. The leaves of some plants serve as important component in the diet of non – ruminant animals (Pachriston and Nastis, 1996) and have been used in diet formulation.

Taro (*Colocasia esculenta*) is a tropical food crop with high potential because of high yield of its root (corm) and foliage. It is grown mostly in some parts of the world such as Nigeria, Ghana, China, Cambodia, Cote d'ivoire and papua New Guinea. Taro leaves are rich in vitamins and minerals such as thiamin, riboflavin, iron, phosphorous, Zinc, vitamin B6, vitamin C, niacin, potassium, copper and manganese (Wagner *et al*, 1999). Taro can be grown in water logged and terrestrial fields. Taro leaf could replace up to 70 – 75% of the fish meal with higher feed intakes and nitrogen retention than with 100% of the protein from fish meal or from taro silage (Bunta et al, 2008). The use of the Taro (*Colocasia esculenta*) leaf silage has been reported in Socorro, Columbia to improve feed intake and body weight gain in fish production (Preston, 2006). The objective of this study is therefore, to evaluate the effect of Taro (*Colocasia esculenta)* leaf meal on the growth and blood profile of the African catfish (*Clarias gariepinus).*

MATERIALS AND METHODS

The experiment was conducted at the fishery section of theTeaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Collection and Processing of Taro leaves: The taro leaves was obtained from a reputable farm in Ibadan. The leaves was chopped into small pieces and sun dried, ground into powder stored in air tight sacks under ambient temperature of 25^0C + 2 for 7 days.

Formulation of experimental diets: Feed ingredients - yellow maize, rice bran, fish meal, ground nut cake, Blood meal, Oyster shell, mineral-premix, Bone meal, Lysine, vegetable oil and salt were purchased from Farmers shop at Ogbomoso. Five experimental diets were formulated: Diet A contained 0% of taro leaf (Control), Diet B contained 5% taro leaf, diet C contained 10% taro leaf, diet D contained 15% taro leaf and diet E contained 20% taro leaf replacement level for fishmeal. The feed were made into pellets with the use of pelletizing machine. Pellets were sun dried for two days to reduce the moisture greatly and to prevent the deterioration.

Experimental Animal, procedure and management: A total of 225 fingerlings were purchased from an hatchery in Ogbomoso. 15 fingerlings were allotted to fifteen circular bowls of 50 litres capacity each and acclamatized for two weeks, after which the fish were fed with five experimental diets: Diet A served as control 0% Taro leaf meal (TLM), Diet B (5% TLM), diet C (10%TLM), diet D (15%TLM) and diet E (20%TLM) for twelve weeks The fingerlings were fed 3% of their body weight daily at 08.00hr and 16.00hr. The fish were weighed every two weeks and their feeding regime was adjusted with respect to their body weight Water in the bowls was siphon to get rid of dirt.

Table 1: Gross Composition of the Experimental Diet

Ingredient	A (0%)	B (5%)	C (15%)	D (20%)	E (25%)
Yellow maize	24.45	23.45	23.09	22.45	21.95
Rice bran	12.23	12.23	11.23	10.73	9.73
Fish meal	36.45	34.63	32.80	30.98	29.16
TLM	-	1.82	3.65	5.47	7.29
Groundnut cake	14.58	14.58	15.98	16.33	17.08
Blood meal	7.29	8.29	8.29	9.04	9.79
Oyster Shell	1.50	1.50	1.50	1.50	1.50
Mineral Premix	1.0	1.0	1.0	1.0	1.0
Bone meal	1.50	1.50	1.50	1.50	1.50
Lysine	0.5	0.5	0.5	0.5	0.5
Vegetable Oil	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100%	100%	100%	100%	100%
Crude Protein	40%	39.99%	39.75%	39.68%	39.70%

TLM - Taro Leaf Meal

DATA COLLECTION: The parameters measured were Mean Weight Gain; Average Daily Weight Gain; Percentage Weight Gain; Feed conversion ratio; Protein Intake; Feed intake; Protein Gain; Protein Efficiency Ratio and Protein productive Value. Each of these parameters was measured at 2 weeks interval.

Mean Weight Gain (MWG) = Final mean weight (g) - Initial mean weight (g); Average Daily Weight Gain (ADWG) = Mean weight gain (g) / length of feeding trial (days); Percentage Weight Gain (PWG) = Mean weight gain (g) x 100 / Initial mean weight; Feed conversion ratio (FCR) = total feed fed (g) / net weight gain (g); Protein Intake (PI) = total feed consumed X % protein in feed 100; Feed intake (FI) = This is the amount of feed throughout the period of the experiment ; Protein Gain (PG) = mean protein intake (g) / length of feeding trial (days); Protein Efficiency Ratio (PER) = Net weight gain (g) / Amount of protein fed (g) while Protein productive Value (PPV) = protein gain in fish (g) / Protein in food (g) x100.

CHEMICAL ANALYSIS: The proximate analysis of Taro leaf meal diet and the fish carcass were done, using the procedure outlined by AOAC (1990).

Table 2: Proximate composition of test ingredient (*Colocasia esculenta*) fed to *Clarias gariepinus* fingerlings

	Moisture content	Crude Protein	Ether extract	Crude Fibre	Ash	Ash Nitrogen Extra
Value	6.01	25.90	15.27	12.04	4.51	36.27

HAEMATOLOGY

Blood Sample Collection: Blood samples for haematological analysis were collected at the end of the feeding trial from the caudal peduncle of both the test and control fish with a sharp blade. The blood samples were dispensed into tubes containing Ethylene Di -amine Tetra Acetate (EDTA). The following haematological parameters were assessed: Erythrocyte count (RBC), Leucocyte count , Heamoglobin (Hb), Packed cells volume (PCV), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin concentration (MCHC) Mean corpuscular haemoglobin (MCH) and Total blood protein.

STATISTICAL ANALYSIS: The data collected were subjected to One Way Analysis of Variance (ANOVA) using the general liner model of SAS (1999). Differences between the means were partitioned by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

Table 3 showed the growth rate of the fish fed with different experimental diets. Weight gain was observed in weight was observed in all the fish at the end of the experiment. The mean body weight average daily body gain were not significantly different (P>0.05). The percentage weight gain, total protein intake and total feed intake were significantly different (P<0.05).

Table 3: Growth performance and feed utilization of *Clarias gariepinus* fingerlings fed diets containing various inclusion levels of Taro Leaf Meal (TLM).

Component	A (0%)	B (5%)	C (10%)	D (15%)	E (20%)	SEM
Initial	7.10	6.63	6.53	6.74	5.72	0.17
Final	19.59	16.98	17.10	15.74	16.80	0.55
MWG	12.5	10.35	10.57	9.0	11.09	0.50
ADWG	0.13	0.11	0.11	0.09	0.11	0.01
PWG	175.22[ab]	156.38[ab]	162.86[ab]	133.81[b]	195.95[a]	8.34
TFI	2.28[a]	1.99[a]	1.88[b]	1.78[b]	1.85[b]	.05
TPI	0.91[a]	0.80[b]	0.75[b]	0.71[b]	0.74[b]	0.02
FCR	0.19	0.19	0.18	0.20	0.17	0.01
PER	13.69	13.02	14.07	12.63	15.01	0.52

Mean on the same row with the same superscripts are not significantly different (P>0.05).

