VOL. 20 NO. 1
ISSN: 2877-1990
MARCH, 2021

African Scholar Publications & Research International

African Scholar Journal of Agriculture and Agricultural Tech. (JAAT-1)

Agroforestry Systems; Towards Sufficiency and Sustainability in Organic Farming in the Nigerian Savanna Ecosystem

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Abstract

The savanna biome of Nigeria, which is agriculturally strategic due to its high level of food productivity, is fast being degraded partly due to climatic variability, and majorly due to impacts of human livelihood, especially farming technologies and cultures. For sufficient and sustainable production of food, organic farming, which integrates trees and woody perennials in various combinations on farms, is here introduced and discussed. This paper showcases the various advantages of organic farming and agroforestry on crop yield, crop quality, soil health and environment and human health. Some techniques for application of these methods are also discussed.

Keywords: *Per-Capita Land, Slash and Burn, Sustainable Agriculture, Food Security, Food Sufficiency, Land Hunger.*

Introduction

Background: Natural and anthropogenic pressure on savanna farmlands.

The savanna biome covers more than two-third of the Nigerian land mass (Coppen, 2018). The trio of increases in climate variability, warming trends and anthropogenic pressure are factors responsible for highest changes in the savanna ecosystem these have important direct and indirect impacts on the soil health and productivity in this highest grain food producing region of the nation (Changnon, 2003; Jenkins, 2011; Hoehanou *et al*, 2012; Niang *et al.,* 2014; Measho *et al.,* 2019). However, anthropogenic (human) disturbance is now considered the biggest threat responsible for rapid loss of soil nutrient, desertification and its consequent problems of drought, wind erosion, and carbon emission (Arifalo *et al*., 2008; Alao, 2008; Idrisa *et al*., 2012; Akwarandu *et al*., 2014). In Nigeria, agriculture remains a major branch of the economy, providing employment for 70% of the entire population and approximately two-thirds of the country's total labour force (Mignouna *et al.*, 2013). It also provides a livelihood for about 90 per cent of the rural population.

Water scarcity on savanna farmlands.

Moisture is a limiting factor in all arid and semi-arid ecosystems (Walker *et al.,* 1981; Higgins *et al.,* 2000; Hipondoka *et al.,* 2003; Sebata, 2017), and perhaps the most important singular factor for arable farm productivity. The impact of drought is felt more because rain-fed agriculture is the economic mainstay for majority of the farming population in African savanna (Measho *et al.,* 2019). In the old Bornu state, percentage of desertified land has increased from 23.71% in 1986 to 46.52% in 2009 (Musa, 2012) with land turning from a productive one to one that can hardly sustain agriculture in most places (MacZulak, 2010) largely due to poor management and unsustainable farming techniques.

Wind erosion on savanna farmlands

Annually, portions of the unprotected sediment cycle vital to plant life lying in the topsoil, which is the nutrient-containing earth no more than a foot deep (0.3m) that surrounds and supports the root systems of crops (McZulak, 2010) and making up vast fertile farmlands, are lost to wind erosion. Studies have shown that materials eroded by wind erosion are

lighter soil particles, comprising mostly of rich dead organic matter and weathered mineral matter that could be useful in crop production (Agbehin *et al*. 2005; Tisdall *et al*. 2012, MacZulak, 2010; Akwarandu *et al.*, 2014; Akwarandu *et al*., 2015). This is exacerbated by the yearly slash and burn, and chemical inputs farming practiced in the savanna. This does not only render the soil impotent for crop growth, it also encourages desertification, which in turn makes the environment uninhabitable for man (Forman, 1995; McGrigal and Marks, 1995; Akwarandu *et al*., 2014; Akwarandu *et al*., 2015).

