GROWTH, ALLELOPATHY AND WEED MANAGEMENT ATTRIBUTES OF AKIDI COWPEA (*Vigna unguiculata* (L) WALP.) IN MAIZE CROPPING SYSTEM

By

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ABSTRACT

Weed interference is a major constraint to maize cultivation. Biological control of weeds has been established to be environmentally safe but has not been widely used in maize cropping system. *Akidi* Cowpea (AC), an underutilised indigenous legume with trailing and vigorous growth, has the attribute to suppress weeds when grown as interplant. Although, AC's nutritional profile and health benefits have been studied intensively, its growth under different Light Intensities (LI) and allelopathic effect on maize has not been fully established. Therefore, growth under different LI, allelopathy and weed management attributes of AC in maize cropping system were investigated.

Akidi cowpea cultivar IT84D-666 (1 seed/pot) was sown in 5 kg pot under four LI: 30% (12396-lux), 50% (20940-lux), 70% (28423-lux) and 100% (40372-lux) in a Completely Randomised Design (CRD) in four replicates. Shoot Dry Weight-SDW (g) and Number of Root Nodules (NRN) were determined at nine Weeks After Sowing (WAS). Shoots and roots of AC were harvested, air-dried and milled into fine powder. Milled samples (144, 72, 36 and 0 g), each of shoots and roots were dissolved in 1 L distilled water to obtain 100, 50, 25 and 0% concentration of Aqueous Shoot Extracts-ASE and Aqueous Root Extracts-ARE. Maize seed (DTMA-Y-STR) was sown in 10 kg pots in screenhouse in a CRD in four replicates. At two WAS and subsequently forthnightly till eight WAS, 300 mL of ASE and ARE were applied to the soil. Plant Height-PH (cm) and SDW at eight WAS were measured. The treatments: maize interplanted with AC at 20,000 (M1), 30,000 (M2), 40,000 (M3) plants/hectare, hoe weeding (M4), weedy check (M5) and Primextra-2.5 L/ha (M6) were evaluated. Treatments were laid in randomised complete block design, each replicated four times. Weed Control Efficiency–WCE (%), maize SDW and Grain Yield–GY (t/ha) were determined at maturity following standard procedures. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05.}$

The SDW of AC at 30%-LI (11.3±0.4) and 50%-LI (11.5±0.2) were similar and significantly lower than 70%-LI (13.0±0.3) and 100%-LI (13.8±0.3). The NRN from 70% (41.4±1.1), 100% (43.6±1.0) were similar and significantly higher than 30% (2.7±0.6) and 50% (7.4±1.0). Maize PH ranged from 97.7±1.1

in 100%-ASE to 106.4±0.7 in 25%-ASE. The highest PH of (106.7±0.6) was obtained under 25%-ARE, while 100%-ARE (101.9±0.6) had the least. The highest maize SDW of 31.3±0.7 and 27.0±0.7 were obtained in 100%-ASE and 100%-ARE, respectively. The WCE was highest in M3 (94.8%) and least in M5 (66.4%). Maize SDW was highest in M3 (84.9± 0.7) and least in M5 (30.2±4.2). The GY of maize at M6 (2.0±0.8) was significantly higher than M3 (1.7±0.6), M4 (1.7±0.6), M2 (1.5±0.6), M1 (1.5±0.6) and M5 (0.7±0.3).

Light intensities of 70% and 100% enhanced shoot dry weight and number of root nodules of *akidi* cowpea. Aqueous shoot or root extracts of *akidi* cowpea at 25% concentration increased maize plant height, while 100% concentration increased dry matter accumulation. Maize and *akidi* cowpea interplant at 40,000 plants/hectare suppressed weeds and improved maize shoot dry weight.

Keywords: Leguminous cover crop, Weed suppressant, Weed control efficiency,

Shoot dry weight

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CERTIFICATION

This is to certify that Imuwahen Aimufua WOGHIREN conducted this research under my supervision in the Department of Crop Protection and Environmental Biology, University of Ibadan.

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DEDICATION

The work is dedicated most to God who remains my mother through this programme and whose light will continue to lead me on in life. Also, I dedicate this work to the evergreen memory of my mother, Late Mrs. R. O. Woghiren, who passed away on the 10^{th} of April, 2014 in the course of this programme. May her gentle soul rest in perfect peace, Amen.

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INTRODUCTION

Over the years, farmers have been faced with challenges of weed infestation that needs to be tackled, because it negates optimum crop yield. The presence of weed seeds could be due to the presence of weeds in the soil seed bank or non-native seeds brought in with crops. Weed is an important pest of crops that has the potential of reducing crop yield if not adequately checked. Globally, weed infestation alone has accounted for 34% loss in crop yield (Jabran *et al*., 2015). In Nigeria, cassava farmers ranked weed infestation as a major pest in cassava cultivation (IITA, 2018). Some weeds are aggressive in nature, a phenomenon that enables them compete squarely with cultivated crops, weeds have resulted in 37 percent reduction in rice yield and 30 percent reduction in soybean yield (Oerke, 2006). In Nigeria, maize is currently an essential cereal crop for a good number of people; however, weed infestation limits its continuous production (IITA, 2012).

Severe weed infestations have resulted in up to 89% loss in maize yield (Imoloame and Omolaiye, 2017). Before now, farmers have made use of fallow period to help minimize the infestation of weeds. An approach that promotes vegetative coverage which can significantly reduce weed diversity as soil temperatures are decreased and/or luminous intensity is changed. Litterfall residues of fallow species may alter soil chemistry and microbial ecology in order to promote losses in soil seed bank by germination, loss of vigour or degradation.

Fallow can be defined as the deliberate act of leaving a previously cultivated land for a period of time. There are two types of fallow, namely the natural and planted fallow. Customarily, farmers have employed several forms of fallow systems, ranging from shifting cultivation to bush fallowing to mention a few, in the management of weeds. The continuous increase in human population has been a major draw–back in this system, due to the long period required for the land to fallow. Considering this there is a need to implement an improved fallow system, which is a more efficient and eco-friendly approach through the use of planted fallow in the suppression of weeds in maize cropping system. This could be an effective approach if they have vigorous growth form, trailing ability and quick ground cover as well as produce high biomass turnover. The inherent ability of low-growing plants to manage harmful weeds effectively will aid in reducing fallow periods and subsequently bring about a significant increase in crop performance (Awodoyin and Ogunyemi, 2005a)

Generally, controlling weeds in crop production can be categorizeded into one or more of the major five groups, which are preventive, cultural, mechanical, biological and chemical weed control method. Preventive weed management technique commences with planning ahead as well as adhering to plan: diverse weed management approaches and crop weed smothering ability, in addition to starting with clean seeds. Cultural weed control means any strategy involving maintaining the conditions of the field, such that weeds are less likely to develop and/or to grow in number. Mechanical weed protection means any strategy involving the use of agricultural machinery to manage weeds. The two mechanical control techniques most often used are tillage and mowing. Biological weeds control means any technique involving the use of natural predators of weed plants to control seed germination or plant propagation and/or establishment. Chemical weed control requires any form of applying a chemical (herbicide) to herbs or soil to prevent the germination or proliferation of weeds.

Mechanical weeding has the advantage of maintaining yield, breaking earth crust, maintains or reduces the cost of weed control, aerates soil, reduce pollution. It however has the disadvantage of requiring a drier soil condition to operate, appropriate timing is required, and it leaves on average 20% more weeds in the field than herbicides. Inorganic herbicides have the advantage of offering a nearly complete weed control, cover large areas in less time. Chemical herbicides do work, but croplands end up having weeds that are resistant to these herbicides, hence the need to adapt integrated weed control that will include cover crops. Over reliance on chemical herbicide brings about numerous ecological and crop management problems, that have deleterious effects on the health of the ecosystem. Soil void of mulch is usually prone to problems such as wearing away of top soil, fertilizer and pesticide runoff into underground and surface water. The use of intensive fallow systems that are cost effective and environmentally friendly using promising leguminous cover crop could profer solution to these problems.

Weed control in conservation agriculture is usually through several modifications which include the use of mulches, plant density manipulation and interplanting (Awodoyin and Ogunyemi, 2005b). Effects of weeds on cultivated crops is more visible under environmentally friendly agriculture due to the fact that it does not provide complete elimination of weeds, since traditional and mechanical weed control is used in place of chemical herbicide which are fast to apply in addition to nearly complete elimination of weeds but usually comes with long lasting negative effect. However, reflecting on the numerous green manure attributes of planted fallow species, they can be introduced into organic agriculture as live mulch for the smothering of noxious weeds in a bid to minimize the use of chemical herbicide. Intensive sown fallow system and mulch interplanting focused at minimizing the effects of weed on the crop yield could be an ideal, non-chemical weed control approach suitable for organic agriculture.

Conventional fallow system is not adequate to suppress weed density over time. The continuous intensification of farming systems can be attained through adequate management of biological variety inside the earth layers, as well as plant overall mass in the community. Over the years, agriculturists have acquired improved approaches in a bid to enhance the application of fallow, from the primordial model (Ikpe *et al*., 2003).

The performance of the agro-ecosystem can be improved through efficient and proper supervision of the biological cycles, as well as intra-component interaction which establishes crops. The ability to trap beneficial nutrients within a fallow system, thereby making them accessible to plants is achievable under enhanced fallow management. It is capable of restoring the earth's basic material, debris strata and biological action of the outer earth's crust which were diminished throughout the period of farming (Hooper *et* al., 2005). Interplanting promotes efficient resource use, through appropriate biogeochemical cycles, thus enhancing the amount of grains being produced as well as its security. Maize grown in interplant with leguminous plants has recorded greater yields and less weed interference relative to maize cultivated in mono cropping (Adesoji *et al*., 2013).

Natural fallow show considerable limitations under intensified rotations, which is usually identified with land and plants degeneration as well as class substitution from forested to herbal variety. Nevertheless, herbaceous varieties on rare occasions might not have what it takes to produce enormous quantities in regard to excellent-standard biofuel and to bring back soil fertility. Grown fallow species, with likelihood to enhance soil structure more than natural fallows, is a desirable step in farming intensification. Planted fallows comprising of herbaceous species are usually chosen and grown within some months till about 3 to 5 years (Alegre *et al*., 2005). Lately, several research have been carried out on enhanced planted fallows as well as adoption of inventive techniques in Africa, Latin America and Southeast Asia (Brookfield, 2004; Noland, 2018).

Sown fallow or planted fallow can act as weed-break by preventing the germination of seeds and establishment of weed seedlings. Some researches / studies have revealed and established the fact that herbaceous legumes are able to suppress weeds, reduced the frequency of weeding and boost crop output in the savanna of West Africa (Awodoyin and Ogunyemi, 2005a). Cover crops of attractive features should not only have the capacity to cover the soil expeditiously, it must also be able to smother weeds swiftly and bring about a reduction in the use of herbicides. Weed control had remained the highest time consuming operation of all the cultural practices in crop production in Nigeria. The growing of live mulches in the midst of arable crops simultaneously has great possibility of reducing man-hour used on weed control and the amount spent on weed management in addition to maximizing return (Weber *et al*., 2017).

Vigna unguiculata, (*akidi*), is a vigorous, annual trailing legume which germinates readily and does not exhibit any form of dormancy. The leaf is pinnately trifoliate and the flower has vexillary aestivation. It produces nodules with pinkish centre readily and requires no rhizobial inoculation for nodulation. *Akidi* can be used as a live mulch or cover crop solely or in company of other legumes. Considering the vigorous growth nature and ability to cover soil surface quickly, *akidi* may be used in planted fallow for suppression of weeds, enhancement of soil productivity and the control of soil erosion (Micheal and Tijani-Eniola, 2009).

The effectiveness of the rapid-growing nature of *akidi* and its green manuring benefits were examined in cropping system as well as its utility in conservation agriculture. Research on proper usage of *akidi* as a cover crop for weed control is required to develop integrated weed management strategies. Due to its vigorous growth and quick ground cover, *akidi* may be an ideal mulch interplant. Therefore, this study was designed to evaluate the growth, allelopathy and weed management attributes of *akidi* cowpea (*Vigna unguiculata* (L.) Walp.) in maize cropping systems in Ibadan, Nigeria.

OBJECTIVES

The objectives of this study were to;

1. Determine acceptability, cultivation and agricultural benefits of *akidi* in Nigeria;
2. Study the biology of germination of *akidi* seeds;
3. Study the early seedlings growth and biomass accumulation of *akidi* as affected by varying light intensity;
4. Evaluate the effects of *akidi* on weed suppression; and maize performance in Ibadan, Oyo state.

CHAPTER TWO
LITERATURE REVIEW

2.1. Weeds

Weeds are so common that most people may appreciate their flowers or color and without recognizing or understanding the detrimental impact they have on crop production. In Nigeria, looking at weeds from an agricultural system management perspective, weeds constitute the most serious pest. As a result, herbicides often account for most of actual pesticide use and they often cause irreversible damage to ecosystems (Damalas and Eleftherohorinos, 2011).

Over the years, numerous scholars have described the term weed based on their understanding and perspective. However, a plant that is growing were its not wanted and not planted purposely or a flora that is aggressive, stubborn, noxious, and meddle antagonistically with man`s activity is referred to as a weed (Hakansson, 2003; Paikekari *et al*., 2016). Regardless of the description being used, weeds are plants whose unacceptable features out-weigh their pleasant points, at least according to humans. The number of flora species in the globe is appproximately 374,000 plant species (Christenhusz and Byng, 2016) of which about 8,000 species of them are weeds, and of which only about 200 to 250 constitute a considerable issue in agricultural scheme globally (Memon *et al*., 2003). Depending on the provenance, territory, anatomy and biological peculiarity, weed can be grouped into categories as follows; annual, biennial or perennial (Hakansson, 2003).

Plants that can complete their stage of life in a year are called annuals for example *Chenopodium album*, Chick weed. They are raised by seeds, they grow, they reproduce, they produce seeds and they die within a year or less, for example *Alternanthera sessile*. Annuals multiply only through seeds and have no vegetative reproductive components. They are best curbed at the seedling phase.

Plants that are capable of completing their live phase in two years are termed as biennials for example bull thistle and garlic mustard. In the first year, the plant manufactures leaves and stores food. In the second year, it will produce fruit and seeds. In unplowed farmlands, meadows and fencerows, biennial weeds are common. They are best controlled at the seedling stage, when they have not produced seeds.

Plants that can live beyond two years are known as perennials for example *Nelsonia canescens*. They reproduce via embryo or by vegetative method. The flora sections that allow perennials to spread without producing seeds consist of stolons (creeping aboveground stems – for example, White clover and Strawberries), rhizomes (creeping below – ground stems – for example Milkweed, Quack grass, and *Eichhornia* spp.) tubers (enlarged underground stems for example potato, yellow nutsedge, dandelion) and bulbs (underground stem covered by fleshly leaves for example, tulip). Because perennials weeds can propagate (spread) belowground, they can be the most difficult weed to control. Pulling out the stem of plants cannot prevent the weed from extending to new areas.

Agricultural production is being placed in an undesirable state by weeds infestation. Mortimer (1990) identified three categories of financial losses due to weeds in crop production systems; namely production inefficiency, commodity yield reduction and loss of commodity price. Commodity yield reduction is caused by reduced components of crop yield through competition; weed parasitism, pests and diseases transmission where weeds act as alternate or alternative hosts. This is more intense base on the reality that weeds are usually present in large numbers and extremely competitive for ground moisture and nourishments (Westendorff *et al*., 2014). Weed nutrient competency can be determined by analyzing the herbaceous plant tissue in order to ascertain the nutrient build-up.

2.1.2. Weed Management

Weed management in cropping system is generally carried out using three approaches namely mechanical, cultural and chemical application (Mutambara et al., 2013). Weed incidence and management as well as obtaining labour for curbing them, have been a serious constraint to crop production over a prolong period of time most especially in smallholder farms (Weber *et al*., 2017). As indicated by Chikoye *et al* (2002), crop producers use 50 – 70% of available labour in weeding, which is usually done by hoe-weeding. Despite the energy and resources used in weed removal, harvests are usually too little, probably arising from inappropriate or inefficient approach to curbing weeds. Maize can tolerate weed interference for the first three to four weeks of cultivation and weed infestation at six to nine weeks from planting have been observed to no longer result in noticeable maize losses (Imoloame and Omolaiye, 2017).

Although, the critical period for weeding has been identified, this is usually not feasible due to shortage in labour, hence other control measures must be considered. The combination of two or more weed management approaches which is also reffered to as integrated weed management (IWM), is recommended as a more efficient substitute in regards to the present weed management procedure (Ullah *et al*., 2008). Mechanical weed control involves using manual or automated machine operated tools. Weed slashing could be done when the soil is too wet to dig or to reduce nutrient uptake by weeds (Rana and Rana, 2016). The amount of money used for the procurement and application of herbicides in the management of weeds is usually higher compared to cultural methods. However, the use of cultural practice such as the planting of appropriate legumes could be employed to reduce resources used in weed control. Legumes cover when cultivated in-situ as live mulch is potentially cost effective (Singh *et al*., 2014).

2.2. Fallowing

This can be described as a previously cultivated land not under rotation that is left uncultivated or unseeded for one or more growing seasons as well as regain fertility before being cultivated again (Lal, 2015). It may also be defined as a soil usually in continuous cultivations, meadows or pastures that is not being used for such purposes for a period of at least one year (Yang *et al*., 2019).

2.2.1. Sown Fallow

The intended use of cultivated species in a way to obtain one or more goals of native fallow within a shorter period of time is referred to as sown fallow. A lot of success has been recorded using this fallow approach for the purpose of obtaining greater productivity in smallholder farming schemes in the tropics. Alien leguminous trees, hedges, or herbaceous species are usually chosen and cultivated in fallow commencing in the early months period till about 3 to 5 years (Kaushal *et al*., 2017).

Due to its efficiency in shielding soil from erosion, reconstruction of soil nutrients and better control over weeds, there has been a series of campaign directed at encouraging the use of herbaceous legumes, in liu of natural fallow systems as a better alternative (Yirdaw *et al*., 2017). This helps to foster better approaches aimed at maximizing farming productivity and to reduce the burden on land use, such species like *Leucaena leucocephala*, *Pueraria phaseoloides* and *Gliricidia sepium* have been used successfully and is recommended.

2.2.2. Fallow Management

The improvement and management of fallow is as ancient as land cultivation itself. In the tropical region, fallow remains an essential component of the crop cultivation system. The expansion of crop production structure and the pattern of land use conversion are firmly corresponding alongside the development of fallow arrangement. Fallow characteristics have served as a basis for the classification of some farming systems (Jayne *et al.*, 2014**)**.

Fallow is also known to improve agricultural potential through: weed control, prevention of erosion, nutrient spinning as well as inclusion of natural substance to the ground through leaf litter, decomposition of root in addition to nitrogen fixation inside the ground by nodulating leguminous floras present in the fallow vegetation (Fanish, 2017)..

2.2.3. Crop Intensification and fallow system

Agriculture in Nigeria over the years has been plagued with food insufficiency. In recents years, the ever escalating growth in food need and population number has lead to her inability to meet the food need of the populace. The reality that the amount of harvested food has not measured up with population growth rate has continued to place the nation in a critical situation. The food production trend has been placed at 2.5% per annum, while the demand for food has witnessed a progressive increase which is greater than 3.5% per annum, due to an increase of 2.8% in the human populace (Kolawole and Ojo, 2007). However, these consequent problems emanating from increasing population as well as access restriction of agricultural land owing to contesting demands for arable lands could possibly degenerate the condition of agricultural land in Nigeria if not properly handled. As a result, the importation of food has significantly risen in Nigeria to mitigate these deficits. Moreover, a disparity exists between the farmer output and the demands of the consumers.

In a report presented by Bruinsma (2009), peasant farmers in a bid to address food shortage, can only apply moderate agricultural input for the sake of improving harvest for each hectare rather than agricultural production. Nevertheless, in most nations, this can´t be achieved anymore due to the reality that the vital environment required for the transformation of native vegetation to agriculture is absent or highly degraded in most sectors of the globe (Edgerton, 2009).

A bid aimed at attaining autonomy in food production is an integral constituent in a developmental plan, and has long been a crucial problem confronting most nations in Sub-Saharan Africa (SSA). A development plan was initiated by the government with the view to increase maize output via proper advocacy for improved production methods such as the utilization of enhanced variety of seeds, pesticides, fertilizer, herbicides and better administrative approaches. Several collaborators have contributed immensely toward the success of this program. In order to ameliorate the difficulties confronting the resource–poor farmers involved in maize cropping, numerous enhanced corn breed such as the dry spell tolerant, minimal nitrogen-tolerant, Striga-tolerant, stem borer-resistant and quick maturing varieties were introduced. Overtime, regardless of the various inputs, very negligible increase has been observed on the output of most edible grain crops (maize in particular) and even when such goals are attained, it is not lasting (FAO, 2006). Generally, a decline in soil richness is a key factor responsible for a decrease in crop productivity.