MBWG – Mean body weight gain: ADWG – Average daily weight gain: PWG- Percentage weight gain: TFI – Total feed intake: TPI – Total protein intake: FCR- Feed conversion ratio: PER- Protein efficiency ratio. SEM–Standard Error of mean.

Fish fed with 20% replacement level of TLM (diet E) showed the highest percentage weight gain; while fish fed diet D (15%TLM) showed the lowest percentage weight gain. The feed conversion ratio and protein efficiency ratio of fish fed with the five different diets were not significantly different (P >0.05).Table 4 showed that fish has the highest crude protein (62.34%) before experiment commences, while diet A showed the least value (58.25%). Crude protein value of diet B, C, and E were not significantly different (P>0.05).

Table 4: Carcass composition (% dry weight basis) of experimental fish samples at the beginning and at the end of the feeding trial.

Diet Parameter	Initial	A(0%)	B(5%)	C(10%)	D(15%)	E(20%)	SEM
M.C	74.91	6.22	5.70	6.16	541	6.11	0.25
D.M	95.09	93.78	94.30	93.84	94.93	93.89	0.26
C. P	62.34[a]	58.25[c]	59.20[bc]	60.05[bc]	60.55[ab]	59.79[bc]	0.38
C. fat	5.75[ab]	6.39[a]	5.96[bc]	6.07[ab]	5.61[c]	5.74[bc]	0.75
C. fibre	9.70[a]	1.47[b]	1.67[b]	1.91[b]	1.96[b]	1.85[b]	0.75
T. Ash	14.60[a]	12.59[b]	12.47[b]	13.00[b]	11.87[b]	11.82[b]	0.26
NFE	2.14[b]	14.96[a]	14.99[a]	12.82[a]	14.60[a]	14.68[a]	1.17

Mean on the same row with the same superscripts are not significant different (P.0.05)

M.C – Moisture content: D.M – Dry matter: C.P- Crude protein: C. FAT- Crude fat C.FIBRE- Crude fibre: T- ASH- Total ash: NFE- Nitrogen free extract

SEM – standard error of mean

Fish fed with diet A has the highest crude fat (6.39%) while fish fed with diet D showed the least value (5.61%) crude fat value. Fish fed with 0%TLM showed the highest value of crude fibre (9.70%), while fish fed with diet A has the least value (1.47). Crude fibre values of the five diets containing 0, 5, 10, 15 and 20% TLM were not significantly different (P>0.05). For ash content, feed containing 0%TLM showed the highest value (14.60), while diet E showed the least value (11.82). Total Ash values of fish fed with diets A -E were not significantly different (P.0.05). Nitrogen free extract of diets A – D were not significantly different. Table 5 showed the blood profile of the fish fed with different experimental diets. The white blood cells (WBC) values obtained were significantly different. Diet A has the highest value, while diet D has the lowest values. The red blood cells (RBC) values were not significantly different. Diet A had the highest value, while diet B has the lowest value.

Table 5: Haematological parameters and Total serum protein of *Clarias gariepinus* fingerlings fed various inclusion levels of Taro leaf meal.

Parameter	A(0%)	B(5%)	C(10%)	D(15%)	E(20%)	SEM
WBC (10^3/µl)	88.7^a	55.5^c	54.9^d	41.7^e	60.6^b	12.96
RBC (10^6/µl)	2.76^a	1.18^e	2.40^b	2.01^d	2.69^c	0.87
Hb (g/dl)	11.8^a	3.6^d	9.2^c	9.1^d	12.1^b	2.33
PCV (%)	40.3^b	30.3^d	30.5^c	27.5^e	42.0^a	9.81
MCV (fl)	146.0^c	153.8^b	127.1^e	136.8^d	156.1^a	11.06
MCH (pg)	42.8^d	45.0^d	38.3^b	45.3^a	45.0^c	4.98
MCHC (g/dl)	29.3^c	29.3^d	30.2^b	33.1^a	28.8^e	3.18
Platelet (10^3/µl)	26.7^d	204^e	587^a	352^c	360^b	24.43
Total protein (g/100ml)	3.3^e	3.6^d	4.3^a	4.0^b	3.9^c	0.06
Albumin	1.3^b	1.1^c	1.2^c	1.0^e	1.5^a	0.05
Globulin	2.0^e	2.5^c	3.1^a	3.0^b	2.4^d	0.78

Mean in the same superscripts are not significant by different ($p>0.05$)WBC – white blood cell: RBC - Red Blood cell: Hb – Haemoglobin: PCV – Packed cell volume: MCV – Mean Corpuscular Volume: MCH – Mean corpuscular Haemoglobin: MCHC – Mean corpuscular Haemoglobin concentration. SEM – Standard error of mean.

DISCUSION

The proximate analysis of the test ingredient showed a crude protein value of 25.90% which is higher than 22.3% reported by Kyriazakis and Emmans (1995) and 21.9% reported by Bach *et al*., (2001). However, the crude fibre of the test ingredient (12.04%) was lower than the value of 26% reported by Leterme *et al*., (2005). The nitrogen free extract value (36.27) was also lower than that reported by Leterme *et al*., (2005).

There are significant different levels between the fibre levels in diet 1 to 5. However experimental diets A to E fall within the range of 10% fibre level recommended by Falaye (1988). There is no significant mean body weight gains in diet A(0%TLM) and diets E (20%TLM). This is in agreement with Ogle (2006) who reported highest body weight gain in 20% replacement level of Taro leaf meal as the optimum in the diet of another monogastric (pig). Diet A has the highest feed intake (2.28g) while there is no significant difference in diets B - E. This is in agreement with Pheng *et al*., (2008) who reported that feed intake reduced with reduction in palatability. The protein efficiency ratio recorded for fish fed with diet C(14.07) was highest. This indicates that at 15% replacement level with TLM, *Clarias gariepinus* will utilize the protein in the diet. The disparity in the protein efficiency ratio could be attributed to the quantity of protein recorded in the diets since according to Falaye *et al*., (1999), digestibility of protein varies with protein source. The result also showed that diet 5 has the lowest FCR of 0.17 is the most efficient in conversion of feed to flesh. Diet 4 has the highest FCR of 0.20. However, there is no significant difference (P>0.05) in the FCR obtained for fish fish fed with diets A-E.

There is an increase in the protein value of fish carcass obtained at the end of the feeding trial compared with that obtained at the beginning of the feeding trial. Initial diet has the highest ash value in the fish carcass compared to the ash value of the fish carcass at the beginning and end of the experiment. Generally, there is a reduction in the fibre content of fish carcass under treatments B-E compared with the fibre content of fish carcass not fed taro leaf meal (diet A).

There was a decline in RBC value compared with the normal value (24 x $10^6/\mu$) by Adedeji *et al*., (2000). The reduced erythrocyte count may prelude the possibility of haemolytic anaemia which as stated by Kelly (1974) may be due to toxic factor, infections and metabolic disease. The MCHC values obtained for all fish across the treatments still fall within the normal range of 30 – 35gm/l recommended by Adedeji *et al*.; (2000). There is a marked decrease in the WBC count across the treatment compared with the normal values (6.6 x $10^6/\mu$) recommended by Adedeji *et al*.; (2000). Decrease in total WBC may be attributed to a reduced production of Leucocytes in the Haemtopoietic tissues of the Kidney and Perhaps the Spleen. Albumin-globin ratio were greater than one across the treatments.