Need for change

In order to ensure sustainability and sufficiency in food crop production, there is need for a paradigm shift on farming from the normal 'slash and burn'/shifting cultivation and 'chemicalized' culture, to engaging agroforestry systems and skills. Population explosion in Nigeria and the resultant 'land hunger' places much limitation on per-capita farm land index. Thus, methods have to be devised by farmers to sustainably manage and optimize available but limited farmlands, not only to meet their economic needs, but to ensure food security for the masses.

Organic farming

Organic farming, otherwise known as sustainable farming is an integrated practice that relies on ecosystem services to produce a number of crops without the use of synthetic chemical fertilizers, herbicides or insecticides while enhancing soil composition and promoting biodiversity. Sustainable agriculture must include integrated farming system (IFS) with efficient soil, water, crop and pest management practices which are environmentally friendly and cost-effective rather than focusing on sowing seeds, manipulating the ecosystem till harvest, abandoning the farmland after harvest, only to come back the following season to repeat same. Sustainable farming can only be ensured when there are integration of trees and other woody perennials, either spatially or temporally, in both the short and long term farming enterprise.

Why the need for agroforestry?

- With population growth, per capita land is fast reducing, both in quality and in quantity.

- Better management of agricultural land is required to reduce the effect of crop production.
- Essentially, sustainable agriculture has the ability to offset global greenhouse emission at a greater rate than conventional agriculture.
- The use of chemical inputs to combat food insecurity caused by population growth bring about soil degradation, environmental pollution and unverified levels of compromise on health.

Table 1: **Some major differences between organic farming and the conventional farming**

ORGANIC (AGROFORESTRY) ECOSYSTEM	CONVENTIONAL ECOSYSTEM
Trees improve microclimate which in turn enhances flowering and fruiting of crops.	Harsh/dry climate reduces fruiting ability of crops.
On-farm trees and other woody perennials, through the function of their deep roots, act as nutrient pump, bringing to the soil surface through litter droppings, minerals necessary for crop growth but inaccessible to their (crop) roots.	Soil nutrients and fertilizers are occasionally washed away vertically and horizontally through leaching and erosion respectively on the bare soil without any recovery mechanism like the nutrient pump.
Tree and other woody perennial covers are left on farm as soil protection from wind erosion and acute dryness.	The soil is made bare after harvesting; leaving it at the mercy of weather elements.
Water body (if any) is conserved and protected from siltation and drying by canopy of trees.	Water body (if any) is silted by wind erosion and exposed to evaporation unchecked.
Soil organisms which work and enrich the soil, are protected, their growth is encouraged by the existence of trees.	Soil organisms which work and enrich the soil, are not protected, they are absent when the environment is not conducive.

The field is generally rejuvenated for the next season's farming.	The field generally reduces in fertility before the next planting season.
FARM PRODUCTION/SERVICES	
Seasonally, additional products like honey, fuel-wood, fruits, vegetables, herbs, medicine among others come with the annually harvested crops in addition to ecosystem services.	Annually harvested crops alone are available at the end of the season.