Before now, conventional farmers depended on lengthened fallow cycles for the reclamation of soil productivity, curbing of pest and pathogens as well as weeds (Styger *et al*., 2007). Long fallow is no longer attainable as a result of progressive population growth which made farmers expand to aggrandizement of arable land use in a bizarre manner and resulted in drastic reduction of fallow duration (Bruinsma, 2009). Farming intensification usually takes place at the cost of material base quality. A key determinant in the degeneration of Africa reserve base is nutrient deficiency.

2.2.4. Fallows for Sustainable Soil Fertility Improvement

All around the world, complementary drive and limitations are observed by impoverished farmers in the tropical zone. In situations where there is a spontaneous increase in human population, severe disturbance is placed on the land area; as a consequence fallow cycle is shortened. Conventional fallow management is no more suffiecient for restoring land for good crop output, and over time result in a subsequent decline in soil and vegetation (Brookfield, 2004). Furthermore, in an attempt to sustain the intensification of agricultural system, the development of knowledge and prowess for improving environmental and farming circumstantial situation are allowed to enjoy upmost priority.

The efficient management of the biorhythm as well as the interactions amidst the basic elements, greatly enhances the agronomic performance of an agro ecosystem. Enhanced fallow management are capable of trapping minerals and thereafter releasing it to available flora, minimizes the rate of weed infestatation, replenish soil organic matter (SOM), increases biomass covering and promote biological cycles that were perturbed during the planting period (Nielsen and Calderon, 2011).

2.2.5. Fallow Systems

Generally, two key renowned fallow structures exist: (I) Fallows made up of innate flora and, (II) Fallows which comprise of conciously sown, established diversity (planted fallow).

2.3. Legume Cover Crops

A leguminous cover crop is planted primarily with the aim of enhancing the soil structure, soil erosion control, soil fertility improvement and weed smothering via ground cover (Christainson *et al*., 2017), in addition to nutrient cycling and biological nitrogen fixation (Sullivan, 2003). A legume cover which is to be used as a living mulch, could be introduced prior to sowing, or implanted along or subsequent to the key crop that has been cultivated (Noland *et al*., 2018); it can be integrated inside the earth to serve as a natural (organic) manure dressing to aid crop production (Gachene and Kimaru, 2003), which is known as green fertilizer (Wittwer *et al*., 2017). The type of live mulch to be grown usually is decided based on the farmers' intended goals. Some of the objectives could be either to mitigate adverse soil erosion, elimination of root-knot nematodes, as source of fertility, pest suppression, and yield improvement in agricultural systems (Kimenju *et al*., 2007). Plant tending operations such as crop arrangement, planting frequency and fertilizer application adopted by the farmers significantly determine the development and output of a particular crop (Yeboah *et al*., 2014).

The genetic specificity greatly determines the growth and /maturity of a legume; for instance *Vigna unguiculata* germinates readily, as well as establishes quickly due to its large seed and relative resistance to moisture stress at shoot emergence (Da Silva *et al*., 2016). Leguminous species with the likes of *Vigna unguiculata* in particular, have well sound development and early plant vigour in two to three weeks after planting (Cook *et al*., 2005).

The current environmental situations (temperatures, light, soil fertility and moisture availability) could impact the performance of legumes to vary from one legume to another after a period of time in regard of their growth and development (Shrivastava and Kumar, 2015).

2.4.1. History and Origin of Cowpea

Cowpea (*Vigna unguiculata* (L). Walp.) is a primordial human food cultivation that has been grown as a vegetable plant since the Stone Age era (Singh, 2005). It root and successive cultivation is intently tied in the midst of pearl millet and sorghum in Africa (World Cowpea Conference, 2010). Due to insufficient archaeological information, there have been several contradictory opinions on Africa, Asia and South America as the point of origin for cowpea.

The actual site of ancestral root of the species is a bit hard to decide. Prior belief about the source and initial cultivation of cowpea were dependent on vegetal and cytological proof, knowledge about its geographic allocation plus developmental process, in addition to archival documents (Ng, 1995). As reported by Allen (1983), cowpea is considered to have been brought through the black continent into the sub-continent of Indian within 2000 to 3500 years ago. On the contrary, Ng and Padulosi (1988) are of the opinion that prior to 300 years before the coming of Christ; cowpea had arrived Europe and probably North Africa from Asia. They unfold the fact that, during the 17th century AD the Spanish took the crop to West India, and the slave trade from West Africa brought about the introduction of the crop to southern USA in the early 18th millenium. Pasquet (2000) was of the opinion that cowpea was cultivated within the subtropical and semi-arid province of Western Africa. Africa is the source of cowpea and also started domestication. The place of maximal variety of domesticated *Vigna unguiculata* is located in Western Africa, in Sub – Saharan Africa (Fuller, 2003). West Africa is without doubt the leading hub of the Vigna unguiculata domesticated varieties (Ng and Padulosi, 1988) and perhaps has been cultivated by grower in the area (Ba *et al*., 2004), the heart of multiplicity of uncultivated (native) *Vigna* varieties is southeastern Africa (Baudoin and Marechal, 1985).

Domesticated cowpea (sub sp. unguiculata) developed as a result of cultivation in addition to picking within the uncultivated cowpea varieties (var.dekindtiana). A loss in seed inertia as well as pod dehiscence was observed all through the period of domestication and after the species was domesticated via selection, which eventually prompted an increment in pod and seed diameter (Fuller, 2007).

2.4.2. Cowpea Taxonomy

According to Padulosi and Ng (1997), cowpea (*Vigna unguiculata*) is a parts of the Dicotyledonae class, in the order Fabales, family Fabaceae, subfamily Papilionoideae, tribe Phaseoleae, subtribe Phaseolinae, and genus Vigna and section Catiang. Morphological attributes was the criterion used in splitting the genus into sub-genera, the measure of genetic combination and terrestrial dispersion of the species (Verdcourt, 1970). Cowpea was earlier classified taxonomically by Linnaeus as *Dolichos unguiculatus* L., which was later in 1753 designated as *Vigna unguiculata* (L.) Walp.). Within 1753 and 1845, greater than 20 onymous (binomials) is believed to have been characterised (marked out) from cultivated *Vigna unguiculata* species. These binomials have been treated as distinct and grouped at infraspecific position amidst the second half of the 19^{th} generation. Now, domesticated types are put together from *Vigna unguiculata* ssp. unguiculata var. unguiculata and undomesticated annual varieties in ssp. unguiculata var. spontanea (Pasquet, 1993). Uncultivated perennial types have been referenced to ten taxonomic groups (Pasquet, 1997). Uncultivated annual cowpeas are crossed without difficulty with their cultivated counterparts (Ng, 1995).

Domesticated cowpeas varieties are pooled together in *V. unguiculata* subspecies unguiculata, that is redivided into four cultivars, namely Unguiculata, Biflora (or cylindrical), Sesquipedalis, and Textilis (Ng and Marechal, 1985). There have not been any contradictory delibration, ever since the acceptance of this classification. The taxonomy and classification of the uncultivated taxa within V. unguiculata, seems complex, and may at times be puzzling. Over 20 nicknames were utilized before now to identify uncultivated taxa under *V. unguiculata* species involved. An intensive study was carried out at IITA to categorise more than 400 uncultivated *V. unguiculata* accessions (Padulosi, 1993). This research together with sampling of live resources in the field and illustrations in key herbaria in Europe and

Africa, in addition to cytological investigation, has brought about the authorisation of fresh groups, as well as a modification in the nomenclature of a number of classes (Ng, 1995). Also, a corresponding research on classification of uncultivated varieties was carried out side by side inside Catiang section (Pien-naar and Wyk, 1992).

2.4.3. Cowpea Genus

The subdivision vigna, in the family Fabaceae once known as Leguminosae, is made up of greater than 100 uncultivated species (Schrire, 2005). *Vigna unguiculata* is jointly connected to Phaseolus that is a collection of above 20 species which are indigenous to the tropic zones of the modern globe. Several of the species that were initially classified under the Phaseolus subfamily are currently in Vigna. The subdivision Vigna is treated as an agriculturally relevant taxon in several third world (developing) nations. This taxon comprise of 10 cultivated varieties (crops) like cowpea (*Vigna unguiculata*), which are major dietetic fundamentals for billions of mankind (Tomooka *et al*. 2011).

Some of these species Vigna serve as an essential cover, forage and green crops in various sectors of the globe. Annually about 20 million hectares of Vigna is being produced globally, with virtually all being produced in the developing countries. The numerous outstanding attributes embedded in the commercial Vigna varities have placed them as an essential inclusion in most farming systems. Many grow well in acute conditions like sandy beaches, arid lands, calcareous knasts, high temperatures, low-rise, marginally soils, with minimum financial inputs (Marécha *et al*., 1978). Nevertheless, a synergetic network has emerged among root nodulating bacteria, which have been conformed harsh weather conditions renders help so as to achieve reduced-input continuous farming (Yokoyama *et al*., 2006; Tomooka *et al*., 2010). Several of these cowpea breed gives various suitable for eating harvest, and these foodstuffs assist small scale farmers with steady supply of edible material all through the planting period and not-moist seeds that are not difficult to load up and drive.

2.4.4. Uses and Importance of Cowpea

Cowpea is of key relevance to the nourishment and sustenance to billions of community's in developing nations of the tropics, where it serves as a major supply of eatable amino-acid which aid in supplementing the nutritional constituents in less–protein foodstuffs like cereals and tuber products (Singh, 2002). The grains of cowpea comprises of 24% crude protein, 2% fat and 53% carbohydrates as well as an excellent supply of dietary fiber, minerals and phosphorus (Adeyemi *et al*., 2012); and it is among crops with the topmost plant-based folate substance (Timko and Singh, 2008). Cowpea leaves and flowers serves as nourishment to man. Cowpea leaves contain protein between 29 and 43% on a dry weight basis; leaves are also a secure phosphate, zinc, iron, vitamin ascorbic acid, beta-carotene, and folate source (Karakou *et al*, 2017). According to Misra (2012), cooked-up foliages contains threefold more iron, two-third the protein, eight times the riboflavin, seven times the calcium, half the phosphorus, five time the folic acid as well as *β*–carotene of the prepared seed. The proportion of amino acid present in cowpea leaf was observed to be of high quality than what is present in the seed (Misra, 2012). Cowpea is sometimes reffered to as "poor man's meat" or "vegetable meat" by scientists because of its rich protein content (Venkatesan et al., 2003).

The undeveloped seeds and pods of cowpea can be used as a suitable vegetable for cooking (Agbogidi and Egho, 2012). Cowpea can effectively provide quality forage hay, and silage for livestocks. In Instances were it used as hay for livestock, it must be slightly grazed (feed on) after anthesis (FAO, 2012). A few varieties of cowpea are particularly cultivated to serves as forage for wildlife such as the deer (Ball *et al*., 2007). It has provided livelihood to rural and urban women that carry out trading on freshly harvested cowpea as well as refined cowpea foods and snacks (FAO, 2012).

In situations where cowpea is utilized as green fertilizer, it can effectively turn into the soil between 2,500 – 4,500 lb/acre/yr due to it`s vigorous growing ability, while at the same time making available 100 – 150 lb/acre of N to the successive plant (Clark, 2007). The active primary metabolite present in the plant may be released as allelochemicals into the environment and could possibly lead to suppression in weed population (Clark, 2007). In addition to fixing nitrogen, farmers commonly grow cowpea types that mature quickly and create an understory that cools the soil, prevents soil loss, and minimizes weed pressure (Tani *et al*., 2017). Cowpea thrives more excellently in friable soils than several other legumes; it is extremely drought tolerant and withstands adverse types of soil pH for a legume, as well as low P and organic matter levels; it forms effective symbioses with mycorrhizal fungi and has a high N fixation ability (Raimi *et al*., 2017) .

2.4.5. The Biology of Akidi (*Vigna unguiculata*)

It is linked with the family Fabaceae and has the accession name TVu-14191 with the accession number 14191 as collected by International Institute of Tropical Agriculture (Table 2.1). It`s country of origin is Nigeria. The plant is partially-erect with branches that do not touch the floor but tend to be horizontal to the core stem. Vines twines moderately with intermediate growth vigour with height greater than 37.5 cm and width greater than 75 cm. It has trifoliate leaves. It has a sub – globose terminal leaflet with length of 151.0 cm and width 100.0 cm. Plant has branches numbering up to eleven, main stem nodes numbering twenty and having raceme in upper leaf layers. At 35 days to bloom and 70 days of plant to first ripe pod, pigmentation pattern on plant is extensive; flower is completely pigmented while the green pods have pigmented tips. Each peduncle has between two to three pods, attached at an angle of 30 degrees to 90 degrees. Pod curved about 147.0 mm long and 8.0 mm wide with about 13 locules per pod.

2.4.6. Phytochemical Contents of *Vigna unguiculata* Shoots and Roots Aqueous Extracts.

The analysis revealed shoots to have a phenolic content of 621.84 mg / 100 g and which was greateer than the root phenolic content of 434.80 mg / 100 g. The shoots had flavonoid content of 182.89 mg / 100 g and were greater than the roots extract content of 161.11 mg / 100 g. The analysis also revealed the shoots as having tannin value of 88.39 mg / 100 g which were higher than the roots content of 71.54 mg / 100 mg. The roots saponin content of 8.32 mg / 100 g was less than the shoots content of 9.69 mg / 100 g. The shoots had alkaloid content of 3.00 mg / 100 g and were higher than the roots content of 1.98 mg / 100 g. Also, the shoots (47.45 m / 100 g) had higher glycosides content which was higher than the root content of 38.48 mg / 100 g.

2.5. *Vigna unguiculata* as a Green Manure

The addition or cultivation of any fresh green crop in the soil, or its immediate blooming in a bid to improve the sustainability of land, is considered as green manures (Sullivan, 2003). Green manures acts as an efficient substitutes to inorganic fertilizers in the control and conservation of land richness as well as harvested yield.

Table 2.1: Taxonomic Categorization of Akidi

Rank	Scientific Name and Common Name
Kingdom	Plantae
Class	Dicotyledonea
Order	Fabales
Family	Fabaceae
Sub-family	Fabiodeae
Genus	*Vigna*
Species	*Vigna unguiculata*.
Accession name	TVu-14191
Species authority	(L.) Walp.
Common name	Akidi (South Eastern Nigeria)

.

Green manure adds natural constituents and it is a source of nourishments to arable land in addition to shielding the topsoil from destruction as a result of cyclones, floods, and sunlight, help to make atmospheric nitrogen available (Fabunmi and Agbonlahor, 2012). In the course of natural constituent disintegration by microbes, syntheses are produced that are impervious to decay for example glues, waxes and resins (Sullivan, 2003). These syntheses and the fungus, mucus and sludge formed by microbes' aids in soil agglomeration. A nice soil assemblage is not difficult to turn over or plough, it allows air movement easily in addition to excellent H_2O percolation. High rate of organic matter deposits have effect on terra firma. Thereby, serves as an avenue to tap from a vast array of benefits in Agriculture. Legumes such as cowpea could possibly be cultivated to serve as summertime cover crops in order to fix nitrogen addition to natural matter (Martens and Entz, 2011). Cowpea has the attributes that enables it serve as a suitable green manure due to its vigorous growth, quick break down and fast nutrients turnover. Green manure could be turned straight into the earth, left on the topsoil as mulch material or fertilized prior to use and intended to achieve a two-fold aims as a channel of feed and green manure. A few green manures can be utilized as feed for livestocks, plus the obtained animal dropping applied as manure.

Recently, the awakening to environmental awareness has intensified the utilization of organic materials like green manuring crops, as well as the urge to minimize expenses (Pappa *et al*., 2006). Organic farmers, tends to make use of this management approach as it is perceived to be more eco-friendly in addition to being cost effective when compared to synthetic fertilizers (Edmeades, 2003).

In a study conducted in Brazil, between 1995 and 1998 maize were planted in intercrop with cowpea, these legumes (cowpea) were seeded in double rows to one row of maize. During the blooming period, the legume shoots served as green manure for *Zea mays*. The legumes were divided into three groups, including 0, 1 or 2 rows for every row of corn and then turned into the soil or implemented as topsoil mulch in the field. The petrified nutrients were absorbed promptly by the *Zea mays* crop. As a result, noticeable rises in nitrogen constituent were observed in treatments having the two-row incorporation of green manure as well as its integration in the ground. The green manuring of the shoot biomass raised maize output tremendously following cover cropping. The intercropping of naturally occurring material has also been noted to have increased noticeably in the most advanced surface strata (0 – 20 and 20 - 40 cm) (Hödtke *et al*., 2016).

According to Yusuf *et al*. (2009) maize grown after soybean gave rise to a noticeable boost of 46 percent in maize output than after maize and natural fallow. Kureh and Kamara (2005) observed a 28% increase in *Zea* mays output following one cropping period of soyabean as well as a 21% increase following one cropping cycle of cowpea when compared to constant planting of maize. After two cropping seasons of soyabean an increase of 85% was observed in corn output as well as an increase of 66% following two – cropping periods of cowpea compared to constantly grown maize. Also, Akinnifesi *et al*. (2007) observed a 34 percent grain yield increase of maize over four consecutive seasons of gliricidia – maize intercropping in correlation with non-fertilized sole maize.

2.6.1. Phenological Development of Legumes

Temperature is the main factor that ascertains plant phenological stage (Elmore, 2010), which is usually expressed in terms of thermal time (TT) or growing degree days (GDD) (^{O}C/days) (Nielson, 2012). Thermal time is called the degree of temperature above a defined base limit temperature, under which an organism does not develop or grow very slowly (Stockle *et al.,* 2012). It varies from one crop to another and is compiled all through its developmental period commencing from planting till crop output, in such a way that a crop can enter the subsequent phase of growth as soon as the thermal time attains the thermal time prerequisite for the particular phase (Stockle *et al.,* 2012). For example, the base temperature for common bean is 8 ^{O}C (Hatfield and Prueger, 2015). Crop phenology could be influenced minimally by light, soil water content, nutrients and salinity (McMaster *et al*., 2002). Based on temperature, accumulated thermal time (TT) can be computed as follows;

TTDD = Σ 0DAP ((Tmax –Tmin)/2) - Tb   (Mburu, 1996)

Where;

DD represent number of days after planting

Tmax represent maximum temperature (^{o}C) per day

Tmin represent minimum temperature (^{o}C) per day

Tb is the base temperature

The minimum and maximum temperatures for most plants (crops) are usually 10 ^{O}C to 30 ^{O}C respectively because most plants do not grow outside that temperature range (Elmore, 2010).

The phenological stages in legumes such as time to emergence, 50% flowering, 50% podding and physiological maturity are reached at different periods in their life cycle (Stockle *et al*., 2012). It has been experimentally proven that variations exist in the time duration required for a legume to attain its flowering stage in a growing season (Shavrukov *et al*., 2017). Flowering in legumes coincides with the time when most root nodules are active for nitrogen fixation which, however, assists in land productivity enhancement (Liu *et al.,* 2011b). The number of nodules present in legumes at flowering differs. However, a cost effective means of nitrogen supply en route for earth is biological nitrogen fixation (Vitousek *et al*., 2013).

Legumes are specific and unique in their growth characteristics. Some legumes are tall and erect (*Crotalaria* sp.), short and erect (e.g soyabean), while others are creeping or spreading (*Centrosema pubescens, Vigna unguiculata*). Quick ground cover for weed suppression and soil erosion control is being facilitated by creeping property of some legumes. Rapid foliage establishment for ground cover is exhibited in annual leguminous species (Snapp *et al*., 2005). Also, legumes with the ability to establish fast coupled with creeping characteristics makes room for good ground cover which is essential for soil erosion (Wilkinson and Elevitch, 2010) and weed control (Uphoff, 2006).

2.6.2. Legumes Biomass Production

Plant biomass can be defined as the mass of living flora substance accommodated beyond and beneath a section of earth outer space per particular phase (Neto *et al*., 2012). The beyond soil biomass consists of the (shoot comprising stem, leaves and reproductive parts) and the below ground biomass is made up of the roots (Neto *et al*., 2012). Production of above ground biomass is greatly dependent on the transpiration, intercepted radiation and uptake of nitrogen by plant (Thuille and Schulze, 2006). Limitation in growth can be made possible by any of these factors. Biomass accumulation estimation is of necessity, when legumes are cultivated for inclusion in the soil as green manure to increase fertility (Sanginga and Woomer, 2009).

When legumes approach maturity, litter fall is experienced as senescence sets in (Ansari and Chen, 2011). One legume differs from another in the amount of litter it sheds even under the same environmental conditions (Akinnifesi *et al*., 2010). Both leaf and stem litters contribute towards soil amelioration in various ways. Leguminous cover plants are known to effectively provide nutrients and natural substances by litter. Hence, organic material aids in improving ground texture and H_2O retaining ability, aeration as well as regulates soil temperature (Gachene and Kimaru, 2003).