This is in contrast with Philips (1965) and Aboaba (1984) who reported an albumin – globin ratio of less than one. The packed cells volume(PCV)values of fish under diet 2,3, and 5 fall within the normal range of 20 – 35% recommended by Wedemeyer and Yasutake (1977). The higher PCV value than normal obtained from fish under treatment 1 (40.3%) and 5 (42.0%) may signify some degree of haemoconcentration (Kelly, 1974). There was no significant difference in the mean corpuscular heamoglobin concentration (MCHC) values obtained from fish fed with diet A and B, while the MCHC value of fish fed with diet D has the highest value of 33.1.

CONCLUSION

From the results obtained, diet E (20% inclusion level of TLM) had the best performance in terms of FCR, ADWG, SGR and PER. Therefore, it can be concluded that fish meal can be replaced with Taro leaf meal of up to 20% in the diet of cat fish fingerlings.

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Decomposition rate of fresh organic cowpea fodder as influenced by intra-row spacing, clipping height and time on soils fertility conservation for sustainable agricultural productivity in savannah region of Nigeria

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ABSTRACT

The vagaries of climate, particularly temperature and moisture conditions are known to affect the rate of decomposition. Under tropical and sub – tropical climate, the rate of decomposition which determines the amount of plant nutrients released into the soil has been estimated for a number of crops. However, for the leguminous dual purpose crops like cowpea, *Vigna unguiculata* (L) Walp, little or virtually no studies on this aspect has been documented in spite of the significant contributions of legume to soil (nitrogen enrichment). Good soil health is a pre-requisite for good plant health. But high doses of nitrogen fertilizers lead to high nitrogen content in the crop with all the attendant health hazards. However, this danger is less when fertilization is organic; as organic matter when decomposed releases nutrient gradually. Results of studies in the savannah soils of Samaru, Zaria, Nigeria, on cowpea sown at high population densities, and under an innovative clipping management, with time, showed that mean fodder yields of 7 – 19 t ha $^{-1}$ were produced and about 62% fresh fodder was obtained when plants were clipped at 74 days after planting (DAP) than at 64 DAP. It took 18 – 24 and 27 – 35 days for the leaves and stems added on the soil surface, and 32 – 40 and 43 – 53 days for the leaves and stems buried into the soil to decompose respectively. The ability of cowpea fresh fodder to decompose when incorporated into the soil could facilitate the release of an appreciable amount of stored plant nutrients such as N; and more so improve the health of the soil through an increase in soil (organic content, organic matter and cation exchange capacity contents). This innovative farming practice could hold the key to rejuvenating the degraded savannah soils of Nigeria and other tropical countries; creating hope in the effort towards the eradication of hunger and poverty and ensuring food security through sustainable agricultural productivity.

Keywords: Cowpea, clipping management technology, fodder, sustainable, organic, decomposition.

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INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) features prominently in the farming systems of the semi-arid tropics where they are grown mainly for their mature seeds (Onwueme and Sinha, 1991); which provide food for human beings (Purseglove, 1974), and fodder, forage, hay, silage, as feed for livestock (Purseglove, 1974; Odion and Singh, 2005).

The above ground plant parts of cowpea, except for its pods, are usually harvested for fodder. In the Sahel, green fodder yields approaching 30 - 40 t ha^1 have been reported (IITA, 1989). In India, under the fodder production system, designed to ensure the availability of succulent, palatable and nutritive fodder throughout the year; cowpea fodder yields (harvested at 60-70 days from sowing) were reported at 250 - 300t ha^1 (Patil and Singh, 2004). Therefore, adopting appropriate cultural and management practices such as clipping and the subsequent use of the vegetative growth for placement and or its incorporation into the soil as green manure for enhancing soil fertility after its decomposition could boost and sustain agricultural productivity by the farmer on the field *in situ*.

But climate, particularly the temperature and moisture conditions, determine the rate of decomposition (green plant materials). In Indian as in Nigerian soils, it has been reported that the content of organic matter is generally low because of the high rate of decomposition under tropical and sub-tropical climate (Murthy and Hirekerur, 2004; Odion *et al.,* 2007). It is reported that 3 to 6 weeks are sufficient to ensure adequate decomposition in the tropics (Arakeri *et al*., 1962). A somewhat shorter interval is necessary for light, sandy soils; while loamy-clayed soils take longer (Klapp, 1967). Though, too early incorporation can result in the loss of mineralized materials through leaching (Muller-Samann and Kotschi, 1994).

For proper decomposition of the green manure, it is necessary that the green fresh material should be succulent and there should be adequate moisture in the soil (Patnaik, 2004; Adams *et al.,* 1998). Plants at the flowering stage contain the greatest bulk of succulent organic matter with low carbon:nitrogen ratio. Therefore, it is recommended that, it is better incorporate the green plant material at full vegetative development so as to achieve maximum effect. This is at flowering stage for legumes and somewhat earlier for grasses. The incorporation of the green-manure crop into the soil at this time when the plants are rich in sugars, energy and easily soluble N-compounds, and poor in lignin and cellulose allows a quick liberation of nitrogen in the available form (Patnaik, 2004; Isichei and Akobundu, 1994). But the quality of organic matter (OM) and its rate of decomposition are dependent on its chemical composition.

As many agricultural farmlands in the savannah are degraded due to various reasons ranging from intensive weathering and high rainfall, high temperature, high decomposition rates, soil erosion, leaching, deterioration of the soil structure generally characterized by low soil organic matter (SOM) content, low cation exchange capacity (CEC), low moisture retention capacity (MRC) on the soil continuous cropping coupled with continuous nitrogen (N) fertilization; resulting in low soil fertility. And more often than not, the ways of reviving such soils is the farmers' headache (Bache and Heathcote, 1969; Jones, 1976; Pichot *et al*., 1981; Kurt, 1982; Kang and Balasubramanian, 1990; Kang, 1993; Singh *et al*., 1997).

Therefore, green manuring practices such as the growing of legumes like the dual purpose cowpea, which has the potential for producing large amounts of fresh clipped crop residues which can be added on the soil surface and or incorporated into the soil, to make available N, after its decomposition, avails a form of management (through keeping a continuous layer of organic residue on the soil surface) which simulates the forest ecosystem (Cooke, 1982; IITA, 1992); and has the additional potential of bringing extra nitrogen into the system (Henao and Baanante, 1999). In fact its ability to biologically fix atmospheric nitrogen in the rhizobia of the root nodules enhances its important use by farmers in traditional farming system. Through this process, it leavs a residue of nitrogen which has been estimated at 30-60 kg N ha^{-1} annually (Reijntjes *et al*., 1992), in the soil which benefits the following crop (Steele, 1978; Onwueme and Sinha, 1991). Indeed, it has been highlighted that a leguminous crop producing 8 to 25 tonnes of green matter per hectare, will add about 60 to 90 kg of nitrogen when ploughed under (Patnaik, 2004).This could be pivotal to sustaining both the fertility status of the soils and the production levels of crops.

This study therefore assessed the total amount of organic plant biomass from cowpea fresh fodder under a clipping management regime and the time taken for it to decompose when placed on the soil surface and or when buried in the soil; for soil fertility maintenance in a typical savannah agro-ecology zone of Nigeria.