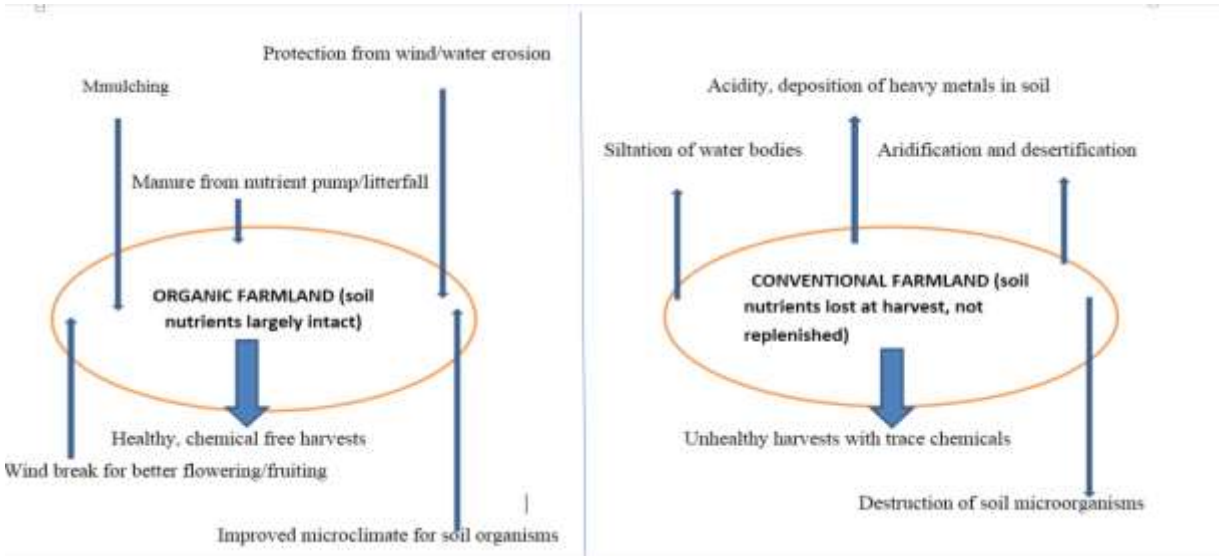

Fig. 1: Graphic presentation of impacts of organic farming and conventional farming on farmland and ecosystem

Efforts made by practitioners of conventional farming annually to revitalize farmlands in some states have continuously recorded less success each subsequent year; thus, there is increasing demand for chemical inputs and land to ensure food sufficiency (YSES, 2008). These chemical fertilizers, pesticides and herbicides alter soil pH, leave trace heavy metals and elements in the soil, and set off an imbalance in the soil that may preclude the optimal performance of subsequent plant diversity (Alloway, 2013; see Fig. 1). Functional woody species integration is necessary in sustaining any arable land for optimal yield (Olajuyigbe and Akwarandu, 2019).

Organic farming techniques.

Considering the peculiarities of the arid and semi-arid ecosystem and her socio-economy, major targets of any organic farming enterprise in the savanna should include:

Water management: Availability of water determines the amount of water and water-soluble nutrients and minerals available to the root of crops for their growth per time. Water is optimized in the arid and semi-arid land (ASAL) farming by inculcating trees like *Acacia* species, *Balanites aegyptiaca, Prosopis africana* (which is a multifunctional agroforestry tree) and *Eucalyptus* species among others. Growing trees on farms can reduce water consumption, help retain water for crops and provide protection to watersheds. The planting of indigenous or exotic deciduous species that produce high-value tree products (such as fruit or timber), while practicing root and shoot pruning, can increase the efficiency of water use while providing new economic opportunities. Another role of trees on farms is in providing shade, helping to maintain soil moisture. Root and leaf pruning and mulching to reduce competition for water and optimization of the benefits of microclimatic modifications in agroforestry systems should also be considered. However, care should be taken to see that crops are not planted directly under the canopy of trees to prevent root competition for water.

Soil nutrient management, Agroforestry can improve crop productivity in several ways: increasing soil organic matter, infiltration and water storage; improving soil physical properties and biological activity; and enhancing nutrient supplies through nitrogen fixation and reduced leaching and soil erosion. Some of the important species for this include *Moringa oleifera*, *Prosopis africana*, *Acasia species, Zizzipus species* and *Diospyros mesiliformis.* Other non-tree crops like cowpea, soybean and groundnut can also be used as cover plants on the field after harvesting for soil nitrogen and protection from unfavorable weather.