2.7. Effect of Light on Plants

Light is generally highly directional from the ecological view point. Illumination is enormously inconsistent. It fluctuates within a tremendous period, often very quickly. Light is needed by most plants, although some can do without it (Carnus *et al*., 2003). Plants possess special traits that help them tolerate wide range of light regimes (Kumar Sit *et al*., 2007). Not only individual plants but also plant communities show adaptations to different intensities of light. In order to ensure plants sustainability two basic requirements should be attended to. Foremost, luminosity should not be as intense to the extent of inflicting severe harm at some point during its life cycle and subsequently, it should have adequate amount of illumination as well as at intervals. The amount of luminous energy being transmitted should be higher than the minimum level of stimulus perceived (threshold) by life form involved, in addition, the net sum of illumination made available all through the stages while it is required should be sufficient. Plants can be classified on the basis of their light requirements; those that need high light intensity and can`t and would not be able to carry on or grow under low light illumination condition are described as non-tolerant or heliophytes, while those that can grow in shady places are termed tolerant or sciophytes. Obligate and facultative floras are together present in the two categories, wherein the facultative floras exibiting a great deal of disparity in their measure of flexibility (Wiener, 2004). True shade floras are obligate sciophytes and are not able to withstand high illumination (Keuskamp *et al*., 2011). In forest ecologies, plants show stratification or layering as they are arranged in different strata due to their shade tolerance.

Heliophytes (sun floras) have high thermal climax for chemical process and also have high rate of respiration. Examples are maize (*Zea mays*), sunflower (*Helianthus annuus*) and Sugar cane (*Saccharum officinarum*). Most sciophytes in nature thrive as undergrowth and beneath vegetations canopies that have dense leafy layers (Lambers *et al*., 2008). Examples include; several plum, ferns and fern allies such as whisk fern (*Psilotum nudum*), belladonna (*Equisetum* spp.) and cone (*Lycopodium* spp.). *Vigna unguiculata* can tolerate moderate shade (Clark, 2007).

On the other hand, a number of floras are more flexible and are thus distinct from the others, as heliophytes exists that can develop under incomplete shade as well as sociophytes that are not affected by high concentration of illumination. However in the two instances, the vegetations are better developed in environments that completely or almost meet their illumination demands. Early colonizers of rainforest are usually sun loving, whereas successional species, that occupy the place following initial inception of heliophytic trees, are plants that thrives best at lowered light intensity (shade - loving). Heliophytes are able to maximize high threshold levels effectively more than shade – loving ones. Nevertheless, irrespective of illumination concentration, sun-loving plants will in no way be able to attain its light saturation point within normal situation. Notwitstanding, shade – loving plants would generally attain saturation point at illumination concentration of barely 20% full sunshine. When sun – loving plants are under low light intensity, it decreases their development, propagation and consequently outputs. On the contrary, shade – loving plants are generally incapable of thriving under full sunshine due to the fact that their chlorophyll synthesis is relatively torpid to correlate decay of the colour by full sunshine. In a bid to maximize effectively the accessible light, shade – loving plants variety grow big foliage that has widespread superficials comprising of a high absorption of haemoglobin and masking pigment.

Light is required by green plants prior to the making of leaf green (haemoglobin) in the plastid. When seeds germinate in low radiant energy conditions the seedling of such a plant would fail to evolve their natural greenish pigment. The unavailability or insufficiency of sun light to floras usually would result in blanching, which is their colour is forfeited and they adapt a negative growth form, while on the contrary, excessive illumination leads to the obliteration of haemoglobin. In a number of floras, excessive assimilation of illumination through the engrossed fiber-tissues is obviated via the shielding activity of coagulated plastid or of vast expanse of plastid close to the superficial. In a number of varieties, as soon as the radiance becomes very lucid, the plastid queues up at the rear of each other so as to enable a greater amount of light to penetrate via the foliage within the plastid. Once the radiance eventually turns out to be inadequate, the plastid is fanned and takes up a utmost amount of incident illumination (Carnus *et al*., 2003).

2.8. The Concept of Allelopathy

Rice (1984), reports that any undesirable or unexpected injury to flora caused through secretion of the deleterious synthesis into the surroundings via another plant is deemed to be allelopathy. This has been further described as any cognitive operation that includes secondary metabolites formed via floras micro-organisms, viruses or fungi that encourages the increase and improvement of farming and organic system (Farooq *et al*., 2013). Floras growth and maturing procedure includes light reaction, breathing, perspiration, biochemical digestion in addition to amino acid and ribonucleic acid combination could be inhibited by allelopathic compounds (Chou, 2006). Based on their concentration and responsiveness of the obtaining aimed plant, their accomplishment might in theory be stimulatory, unbiased or inhibitory (Rice, 1979).

Generally, in allelopathic studies ″seeds have always been the preferred bioassay due to the fact that they are quick to respond to allelochemicals″, thus seed sprouting has usually served as the ideal assay in allelopathic investigation (Aliotta *et al*., 2006). The implementation of seed sprouting in biological assays in allelopathy is however beneficial because sprouting of plants represents a crucial phenomenon in the multiplication and maintenance of many types of plants (Ishii-Iwamoto *et al*., 2006). The discharge of chemicals is an integral feature in balancing the composition of the crop community in organic and agro-systems (Inderjit and Duke, 2003). These processes are made possible by creating biological pressure for the sprouting seeds in a sort of allelopathic intrusion (Gawronska and Golisz, 2006).

2.9. Use of Cover Crops in Weed Management

An appropriate and sustainable option for farmers that have low resource base is the use of organic amendments which are cheaper and safer when compared to conventional Agriculture that is usually identified by high external inputs. The utilization of biological resources that include Legume Cover Crops (LCC) for the control of weeds is termed organic amendments (Bationo *et al*., 2004). According to Obalum *et al*. (2017), the use of LCC as 'live mulch' to maintain soil cover was observed to control both weeds and soil erosion in Nigeria. At maturity, if slashed back into the soil their residues prolong the duration for soil cover and weed control (Wallace *et al*., 2017).

Key factors that facilitate effective weed suppression by LCCs include their ability to develop fast ground cover, their twining ability and allelopathic properties (Ekeleme *et al*., 2003). These properties vary with species. *Vigna unguiculata* (Akidi) is suitable for weed control because of its high biomass production, good ground cover and twining ability.

2.10.1. History and Importance of Maize in Nigeria

Maize (*Zea mays* L.) is included in the taxonomic group Poaceae. It is an annual cereal plant endemic to Mexico (Hugar and Palled, 2008). Corn which is a preferred important staple crop is placed on third position in Nigeria, following kafir corn and oats (Adebayo and Ibraheem, 2015). The name maize is supposed to come from the South American Indian Arawak-Caribbean term mahiz. It is generally reffered to as Indian corn (Purseglove, 1992). According to Osagie and Eka (1998), it is believed to have been brought into Nigeria perhaps during the sixteen hundreds by the Portuguese. Maize is usually cultivated on a subsistence and commercial scale as an essential food, fodder, and industrial crop in Nigeria (Eleweanya *et al*., 2005). Maize is cultivated primarily for its grain which is a rich source of carbohydrate. Its nutrient constituents is as follows; carbohydrate (65%), protein (10 – 12%) and fat (4 – 8%) (Iken and Amusa, 2004). Maize consists of minerals and vital micronutrients for instance beta-carotene, aneurin, folic acid and tocopherol; and in addition vitamins A, B, C and E (De Groote, 2002). Maize is essential in human and animal dietary intake, while it is being processed in the industry into starch, oil and alcohol (Onuk *et al*., 2010). It is extensively used in traditional food preparation, including pap, tuwo, gwate, and donkunu (Abdulrahaman and Kolawole, 2006).

Nigeria is listed universally as 13th biggest producer of maize and second-massive producer of maize in Africa, after South Africa which is presently the 9th massive producer of maize in the globe and the greatest producer of maize in West Africa, with yearly maize yield of 14.982,000 metric tons in 2014 (World Data Atlas, 2014). Maize is cultivated all through the nation (both yellow and white varieties) with its major production in North central region. The ecological zone for maize production comprises of the mangrove swamp, great depth of water, inundate plain, rain fed plain, and rain fed highlands (IITA, 2013).

2.10.2. Environmental Requirements of Maize

Environmental issues act as a very important driving force under the invigorative factors influencing excellent maize yield. In a bid to attain optimal maize yield by the farmers, these necessary factors should as a matter of fact be adequately harnessed and managed in agreement to sustain the increase and expansion of the crop (Ncube *et al*., 2012). The ecological needs affecting maize plant development and production are as follows; illumination, climate, mineral, earth and water.

The amount of illumination required by maize is high and its process for absorbing carbon provides it with the elemental scope for starch synthesis, as long as there is sufficient solar radiation. Thus, several circumstances together with insufficient accessible earth moisture tend to decrease seed sprouting (Etejere, 2004). Germination rate in a good number seeds is greatly dependent on the volume of moistness which is accessible to the seeds (Manz *et al.*, 2005). Maize is at its best performance within the temperature range of 20^{O}C to 25^{O}C (Arora, 2004).

The maize plant water use efficiency is fairly high. The amount of annual rainfall should not be less than 600 mm, for the rain fed crops (Arora, 2004). Nevertheless, water constraint is strongly linked with the climate (FAO, 2007). The maize crops remove moistures reserves in the soil via their roots. The bigger this store bank is, the more improved the bringing in of water and water retension ability of the soil via adequate soil through good land preparation (turn out/tilling) improvement with organic matter (Zobel, 2005).

2.10.3. Maize Agronomic Requirement

Maize is cultivated by sowing the seeds directly in the soil. There is variation in the growth/maturity period, with the 2008-DTMA-Y-STR variety which reaches 50% tassel between 44 to 57 days and reaches 50% silk between 47 – 60 days (Badu-Apraku *et al*., 2012). Consequently, maize farming requires the subsequent actions; field location, sowing, crop protection (fertilizer use, weed management etc.), harvesting and preservation (Iken and Amusa, 2014).

Selection of site is a necessary step taken in order to ensure good maize production. An ideal land for maize production should be well drained, have good amount of evenly distributed rainfall, and the presence of wind breaks where the wind speed is high (Badu-Apraku *et al*., 2012). Maize is usually cultivated as a monocrop using mechanized equipment, whereas in substitence farm scenario, the land is prepared using cutlasses and hoes to slash the weeds.

The application of fertilizer in maize production is carried out at three weeks after sowing (Miao *et al*., 2007). It is however imperative to know that the quantity of soil ammendments to be administered is reliant on two features; the predictable maize produce that seems achievable in the area, in addition to the soil richness as ascertained through soil analysis.

A major problem militating against high - quality maize production is weed control inefficiency. When maize is disturbed during its early growth stages, it cannot recover fully from it (Rana and Rana, 2016). Weeds can be restricted in large farms through the utilization of tractor mounted cultivators. In place of cultivators, inorganic herbicides could serve as a suitable approach in weed control. In smallholdings, initial clearing is carried out usings manual hoe at three (3) weeks after sowing and two additional weeding are usually performed at equivalent interval. On the other hand, it will be imperative to realize that chemical weed control should be thoroughly checked in accordance with the cropping pattern applied, the land, the precipitation and the manner of weed incidence (Badu-Apraku *et al*., 2013). Nevertheless, it is vital to ascertain whether it is cost-effective, permissible in regards to time frame, while also considering the actual amout of weeding per hectare.

The maize cobs can be harvested preterm (green) or full bloom and desiccate, depending on usage. The average return for maize is nearly 3.6 tons / ha. However, the mean maize output is within 1.3 – 1.5 tons/ha, in Nigeria (Badu-Apraku *et al*., 2013).

2.10.4. Maize Response to Uncontrolled Weed

Maize (*Zea mays* L.) is an annual, sturdy and is a high growing plant, which is predisposed to competitiveness from unwanted plant at early stage of growth (Imoloame and Omolaiye, 2017). Average global weed economic loss varies between 34 to 60% (Oerke, 2006). The maize output obtainable in Nigeria is less than anticipated arising from numerous factors including weeds, poor soil richness and inadequate workforce. In a report by Lagoke *et al*. (1998), 60 - 81% loss in maize turn over (harvest) was observed as a result of weed infestation. Also, Imoloame and Omolaiye (2017) observed losses greater than 89% due to uncontrolled weeds infestation in maize yield. In Nigeria, an average of 51 – 100% decrease in maize output arising from weed infestation has been recorded (Akobundu and Ekeleme, 2000).

Cultivated floras and wild plants hamper developmental actions of one another at various stages and contend for water, minerals, nutrients and illumination as well as hamper outputs (Maqbool *et al*., 2006). Chikoye *et al*. (2005) observed 50 – 90% decrease in maize output due to season – long weed competition. The mean achievable harvest by small farms is significantly lesser than yield exhibited in African research plots making use of the most excellent management approach. In a study carried out by Akobundu (1987) maize parcels kept weed-free for the initial fifty - six days following planting were observed to be the most productive. Postponement in initial weeding by a week might reduce maize output by thirty three percent, and two weeks hindrance in subsequent weeding might lessen maize out put by twenty five percent (Orr *et al*. 2002). Inadequacy of labour early in the cultivation phase brings about an overdue weeding and successive 15% to 90% reduction in maize yield owing to competitiveness (Kibata *et al*. 2002). In line with Nasrollahzadeh *et al*., (2014) weed infested maize plots left weedy all through its growth phase was observed to have led to 53% decline in total yield of plant material when in comparision with control plots kept weed–free all through crop growth. In Nigeria, one time weeding operation in maize cropping led to a 42% reduction in output in contrast to plots weeded three times (Chikoye *et al*., 2004).

2.10.5. Maize Response to Inorganic Fertilizer

To achieve optimal production of maize crops, soil modification for the most limited nutrients, which in most cases are nitrogen, could be necessary. The use of inorganic fertilizer in Africa has been on the low side, possibly owing to the soaring purchase price and untimely accessibility of chemical fertilizer. The use of fertilizers has currently increased tremendously as a result of input subsidies as seen in countries offering subsidies for inputs like Malawi, Mali and Nigeria (Druilhe and Barreiro-Hurle, 2012), a trend with the prospect of increasing in the future.

Maize being a crop of major concern within the forerunner agricultural programs of the Nigerian government since the year 2012, maize growers has been awarded purposive assistance in regards to obtaining subsidy for soil ammendment and enhanced seeds (Federal Ministry of Agriculture, 2011). However, the amount of dangerous input (like fertilizer) to be used in each treatment unit should be minimized by farmers. Also, contemporary inputs like fertilizer have been found to augment equally the average and the unpredictability of the gross proceeds to production (Just and Pope, 1979). Studies have revealed that several maize growers in Nigeria are currently working in nitrogen into the soil above amounts regarded to be economically favorable (Liverpool – Tasie *et al*., 2016). Sadly, fertilizers are often not directed at a specific crop, soil or agro-ecology and applications have depended on generalized suggestions for many years (Giller *et al*., 2011).

However, because virtually all Nigerian corn farmers generally render NPK as a base fertilizer or urea as foliar spray solution alongside NPK, the link between worked nitrogen and phosphorus is high. However, the maize reaction to nitrogen and phosphorous administration can not be evaluated individually. Also, even as crops typically ingest the bulk of used nitrogen during comparable implementation, the phosphorus embedding method is much longer (Goedeken *et al*., 1988; Sheahan, 2012) in so doing, has made it complicated to effectively categorize the yield reaction of applied against formerly occurring phosphorous. As a result of this, most research on the effect of fertilizer on cereals usually concentrates on nitrogen (Liverpool – Tasie *et al*., 2016).

The endogenous selection of fertilizer and the amount of fertilizer used in a corn farm is a significant issue in determining the effect of fertilizing on yields. The use of fertilizers is possible with the intention of propelling farms (for example, the overlooked disparity of soil properties, administration or potentials) and this limits all underlying explanations to the application of fertilizers in a return model. This combination of the unnoticed and autonomous error term impact and the fertilizer application rate lead to an inclusion of ordinary least square (OLS) estimators (Liverpool-Tasie *et al*., 2017).

However, Kihara et al. (2016) conducted a field research survey to assess maize reaction to NPK and other mineral inputs. Cluster assessment disclosed that maize plant in eleven percent of plots had high response to nitrogen use, twenty - five percent (i.e., twenty – one percent marginal and four percent productive) ‘inresponsive’ to another nutrient or soil adjustment, twenty – eight percent being ‘low receptiveness’ and thirty - six of ‘medium receptiveness’. These observations shows that limitation to crop productivity differ greatly even the inside same field and that attending to constraint in secondary and micronutrients in addition to intensifying soil organic carbon can enhance reaction to soil ammendment.

Also, in a study by Liverpool – Tasie (2016) revealed that maize production is mainly a low-acreage farm venture in Nigeria. The mean maize field is within 1 and 1.5 ha, controlled by a midlife man who possesses inadequate utilization of inundation as well as high technology use. Whereas, close to twenty percent of maize fields utilize procured seed, nearly fifty percent of growers apply various unnatural (weed killers and pesticides) in maize cultivation; the mean applicable fertilizer rate is forty and forty - five kilograms of applied nitrogen. According to Sheahan and Barrett (2014), the unrestrained utilization of fertilizer in Nigeria is around 130 kg/ha. Maize prices differs greatly across the diverse geographical zones of Nigeria, which likely disclose locality dissimilarities like closeness to the town seaport (for fertilizer), local utilisation and cultivation of maize.

2.10.6. Maize Response to Organic Fertilizer and Green Manure

Natural sources of nourishments include; animal waste, left over from dietary processing and municipal biosolids garbage alluvium, waste waters, pomance and vinasse. According to Mondini and Sequi (2008), both the consumption of un-renewable reserve material and surplus of energy outflow are eluded from reprocessed organic remnants as manure for augumentation and improvement of cropland. Nevertheless, this approach will be important in mitigating the adverse effects of global warming by sequestrating soil carbon.

Several beneficial impacts of untreated and composted organic material exist, for example the discharge of nutrients develops gradually, thereby needing additional time to be determined. Diacono and Montemuro (2010) witnessed a 90% rise in soil organic carbon in regards to unimpregnated soil; and greater than 100% increase when set side by side with inorganic fertilizer. These advantages can only be obtained with continuous applications of natural nutrient materials available. Also, such application may probably accumulate soil organic N for mineralization in the subsequent farming period. On the other hand, the addition of exogenous natural material to crop land has the potential to boost the biological roles of soil for greater than 15 years following application, as these depend on the amount and sort of material applied. As reported by Van-Camp *et al*. (2004), soil physical productiveness is augmented, majorly by enhancing aggregates firmness.

Natural manure when applied as a partial replacement of mineral fertilizer, attained similar output as of the maximum amount of mineral treatment (8.8 and 8.9 t ha^{-1}, respectively) assuring the peak addition of overall organic carbon and the lowest N mineral soil shortfall at the completion of the investigation (Montemurro *et al*., 2006).

The amount of carbon dioxide available to crops is increased all through the breakdown of green manure. The solvability of lime is enhanced and hence quickens the restoration of alkali soils (Fabunmi and Balogun, 2015). Studies have revealed that green manure may serve as a replacement for as much as sixty to hundred kilograms of inorganic nitrogen fertilizer utilized in the cultivation of cereals per hectare (Kimetu *et al*., 2004). In a report by Maobe *et al.* (2011) green manure was observed to promote the accessability of natural phosphorous and extra micronutrients to crop plant in addition to improving soil aeration as well as natural materials (Maobe *et al*., 2011). The incorporation of products obtained from nature is a major benefit from green manures, and around forty to sixty percent of the entire quantity of nitrogen present in green manure is accessible by the subsequent plants. A key advantage achieved from green manures is the inclusion of natural materials into the earth and around forty to sixty percent of the bulk sum of nitrogen enclosed in green manure is accessible to the subsequent plant (Olesen *et al*., 2007). In a survey conducted by Mamzing *et al*. (2016) it was disclosed that green compost has the attribute of improving maize yield for the extremely poor farmers in Nigeria. In a report by Sileshi *et al*. (2009) the reaction of maize to leguminous green dung proved to be much better than unamended soil as well as soils of natural fallow system.

According to Tamiru (2013), in a study where several green manures were incorporated into the soil at various stages of development, he observed that cowpea had the utmost amount of fresh mass and total as well as active nodules more than others, mostly at mid-blooming phase of development. This gave the highest biomass and grain outputs of maize plant in the following cycle and was considerably greater. In this respect, cowpea enhanced the dry matter and grain yields of the following corn crop, noticeable for distinctive crop growth and dry matter production. The economic assessment showed that the maximum net advantages were acquired at the stage of pod development as well as green manure from cowpea.