MATERIALS AND METHODS

Field experiments were carried out at the Research Farm of the Institute for Agriculture Research, Samaru (11^0.11'N, 07^0.38'E and 686m above sea level) Zaria, Nigeria, during the 2002, 2003, 2004 and 2005 cropping seasons. The research area was located in the northern guinea savanna agro-ecology zone of Nigeria. Usually, rainfall in the region establishes between mid-May and early June and peaks in July/August. Total annual rainfall ranges between 883-1062 mm, with an average of 945.20mm. The dry season starts at about mid-October and extends to the end of April. The soil of the experimental site was loamy textured (USDA classification), characterized with pH of 6.6; low organic carbon content (0.30g kg^{-1}); low total nitrogen (0.88g kg^{-1}); a phosphorus value of 6.51mg kg^{-1} and a low level of potassium (0.10 Cmol kg^{-1}).

The treatments comprised of three intra-row spacing, 15.0, 30.0 and 45.0cm on ridges, 75cm apart; three clipping heights (no clipping control, 12.5cm and 25.0cm); and three clipping periods (64, 74 and 84 days after planting); giving a total of 27 treatment combinations. This experimental was laid out in a randomized complete block design, replicated three times.

Two seeds of cowpea were planted per hole at about 5cm depth manually; at the specified intra-row spacing of 15, 30 and 45cm on 75cm ridges. The fields were planted on 13th July, 17th July, 7th June and 17th June, in 2002, 2003, 2004 and 2005 respectively.

Fertilizer was applied at the recommended rates of 10kg N $ha^{-1,}$ 36kg P_2O_5 ha^{-1} and 20kg K_2O ha^{-1} (Enwezor *et al*, 1989); sourced from NPK (20:10:10), super phosphate (18%) and muriate of potash-MOP (60%). Application was by placement 2 - 3 weeks after planting.

The clipped fodder yield was obtained by weighing and recording the total clipped crop residue (fodder) from each plot at 64, 74 and 84 DAP, and this was recorded per plot; and subsequently converted to total fodder yield in tons per hectare (t ha^{-1}) basis. The first (harvest) clipping was done on 15th September, 2002; 19th September, 2003; 10th August, 2004, and 17th August, 2005, respectively. The clipped fodder was placed on the plots to decay; while samples were buried at 15 – 30cm depth; and the number of days it took for the leaves and stems to decompose was determined by observing and recording the time for 100% of the clipped crop materials to completely decompose from the date of the first clipping harvest.

The data collected was compiled and analyzed statistically using the analysis of variance test (F-test) as described by (Snedecor and Cochran 1967). The means were partitioned using the Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The influence of intra-row spacing on harvested fresh fodder yield was significant in 2002, 2005 and the combined analysis only; and the fresh fodder yield obtained was consistently, significantly higher at 15cm (closest) spacing. The influence of clipping at 12.5 and 25.0cm heights on harvested fresh fodder was not significant in all the years investigated and the combined analysis. While in all these years, except for 2003, an increase in the time of clipping from 64 DAP to 74 DAP significantly increased fresh fodder yield. However, a further increase in clipping time to 84 DAP, did not significantly increase fresh fodder yield (Table 1).

Table 1: Harvested fresh fodder yield (t ha $^{-1}$) of Cowpea as influenced by intra-row spacing, clipping management and time treatment at samara, Zaria, Nigeria.

Treatment	2002	2003	2004	2005	Combined Analysis 2002 – 2005
Intra-row spacing (cm)					
15	42.86a	1.19	12.75	19.03a	18.96a
30	29.88b	1.17	12.95	11.81b	13.95b
45	19.05c	1.03	12.67	12.98b	11.43b
SE±	2.90	0.17	0.86	1.97	0.93
Clipping height (cm)					
0 (Control)	-	-	-	-	-
12.5	30.26	1.29	12.83	16.48	15.22
25.0	30.93	0.98	12.74	12.74	14.35
SE±	2.90	0.17	0.86	1.97	0.93
Clipping Time (DAP)					
64	7.64b	0.78b	11.45	9.33b	7.30b
74	43.66a	0.98b	13.10	19.50a	19.31a
84	40.49a	1.64a	13.80	15.00a	17.73a
SE±	2.90	0.17	0.86	1.97	0.93

Means followed by different letter(s) are significantly different at 5% level of probability using Duncan's Multiple Range Test (DMRT).

A mean value of 7 – 19t ha^{-1} was obtained in this study. Though, this is lower than the 30 – 40t ha $^{-1}$ reported by IITA (1989) in Nigeria; and the 250 – 300t ha $^{-1}$ in India (Patil and Singh, 2004). However, these differences could probably be accounted for by a combination of the vagaries of climate, soil, cultural and management practices; and even the desired purpose of production. But, on the whole, the production of a large quantity of green organic plant biomass at the closest densities (i.e. at the highest plant densities) is attributed to the fact that higher yield per unit area could be achieved through greater population pressures on available resources (Wiley and Osiru, 1972; Beets, 1982); and clipping of the crop plants at shorter height (i.e. close to ground surface). This large volume of biomass which was made available and deposited on the soil surface or incorporated into the soil at 74 DAP; which incidentally also coincided with the crops maximum period of vegetative growth, crop coverage and flowering (Musa, 1990). In effect, it has been reported that green plant materials are better incorporated into the soil at this stage, especially in the case of legumes where the uptake of plant food as well as the assimilation of carbon and the development of organic matter reach practically the maximum. Moreover, at this time, the plants are reported to be rich in sugars energy and easily soluble N –compounds, and poor in cellulose. Also favorable conditions exist for rapid decomposition and mineralization which has a direct relationship not only nitrogen supply, but also with regards to the soil organic matter and other elements such as phosphate and micro – elements which are concentrated in the top soil and made available for plant growth (Muller-Samann and Kotschi, 1994; Reijntjes *et al.,* 1992; Yegna Naraya Aiya, 1975).

The number of days to decomposition of leaves and stems added on the soil surface and buried into the soil was not significantly influenced by the crops intra-row spacing and clipping height in the combined analysis in this study. While clipping time consistently, and significantly increased the number of days to decomposition of both leaves and stems added on the soil surface and buried into the soil, from 64 to 84 DAP, in the combined analysis (Table 2).

Leaves and stems of cowpea left on the soil surface decomposed between 18 – 24 and 27 – 35 days respectively; while, it took longer days, 32 - 40 and 43 - 53 days for the decomposition of the leaves and stems when they were buried into the soil at 15 - 30cm depths respectively. These findings are in conformity with those of Arakeri *et al*., (1962); Muller – Sammann and Kotsch, (1994), who had reported that it took between 21 - 42 days to ensure adequate decomposition in the tropics; and IITA (1992) reported that 40 – 50% of the residues from legumes can be decomposed in a month (about 30 days).

Table 2: Time of decomposition of Cowpea leaves and stems as influenced by intra-row spacing, clipping management and time treatment at Samaru, Zaira - Nigeria.

Treatment	Combined Analysis 2002 – 2005 Added on Soil Surface		Combined Analysis 2002 – 2005 Buried in Soil	
	Leaves	Stems	Leaves	Stems
Intra-row spacing (cm)				
15	20.89	30.05	36.19	48.18
30	20.90	30.93	36.22	48.22
45	20.91	31.94	36.36	48.27
SE±	0.10	0.09	0.11	0.11
Clipping height (cm)				
0 (Control)	-	-	-	-
12.5	20.19	31.10	36.24	48.41
25.0	20.87	31.09	36.35	48.44
SE±	0.10	0.09	0.11	0.11
Clipping Time (DAP)				
64	18.19c	27.27c	32.31c	43.50c
74	20.77b	30.64b	36.04b	47.86b
84	23.74a	35.01a	40.43a	53.31a
SE±	0.10	0.09	0.11	0.11

Means followed by different letter(s) are significantly different at 5% level of probability using Duncan's Multiple Range Test (DMRT).