Insect and disease management: *Eucalyptus species, Azadiratcha indica* are some woody species that has been used either as anti-feedant or repellant. Different parts of these species have been used in different mixtures, with or without some additives like chili pepper, wood ash and soap to treat infestation on crop farms, wood and fruit orchards (Akwarandu *et al*., 2017). Others are which is; garlic which repels root maggots and Mexican bean beetle; castor bean, which repel pathogenic moles and lavender which repel moths, fleas and

mosquitoes. These plants can be introduces on farm (for those adapted to the geo-climatic condition) or have their fluids, ash or oil extracted for use or additive on farm. It is important to know that essential oil of most of these plants, especially plants of the *Laminaceae* (mints) *Poaceae* (true grasses) and *Pinaceae* (pines), are common haematophagous insect repelant.

Soil stabilization and structure management. Virtually all savanna tree and shrub species are good in managing soil structure. Their roots are specially adapted to bind the sandy soil and protect it from wind/water erosion. According to the Royal Horticultural Society (RHC), the following considerations are to be taken before establishing trees and other woody plants for windbreak and soil stabilization in the Arid and Semi-Arid Lands (ASALs):

- Shrubs and trees should be planted fairly close together: 30-90cm (1-3ft) between most plants within the row is suitable
- In shelterbelts large trees should be spaced at least, 2-4 (6½-13ft) apart, with shrubs planted between the lines of trees to slow wind at the base of the belt. In deep shelterbelts, plant the tallest trees at the center, with shorter trees or shrubs at the front and back.
- Put tree guards in place to protect trunks from rabbit damage
- Keep new plantings well mulched, watered and weed-free until they are established
- Rows of trees and hedges can be pruned annually to keep them dense

When seedlings are to be introduced by planting, they should be hardened out in the nursery before planting out, and this involves simulating expected field conditions of the sand dune. This may involve gradual removal of shade and water available to the seedlings before transplant. Planting holes should be dug in the sand dune just before planting, and care should be taken to prevent contact between the seedling and dry sand. Some locally available indigenous tree species that are adapted to ASAL conditions are some *Acacia* species like *Acacia Senegal* otherwise known as 'gum Arabic and *Acacia seyal*, *Balanites aegyptiaca* and *Tamarindus indica* and *Borassus aethopium.* Apart from the qualities above, they are also known to withstand seasonal fire attacks. The evergreen Balanites is used by farm owners as buffer against fire outbreak. Other methods that can be used in soil stabilization (accorsing to Akwarandu *et al.*, 2016) include: s**oil stabilization using fungal hyphae** which, due to high

technological skills required, is impracticable for ordinary farmers, and **improved grass and legume pasture** (Agbehin and Adewuyi, 2005).

Sense of ownership (Title right), a necessity for adequate care from farmers.

Sense of ownership on farmland will encourage a farmer to engage in tree or orchard farming or agroforestry practices like strip/alley farming, and perennial crop farming, all of which can bring diversification in farmers' production, improve their economy, conserve soil nutrients and even replenish ones lost to arable crop harvesting through the nutrients pumping effect on tree crops. Farmers will also tend to care for the land and make it yield for a long time, and thus reduce the rate of use of chemicals that might have negative residual effects on the soil and possibly opt for organic farming. This way, less forest will be opened up per farmer per time in search of fertile land and there will be more productive soil for large scale farming (Agbeja, 2008; Akwarandu, 2015).

Finally, for a successful organic farming, on-farm compost should be prepared and used in place of chemical fertilizers. To save cost, compost should be prepared from vegetation removed from the farm.

Preparation of compost

Preparation starts by digging up the ground to 1 foot deep and any length and width of one's choice. Sprinkle ash on the ground then water, spread the dry matter and pour the animal waste on top of the dry matter, then put the green leaves, then cover with a thin layer of soil and sprinkle water to make the first layer. Repeat the process up to 1.5 meters high then insert a tree diagonally and ensure it penetrates to the ground at the other side, this will help to monitor the temperatures. Leave the heap for 3 weeks undisturbed then rearrange the layer starting from the top layer going up and leave for another 3 weeks, repeat the turnings until 3 month time is over that is when the manure is ready for use. Tree prunings, wood ash and urine this is a ready source of replenishment for nutrient lost to harvesting.

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