In a report by Fageria (2007), green manure was advocated for use in a situation where soil fertility is dwindling and inorganic fertilizer seems unattainable. A vast number of leguminous green manure has been attributed to have the ability of accumulating significantly high amount of N within quite a short period. Cowpea and soybean within a space of six (6) weeks can accumulate up to seventy – five and one hundred and fifteen kilogram nitrogen per hectare, respectively. Also, in a research to assess maize response to incorporated cowpea green manure, in the first year maize grain output was not extensively diverse among treatments. However, in the following year both maize yield as well as cob size were significantly greater than before on green manure fields, and the yields of maize grain studies have been increased 37% - 98% and 89% - 147% (Fabunmi and Balogun, 2015).

CHAPTER THREE

3.1. MATERIALS AND METHODS

3.1.1. General Description of Study and Experimental Sites

Various methods of experimentation were used in this research. The questionnaire survey was conducted in Ivo Local Government Area (LGA) of Ebonyi State (Latitude 5^{o}91`N; Longitude 7$^{o}$63`E), where akidi cowpea is cultivated by farmers as a local delicacy. Laboratory studies were conducted in the Ecology laboratory while screen house and crop garden were used for the pot experiment in the Department of Crop Protection and Environmental Biology (CPEB), University of Ibadan (Latitude 7^{o}27`N; Longitude 3°53`E; Elevation 218 m ASL), Ibadan, Nigeria. The field study was also conducted in the crop garden, from December, 2014 to August, 2016. Ibadan is located in a transitional rainforest-savanna region with precipitation: evapotranspiration ratio of 1.0 (Awodoyin and Olubode, 2009). Ibadan is situated in the rainforest Guineo-Congolian: drier type with a mosaic flora that is made up of rainforest lowlands and secondary grasslands (White, 1983). The soils are underlain by rocks of pre-cambrain basement complex. The soils are characterized by deep and intensely weathered pedon with few remaining weatherable mineral materials. The soils have low clay content which is made of Kaolinite (Akindele, 2011). This area is characterized by bimodal yearly precipitation with peaks in July and September. The yearly precipitation is 1200-1500 mm. The moist time runs from April through October; the ambient temperature is moderately (60-80 percent); the average temperature is between 27^{O}C - 32^{O}C (Adelekan and Gbadegesin, 2005). The weather station for International Institute of Tropical Agriculture (IITA), Moniyan, Ibadan was the source of the rainfall information for the research site which has been certified agriculturally suitable for growing most legumes like cowpea, groundnut and cereals, including maize, sorghum and rice (Ajeigbe *et al*., 2009).

3.1.2. Climatic Information of Ibadan

The 2014, 2015 and 2016 Ibadan climate overview, as recorded by the National Horticultural Research Institute, disclosed seasonality with a humid season lasting nine months and a three-month drought season during the three years. The wet season was from March to November, for the three years. The total annual rainfall was 1965.7 mm in 2014, 2014.2 mm in 2015, and 2876.7 mm in 2016. During the three years, the distribution of precipitation comprised of two peaks. The highest peaks occurred in May and October 2014 and June and September 2016.

In 2014, the mean monthly temperature ranged from 25.1 ºC (August) to 31.9 ºC in January; while in 2015, it ranged from 21 ºC (June) to 33 °C (November and December) and in 2016 it ranged from 25.5 °C (August) to 29.5 °C (February and April). The average temperature was 28.5 °C in 2014, 25 ºC in 2015 and 27.6 ºC in 2016.

In 2014, ambient temperature varied from 62% in February to 91.5% in August. In 2015, it ranged from 72% in March to 91% in June and in 2016, relative humidity ranged from 82% in May to 91% in September. The mean monthly relative humidity averages were 79.4%, 87.8% and 88.2% in 2014, 2015 and 2016, respectively.

3.2. The Physico-chemical Properties of Soil

Soil samples of the planting site were collected using soil auger at a depth 0 - 15 cm. Samples obtained from similar plot/site were bulked and taken to the laboratory, where plant trimming and pebbles were hand picked and specimens air-dried. The dried samples were then sent to laboratory for routine analyses. According to Yoder's technology, total stability was calculated with dry and moist sieving (Tian *et al*., 2015). Soil was uniformly broken to about five milimeter particles and passed through two strainers of 2 mm and 0.25 mm dimension. Afterward, the left particles loosely compacted together on the surface of the filter were gathered. Large macro aggregates (greater than two milimeter) were collected from the two milimeter strainer, small macro aggregates from the 0.25 mm strainer, and micro aggregates (<0.25 mm) categorized as soil content passing through the 0.25 mm strainer. Following Dorodnikov *et al*. (2009), it was established that the amount of time spent on filtering was adequate to sever soil mass into their various textural class sizes, while reducing the wearing away of aggregate during the filtering procedure.

Subsequently, subsamples of the various aggregate size classes were ground with the use of ball mill for one minute, and these samples were defined as compressed aggregates. The soil physical and chemical properties analysed were as follows:

3.3. Soil Analysis Procedure

A. Soil pH Determination

This was determined following the procedure illustrated by Rhodes (1982), a large depression of porcelain was filled up with soil to one third level. Indicator was added drop by drop until one drop could be detached from the soil mass for a pH reading. This was brought to equilibrium by gently rotating the sample for two minutes. A stirring rod was used to withdraw a drop of liquid into the grove of the test plate. The colour in the drop was noted and assigned a pH values. In situation were the pH was found to be out of range, the next appropriate dye was tried. The dye mixtures were uded as well. Generally, a mixture of indicator dyes (bromthymol blue, bromcresol green, and bromcresol purple) gave a satisfactory colour and pH range for most agricultural soils. The mixture had an orange colour at pH 4.5, ranges through yellow to become green as pH 4.5, ranges through yellow to become green as pH 5.5, through light blue to deep blue at pH 7.0 and to purple beyond pH 7.0.

B. Percentage Organic Carbon (Walkley Black Method)

For organic carbon, Nelson's and Sommers (1996) Walkley-Black-wet oxidation technique was used. Twenty five grams of ground soil was made to pass through a 60 – finr mesh srainer and thereafter a duplicate 0.25 to 0.5 g sample of air dried soil was weighed out and transferred to 500 ml Erlenmeyer flask and afterward ten millimeters of 1N $K_2Cr_4O_7$ was added and the mixture was swirled gently. It was then made to stand for twenty to thirty minutes. The suspension was diluted with about two hundred milliliters of distilled water. Later on, with a measuring spoon 10 milliliter of 85% H_3PO_4 about 0.2 g of NaF was added and three to four drops of O – Phenanthroline indicator. The excess Cr_2O_7 was back titrated with 0.25 M ferrous solution to wine – red end point. The organic carbon value was evaluated by using standard formulation and presented in percentage with the formula below:

$$\%Org\ C = \frac{(B-T) \times N \times 1.33 \times 0.003 \times 100}{M}$$

Where B = Blank titre value

T = Titre value of sample

N = Normality of ferrous sulphate

M = Mass of Soil Sample (dry weight)

% Organic matter = % Org C ×1.724

C. Total Nitrogen

Ten gram of air – dried soil was precisely measured on a filter paper (in duplicate). The sample was screwed up in a filter paper and then placed in a dried 500 ml Kjeldahl flask. Thereafter, the catalyst (selenium, copper sulphate and sodium sulphate) mixture was added in a tablet form. Thirty millimeter of technical – grade concentrated H_2SO_4 was incorporated and the flask content was mixed by swirling. It was then heated on a heater, inside a fume cupboard; the flask was rotated at intervals, until the digest cleared (to give a light green or grey colour). Subsequently, it was heated for one hour. It was then left to sit, before 100 ml of tap water was added, shook and transferred to a clean flask. The washing of the sandy residue was repeated, using approximately 50 ml aliquots until 250 ml – 300 ml of solution was obtained. The flask was stoppered to prevent ammonia fumes or extraneous matter from entering the flask in which the 150 ml level has marked with a grease pencil. Three drops of mixed indicator (methyl red plus methylene blue) was introduced to boric alert. The receiving flask was mounted whilst the condenser tube tip was underneath the boric acid surface. A small piece of litmus paper was added to the flask that contained the diluted digest. Thereafter, 125 ml of appropriate 45% sodium hydroxide was added carefully down the side of the flask so that the alkali could form a layer below the acid. The flask was attached to the condenser and its contents were mixed by means of a circular swirling motion. The litmus paper showed that the solution was alkaline. The solution was distilled until 150 ml of liquid of liquid was present in the receiving flask. The distillation was observed carefully and the flame was adjusted to prevent sucking – back or excessive frothing. Titration was carried out using standard hydrochloric acid (approximately 0.05 N). The end – point was a grey – blue colour, intermediate between purple (acid) and green (alkaline) colour.

D. Available Phosphorus

Spectrometer was used to ascertain the amount of phosphorus in water and soil extracts as illustrated by Nelson and Sommers (1982) by weighing two grams of soil into a reaction cup. Prior to adding fifteen milliliters of purified H_2O, five milliliters of Murphy and Riley colour reagent were added. Phosphorus absorbance was read using the spectrophotometer.

E. Exchangeable Acidity

The KCL extraction technique was used to evaluate exchangeable acidity. In a 150 ml plastic container 2 g of air dehydrated soil were measured**.** Two grams of air dehydrated soil was measured in a 150 ml plastic container. Twenty millilitres of 1N KCL was added and shook for an hour. It was subsequently filtered into a conical flask via filter paper. Three drops were added and it was titrated to 0.01 NaOH till colourless became pink solution.

F. Determination of Exchangeable Bases (Ca, Mg, K and Na)

The Exchangeable bases were measured from five grams of soil dried at room temperature using 100 ml of neutral ammonium acetate as the extractant (Rhodes, 1982). In a plastic bottle was measured 5 g of soil dried at room temperature and 100 ml of neutral 1 M ammonium acetate was applied thereafter. The mixture was shaken vigourously for 10 minutes and then made to pass through a Whatman filter paper into a hundred milliliters dimension flask. This was later made up to mark with acetate. The method of the 0.01 M EDTA titration of the sample was taken for calcium and magnesium, whereas the flame photometer was used for potassium and sodium (Nelson and Sommer, 1996).

G. Micro Nutrient Extraction

The soil copper, iron, manganese and zinc contents were determined using the hydrochloric acid procedure (Rhodes, 1982). Ten grams of soil were measured in plastic bottles and hundred milliliters of 0.1 M hydrogen chloride were introduced prior to inserting a stopper. This was shaken for 10 minutes before filtering via Whatman filter paper No.42. Atomic absorption spectrometer was used to determine the nutrient concentration (Adams *et al*., 1980).

H. Particle Size Distribution

The Bouyoucos hydrometer technique was utilized in carrying out particulate size analysis on the soil samples (Nelson and Sommer, 1996). In a dispersion cup, 50 g of air dried soil was weighed and later on, twenty millilitres of 25% sodium hexametaphosphate (calgon) was applied to act as dispersant. Two hundred and fifty millilitres of H_2O was applied and for ten minutes the combination was exposed to the conventional stirrer. After mixing, a 210 micron sieve decanted the suspension into the sedimentation cylinder. The coarse fraction collected in the sieve was oven-dried in a moisture can at 105 ºC and weighed. The suspension in the sedimentation cylinder was topped to the 1 L mark by adding distilled water. The temperature and density of the suspension were taken with the aid of a thermometer and the Bouyoucos hydrometer, respectively at 1 minute (silt and clay concentration) and 2 hours (clay concentration).

3.4. Field Survey: Field Survey on the Cultivation of Akidi in Two Extensions (ADP) Blocks of Ivo Local Government Area, Ebonyi State, Nigeria

A multi-stage samplingprocedur was utilized for the investigation of sixty participants for this research. In this arrangement, each of the two extension Blocks in the local government council received 30 copies of questionnaire, which consisted of one third (1/3) of the extension circles, and 10 respondent farmers per circle. In Ivo Local Government Area, the farmers have been classified into different groups by Agricultural Development Program (ADP). The sample framework for this research was the list of contact farmers in the villages (equivalent for extension circles). Thirty farmers were randomly chosen from this list by extension block as previously described, which was the sample size for this research. Quantitative primary data were obtained via analytical questionnaire.

Data analysis was conducted through the use of descriptive information to obtain a distribution average, percentage and frequency.

3.5. Experiment 1: Phenology and Biomass Accumulation of *Vigna unguiculata* as they Relate to Season Both in Pot and on Field

Twenty-five polythene bags (each 22 cm surface diameter and 30 cm deep) were filled each with 5 kg of dry soil obtained from the crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan. Two seeds of akidi were sown per pot. A week after sowing, *akidi* seedlings were thinned to a single plant per pot. Five bags were chosen randomly for growth and dry matter development with destructive selection over a period of two weeks for 10 weeks. Height of the plant was taken with a meterstick; diameter of stem (cm) with a vernier caliper (power fix model); number of leaves were ascertained by visual enumeration. The crop in every container was raised with a lump of soil and then placed into a container with water to unlock the earth so that the root could be recovered fully. Plants were subdivided into root and shoot, packaged and oven dried at 80 ºC to unvarying mass in Gallenkemp oven, in order to establish dry weight. The dry crops were then weighed using the Metler Balance (Metler P1210).

All data were analyzed by means of Analysis of Variance Analysis (ANOVA) and means differentiated by using the LSD at 5 percent confidence interval.

3.6. Experiment 2: Effect of Varying Light Intensity on the Growth and Biomass Accumulation of Akidi

A pot experiment was established in the crop garden of the Department of Crop Protection and Environmental Biology (CPEB), University of Ibadan, Ibadan. The aim of this study was to determine the performance of *akidi* under varying light intensities to ascertain their survival as interplant under canopy of crops. Sixty four pots (each 22 cm surface diameter and 30 cm deep), each filled with 5 kg soil were arranged in a Completely Randomized Design, among treatments comprising of 16 pots. Two seeds of *akidi* were sown per pot and subsequently reduced to single plant per pot, a week after sowing (1 WAS). Rectangular iron frame with dimensions of 2 meter by 1 meter and 1.5 meter (Plate 3.1) was covered with 0.5 mm blue nylon net to provide shade at three distinct shading regimes, except the control. Three distinct shading levels 30, 50 and 70% and full sunlight (100%) served as control. The light intensity was varied by varying layers of nylon-net to have 0, 1, 2, and 3 layers nets that reduced light inception to varying degrees. Each treatment was repeated in two similar trials.

Four pots were randomly harvested destructively at 3, 5, 7 and 9 WAS. The plant height was taken with the use of a meter rule; stem diameter (mm) measured by means of vernier caliper (power fix model), numbers of leaves were ascertained by visual enumeration. The crop in every container was raised with a lump of soil and then placed into a container with water to unlock the earth, so that the roots could be recovered fully. Plants were split into shoot and root, each plant was packaged, oven dried at 80 ºC to a steady mass in Gallenkemp oven. A top-loading meters weigh (Metler P1210) was used to measure the oven dehydrated plants. The light intensity was measured using a Lux meter (Hp 881A) at 3 days per week for the first 3 weeks at 10.00 hr, 14.00 hr and 18.00 hr, and subsequently at 5, 7 and 9 WAS.

All data were analyzed by means of Analysis of Variance Analysis (ANOVA) and means differentiated by using the LSD at 5 percent confidence interval.

3.7. Allelopathic Study of Aqueous Extracts of Akidi

The aqueous solution of the shoots and roots of akidi were prepared and administered to maize seeds and seedlings. The research was focused at ascertaining the potential impacts of the extracts used as cover crops on maize field.

3.7.1. Preparation of Aqueous Extracts from Dried Shoot and Root

The aqueous extraction process was performed by following the technique described by Ahn and Chung (2000). Plant material comprising shoots and roots were collected from cultivated field plot. Plant materials were then washed thoroughly in running water and subsequently cleaned with purified H_2O. The plant materials were partitioned into shoots and roots. These were later slice into chips and air dried at a temperature of 27 ^oC for fourteen days. After drying, the specimens were grounded into fine particles, using mechanical blender (Thomas milling machine) and made to go through a strainer with a diameter of one milliliter. One hundred and forty–four grams of dried milled plant parts (shoots and roots) were used. It was then submerged in a litre of purified water for a period of twelve hours and subsequently made to pass through light clothing material and Whatman No. 1 filter paper. The stock distillate of 100% w/v was prepared per plant part. Other concentrations of the aqueous extract 50%, 25% and 0% (distilled water) were achieved through sequential dilution by the use of purified H_2O (v/v). The botanicals were kept in the fridge at 20 ^oC before application to avoid disintegration and degradation of the allelochemicals which might be inherent in them (Owoseni and Awodoyin, 2013).

3.7.2. Experiment 3a: Effect of Varying Concentrations of Aqueous Extract of Dried Shoot and Root of Akidi on the Germination of Seeds of *Zea mays*

The impact of *akidi* extract on maize seed germination was assessed. Randomly selected seeds were washed in distilled water. Seeds of *Z. mays* were disinfected using five percent NaClO (bleach) for ninety seconds to avoid contamination by fungus; afterwards they were washed in running water for 5 minutes. A total of twenty one Petri-dishes used for the experiment were disinfected using five percent NaClO,

Plate 3.1: Experimental layout of the varying light intensities used for the growth and biomass study of akidi

completely cleaned and coated with whatman No.1 (9 cm) filter paper.

The treatments were;

Distilled water – CONTROL

100% Shoot Extract – SE100

50% Shoot Extract – SE50

25% Shoot Extract – SE25

100% Root Extract – RE100

50% Root Extract – RE50

25% Root Extract – RE25

There were ten maize seeds in each petri-dish. The filter paper lining was moistened by applying two milliliters of the suitable treatments every day to avoid drying out. The experiment was laid out in a Completely Randomized Design (CRD) on the laboratory bench at a room temperature of 27 ± 2 ^{o}C and replicated three times. The experiment lasted for 7 days. Radicle emergence was used as the germination criterion and this was noted daily. The percentage germination was computed as;

$$\frac{\text{No. of germinated seeds}}{\text{Total no. of seeds in the Petri-dish}} \times 100$$

3.7.3. Experiment 3b: Effect of Varying Concentrations of Aqueous Extracts of Dried Shoots and Roots of Akidi on the Growth of *Zea mays*

This was done to ascertain the possible allelopathic impacts of *akidi* on maize seedling growth. The test was conducted in a Completely Randomized Design (CRD) that consisted of seven (7) treatments and four (4) replicates. Twenty eight bags (each 22 cm surface diameter and 30 cm deep) were loaded each with 10 kg soil obtained from the Crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan and the base were perforated to ensure good drainage, arranged in a Completely Randomized Design, among treatments comprising of four bags. Two disinfected seeds of maize were planted per bag. A week later, the seedlings were reduced to one seedling per bag. Thereafter, 300 mls of each treatment was administered from two (2) to eight (8) weeks after sowing. Growth parameters; plant height, number of leaves and dry weight were obtained by destructive sampling. Readings were made two weeks after sowing prior to the commencement of treatments for zero application treatment. Thereafter, destructive sampling was done fortnightly with the bags randomly selected.

Measurement of Growth Parameters

The plant height was measured using a meter rule from soil surface to the tips of the plant's terminal bud. The root length was measured from the soil surfaces where the shoots were cut to the root tip with the use of a meter rule. The number of leaves on individual crop was visually counted (Otusanya *et al*., 2007). The crop in every container was raised with a lump of soil and then placed into a container with water to unlock the earth, so that the root could be recovered fully (Taylor, 1986). Plants were segmented into shoots and roots, packaged and oven dried at 80 °C to unvarying weight in a Gallenkemp oven to determine the dry weight which were measured on a top loading metler weigh (Metler P1210).

3.7.4. Analyses of Plant Samples for Secondary Metabolites

Samples Preparations:

1. Plant material comprising the shoots and roots were collected from cultivated plots.
2. The plant products were carefully cleaned and subsequently rinsed in purified H_2O.
3. The plant materials were then partitioned into the shoots and the roots.
4. They were subsequently sliced into chips and air dried for two weeks at room temperature.
5. Grinding was done using motorized blender and the extracts were pulverized into fine particles using the (Thomas milling machine). The particles were then made to pass through a sieve of 1 mm diameter prior to phytochemical screening.
6. The ground shoots and roots of *akidi* were tested for the occurrence of alkaloids, cardiac glycosides, flavonoids, saponins, tannins and terpenes (Borokini and Omotayo, 2012).

3.7.5. Determination and Quantification of Secondary Metabolites

Analysis for Alkaloids

Dragendoff's reagent was applied and the technique illustrated by Hikino *et al*. (1984) was adopted. Ground shoots and roots (0.2 g) were split for six hours with 95% ethanolet in a soxhlet extractor and ethanol extract evaporated by a vacuum evaporator at 45 ºC to dehydrate. The leftover was re-dissolved in five millimeters of one percent hydrochloride and 5 drops of Dragendoff's was introduced. A change in colour was used to draw conclusion.