The observed increased in the period of decomposition with increasing age in this study, agrees with the findings of various researchers (Adams *et al*., 1998; Muller-Samann and Kotschi, 1994; Isichei and Akobundu, 1994; Onwueme and Sinha, 1991) who ascribed this observation to the fact that the quality of organic matter (OM) and its rate of decomposition depends on its chemical composition. Young, succulent plants rich in sugars, energy and easily soluble N-compounds decomposed quickly, while older organic crop plant residues containing lignin and cellulose tend to decompose very slowly, hence take longer time.

Decomposition rates also depend on the time the green manure is incorporated into the soil, and on the soil conditions. Good decomposition is reported when the soil is well aerated, sufficiently moist, and already fairly fertile, with relatively high soil temperature and (Muller – Samann and Kotschi, 1994; Steiner, 1982). This give credence and explains the findings of this investigation, where faster decomposition rates were observed when the fresh organic crop residues were placed on the surface of the soil with adequate moisture, good aeration and high incipient temperatures (27 - 32^{0}C, sometimes exceeding 40^{0}C) as recorded during the study period. Conversely, they noted that the extremity of dryness or water lodging hinders decomposition.

In essence, the addition of cowpea fodder (organic crop residue) has proved to serve as a source for both soil nutrients - OC and OM - as well as it's being used for other beneficial agricultural purposes such as the lowering of the soil pH and decreased Al and Mn toxicity (Virtarien and Meitinen, 1963; Lu and Hue, 1990; Grahammer *et al*., 1991; Woomer and Mulchena, 1993).

CONCLUSION:

Based on the results obtained from these investigations, it can be concluded that, under this innovative clipping management technology adopted in the Samaru, Zaria agro-ecology zone, Sudan savannah of Nigeria, it took between 18 - 24 days and 27 - 35 days for the leaves and stems of cowpea to decomposed when placed on the soil surface; and 32 - 40 days and 43 - 53 days when incorporated into the soil at 15 - 30cm depths respectively.

The application of this innovative clipping management technology is proved to have many advantages. It can increase the soil physical and chemical properties markedly through increasing the soil-OC and OM content; which in turn enhances better soil texture; decreased soil acidity, increased soil CEC capacity amongst others. But the most important effect is the increase in the available N-content of the soil, through the production of relatively large amounts of green biomass The advantage here is that, the maintenance (or increase) in soil fertility is based on the farmer's own resources and less capital input is required.

On the whole, overcoming soil-OM decline is an important component in the development of more sustainable agro-systems. The addition of large biomass of green organic plant material residues is primarily a biological method of soil fertility maintenance; which can mobilize and make available significant quantities of N when placed on the soil surface and/ or incorporated. This has proven to be beneficial in improving the soil physical and chemical properties in the savannah region of Nigeria (Lee and Wani, 1988, Lal *et al*., 1979, IITA, 1992).

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Effects of Nigerian commercial organic fertilizers, compost and NPK on growth, shoot yield and nutritional quality of *Solanum macrocarpon*

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ABSTRACT

Effects of three commercial organic fertilizers (Providence, Pacesetter and Sunshine), tithonia compost and NPK inorganic fertilizer were assessed in two trials on growth, shoot yield and nutritional quality of *Solanum macrocarpon* at Ogbomoso, southwest Nigeria. The treatments were Providence fertilizer, Pacesetter fertilizer, Sunshine fertilizer, tithonia compost, NPK mineral fertilizer and control (non-fertilized plants). All the fertilizer treatments were analyzed and applied at equivalent fertilizer recommendation rate of 60 kg N/ha. The experimental design was randomized complete block with four replicates. Parameters taken were stem height and girth, number of leaves and leaf area, number of off shoots, dry matter and shoot yield as well as shoot elemental and proximate composition. Application of fertilizers enhance development of growth, shoot yield and nutritional

quality of *Solanum macrocarpon* when compared with the control (nonfertilized plants). The growth, shoot yield and nutritional quality of plants fertilized with

Providence, Pacesetter and Sunshine organic fertilizers compared favourably with what was observed with plants fertilized with NPK inorganic fertilizer. The shoot yield varied from 4.6 t /ha in control plants to 21.2 t /ha in plants nourished with Sunshine Organic fertilizer. The shoot nutritional quality also varied significantly with the three commercial fertilizers having the best, followed by NPK, and tithonia compost while control plants had the least. From the results of this study, it could be concluded that any of the three commercial organic fertilizers (Providence, Pacesetter and Sunshine) is suitable for optimum production of *Solanum macrocarpon* in south western Nigeria.

Key words: *Solanum macrocrpon*, compost, organic fertilizers, shoot yield, nutritional quality

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INTRODUCTION

Solanum macrocarpon (L), a member of *Solanum* species, is an herbaceous popular leaf vegetable found throughout the warmer and non-arid parts of Africa where it is widely cultivated as important leafy vegetable. The herb is grown for the leaves and young shoots which are used in making soups and sauces. The nutritional values of the edible portion, the shoot, has been reported to be protein, 4.6g; fat, 1.0g; carbohydrate, 6.0g; fibre, 1.6g; calcium, 391mg and phosphorus 49mg per 100g edible portion (Tindal, 1986; Olaniyan, et al 2006). The crop is recently reported to contain high iron content (Akanbi *et al*., 2006) and hence is a recipee for children and adult suffering from anemia most especially in low per capital income country like Nigeria.

S. macrocarpon in Nigeria is always intercropped with staple food crops like maize, cassava and yam, however, it is not uncommon to have its sole production. Sole production of this vegetable is common in peri urban /home intensive gardening. Despite the nutritional importance of the crop and its position in farming /cropping system in areas of its production, its cultivation is still limited by a number of factors. Among the cultural practices, fertilizers and soil fertility can influence the level of functional food components in crops.

The society has been increasingly concerned about environmental damage caused by agricultural activities, especially with regard to health hazards resulting from the use of agrochemicals (Maharishnan *et al*., 2004). Many alternative cropping systems have been developed and among them, organic agriculture has been established and certified in many countries (Stanbill, 1990). Organic agriculture is characterized by the absence of synthetic fertilizer and pesticides in addition to the frequent utilization of organic fertilizers (such as compost, poultry manure cow and goat wastes, etc) as sources of crop nutrients (Olaniyan *et al.,* 2006). The acceptance of crop produced can be influenced by the source of nutrients involved in its production. In the recent past some studies have been conducted to elucidate the beneficial effects of adding crop residue compost into the soil. The practice improves soil physical, chemical and biological activities as well as improving crop yields and nutritional values (Adediran et al., 2003; Maharishnan *et al*., 2004; Ghosh *et al*., 2004).