Analysis for Tannins

This was ascertained following the procedures of Trease and Evans (2002). Milled shoot and root specimen (0.5 g each) was incorporated in five milliliters of distilled water and subsequently simmered gently and chilled. One milliliter of this mixture was placed in a test tube and three droplets of $FeCl_3$ mixture were added. The specimen colour was used to draw inference.

Analysis for Saponin

The Ejikeme *et al*. (2014) detailed illustration of recurrent saponin foaming test was followed for this analyses. Thirty mililitres of tap water was added to one gram each of the pulverized shoot and root specimens. The mix was firmly wobbled and warmed. To conclude, the specimen was inspected for the appearance of bubbles.

Analysis for Flavonoids

In a part of the aqueous percolate of the various plant distillates, five milliliters of diluted ammonia mixture was added which was followed by addition of concentrated H_2SO_4. Change in colour was noted to conclude.

Analysis for Cardiac Glycosides

The Keller-Killani analysis procedure was adopted. Four millilitres of CH_3COOH was added to 10 milliliters of the powdered leaves sample of shoots and roots and one drop of $FeCl_3$ solution, was added. This was coated with 1 ml of undiluted H_2SO_4. A brown interaction ring shows a $C_{23}H_{34}O_2$ characteristic. A violet ring may be visible under the brown ring, whereas in the CH_3COOH coating, a greenish ring may appear precisely through a thin layer.

Analysis for Terpenoids

The Salkowski test was adopted. Ten milliliters of each extract was mixed differently into four milliliters of $CHCl_3$ and six milliliters of undiluted H_2SO_4 was carefully introduced for the formation of a coating. The interface was formed with a reddish brown colour to affirm the occurrence of terpenoids.

3.8. Experiment 4: Effects of planting Densities on Early Growth of *Akidi* and Its Weed Control Potentials

The field trial spanned for 10 weeks from 14 August, 2015 to 23 of October, 2015 for the first trial and from 18 of May, 2016 to 27 of July, 2016 for the second trial. The following densities were studied:

A. (D1) 30,121 plants per hectare obtained by spacing 0.83 m × 0.40 m
B. (D2) 40,323 plants per hectare obtained by spacing 0.62 m × 0.40 m
C. (D3) 50,000 plants per hectare obtained by spacing 0.50 m × 0.40 m
D. (D4) 60,976 plants per hectare obtained by spacing 0.41 m × 0.40 m
E. (D5) 80,645 plants per hectare obtained by spacing 0.31 m × 0.40 m
F. (D6) check plot (Control) was not planted with *akidi*

The trial was in a randomized complete block design (RCBD) with four replications. In each block, the five test densities and control were randomly allocated to plots 1 m × 1 m in size. The distance connecting plots was 0.5 m and among blocks was 0.5 m (Figure 3.1).

The field was cleared and turned with hoe. The seeds were planted at 1 cm – depth. An extra plot, not planted up with *akidi*, was maintained in each block. The extra plots served as a check to compare the weed control efficiency of the plant at the test densities. All plots were weeded once at two weeks after sowing by manual rogueing.

At harvest, three plants selected randomly for each parcel were assessed for the following parameters:

(i) **Vine length** was measured using a meter rule (cm)
(ii) **Diameter of the Stem** was assessed at five centimeters above soil surface with a vernier caliper (mm)
(iii) **Biomass accumulation** (g)

The plants were clipped on the ground and dehydrated at 80 ºC for two days in a Gallenkemp oven. On top loading metler balance, the materials dried from the oven were weighed (Model P1210) to monitor the effect of density on shoot biomass. Two 25 cm × 25 cm quadrats were randomly laid within each plot, including the control plots at 10 weeks to assess the weed control effect of the trial. All weeds that rooted within the quadrat were identified and clipped at soil surface. The weeds were allowed to dry in the oven at 80 ºC for two days and

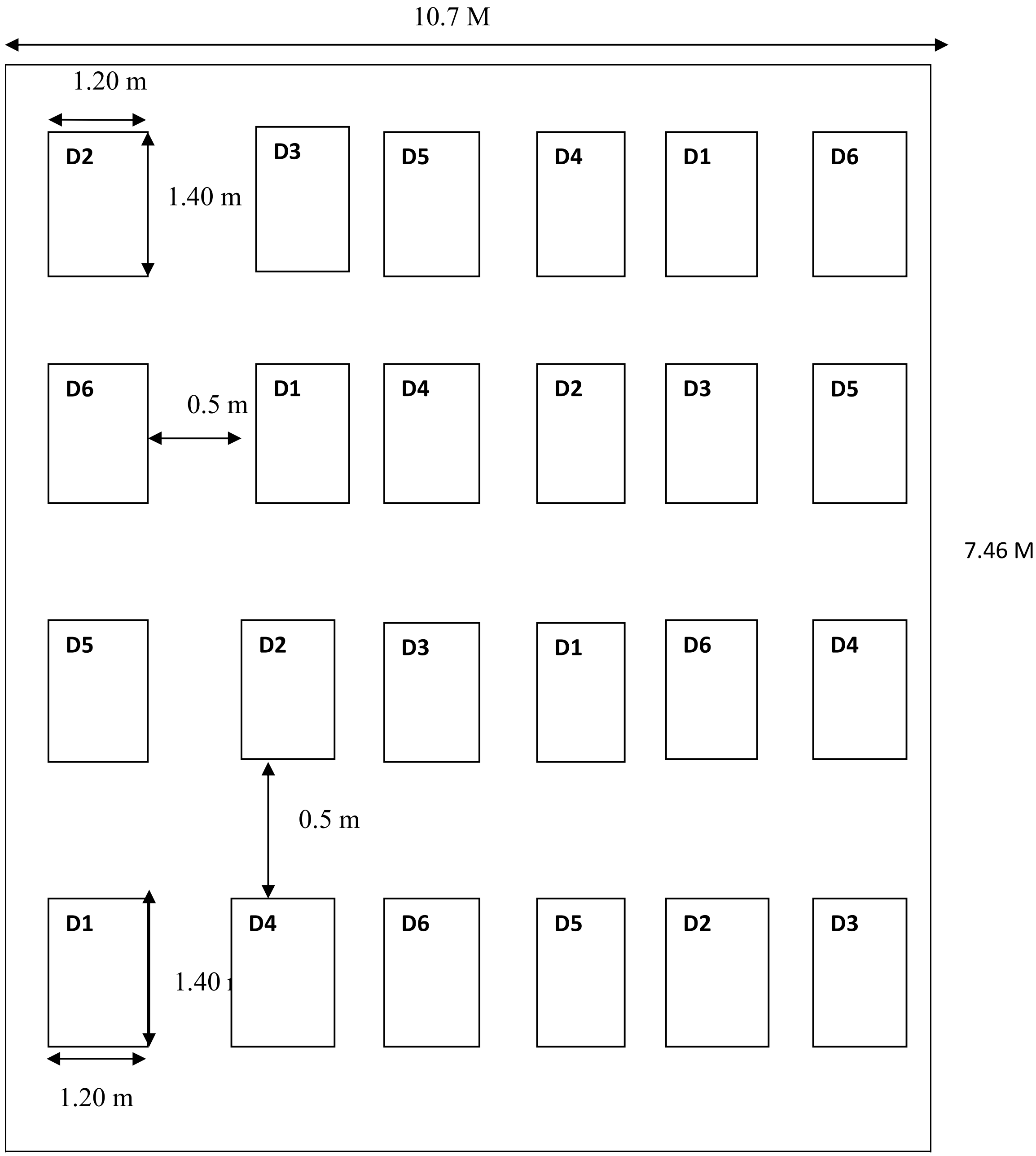


Figure 3.1: The field layout for the effects of stocking densities on early growth of akidi and its weed control potential. D1 = 30,121 plants per hectare; D2 = 40,323 plants per hectare; D3 = 50,000 plants per hectare; D4 = 60,976 plants per hectare; D5 = 80,645 plant per hectare; D6 = Control plot (not planted with akidi)

weighed to determine the dry matter.

(iv)**Weed control assessment**

3.9. Experiment 5: Effects of Various Population of Akidi on Weed Suppression and Performance of Maize

The experiment was conducted at the Crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan. The field site was cleared manually with cutlasses and hoes and soil was collected. The soil's physical and chemical characteristics were determined as illustrated in chapter 3.2. The experiment was a Randomized Complete Block Design (RCBD) with six treatments and four replicates. The experimental plot dimension was 19.4 m × 13.5 m which resulted in an area of 262 m^2. Each replicate had a dimension of 2.5 m × 1.6 m with an alley of 0.5 m between two blocks.

Three seeds of maize (DTMA - Y - STR) 60 days maturing variety, were sown on flat at a spacing of 0.80 m × 0.50 m. In the maize herbicide plots, primetra gold herbicide was applied (3.2 l/ha) to the experimental plots immediately after sowing. Maize plants were thinned to two (2) plants at two weeks after sowing (WAS), to give a plant population of 50,000 plants / ha. Two seeds of akidi were sown in between maize inter row (0.40 m) and later thinned at two weeks to one plant per stand. The M + A 20 (20,000 *akidi* plants per hectare) treatment were sown in between maize alley at a spacing of 0.62 m. The M + A 30 (30,000 *akidi* plants per hectare) treatment were planted in the maize alley at 0.41 m. The M + A 40 (40,000 *akidi* plants per hectare) treatment were sown in the maize alley at a spacing of 0.31 m. The intra-row spacing for the cover crops are indicated in Table 3.1. While the sole maize (hoe-weeded, weedy all through and herbicide) control treatment, were sown at a distance of 0.80 m wide inter row and 0.50 m intra row spacing.

The treatment plots had one weeding which was at 3 WAS, with the exception of the weedy and the herbicide control, which were not cleared throughout the study. The experiment aimed at evaluating the various densities of *akidi* that would enhance weed suppression, improve soil fertility and improve maize crop performance.

Data Collection

The weed species were enumerated at 3 WAS of the main crop (maize) growth for the flora composition and at the physiological maturity of maize (60 DAS). The weeds rooting within the quadrat were identified to species level and counted using a flora handbook by Akobundu and Agyakwa (1987). The species that were not identified on the field were kept in wooden press and taken to UI herbarium in the Department of Botany, University of Ibadan for identification. The weed samples were oven-dried at 80 ºC to a constant weight and weighed for dry matter content.

The compiled weed floristic information was evaluated using Paleontological Statistical Software (PAST, Version 2.01) of Hammer *et al*. (2001). The Relative Density (RD), Relative Frequency (RF) and Relative Importance Value (RIV) of floral species were calculated (Awodoyin and Olubode, 2009) as follows:

Absolute Frequency (%) = The probability of a species occurring in a quadrat

$$= \frac{\text{overall number of quadrats that have a species}}{\text{Total number of quadrats}} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total Frequency of all species}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Absolute Density = Total number of individuals of a species in a stated area ….. (3)

$$\text{Relative Density} = \frac{\text{Absolute Density of a species}}{\text{Total Density of all species}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{Relative Importance Value (RIV \%)} = \frac{\text{Relative Density + Relative Frequency}}{2} \ldots\ldots (5)$$

The species diversity was computed using Shannon-Weaver index (Kent, 2012) as

(i) Shannon-Weaver index (H^1) = $-\sum [pi (\ln pi)]$

Whereby;

pi = The percentage of individual species

ni = Number of organisms in the ith species, N = Overall number of sampled species,

ln = log base n (Naperian log 2.303 x $\log_{10}$)

(ii) Equitability Index (J) = $\underline{H}^1$ / ln S

Where S = Overall number of individuals in the biotic association.

Maize Growth Parameter

Four maize crops in each plot were randomly labelled for data collection. At vegetative stage, data were obtained on the following variables: plant height (cm) measured with a meter rule and was rounded up to the closest whole value from the surface of the soil to the top; the mean height of four randomly chosen plants

Table 3.1: Maize and *Akidi* Field Experimentation Treatment Combinations

Treatments	Cover Crop Density	Planting Spacing	
Crops Combinations	(Number of Plants / ha)	Maize	Cover Crops
Maize + *Akidi*	20,000	0.5 m x 0.8 m	0.62 m x 0.8 m
Maize + *Akidi*	30,000	0.5 m x 0.8 m	0.41 m x 0.8 m
Maize + *Akidi*	40,000	0.5 m x 0.8 m	0.31 m x 0.8 m
Sole maize HW control	-	0.5 m x 0.8 m	-
Sole maize weedy control	-	0.5 m x 0.8 m	-
Sole maize Herbicide Control (Primextra)	-	0.5 m × 0.8 m	-

Note: HW = Hoe-weeded; Maize population per hectare = 50,000 plants / ha per plot was taken as the plant height, stem diameter (cm) was taken at 10 cm height from the soil surface using a vernier caliper; while days to tasseling was assessed by enumerating the days it took the plant to tassel in each treatment as well as to reach 50% tassel.

At maturity the following data were collected:

Measurement of yield characteristic

a. **Fresh weight of cob (g):** using Mettler top loading balance.

b. **Dehusked maize weight (g) / cob:** The weight of four ears after the husk was carefully removed before oven drying. The mean values were then calculated for each cob.

c. **Shelled maize weight (g) / cob:** The grain was carefully harvested, oven dried to a stable weight and threshed and weighed on a Mettler top loading balance.

d. **Weight of 100 - seed (g):** was obtained by randomly picking 100 oven dried maize seeds (oven dried to 13% – 14% percent moisture) measured to the closest gram using a Mettler top loading balance.

e. **The grain yield per hectare (tha^{-1}):** At maturity, four maize plants per plot were arbitrarily selected and assessed for their yield (oven dried to between 13 and 14 percent moisture content) and their mean was used to score for the grain yield per plot. The yield per treatment was subsequently obtained by calculating the mean of the four replicate plots per treatment. The grain yield per hectare was deduced on the basis of the 50,000 plant / hectare plant population used in this study. This was estimated according to the relationship below;

$$\text{Yield kg / ha} = \frac{10{,}000\ m^2 \times \text{Plot yield in kg}}{\text{Plot area in } m^2}$$

f. **Biomass weight (g):** Four randomly tagged maize dried stalks were clipped at 5cm above the ground, placed in a properly identified wrapper and later oven dried to a steady weight at 70 ºC and measured using Mettler top loading balance. The mean of four randomly sampled plants was used as score for each plot.

g. **Biomass accumulation:** At maturity of the test crop (maize), the biomass accumulation by the cover crops in each of the treatments was estimated by randomly placing three 0.25 m^2 quadrat per treatment (Tremelling *et al*., 2002). The cover crop samples' biomasses were assessed by harvesting the leaf and stem materials and oven drying at a temperature of 70 ºC to a constant weight.

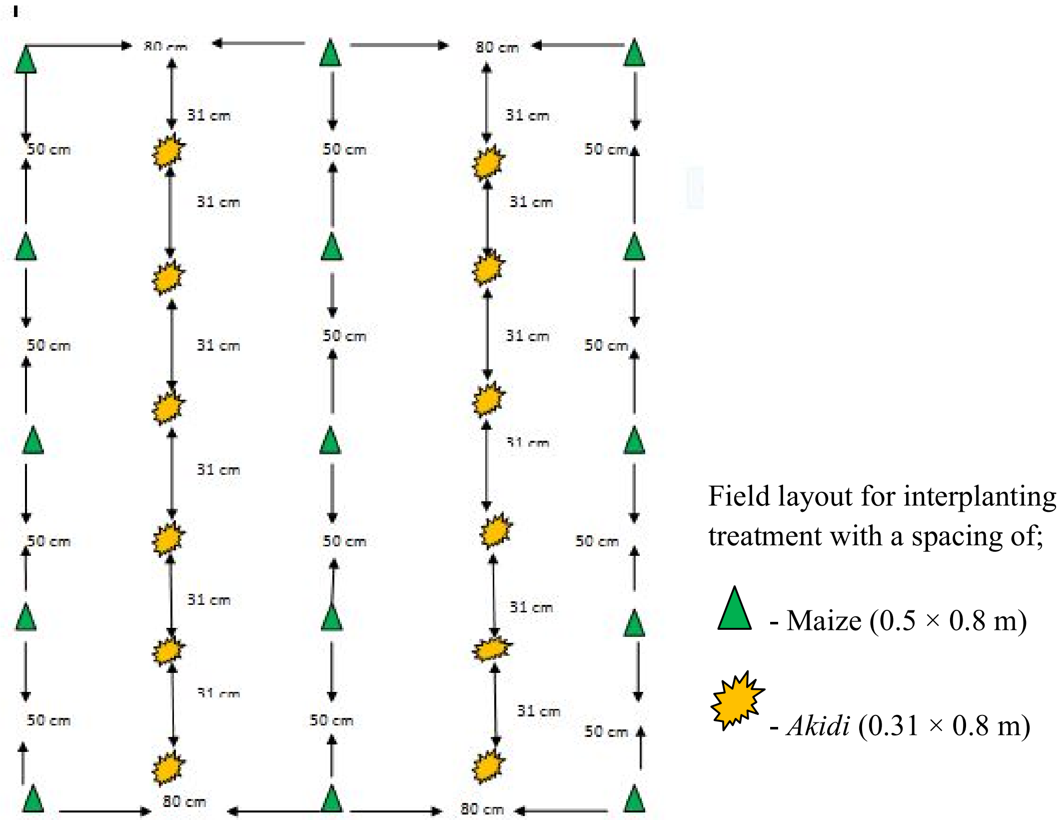
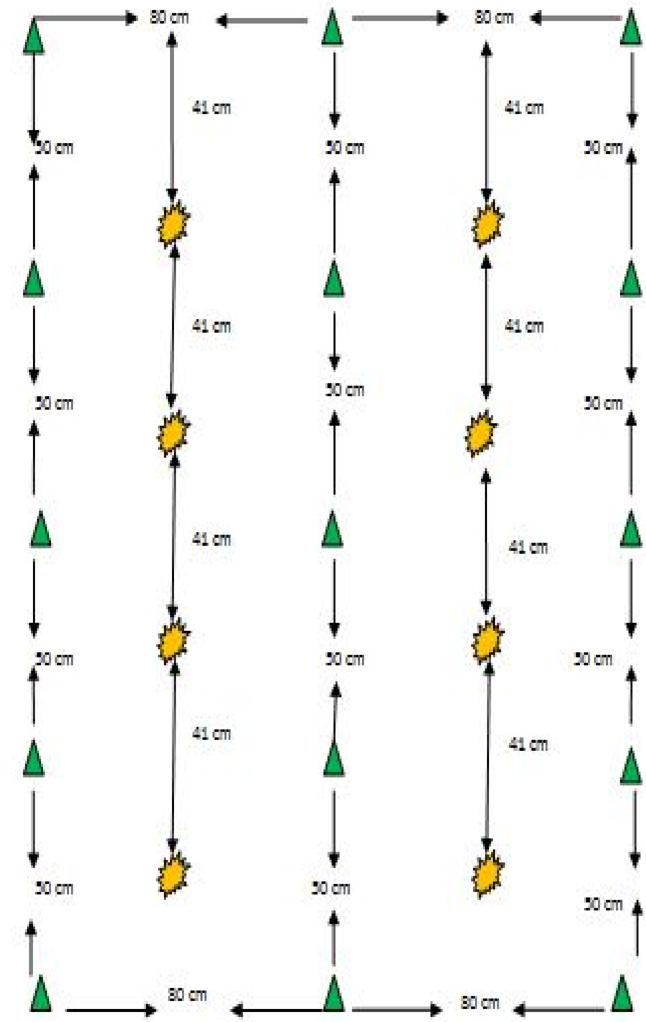


Figure 3.2: Field layout for maize and *akidi* (40,000 plants per hectare)

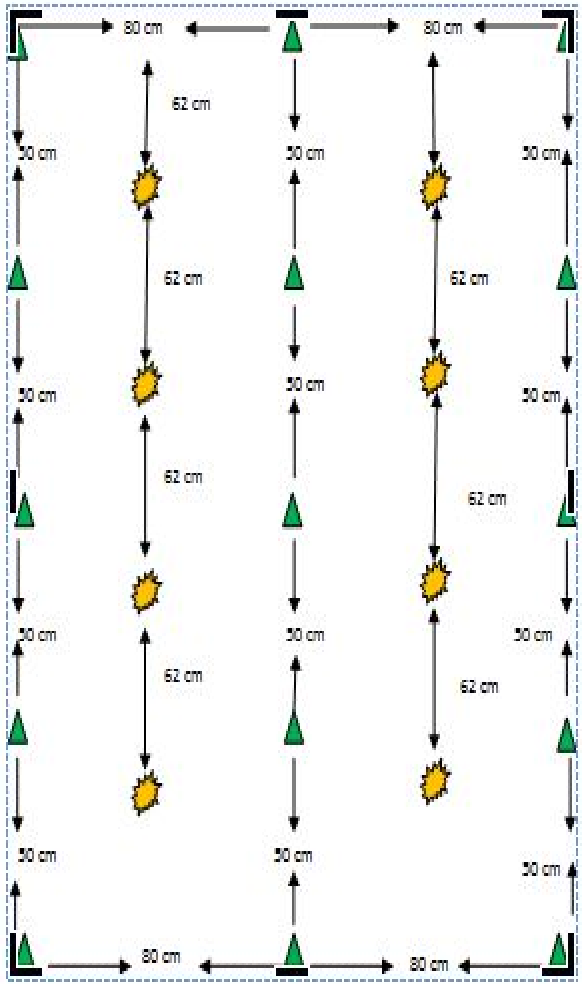


Field layout for interplanting treatment with a spacing of;