Crop growth, yield and product quality in relation to application of different organic fertilizers has been widely reported (Togun *et al*., 2003, Akanbi *et al*., 2007). For instance, high fruit yield due to compost application were reported on tomatoes with combine application of 2 t/ha compost and 30 kg N /ha. In most of these studies compost application was observed to have positive effects on soil physical, chemical and biological properties (Akanbi, 2002; Maharishnan et al., 2004; Ghosh et al., 2004), thus, enhancing crop growth, development and yield, with improved crop nutritional components. In another studies, Ojo and Olufolaju (1999) and Olaniyan and Nwachukwu (2004) established the need to apply fertilizer be it organic or inorganic in the cultivation of *S. macrocarpon.* They reported further that Nitrogen is vital in vegetative development, phosphate for stimulation of flowering and fruit formation while potassium is for seed setting.

In South west Nigeria, many organic fertilizers are in the market at commercial levels. They are being produced by various state governments or individual in response to farmers' agitation for alternative to ever increasing and scarce NPK fertilizers. These include Pacesetter fertilizer, produced by Oyo state government; Sunshine fertilizer produced by Waste to wealth factory, own by Ondo State government; Alesinloye Organic fertilizer produced by urban waste conversion factory located at Ibadan, Oyo state; and Providence Organic fertilizer produced in Ogun state. These organic fertilizers varied in nutrient compositions and even some are produced with graded nutrient analysis. Because of variability in nutrient composition, their effects on the growth and yield of crops could not be the same. Despite this, vegetable gardeners / farmers' belief is that all organic fertilizers are equally good for vegetable crop production. This study therefore attempt to assess variability on the growth, shoot yield and nutritional quality of *S. macrocarpon* in response to selected organic fertilizers, tithonia compost and NPK mineral fertilizer.

MATERIALS AND METHODS

Experimental site: The experiment was conducted at the Teaching and Research Farm, Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria (latitude 8^0 10'N, longitude 4^0 10' E, altitude 420 m). The area has a bimodal rainfall pattern with peaks in July and September, with a short rainfall break in August. Early rains usually from late March / early April to end of July while late rain usually starting in early September and ends in late October /early November. The dry season lasts from November to March. The experimental site had been under cassavacultivation for 2 concecutive years before cleared for use. The bimodal rainfall of the area is between, 150mm – 1250mm of rainfall. The temperature regime is high all the year round. The mean minimum temperature is 28^0C and the maximum temperature 33^0C with a high relative humidity of about 74% all year round except in January when the dry wind blow from the north. The preplanting soil analysis shows that the soil is grossly inadequate and lacks sufficient amount of nutrients required to grow *Solanum macrocarpon.*

Treatments: The treatments were six comprising of five fertilizer types (Providence fertilizer, Pacesetter fertilizer, Sunshine fertilizer, tithonia compost, NPK mineral fertilizer) and control (non-fertilized plants). The non fertilized plots constituted the control. Providence Organic fertilizer is a product of a factory in Ogun states; Pacesetter fertilizer, produced by Oyo state government while the Sunshine fertilizer is produce by Waste to wealth factory own by Ondo State government. The tithonia compost is Tithonia based fertilizer prepared at Ladoke Akintola University of Technology, Ogbomoso, Nigeria. The mineral fertilizer is NPK 15-15-15 obtained from open market in Ogbomoso.

Prior to the use of the fertilizers, samples were taken from each fertilizer type and analysis for N, P, K and Zn contents in the laboratory (Table 1). Based on the result of laboratory analysis and general fertilizer recommendation for *S. macrocarpon* plant in south western Nigeria, 60 kg N, 20 kg P and 40 kg K /ha (FPDD, 1990), the quantity of each fertilizer type were calculated. The treatments were arranged in a randomized complete block design with four replicates. The crop was 50 x 50 cm apart, at 1 plant per stand giving a plant population of 40,000 plants/ha. A plot measured 6.25 m^2 (2.5 m x 2.5 m) and contained six rows of crop and each row had 6 plants making 36 plants per plot. A replicate was 50 m^2 (20 m x 2.5 m) in dimension and adjacent replicates were separated by gaps of 2 m. The total experimental area was 320.0.m^2 (20.0 m x 16 m).

Table 1: Nutrient composition of different organic fertilizers

Organic fertilizers	N	P	K	Zn	Cu
Providence fertilizer	2.18	12.7	0.57	1.22	2.4
Sunshine fertilizer	4.83	15.8	0.6	1.33	3.5
Pacesetter fertilizer	4.7	14.7	0.63	1.25	3.4
Tithonia compost	1.9	12.8	0.55	1.14	2.25

Field establishment and crop management: The seed of the *S. macrocarpon* was obtained from the Genetic Resources Unit of National Institute for Horticultural Research, Ibadan, Nigeria. The seeds were sown in a nursery beds contained 1:3 top soil: compost proportion by weight (Akanbi, 2002). The seedlings were allowed to grow for a period of six weeks. At transplanting, healthy seedlings were selected and transplanted into well prepared beds on 16 June, and 20 June, for 2007 and 2008 trials, respectively. Organic fertilizer treatments were applied at transplanting while NPK mineral fertilizer treatments was applied two weeks after transplanting (WAT). Manual weeding was done thrice starting from 2 WAT and repeated every 3 weeks interval. Insect pests were controlled by spraying *S. macrocarpon* with compost extract - Tithonia compost in distilled water at ratio 1:10 w/v. (Akanbi *et al*., 2007) at two week interval starting from 2 WAT till final harvest.

Data Collection and laboratory analysis of shoot samples: Four plants were randomly tagged per plot data for collection. Data were collected on the growth, reproductive and seed parameters of *S. macrocarpon*. The growth parameters were number leaves and offshoots, plant height, girth and dry matter yield. The reproductive and seed traits that were measured include days to 50% flowering, number of flowers and fruit / plant, % fruit sets, mean fruit weight, number and weight of fruit/ plant.

For determination of shoot elemental and nutritional compositions, at 10 WAT, fresh shoot samples were harvested from three plants selected at random from each plot. They were packed in brown envelopes and dried in the oven at 80^0C for 72 hours in the Agronomy Research Laboratory, Ladoke Akintola University of Technology, Ogbomoso. Samples were taken and analysed for moisture content, crude protein, fat, carbohydrate, crude fibre, P, Ca, Fe and ascorbic acid contents. Proximate compositions were determined using AOAC (1984) method. The total shoot N was determined by a semi micro-kjeldahl procedure (Bremner, 1965; Ulger et al., 1997) and shoot protein was calculated from the Kjeldahl nitrogen using the conversion factor 6.25. Crude fibre content was estimated from the loss in weight of the crucible and its content on ignition. 50 g homogenized paste was digested in 1.25% tetra-oxo-sulphate (IV) acid and 1.25% sodium hydroxide. The digest was put in crucible and transferred into a muffle furnace at 550 for 3 ½ hours. The weight difference expressed as a percentage of the fresh weight constitutes the percent crude fibre. The fat (ether extract) was estimated by exhaustively extracting a known weight of sample with petroleum ether (BP 60^0 C) using a Tecator Soxhlet apparatus. Mineral elements were estimated using the AOAC (1984) method. The atomic absorption spectrometer was used to determine Ca and Fe. Phosphorus (P) was determined using the colorimetric molybdenum-blue procedure (Murphy and Riley, 1962).

Shoot yield: Samples of four plants were selected for computation of cumulative shoot yield. At first harvest (10 WAT), the selected plants were harvested and shoot yield taken. Two more harvests were carried out at interval of 2 weeks, making a total of three harvests. Cumulative shoot yield for each treatment was obtained by adding together the shoot yield per treatment over the three harvests. This was expressed in kg /hectare.