- Maize (0.5 × 0.8 m)

- *Akidi* (0.41 × 0.8 m)

Figure 3.3: Field layout for maize and *akidi* (30,000 plants per ha)

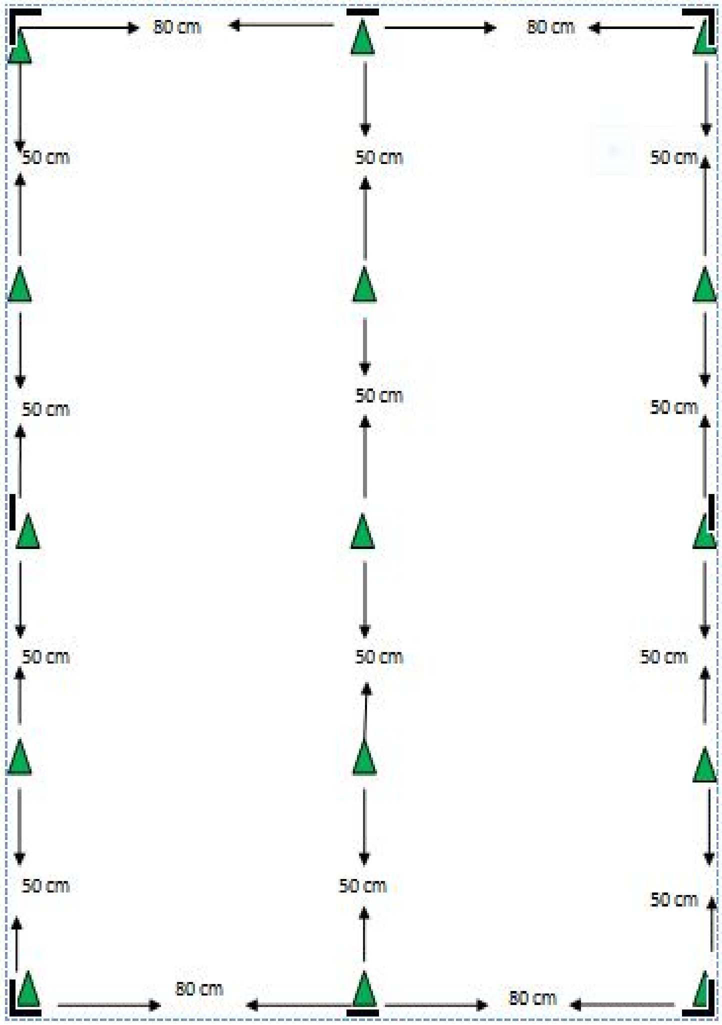


Field layout for interplanting treatment with a spacing of;

- Maize (0.5 × 0.8 m)

- *Akidi* (0.62 × 0.8 m)

Figure 3.4: Field layout for maize and *akidi* (20,000 plants per ha)



Control Treatment

- Maize hoe – weeded
- Maize weedy control
- Maize herbicide control

- Note: All had an inter-row spacing of 0.5 m with an intra-row spacing of 0.8 m

Figure 3.5: Control treatments

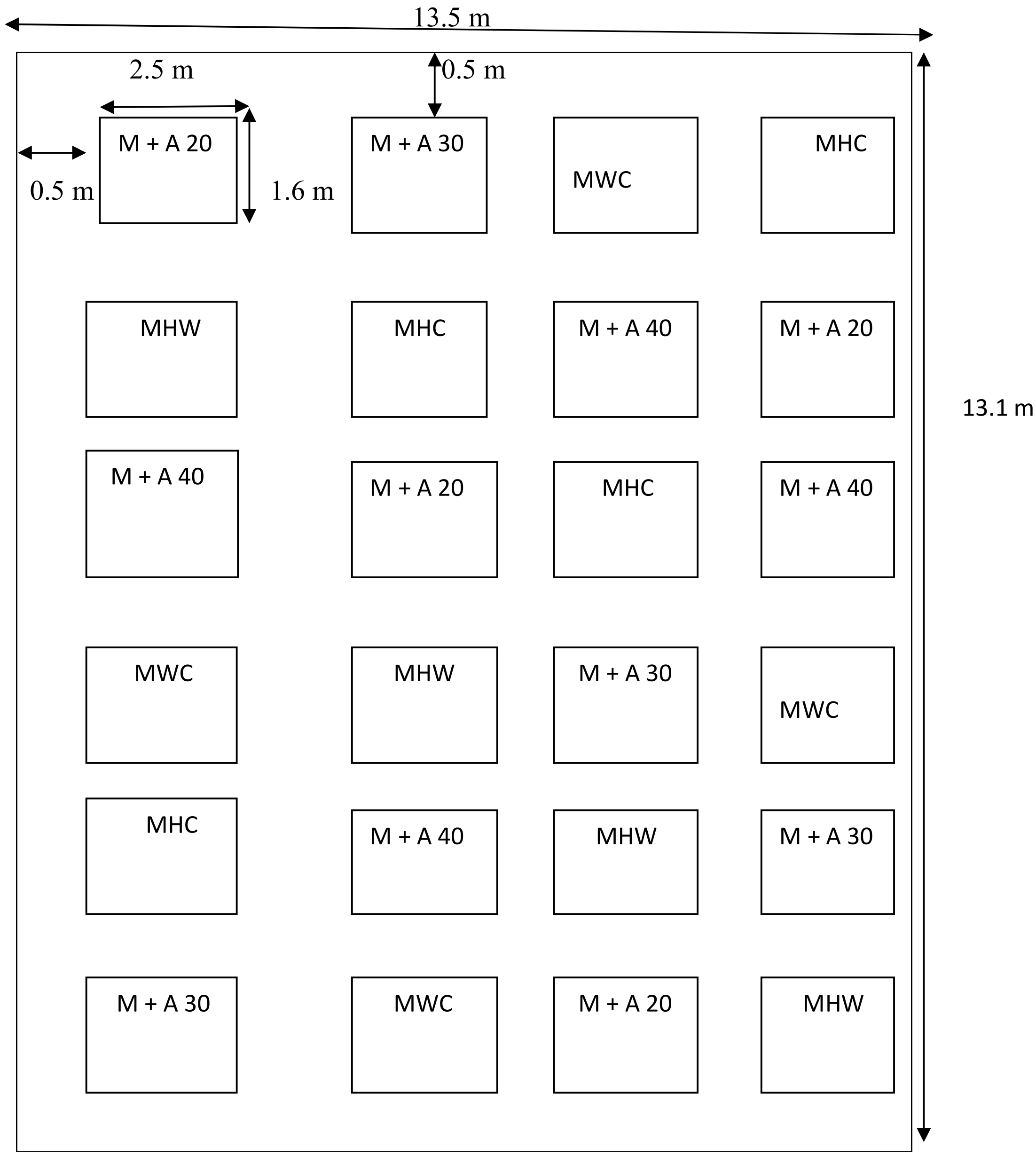


Figure 3.6.: Field layout for the effect of varying densities of cover crop on the performance of maize.

M + A 40 = Maize (50,000 plants / ha) + *Akidi* (40,000 plant / ha) ; M + A 30 = Maize (50,000 plants / ha) + *Akidi* (30,000 plant / ha); M + A 20 = Maize (50,000 plants / ha) + *Akidi* (20,000 plants / ha); MHC = Maize Herbicide Control (Maize (50,000 plants / ha); MWC = Maize Weedy Control (Maize (50,000 plants / ha); MHW = Maize Hoe–Weeded Control (Maize (50,000 plants / ha)

CHAPTER FOUR

RESULTS

4.1. Field survey of the potential of *Vigna unguiculata* for weed suppression and soil fertility improvement within ADP blocks in Ebonyi State, Nigeria

4.1.1. Demographic characteristics social and literacy status of respondents

The demographic distribution of participants shows that the mean age of participants was 33.65 years, 3.3% were less than or equal to 20 years, 38.3% were between 21 and 30 years, 40.0% were between 31 and 40 years, 13.3% were between 41 and 50 years, and 5.0% were above 50 years (Table 4.1). As noted, most participants were at their active ages (21 – 30 years to 41 – 50 years). There were more female farmers (51.7%) than male farmers (48.3%) (Table 4.1). Also, majority of the farmers were married (60.0%). This reveals high level of success among farmers as it sustains them in meeting family needs (Table 4.1). The household sizes were 2 to 3 persons (18.3%), 4 to 5 persons (30.0%), 6 to 7 persons (23.3%), 8 to 9 persons (21.7%) and > 10 persons was least (6.7%). This indicates that participants had quite a big family size (Table 4.1).

The survey also revealed that 6.70% of respondents did not have formal education, 16.7% had primary school education, 13.3% had secondary education, while 63.4% of the respondents had tertiary education (20% had OND, 21.7% had NCE, 21.7% had HND/BSc/BA/BEd). As observed, greater than 60.0% (majority) of the respondents were literate (Table 4.1), though 70.0% of them chose farming as the main occupation. Twenty percent (20.0%) of the respondents were majorly civil servant; 8.3% were traders and 1.7% was majorly artisans (Table 4.1). Majority (23.4%) of the respondents had no secondary occupation. Thirty five percent of the respondents had farming as secondary occupation and 18.3% had trading as secondary occupation (Table 4.1).

Personal characteristics

Table 4.1: Distribution of respondents by personal characteristics

Variables	Category	Frequency	Percentage	Mean
Sex	Male	29	48.3	
	Female	31	51.7	
Age (years)	Less than equal to 20	2	3.3	
	21 – 30	23	38.3	
	31 – 40	24	40.0	33.65±9.96
	41 – 50	8	13.3	
	Above 50	2	5.0	
Marital status	Single	24	40.0	
	Married	36	60.0	
Household size	2 – 3 persons	11	18.3	
	4 – 5 persons	18	30.0	
	6 – 7 persons	14	23.3	
	8 – 9 persons	13	21.7	
	10 persons and above	4	6.7	
Level of Education	No formal education	4	6.7	
	Primary	10	16.7	
	Secondary	8	13.3	
	OND	12	20.0	
	HND	13	21.7	
	HND/ BSC/ BA/ BED	13	21.7	
Major occupation	Farming	42	70.0	
	Civil service	12	20.0	
	Trader	5	8.3	
	Artisan	1	1.7	
Minor occupation	No minor occupation	28	46.7	
	Farming	21	35.0	
	Trader	11	18.3	

Field survey, 2017

4.1.2. Distribution of respondents based on agricultural enterprise

The survey revealed that 100.0% of the respondents planted *akidi*. The respondents cultivated *akidi* in several cropping systems, 13.3% of the respondents cultivated *akidi* as a sole crop, 31.7% cultivated it in mixture with other legumes and 55.0% of the respondents interplanted *akidi* with other crops. It was observed that 38.3% of the respondents had planted *akidi* within 1 – 3 years, 23.3% of the respondents had planted *akidi* within 4 – 6 years, 15.0% had planted the crop for more than 7 – 10 years while 23.3% of the respondents have been planting *akidi* for more than 10 years. This means that majority of the respondents only recently started planting *akidi* in their farms. The respondents sourced for their *akidi* seeds from within their agricultural zones, as 73.3% of the respondents got their *akidi* seeds from local sellers, while 26.7% of the respondent got theirs from nearby farms. This shows that *akidi* is a desired crop among the indigenes. Also, 86.7% of the respondents have multiplied their seeds over the years and the remaining 13.3% did not multiply their seeds. As observed, 61.7% of the respondents had between one to five years of practice, 25.0% had six to ten years of practice, and while only 6.7% had eleven to fifteen years and above years of practice. This further revealed that a lot of the participants were inexperienced as majority of them started the cultivation of *akidi* only recently (Table 4.2).

The respondents had farms in fragments, probably due to land use problems. The respondents farm locations were as follows; 68.3% had farm within (1- 2) farm locations, 25.0% had farms within (3 – 4) farm location and 6.7% had farms within 5 and above (≥5) farm locations. The farm sizes (a plot = 5000 m^2) of the respondents were in the range of 1 – 10 plots (60%), 11- 20 plots (23.3%), 21 – 30 plots (8.3%) and above 30 plots (8.3%). Numerous types of crops were grown by the respondents, 35.0% cultivated cassava, 26.7% cultivated yam, 21.7% cultivated maize, 13.3% cultivated *akidi* and 3.3% cultivated potatoes. This further shows that most participants grew *akidi* as interplant or intercrop (Table 4.2).

4.1.3: Distribution of respondent by occurrence and management of weeds.

It was noticed that almost all of the participants controlled weeds manually on their farm. In the study, 65.0% of the respondents used mechanical method of weed control, 31.7% of the respondents used the chemical method of weed control and

Table 4.2: Distribution of respondents based on agricultural enterprise

Variables	Category	Frequency	Percentage	Mean
Planted Akidi	Yes	60	100.0	
	No	0	0.0	
Cropping System	Sole Crop	8	13.3	
	Mixture of other legumes	19	31.7	
	Interplant with other crops	33	55.0	
Last Planted	1-3years	23	38.3	
	4-6years	14	23.3	
	7-10years	9	15.0	
	10years above	14	23.3	
Seed Source	Nearby farms	16	26.7	
	Local vendors	44	73.3	
Seed Multiplication	Yes	52	86.7	
	No	8	13.3	
Years of Experience	1-5 years	37	61.7	
	6-10 years	15	25.0	6.65
	11-15 years	4	6.7	
	above 15 years	4	6.7	
Number of Farm Location	1 – 2	41	68.3	2.37
	3-4	15	25.0	
	5 and above	4	6.7	
Farm Size	1-10 plots	36	60.0	
	11-20 plots	14	23.3	13.66
	21-30 plots	5	8.3	
	above 30 plots	5	8.3	
*Main Crops	Yam	16	26.7	
	Cassava	21	35.0	
	Akidi	8	13.3	
	Potatoes	2	3.3	
	Maize	13	21.7	

Field Survey, 2017

3.3% of the respondents used biological method (cover crop) for the control of weed (Table 4.3). Among the respondents that used herbicides for the control of weeds on their farms, 47.4% of the respondents used 2, 4 – D herbicide, 47.4% of the respondents used Glyphosphate (Round up) and 5.3% of the respondents used Paraquat. In the survey, 48.3% of the respondents used hoe weeding, 28.3% of the respondents used cutlass and hoe weeding and 38.8% of the respondents used cutlass. As observed, 68.3% of the respondents reported rapid spread of weeds on their farms, while 31.7% did not witness quick proliferation of weeds on their farms (Table 4.3).

However, the weeds frequently encountered by the respondents were as follows: 21.7% was *Heteropogon contortus,* 15.0% was *Centrosema pubescens*, 15.0% was *Pennisetum purpereum*, 18.3% was *Ageratum conyzoides*, 10.0% was *Sporobulus pyramidalis*, 6.7% was *Axonopus compressus,* 5.0% was *Mucuna pruriens*, 3.3% was *Turbina corymbosa*, 3.3% was *Megathyrsus maximus* and 1.7% was *Cynodon plectostachyus.* In the survey, ten (10) species of weeds belonging to four families namely: Asteraceae (1), Convolvulaceae (1), Fabaceae (2) and Poaceae (6) were frequently noticed in the field.

4.1.4. Distribution of respondents by cultivation of *akidi* and its agricultural benefits

The survey showed that majority of the respondents deliberately cultivated *akidi*. As observed in the study, 61.7% of the respondent's delibrately cultivated *akidi* and 38.3% did not cultivate it deliberately. Majority of the respondents that cultivated *akidi* observed a reduction in weeding frequency, as 18.3% of them carried out weeding every week, 66.7% carried out weeding monthly, 9.0% of the respondents carried out weeding bi-monthly and 5.0% carried out weeding once in three months. This may mean that *akidi* helped in suppressing weeds, thus reducing the number of weeding regime carried out by the respondents. As observed in the study, farmers that interplanted akidi with their crops witnessed less pest infestation as, 20.0% of the respondents observed pest infestation weekly, 65.0% of the respondents observed pest infestation monthly, 10.0% of the respondents observed pest infestation every two months and 5% of the respondents observed pest infestation every three months. As observed 23.3% of the respondents believed that maize interplanted with *akidi* were susceptible

Table 4.3: Distribution of respondents by occurrence and management of weeds

Variables	Category	Frequency	Percentage
Weed Control	Biological	2	3.3
	Chemical	19	31.7
	Physical / manual	39	65.0
Types of Herbicide	Paraquat	1	5.3
	2,4 – D	9	47.4
	Glyphosphate (round up)	9	47.4
Mechanical Control	Hoe weeding	29.0	48.3
	Cutlass / Machete	14.0	38.8
	Cutlass and hoe weeding	17.0	28.3
Rapid Spread of Weed	Yes	41	68.3
	No	19	31.7
Rate of Spread	High	13	31.7
	Moderate	20	48.8
	Low	8	19.5
Frequent Weeds	Spear grass (*Heteropogon contortus*)	13	21.7
	Centrosema pubescens	9	15.0
	Elephant grass (*Pennisetum purpereum*)	9	15.0
	Goat weed (*Ageratum conyzoides*)	11	18.3
	Sporobulus pyramidalis	6	10.0
	Carpet grass (*Axonopus compressus*)	4	6.7
	Devil`s beans (*Mucuna pruriens*)	3	5.0
	Turbina corymbosa	2	3.3
	Megathyrsus maximus	2	3.3
	Wild snake gourd (*Trichosanthes cyeumerina*)	1	1.7

Field Survey, 2017

to pests, 45.0% of the respondents were of the notion that maize interplanted with *akidi* are not susceptible to pest and 31.7% of the respondents had no idea if maize interplanted with *akidi* would be susceptible or not. Also, 51.7% of the respondents used *akidi* in erosion control, while 48.3% of the respondents do not use *akidi* in the control of erosion on their farms. This further confirms the fact that *akidi* can be effectively used as a cover crop and thus prevents the run-off of the surface soil. However, 48.3% of the respondents could be categorized as utilizing *akidi* as an eco-friendly fertilizer by default, while 51.7% of the respondents did not use *akidi* as a green manure. In a bid to decrease the dependence on external resources, there is the need to effectively harness the potentials of *akidi* as green manure (Table 4.4.).

In the study, despite the fact that most participants never planted *akidi* with the deliberate intention of improving crop yield, 60.0% of the respondents however, observed significant increase in the yield of their plants, while 40.0% of the respondent felt they did not observe a rise in their crop output. In the survey, majority (94.5%) of the respondents attested that *akidi* when interplanted with their crops gave higher yield, as 33.3% of respondents observed a very high increase, 30.6% of the respondents observed high increase, while 30.6% of the respondents observed moderate increase and 5.6% of the respondents observed low crop yield. Majority of the respondents found *akidi* in mixture of other crops to be beneficial as, 75.0% of the respondents found *akidi* to be beneficial in mixture, while 25.0% of the respondents did not find *akidi* to be of benefit to their crops in mixture. Although, 20.0% which is a minority of the respondents observed a reduction in maize growth inter-planted with akidi, 80% which constitute vast majority of the respondents did not observe hindrance in maize growth interplanted with *akidi*. As observed, 51.7% of the respondent witnessed enhanced growth in their maize interplanted with *akidi* and 48.3% of the respondent did not observe stimulated growth in maize interplanted with *akidi*. However, 61.7% of the respondents had a high increase in growth and 38.3% of the respondents did not observe rise in the growth of following plants. Among the respondents that witnessed increase in subsequent crop, 62.2% reported high yield, while 37.8% observed minimal yield increase. This implies that *akidi* can be deliberately cultivated as a sown fallow crop to promote the growth of subsequent crop. As observed, majority of the respondents (81.7%) of which 79.6% observed high yield, while 20.4% observed a relatively low yield of the subsequent crop and

Table 4.4: Distribution of respondents by cultivation of *akidi* and its agricultural benefits

Variables	Category	Frequency	Percentage
Deliberate cultivate *akidi*	Yes	37	61.7
	No	23	38.3
Weeding frequency when *akidi* is used	Weekly	11	18.3
	1 month	40	66.7
	2 months	6	9.0
	3 month	3	5.0
Frequency of pest infestation	Weekly	12	20.0
	1 month	39	65.0
	2 months	6	10.0
	3 month	3	5.0
Maize susceptible	Yes	14	23.3
	No	27	45.0
	No idea	19	31.7
Akidi control erosion	Yes	31	51.7
	No	29	48.3
Akidi manure	Yes	29	48.3
	No	31	51.7
Effect of *akidi* on maize yield in intercrop	Yes	36	60.0
	No	24	40.0
If yes, how was *akidi* yield	Very high	12	33.3
	High	11	30.6
	Moderate	11	30.6
	Low	2	5.6
When *akidi* is interplanted with maize is it beneficial	Yes	45	75.0
	No	15	25.0
Do *akidi* hinder maize growth	Yes	12	20.0
	No	48	80.0
Do *akidi* promote growth of maize	Yes	31	51.7
	No	29	48.3
Does interplanting with *akidi* increase the growth of subsequent crop	Yes	37	61.7
	No	23	38.3
If yes, is the yield	High	23	62.2
	Low	14	37.8
Does inter-planting with *akidi* Increase the yield of subsequent crop grown on the farm	Yes	49	81.7
	No	11	18.3
If yes, how is the yield	High	39	79.6
	Low	10	20.4

Field survey, 2017

18.3% of the respondents did not witness any increase in the subsequent crop output (Table 4.4).