Statistical analysis: Data collected in 2007 and 2008 were pooled together and analysed following procedure of Gomez and Gomez (1991) and significant means were compared using Duncan's multiple range test ($P \leq 0.05$).

RESULTS

Growth parameters: The growth parameter of *S. macrocarpon* in response to different organic fertilizers is presented in Table 2. Application of fertilizers enhanced the growth of *Solanum macrocarpon*. Stem height varied significantly from 25.6 cm in non-fertilized plants to 29.3 cm in plants fertilized with NPK fertilizer. Stem height was similar among the three commercial organic fertilizers, but they are taller than non fertilized plants and plants nourished with tithonia compost.

Table 2: Effect of fertilizer types on the growth parameters and dry matter yield of *Solanum macrocarpon*

Fertilizer type	Stem height (cm)	Stem girth (cm)	No of leaves/ plant	Leaf area (cm^2/plant)	No of offshoot /plant	Dry matter yield / (g) plant
Control	25.6b	2.3b	13.5b	984.15b	1.8c	22.4b
Sunshine	28.0a	3.0a	21.2a	2457.52a	2.7	20.6c
Providence	27.2a	3.1a	21.0a	2818.22a	2.7a	34.7b
Pacesetter	28.7a	3.0a	22.8a	3985.44a	2.3b	45.2a
Tithonia Compost	26.6b	3.0a	21.5a	2205.94ab	2.2b	34.9a
NPK	29.3a	3.1a	22.3a	2466.38a	2.2b	44.6a

Means with the same alphabet along the column are not significant ($P \leq 0.05$)

Plant stem girth, number of leaves and leaf area per plant were significantly affected by type of fertilizer. Stem girth ranges from 2.3 in the control to 3.1 cm in the Providence and NPK treatments. The number of leaves per plant was highest in Pacesetter (22.8) and least with control plants (13.5). Number of leaves observed with Pacesetter Organic fertilizer was similar to what was obtained with the use of NPK, Sunshine, Providence and tithonia compost. Leaf area per plant was highly ($P \geq 0.01$) influenced by type of fertilizer. Pacesetter fertilizer produced the largest leaves followed by Providence, NPK, Sunshine, tithonia compost and control. There was no significant difference among the various types of organic fertilizer used but the control had significantly smallest leaves than the commercial organic fertilizers and NPK. Dry matter accumulation of plants fertilized with Pacesetter was the highest. This was 1.3, 2.2, 2.3, 50.4 and 54.0 % higher than what was observed with the use of NPK, tithonia, Providence, control and Sunshine, respectively.

Reproductive parameters: Days to 50% flowering ranged between 48 to 52 days. Plants that were fertilized with pacesetter organic fertilizer experienced 6 days delay in flowering when compared with days to flowering in control plants. Number of flowers and fruits, % fruit sets and mean fruit weight were all significantly affected by fertilizer types. Number of flowers and fruits /plant was at highest with NPK mineral fertilizer. However, plants nourished with tithonia compost had the highest % fruit set (44.3%). This value was statistically similar to what was observed with other organic fertilizers. Mean fruit weight was highest in plants fertilized with Providence fertilizer and least with control (non-fertilized plants). The mean fruit weight observed with Providence fertilizer was similar to what was obtained with NPK and Pacesetter and statistically higher than values obtained with Sunshine, tithonia and control treatments (Table3).

Table 3: Effect of fertilizer types on reproductive parameters of *Solanum macrocarpon*

Fertilizer type	Days to 50% flowering	No of flowers /plant	No of fruit /plant	% fruit Set	Mean fruit weight (g)
Control	48b	11.2b	2.6c	23.2c	47.8c
Sunshine	52a	10.2b	4.2b	41.2a	62.4b
Providence	52a	16.4a	5.2a	31.7b	80.2a
Pacesetter	54a	14.2a	6.0a	42.2a	73.6ab
Tithonia Compost	48b	13.1b	5.8a	44.3a	69.9b
NPK	49b	16.6a	6.2a	37.3ab	75.6ab

Means with the same alphabet along the column are not significant ($P \leq 0.05$)

Seed quality parameters: Seed weight / fruit, number of filled and unfilled seeds, % filled seed, and total numbers of seeds /fruits were all significantly influenced by the organic and inorganic fertilizers. The order of increased in seed weight /fruit was NPK (2.32g), Sunshine (2.30g), tithonia compost (2.21g), Providence (2.11g) and control (0.91). The % filled seed was highest (86.5) with plants that received NPK fertilizer while it was least (46.4%) with control plants. The % filled seed of the four organic fertilizers were similar and not significantly higher than situation where NPK fertilizer was applied (Table 4).

Table 4: Effect of fertilizer types on the seed characteristics of *Solanum macrocarpon*

Fertilizer type	Seed weight /fruit (g)	No of filled seeds	No of unfilled seeds	Total No of Seeds /fruit	% filled seed
Control	0.91b	110d	127a	237c	46.4b
Sunshine	2.30a	394a	65d	459a	85.8a
Providence	2.11a	370a	72c	442a	83.7a
Pacesetter	1.98ab	287c	61d	348b	82.5a
Tithonia Compost	2.21a	301b	97b	398b	75.6ab
NPK	2.32a	390a	61d	451a	86.5a

Means with the same alphabet along the column are not significant ($P \leq 0.05$)

Nutritional quality: The shoot protein of *S. macrocarpon* differed significantly among the applied fertilizers. Values for this parameter range from 2.8g in the control experiment to 4.8 g /100 g edible portion in Pacesetter Organic fertilizer (Table 4). The fat content of all fertilized plants, irrespective of the fertilizer type, were similar and significantly higher than the control plants. The carbohydrate composition was highest in NPK treatment and least in control treatment. However, the crude fibre of the control plants was highest while it is least with application of Sunshine. In case of P, Ca and Fe contents, the non fertilized plants consistently had lowest values. The shoot P varied from 36.2 to 47.1 g / 100 g edible portion. The P, Ca and Fe shoot contents of plants that received the four organic fertilizers compared favourably with the values obtained under NPK situation. The ascorbic acid was equally significantly affected by different fertilizers. The ascorbic acid of the control plants was significantly lower than where fertilizers were applied. The order of ascorbic acid content was Sunshine > Providence > Pacesetter > NPK > tithonia compost > control. Despite the low level of Ca and Fe in the shoot of plants fertilized with Sunshine organic fertilizer, this fertilizer type produced plant with highest ascorbic content.