4.2.1. Experimental soil

The physico-chemical analysis of the experimental field revealed that the soil had a basic pH (6.5), consisting of minimal organic carbon (16.3 g/kg) and low total nitrogen (2 g/kg). Using textural triangle of the USDA, the soil was loamy sand in texture (Table 4.5).

4.2.2. Growth and biomass accumulation of *Vigna unguiculata* (*akidi)* in Ibadan, Nigeria

Vine length

Vine length, increased from 22.90 cm and 23.00 cm at 2 weeks after sowing (WAS) to 102.01 cm and 113.18 cm at 10 WAS, in both trials respectively. Vine length at an interval of two weeks differed significantly from one another (Table 4.6).

Number of leaves

The number of leaves of *akidi* ranged from 8.00 at 2 WAS for the first and second trial to 112.00 and 114.00 at 10 WAS during the first and second trials respectively. At every two weeks interval, the number of leaves differed significantly from each other during both trials.

Stem diameter (mm)

The stem diameter at the first and second trial increased with increasing week periods. In both trials, stem diameter increased from 1.85 mm and 2.10 mm at 2 WAS to 6.47 mm and 6.38 mm at 10 WAS during the 1st and 2nd trials respectively. Stem diameter at interval of two weeks, differed significantly from each during both trials (Table 4.6).

Plant dry weight (g)

At 2 WAS, *akidi* had accumulated an average of 0.45 gram per plant shoot dry weight and 0.09 gram per plant root dry weight in the first trial, and 0.44 gram per plant shoot dry weight and 0.17 gram per plant root dry weight in the second trial. At 10 WAS, the value increased to 15.97 gram per plant shoot dry weight and 1.76 gram per plant root dry weight in the first trial and 15.98 gram per plant shoot dry weight

Table 4.5.: Analysis of the soil used for the growth and biomass accumulation study

Properties	Values
pH (H_2O)	6.5
Organic carbon (g/kg)	16.30
Total N (g/kg)	2.00
Available P (mg/kg)	15
Exchangeable base (cmol/kg)	
K (Potassium)	0.3
Ca (calcium)	7.0
Mg (Magnesium)	2.1
Na (Sodium)	0.6
Extractable micronutrient (mg/kg)	
Fe (Iron)	17
Zn (Zinc)	28
Cu	3
Physical properties (g/kg)	
Sand	796.0
Silt	136.0
Clay	68.0
Textural classification	Loamy sand

Table 4.6: Growth and Yield Parameters of *Akidi* (*Vigna unguiculata*) in Ibadan, Nigeria

	Period	Vine Length (cm)	Number of Leaves	Stem Diameter (mm)	Shoot Dry Biomass (g)	Root Dry Biomass (g)	Number of Nodule
				First Trial			
	2 WAS	22.90 ± 1.07	8.00 ± 0.55	1.85 ± 0.08	0.45 ± 0.02	0.09 ± 0.01	0.0 ± 0.00
	4 WAS	35.43 ± 0.70	47.00 ± 1.00	5.19 ± 0.13	5.47 ± 0.28	0.70 ± 0.04	19.4 ± 2.02
	6 WAS	57.87 ± 0.94	64.00 ± 0.76	5.36 ± 0.18	7.76 ± 0.32	0.92 ± 0.04	37.2 ± 1.29
	8 WAS	85.02 ± 1.67	89.00 ± 0.57	5.88 ± 0.18	10.51 ± 0.76	1.12 ± 0.06	75.2 ± 1.24
	10 WAS	102.01 ± 1.65	112.00 ± 2.66	6.47 ± 0.27	15.97 ± 0.84	1.76 ± 0.08	101.4 ± 1.82
LSD (0.05)		3.03	3.59	0.48	1.43	0.14	4.37
				Second Trial			
	2 WAS	23.00 ± 0.61	8.0 ± 0.65	2.10 ± 0.04	0.44 ± 0.03	0.17 ± 0.02	0.0 ± 0.00
	4 WAS	36.02 ± 0.86	47.0 ± 1.29	5.16 ± 0.13	5.51 ± 0.28	0.51 ± 0.05	18.6 ± 1.04
	6 WAS	56.26 ± 0.98	65.0 ± 1.15	5.32 ± 0.20	7.70 ± 0.22	0.89 ± 0.08	37.2 ± 0.74
	8 WAS	85.56 ± 0.74	87.0 ± 1.08	5.56 ± 0.21	11.04 ± 0.52	0.97 ± 0.08	79.4 ± 1.15
	10 WAS	113.18 ± 2.96	114.0 ± 2.42	6.38 ± 0.24	15.98 ± 0.32	1.74 ± 0.08	99.0 ± 0.79
LSD (0.05)		3.98	3.82	0.48	0.83	0.17	2.54

Values are mean ± standard error, n = 5

LSD (0.05) = Least significant difference at 5% level of probability

and 1.74 gram per plant root dry weight in the second trial. Plant dry weight at an interval of two weeks differed significantly from one another in both trials (Table 4.6).

Number of nodules

At 2 WAS, no nodule was observed in the plants during the first and second trials. At 4 WAS, 19.40 nodules were produced in the first trial and 18.60 nodules were produced in the second trial. At 10 WAS, the number increased to 101.40 nodules in the first trial and 99.60 nodules in the second trial (Table 4.6).

4.3. Effect of varying light intensities on the performance of *akidi* (*Vigna unguiculata*) in Ibadan, Nigeria

4.3.1. Experimental soil

The physico-chemical analytical breakdown of the experimental site soil showed the soil to have; pH (6.7), organic carbon (1.8) and low nitrogen (0.2). Using textural triangle of the USDA, the soil was loamy sand in texture (Table 4.7).

Light intensity (Lux) under varying layer of mesh

The light intensity at 10.00 hrs in the open (0 - Net), 1 – Net, 2 – Nets and 3 – Nets treatments were 33900 lux, 24743.25 lux, 16944 lux, and 9321.63 lux respectively; at 18 hrs; 82050 lux, 57232.13 lux, 43475.75 lux and 26459.25 lux respectively; and at 18.00 hrs 5166.25 lux, 3293.25 lux, 2410.5 lux, and 1406.75 lux respectively. The mesh layers, 1 – Net, 2 – Net and 3 – Net reduced light intensity to approximately 73%, 50% and 28% at 10.00 hours; 70%, 53% and 32% at 14.00 hours and 64%, 47% and 27% at 18.00 hours respectively when values of measurement were expressed as percentages of value outside the cage (100% light intensity) (Table 4.8). On the average the 3, 2, and 1 net layer(s) reduced light intensity to about 30%, 50% and 70% respectively.

Vine length (cm)

At three Weeks After Sowing (WAS) of *akidi* under the 30% light intensity treatment the vine length was 34.78 cm and this was significantly (P = 0.5) higher than other treatments which ranged from 23.5 cm to 24.75 cm (first trial). A similar pattern was noted in the second trial with vine length of 35.50 cm which was also significantly

Table 4.7: Analysis of soil used for light intensity study

Properties	Values
pH (H_2O)	6.7
Organic carbon (%)	1.8
Total N (g/kg)	0.2
Available P (mg/kg)	15.0
Exchangeable base (cmol/kg)	
K (Potassium)	0.3
Ca (calcium)	7.0
Mg (Magnesium)	2.1
Na (Sodium)	0.6
Extractable micronutrient (mg/kg)	
Fe (Iron)	15.0
Zn (Zinc)	30.0
Cu	2.6
Physical properties (g/kg)	
Sand	846.0
Silt	108.0
Clay	46.0
Textural classification	Loamy sand

Table 4.8: Mean Light Intensity (Lux) Under Varying Layers of Mesh at Different Time in Ibadan, Nigeria

	10.00 hr		14.00 hr		18.00 hr		Daily	Mean
Net Layers	Light Intensity (Lux)	Percentage of Open	Light Intensity (Lux)	Percentage of Open	Light Intensity	Percentage of Open	Light Intensity (Lux)	Percentage of Open
0 – Net	33900	100	82050	100	5166.25	100	40372.08	100
1 – Net	24743.25	72.99	57232.13	69.75	3293.25	63.75	28422.88	70
2 – Net	16944	49.98	43475.75	52.99	2401.50	46.48	20940.42	50
3 – Net	9321.63	27.50	26459.25	32.25	1406.75	27.23	12395.88	30

higher than all other treatments which ranged from within 24.75 cm to 26.75 cm in the second trial.

At 5 WAS and 7 WAS *akidi* under the 30% light intensity had vine length of 141.09 cm and 188.55 cm which were significantly greater ($P \leq 0.05$) than other treatments that ranged from 52.20 cm and 84.05 cm to 116.28 cm to 143.21 cm in the first trial. A similar pattern was noticed in the second trial, where the vine length of *akidi* under 30% light intensity were 150.04 cm and 189.25 cm which were as well significantly ($P \leq 0.05$) greater than that of all other treatments which ranged from 53.25 cm and 87.75 cm to 122.25 cm and 186.25 cm, respectively. This trend was observed throughout the experiment.

At 9 WAS the vine length at 30% light intensity was 191.33 cm (first trial) and 194.5 cm (second trial). This, when compared to other treatments was significantly ($P \leq 0.05$) higher. The lowest vine length was recorded in the control treatment (100%) throughout the experiment (Table 4.9).

Number of leaves

At three WAS of *akidi*, the 30% light intensity treatment had the highest number of leaves (28.50) which were significantly ($P \leq 0.05$) greater than all other treatment (Table 4.10). The second trial followed the same trend with the highest leaves number, 28.25 being significantly ($P \leq 0.05$) greater than all the other treatments. The 100% light intensity (control) treatment had the lowest number of leaves 22.75 and 22.25 leaves in the 1st and 2nd trials respectively.

At 5 WAS the number of leaves under 30% light intensity treatment was 65.50 for the first and second trial. These treatment means were significantly ($P \leq 0.05$) higher than those of other treatments ranging from 50.50 to 56.00 and 50.75 to 57.25 leaves for first and second trial respectively. These were followed by the 50% light intensity treatment (56.00 and 57.25) leaves respectively for the first and second trials. This trend was also maintained at 7 WAS. At 9 WAS, the number of leaves under the 30% light intensity treatment was 144.25 for the first trial and 146.00 for the second trial. These were significantly higher than all other treatments which ranged from 108.00 to 135.00 and 107.75 to 137.50 for the first and second trial respectively (Table 4.10).

Table 4.9: Effect of Varying Light Intensity on Vine Length (cm) of *Vigna unguiculata* in Ibadan, Nigeria

	Light Intensity (%)	3WAS	5 WAS	7 WAS	9 WAS
		First Trial			
	100	23.50 ± 1.02	52.20 ± 1.08	84.05 ± 0.82	102.98 ± 0.85
	70	24.75 ± 0.83	57.03 ± 1.24	105.34 ± 0.95	116.31 ± 0.92
	50	24.50 ± 0.91	116.28 ± 0.94	143.21 ± 1.22	179.43 ± 0.88
	30	34.78 ± 0.84	141.09 ± 0.80	188.55 ± 1.13	191.33 ± 0.87
LSD (0.05)		2.41	2.74	2.78	2.35
		Second Trial			
	100	24.75 ± 0.87	53.25 ± 1.05	87.75 ± 0.71	107.50 ± 0.90
	70	26.75 ± 0.73	58.04 ± 0.92	111.75 ± 0.80	119.25 ± 1.03
	50	26.88 ± 0.85	122.25 ± 1.12	154.25 ± 0.68	186.75 ± 0.96
	30	35.50 ± 1.39	150.04 ± 0.89	189.25 ± 0.95	194.50 ± 0.78
LSD (0.05)		2.65	2.66	2.11	2.46

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Week After Sowing

Table 4.10: Effect of Varying Light Intensity on the Number Leaves of *Vigna unguiculata* in Ibadan, Nigeria

	Light intensity (%)	3WAS	5 WAS	7 WAS	9 WAS
			First Trial		
	100	22.75 ± 0.55	50.50 ± 0.75	80.75 ± 1.19	108.00 ± 0.82
	70	25.75 ± 0.73	54.50 ± 1.20	106.50 ± 0.75	129.50 ± 0.75
	50	26.75 ± 0.55	56.00 ± 0.82	126.25 ± 0.73	135.00 ± 0.94
	30	28.50 ± 1.11	65.50 ± 1.00	129.00 ± 0.94	144.25 ± 0.87
LSD (0.05)		2.05	2.55	2.46	2.26
			Second Trial		
	100	22.25 ± 0.99	50.75 ± 0.99	80.50 ± 0.75	107.75 ± 0.99
	70	25.25 ± 0.87	53.25 ± 0.73	108.25 ± 0.73	131.50 ± 0.87
	50	26.25 ± 0.73	57.25 ± 0.55	128.50 ± 1.11	137.00 ± 0.67
	30	28.25 ± 1.19	65.50 ± 0.75	130.00 ± 0.94	146.00 ± 1.05
LSD (0.05)		2.55	2.05	2.38	2.42

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Weeks After Sowing

Stem diameter

At three weeks after sowing (WAS) of *V. unguiculata* the highest stem diameter, 4.09 mm, was observed under the 100% light intensity treatment in the first trial (Table 4.11). The second trial was also similar with the 100% light intensity treatment producing the thickest stem with the value of 4.02 mm. At 5 WAS the highest stem diameter of 5.95 mm was recorded for the 100% light intensity treatment for the first trial and 5.85 mm for the second trial. The treatment means for the 100% light intensity when compared with other treatment means was significantly ($P \leq 0.05$) higher than other treatments means across the trials. At 7 WAS, the 100% light intensity treatment recorded the highest stem diameter value of 5.66 mm for the 1st trial and 5.89 mm for the 2nd trial.

Also at 9 WAS, the highest stem diameter, 6.20 mm, was recorded under the 100% light intensity treatment for the 1st trial while the highest value of 6.29 mm was recorded for the second trial. The 30% light intensity treatment had the lowest stem diameter for both trials (Table 4.11).

Shoot dry weight

At three weeks after sowing, the 100% light intensity treatment had the highest shoot dry weight of 1.16 g and 1.12 g for the first and second trials. The lowest shoot dry weight 0.72 g and 0.67 g for the first and second trial respectively. At five weeks after sowing, the highest shoot dry weight 9.47 g, for the first trial and 9.52 g for the second trial were recorded under 100% light intensity treatment. These were followed by 70% light intensity treatment, 7.71 g in the first trial and 7.92 g in the second trial. The lowest shoot dry weight, 5.87 g (1st trial) and 5.65 g (2nd trial) were recorded under the 30% light intensity treatment and were significantly lower than every other treatment means (Table 4.12). The highest shoot dry weight value of 9.98 g (1st trial) and 10.05 g (2nd trial) was recorded under the 100% light intensity treatment, while the lowest value, 7.14 g (first trial) and 7.72 g (second trial) were recorded for the 30% light intensity treatment.

Table 4.11: Effect of varying light intensity on stem diameter (mm) of *Vigna unguiculata* in Ibadan, Nigeria

	Net layer	3WAS	5 WAS	7 WAS	9 WAS
		First Trial			
	100	4.09 ± 0.18	5.95 ± 0.19	5.66 ± 0.25	6.20 ± 0.18
	70	4.01 ± 0.15	5.39 ± 0.17	5.52 ± 0.24	6.17 ± 0.15
	50	3.85 ± 0.18	5.28 ± 0.22	5.05 ± 0.16	5.91 ± 0.18
	30	3.77 ± 0.21	4.86 ± 0.21	4.71 ± 0.21	5.26 ± 0.14
LSD (0.05)		0.48	0.52	0.58	0.43
		Second Trial			
	100	4.02 ± 0.29	5.85 ± 0.16	5.89 ± 0.13	6.29 ± 0.13
	70	3.90 ± 0.19	5.49 ± 0.19	5.53 ± 0.33	6.00 ± 0.22
	50	3.66 ± 0.17	5.19 ± 0.14	5.28 ± 0.26	6.09 ± 0.14
	30	3.14 ± 0.16	4.88 ± 0.22	5.09 ± 0.18	5.89 ± 0.16
LSD (0.05)		0.56	0.48	0.64	0.44

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Week After Sowing

Table 4.12: Effect of Varying Light Intensities on Shoot Dry Weight (g) of *Vigna unguiculata* in Ibadan, Nigeria

	Light Intensity (%)	3WAS	5 WAS	7 WAS	9 WAS
		First Trial			
	100	1.16 ± 0.10	9.47 ± 0.34	9.98 ± 0.70	13.86 ± 0.44
	70	1.05 ± 0.08	7.71 ± 0.37	9.65 ± 0.64	13.16 ± 0.54
	50	0.98 ± 0.11	7.05 ± 0.25	8.07 ± 0.31	11.45 ± 0.41
	30	0.72 ± 0.09	5.87 ± 0.31	7.14 ± 0.27	11.32 ± 0.75
LSD (0.05)		0.26	0.85	1.38	1.47
		Second Trial			
	100	1.12 ± 0.18	9.52 ± 0.31	10.05 ± 1.05	13.74 ± 0.43
	70	1.01 ± 0.15	7.92 ± 0.37	9.52 ± 0.39	12.83 ± 0.36
	50	0.92 ± 0.13	7.03 ± 0.29	8.07 ± 0.36	11.63 ± 0.37
	30	0.67 ± 0.18	5.65 ± 0.32	7.72 ± 0.43	11.22 ± 0.62
LSD (0.05)		0.43	0.86	1.68	1.23

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Weeks After Sowing

However, at 9 WAS, the 30% light intensity treatment had the highest shoot dry weight of 13.86 g for the first trial and 13.74 g for the second trial (Table 4.12). This was closely followed by the 100% light intensity treatment with a shoot dry weight of 13.16 g (1st trial) and 12.83 g (2nd trial). The lowest shoot dry weight values of 11.32 g for the first trial and 11.22 g for the second trial were obtained under the 50% light intensity treatment (Table 4.12).

Root dry weight

At 3 WAS of akidi, the 30% light intensity treatment recorded the lowest root dry weight value of 0.21 g and 0.20 g for the first and second trial, respectively. These treatment means were significantly ($P \leq 0.05$) lower than all other treatments (Table 4.13). At 5 WAS, the lowest root dry weight values of 0.30 g (1st trial) and 0.33 g (2nd trial) were obtained under the 30% light intensity treatment. These values differed significantly from all other treatments (Table 4.13).

At 7 WAS the lowest root dry weight value of 0.32 g (1st trial) and 0.41 g (2nd trial) was recorded under the 30% light intensity treatment which were also significantly ($P \leq 0.05$) lower than all other treatments value (Table 4.13). At 9 WAS the 30% light intensity treatment had the lowest root weight value of 0.77 g and 0.75 g for the first and second trials, while all other treatments ranged from 0.89 g to 1.31 g (1st trial) and 0.87 g to 1.26 g (2nd trial) (Table 4.13). The 100% light intensity treatment had the highest root dry weight all through the experiment ranging from 0.25 g to 1.31 g (first trial) and 0.26 g to 12 g (second trial).

Number of nodules

At 3 WAS of *akidi*, all the treatments had nodules ranging from 2.25 to 10.50 and differed significantly ($P \leq 0.05$) from one another in the first trial. Also, in the second trial a similar pattern was observed. The nodules observed ranged between 2.75 to 9.25 and they differed significantly ($P \leq 0.05$) one from another. The 100% light intensity (control) treatment had the highest number of nodules, 10.50 (1st trial) and 10.75 (2nd trial) (Table 4.14).

At 5 WAS, a total of 34.75 root nodules were observed to be present under the 100% light intensity treatment and when compared with other treatment mean ranging from 4.25 to 27.25 were significantly ($P \leq 0.05$) higher in the first trial (Table 4.14).