Table 5: Effect of fertilizer types on shoot nutritional contents of *Solanum macrocarpon*

Fertilizer type	Water (%)	Crude protein	Fat	Carbohy-drate	Crude fibre	Phosp-horus	Calcium	Iron content	Ascorbic Acid
		→ *g / 100g of edible portion* ←				→ *mg / 100g of edible portion* ←			
Control	87.2a	2.8b	0.95b	5.2b	1.41a	36.2b	290.1b	0.67b	18.2b
Sunshine	82.3a	3.9a	1.21a	6.6ab	1.09c	45.2a	286.4b	1.13a	23.4a
Providence	84.2a	4.6a	1.22a	6.5ab	1.12c	46.9a	304.1ab	1.09a	23.1a
Pacesetter	83.2a	4.8a	1.23a	6.9ab	1.20b	46.8a	356.2a	1.20a	22.4a
Tithonia Compost	86.4a	3.1ab	1.11a	6.1ab	1.23b	44.2ab	320.4a	0.92b	21.1ab
NPK	87.0a	4.3a	1.24a	7.4a	1.11c	47.1a	378.2a	1.12ab	22.3a

Means with the same alphabet along the column are not significant ($P \leq 0.05$)

Shoot yield: The highest shoot yield (21.2 t/ha) was recorded for Sunshine fertilizer treated plants while the least (4.6 t/ ha) was obtained on plants where no fertilizer was applied (control). Generally, application of fertilizer enhanced shoots yield production in *S. macrocarpon.* The shoot yield produced with Sunshine (21.2 t./ ha) and Providence (20.4 t./ ha) organic fertilizers compared favourably with what was obtained with NPK mineral fertilizer (20.6 t/ ha). The shoot yield of plants nourished with tithonia compost was equivalent to that of Pacesetter and significantly higher than that of control plants (Fig. 1).

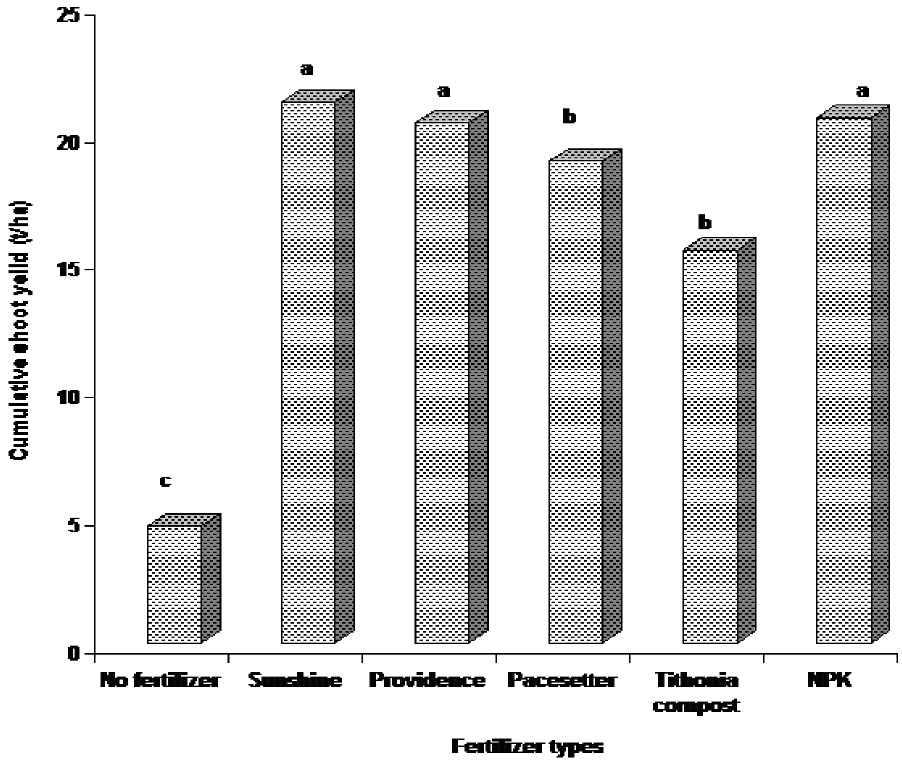

Fig. 1: Effect of fertilizer types on cumulative shoot yield of *Solanum macrocarpon*
Bars with the same alphabet are not significantly different

DISCUSSION

Enhancement of development of growth parameters of fertilized plants observed in this study could be as a result of inadequate essential nutrients in the growth medium of the control plots. It has been asserted that cultivation of crop on soil with non limiting nutrients aid crop yield, growth and development thereby improving the crop nutritional components. This upholds what Akanbi (2002) and Olaniyan *et al.,* (2006) reported on tomato and *S. macrocarpon,* respectively. In these two reports, availability of essential nutrients (most especially N) in adequate quantity and form enhanced protoplasmic development and cell proliferation. These culminated in proper crop growth and development. For most of the parameters taken, values observed with any of the three commercial organic fertilizers compared favourably with that of NPK. This implies that these organic fertilizers contained adequate nutrients required for normal plant growth and development as contained in the NPK. Again, it also indicates that the nutrients contained in any of these 3 organic fertilizers could be bio available for plant use as it occurred with NPK. This negates the general belief that organic fertilizers slowly release nutrients for plant use in all cases. At least under the prevailing condition of this experiment, nutrient release could not be said to be slow.

The delay in days to reach 50 % flowering as observed in fertilized plant in this study may be attributed to the fact that crop tend to extend its vegetative period at the expense of reproductive phase under luxury consumption of the available soil nutrients. According to Stuart (1988), this has been viewed to be vacuolar storage of nutrient during the period of active growth and it occurs whenever nutrient uptake exceeds growth demands. Again, variability observed in number of flowers and fruits in this study could be linked to differences in the ability of the various organic fertilizer used in this study to make nutrients available for crop use. It could be viewed that NPK and providence fertilizers make their nutrients more readily available when compared to other. This is in line with observation of Maharishnan *et al*., (2004) and Ghosh *et al*., (2004) who reported marked differences in the ability of the various fertilizer materials used and this invariably affect the rate of nutrient uptake and assimilation as well as crop growth rate.

Seed production could be optimum in any plant when all growth factors that are required are present. As reported by Ojo and Olufolaju (1999) and Olaniyan *et al* 2006, ability of a crop to exhibit its genetic potential for seed production and quality depends to certain extent on the nutrients available for the plant use during the seed formation process. This implies that under low nutrient regime processes that are involved in seed production will be highly affected. This may explain differences observed in quantity and quality of seeds of *S. macrocarpon* grown with different fertilizer. That NPK had the best seed in term of quantity and quality means that this treatment contained nutrients sufficient enough to produce high quality seeds. This is in line with the report of Olaniyan, et al (2005). The report indicated that fertilizer application generally enhanced fruit production in *S. macrocarpon* and that plant grown without fertilizer produced fruits which were smaller and fewer in numbers with many unfilled seeds. From the observation recorded in the present study, the use of any of the four organic fertilizers could produce seeds of equal quantity and quality like that of NPK.

The source of nutrients used to grow a crop could have great influence on the crop nutritional attributes. The use of different organic fertilizers in the present study accounted for various observations on nutritional quality of *S. macrocarpon* recorded. Application of fertilizer, irrespective of its type enhanced nutritional values of the crop. This confirms the report of Ghoname and Shafeek (2005).

CONCLUSION

Application of fertilizer enhances growth and development of *S. macrocarpon.* The growth, shoot yield and nutritional quality of plants fertilized with Providence, Pacesetter and Sunshine organic fertilizers compared favourably with what was observed with plants fertilized with NPK inorganic fertilizers. The shoot yield varied from 4.6 t /ha in control plants to 21.2 t /ha in plants nourished with Sunshine Organic fertilizer. The shoot nutritional quality also varied significantly with the three commercial fertilizers having the best, followed by NPK, and tithonia compost while control plants had the least. It is concluded that any of the three commercial organic fertilizers (Providence, Pacesetter and Sunshine) is suitable for optimum production of *Solanum macrocarpon* in the South western Nigeria.

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