Table 4.13: Effect of Varying Light Intensities on Root Dry Weight (g) of *Vigna unguiculata* in Ibadan, Nigeria

	Light Intensity (%)	3WAS	5 WAS	7 WAS	9 WAS
		First Trial			
	100	0.25 ± 0.03	0.69 ± 0.12	0.70 ± 0.10	1.31 ± 0.21
	70	0.24 ± 0.03	0.59 ± 0.13	0.69 ± 0.07	1.24 ± 0.11
	50	0.22 ± 0.04	0.50 ± 0.06	0.64 ± 0.11	0.89 ± 0.15
	30	0.21 ± 0.02	0.30 ± 0.06	0.32 ± 0.06	0.77 ± 0.16
LSD (0.05)		0.08	0.26	0.24	0.44
		Second Trial			
	100	0.26 ± 0.04	0.66 ± 0.05	0.79 ± 0.05	1.26 ± 0.27
	70	0.24 ± 0.04	0.57 ± 0.07	0.72 ± 0.04	1.14 ± 0.12
	50	0.23 ± 0.05	0.54 ± 0.08	0.69 ± 0.03	0.87 ± 0.16
	30	0.20 ± 0.02	0.33 ± 0.04	0.41 ± 0.08	0.75 ± 0.17
LSD (0.05)		0.10	0.16	0.14	0.50

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Weeks After Sowing

Table 4.14: Effect of Light on the Number of Nodules Produced by *Vigna unguiculata* in Ibadan, Nigeria

	Light Intensity (%)	3WAS	5 WAS	7 WAS	9 WAS
		First Trial			
	100	10.50 ± 0.75	34.75 ± 0.87	58.25 ± 0.55	43.75 ± 1.59
	70	8.50 ± 1.20	27.25 ± 0.73	37.75 ± 0.73	41.25 ± 1.19
	50	4.50 ± 1.00	11.25 ± 0.99	27.25 ± 2.08	7.25 ± 1.19
	30	2.25 ± 0.55	4.25 ± 0.73	6.25 ± 1.28	2.50 ± 0.75
LSD (0.05)		2.42	2.22	3.47	3.25
		Second Trial			
	100	10.75 ± 1.19	33.50 ± 0.75	52.50 ± 1.20	43.50 ± 1.53
	70	9.25 ± 0.99	25.25 ± 1.36	41.75 ± 0.99	41.50 ± 2.13
	50	4.25 ± 0.87	11.50 ± 1.00	23.50 ± 1.00	7.50 ± 2.03
	30	2.75 ± 0.87	5.25 ± 0.73	10.50 ± 0.33	2.75 ± 1.28
LSD (0.05)		2.63	2.65	2.51	4.74

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Weeks After Sowing

A similar pattern was also noted in the second trial with the highest nodules value of 33.50 observed under the 100% light intensity treatment and differed significantly ($P \leq 0.05$) from other treatments that ranged between 5.25 to 25.25 nodules.

At 7 WAS, the highest root nodules value of 58.25 was recorded under the 100% light intensity treatment and differed significantly ($P \leq 0.05$) above every other treatments ranging between 6.25 to 37.75 nodules in the first trial (Table 4.14). The second trial also followed similar trend, the highest root nodules value of 52.50 was observed under the 100% light intensity treatment and differed significantly ($P \leq 0.05$) from all other treatments means ranging between 10.50 to 41.75 nodules.

At 9 WAS, the 100% light intensity treatment had nodules numbering up to 43.75 in the 1st trial and 43.50 in the 2nd trial. These were higher than other treatments that ranged between 2.50 to 41.25 nodules (1^{st} trial) and 2.75 to 41.50 nodules in the (2^{nd} trial). The 30% light intensity treatment had the lowest root nodules value throughout the study with nodules ranging between 2.25 to 6.25 (1st trial) and 2.75 to 10.50 (2nd trial) (Table 4.14).

4.4. The Allelopathic Study of Aqueous Extracts of Dried Shoot and Root of Akidi on *Z. mays*

4.4.1. Effect of varying concentration of aqueous extracts of dried shoot and root on germination of *Z. mays* after 7 days

Germination of maize seeds declined at higher concentration of aqueous solution (Table 4.15). The Aqueous Root Extracts (ARE100) had 53.33% and 80.00% germination in the first and second trial respectively which was significantly ($P < 0.05$) lower than other treatments extract (Table 4.15). The highest germination value 93.33%, was observed under the control treatment for the first and second trial. The Aqueous Shoot Extract (ASE25), also with 93.33%, was similar. The result revealed significant ($P < 0.05$) difference among the aqueous extract treatments (Plate 4.2 and 4.3).

4.4.2. Effect of varying concentration of aqueous extract on plumule length of *Z. mays* after 7 days

Higher concentration of aqueous shoot and root extracts of *akidi* retarded the plumule length of *Z. mays*. The ASE100 significantly impaired plumule length of *Z.*

mays. A plumule length of 2.57 cm and 1.62 cm were obtained for the first and second trials which was significantly lower than all other aqueous extracts (Table 4.15). The control treatment recorded the highest plumule length of 7.89 cm and 7.64 cm respectively for both trials.

4.4.3. Effect of varying concentrations of aqueous extracts of *akidi* on radicle length of *Z. mays* after 7 days

As with the plumule, higher concentrations of aqueous shoot and root extracts of *akidi* impaired radicle length (Table 4.15). The ASE100 significantly impaired *Z. mays* radicle growth. The radicle length of 0.36 cm and 0.25 cm were obtained for the first and second trial which were significantly less than those of other treatments across the two trials which ranged between 0.49 cm to 0.72 cm (1^{st} trial) and 0.48 cm to 0.78 cm (2^{nd} trial).

4.4.4. Experimental soil

The physico-chemical analysis revealed that the soil of the experimental site is basic (6.2) with low organic carbon (1.8%) and low total nitrogen (0.2) (Table 4.16). Using textural triangle of the USDA, the soil was loamy sand in texture.

4.4.5. Effect of Varying Concentrations of Aqueous Extracts of Dried Shoots and Roots of *Akidi* on Some Vegetative Parameters of *Z. mays* Sown in Pots

Plant height

There were no significant effect of the extracts on the height of maize at 2 WAS, across the two trials (Table 4.17). The tallest height 24.98 cm and 22.21 cm respectively for the first and second trials recorded under the control were not superior for the shortest heights 23.38 cm and 21.96 cm recorded under ASE 100.

At 4 WAS, the shoot extract were more allelopathic than the root extracts. Also, allelopathy was directly proportional to concentration. This trend is similar across the experimental duration.

Table 4.15: Effect of Varying Concentration of Aqueous Extracts of Dried Shoot and Roots of Akidi on the Germination Percentage of *Zea mays* Seeds After Seven Days in a Laboratory

	Treatments	Germinated Seeds	Plumule Length (cm)	Radicle Length (cm)
		First Trial		
	100% w/v shoot extract (ASE100)	70.00 ± 0.71	2.57 ± 0.49	0.36 ± 0.07
	50% w/v shoot extract (ASE50)	73.33 ± 0.41	5.99 ± 0.46	0.56 ± 0.08
	25% w/v shoot extract (ASE25)	76.67 ± 0.82	6.19 ± 0.58	0.67 ± 0.09
	100% w/v root extract (ARE100)	53.33 ± 1.08	4.50 ± 0.45	0.49 ± 0.05
	50% w/v root extract (ARE50)	63.33 ± 0.81	5.65 ± 0.55	0.60 ± 0.06
	25% w/v root extract (ARE25)	86.67 ± 0.41	6.33 ± 0.46	0.72 ± 0.06
	Control (distilled water)	93.33 ± 0.82	7.89 ± 0.52	1.10 ± 0.13
LSD (0.05		1.87	1.25	0.20
		Second Trial		
	100% w/v shoot extract (ASE100)	90.00 ± 0.71	1.62 ± 0.43	0.25 ± 0.05
	50% w/v shoot extract (ASE50)	90.00 ± 0.71	6.26 ± 0.53	0.67 ± 0.10
	25% w/v shoot extract (ASE25)	93.33 ± 0.82	6.23 ± 0.51	0.73 ± 0.09
	100% w/v root extract (ARE100)	80.00 ± 0.71	4.26 ± 0.19	0.48 ± 0.06
	50% w/v root extract (ARE50)	83.33 ± 0.82	6.47 ± 0.63	0.67 ± 0.12
	25% w/v root extract (ARE25)	90.00 ± 0.71	6.90 ± 0.48	0.78 ± 0.11
	Control (distilled water)	93.33 ± 0.41	7.64 ± 0.62	1.10 ± 0.10
LSD (0.05		1.75	1.25	0.23

Values are mean ± standard error, n = 4

LSD (0.05) = Least significant difference at 5% level of probability

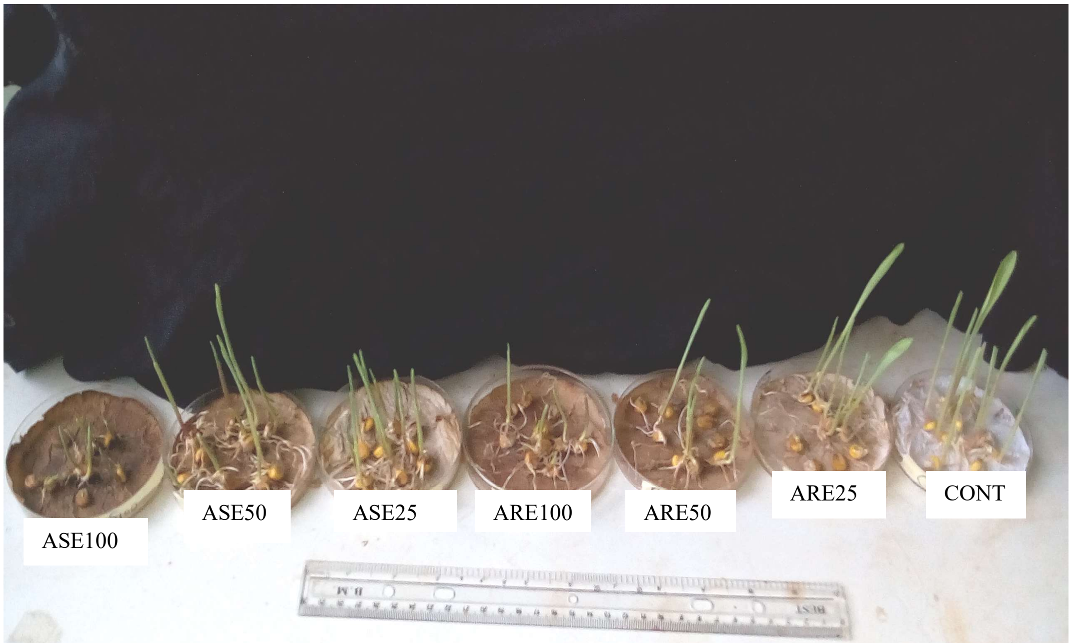


Plate 4.1: Effect of different concentration of aqueous extracts of dried shoot and roots on the germination of *Z. mays* after 7 days (First trials)

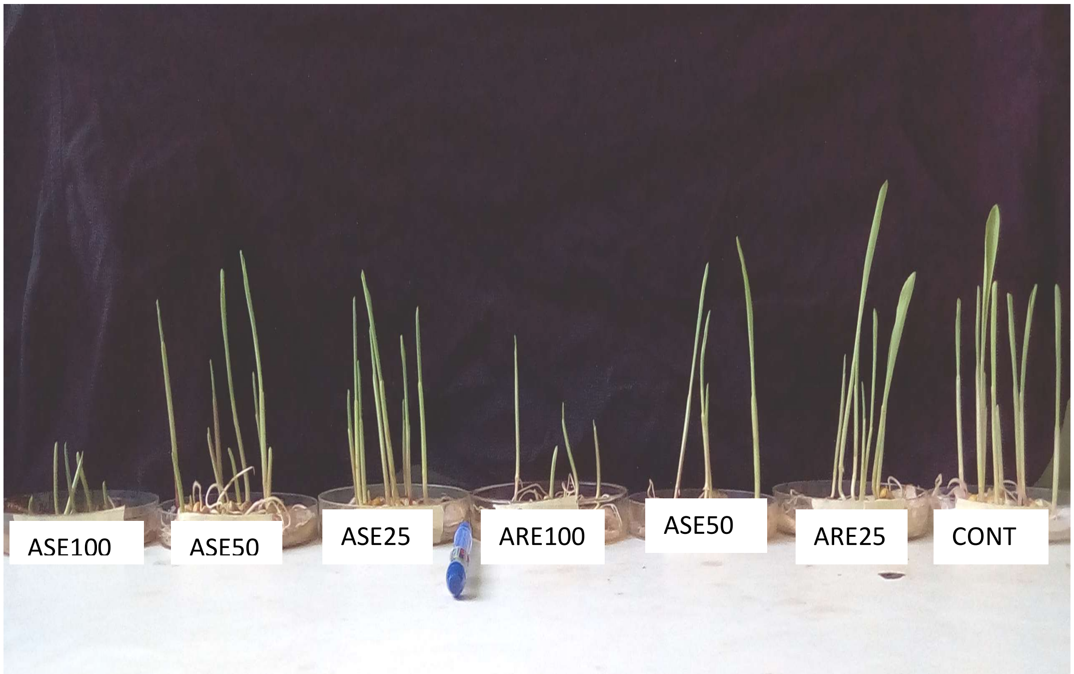


Plate 4.2: Effect of different concentration of aqueous extracts of dried shoot and roots on the germination of *Z. mays* after 7 days (Second trial)

Table 4.16: Analysis of Soil Used for Allelopathic Study

Properties	Values
pH (H_2O)	6.2
Organic carbon (%)	16
Total N (g/kg)	2
Available P (mg/kg)	15
Exchangeable base (cmol/kg)	
K (Potassium)	0.2
Ca (calcium)	4.6
Mg (Magnesium)	1.9
Na (Sodium)	0.7
Extractable micronutrient (mg/kg)	
Fe (Iron)	18
Zn (Zinc)	25
Cu	1
Physical properties (g/kg)	
Sand	783.0
Silt	145.0
Clay	72.0
Textural classification	Loamy sand

Stem diameter

There were no significant effects of the extract on the stem diameter of maize across the growth duration (Table 4.18). However, as in the plant height, allelopathy was directly proportional to the concentration of the extracts i. e. the higher the concentration the higher the retardation across the two trials. Unlike the plant height, the control treatment was not superior to the treated plants with respect to stem diameter.

Leaf area

The effect of the extracts of akidi shoots and roots on leaf area of maize is presented in Table 4.19. As with the plant height and stand diameter, the allelopathy effects of the extracts is directly proportional to the concentration. There were no significant effect of the extracts on maize leaf area of 2 WAS regardless the concentration. However, leaf area increased with reducing concentration of the twon extracts. At 4 WAS and above, the effects of the concentration of extract were significant on the leaf area for both trials. The control treatment was superior in leaf area across the two trials. The results also showed that there was no definite trend with report to the effect of the shoot and root extracts on comparison.

4.4.6. Effect of Varying Concentrations of Aqueous Extracts of Dried Shoot and Roots of Akidi on Some Yield Component of *Zea mays* in Pots

Fresh weight

The highest fresh weight of 103.25 g (1st trial) and 101.93 g (2nd trial) maize was observed under the control treatment. The values were significantly ($P < 0.05$) different from those of other treatments. The least fresh weight value was obtained from the ASE100 treatment, with 45.48 g (first trial) and 43.81 g (second trial) (Table 4.20).

Dehusked maize weight

The highest dehusked maize weight, 66.50 g (first trial) and 64.84 g (second trial), the result had significance difference in the midst of other treatment used for the study (Table 4.19) was obtained under the control treatment. The ASE100 treatment produced the lowest dehusked maize weight, 22.31 g (1st trial) and 21.59 g (2nd trial) (Table 4.20).

Table 4.17. Effect of Varying Concentration of Aqueous Extracts of Dried Shoot and Roots of Akidi on Plant Height of *Z. mays* in Pot

	Treatments	2 WAS	4 WAS	6 WAS	8 WAS
		First Trial			
	100% w/v shoot extract (ASE100)	23.38 ± 1.01	41.63 ± 1.11	70.03 ± 1.07	98.43 ± 0.95
	50% w/v shoot extract (ASE50)	24.20 ± 0.92	42.68 ± 2.13	70.58 ± 1.42	104.33 ± 0.91
	25% w/v shoot extract (ASE25)	24.40 ± 0.56	46.95 ± 1.48	72.10 ± 1.29	106.90 ± 0.95
	100% w/v root extract (ARE100)	23.78 ± 0.60	47.33 ± 1.51	70.45 ± 1.84	102.28 ± 0.90
	50% w/v root extract (ARE50)	24.10 ± 0.57	51.58 ± 1.05	71.58 ± 1.10	103.48 ± 0.78
	25% w/v root extract (ARE25)	24.38 ± 0.87	53.30 ± 1.22	71.90 ± 1.00	107.13 ± 0.86
	Control (distilled water)	24.98 ± 1.02	55.43 ± 1.23	78.75 ± 1.17	118.20 ± 0.91
LSD (0.05		2.08	3.64	3.30	2.28
		Second Trial			
	100% w/v shoot extract (ASE100)	21.96 ± 1.15	39.57 ± 1.13	68.30 ± 1.35	96.87 ± 2.38
	50% w/v shoot extract (ASE50)	22.01 ± 0.95	41.51 ± 0.80	71.32 ± 1.63	102.82 ± 2.14
	25% w/v shoot extract (ASE25)	22.13 ± 0.88	44.61 ± 0.80	75.98 ± 1.52	105.88 ± 1.25
	100% w/v root extract (ARE100)	22.00 ± 1.06	46.11 ± 1.34	68.41 ± 1.63	101.60 ± 1.06
	50% w/v root extract (ARE50)	22.04 ± 0.82	51.03 ± 0.94	70.42 ± 1.95	102.19 ± 1.51
	25% w/v root extract (ARE25)	22.06 ± 1.25	52.59 ± 0.86	70.91 ± 3.38	106.19 ± 0.92
	Control (distilled water)	22.21 ± 0.75	52.70 ± 0.93	77.36 ± 0.89	115.40 ± 0.83
LSD (0.05		1.92	2.52	4.86	3.94

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability
WAS = Week After Sowing

Table 4.18. Effect of Varying Concentrations of Aqueous Extracts of Dried Shoot and Roots of *Akidi* on the Stem Diameter of *Zea mays* in Pot

	Treatments	2 WAS	4 WAS	6 WAS	8 WAS
	First Trial				
	100% w/v Aqueous Shoot Extract (ASE100)	6.21 ± 0.66	8.96 ± 1.10	10.94 ± 1.51	13.89 ± 1.49
	50% w/v Aqueous Shoot Extract (ASE50)	6.59 ± 0.69	9.77 ± 1.27	11.86 ± 1.21	14.15 ± 1.30
	25% w/v Aqueous Shoot Extract (ASE25)	6.77 ± 0.71	10.61 ± 1.07	12.73 ± 1.43	15.51 ± 1.21
	100% w/v Aqueous Root Extract (ARE100)	6.35 ± 0.77	9.88 ± 1.09	11.03 ± 1.23	14.53 ± 1.01
	50% w/v Aqueous Root Extract (ARE50)	7.00 ± 1.03	10.18 ± 1.02	11.33 ± 1.12	15.42 ± 0.92
	25% w/v Aqueous Root Extract (ARE25)	7.01 ± 0.79	10.83 ± 1.01	11.65 ± 0.81	15.55 ± 1.21
	Control (distilled water)	7.87 ± 1.09	11.57 ± 1.65	13.71 ± 1.59	16.55 ± 1.42
LSD (0.05)		2.13	3.04	3.29	3.22
	Second Trial				
	100% w/v Aqueous Shoot Extract (ASE100)	6.28 ± 0.71	8.89 ± 0.90	11.16 ± 1.16	13.50 ± 0.64
	50% w/v Aqueous Shoot Extract (ASE50)	6.45 ± 0.86	9.81 ± 0.83	11.73 ± 1.14	15.12 ± 0.84
	25% w/v Aqueous Shoot Extract (ASE25)	6.80 ± 0.82	10.44 ± 0.93	12.39 ± 0.72	15.26 ± 0.71
	100% w/v Aqueous Root Extract (ARE100)	6.15 ± 0.87	8.40 ± 0.75	11.20 ± 0.80	14.50 ± 0.78
	50% w/v Aqueous Root Extract (ARE50)	6.43 ± 0.90	9.63 ± 0.97	12.48 ± 0.95	15.35 ± 0.63
	25% w/v Aqueous Root Extract (ARE25)	6.74 ± 0.81	9.96 ± 0.75	12.94 ± 0.74	15.40 ± 0.94
	Control (distilled water)	6.97 ± 0.75	10.77 ± 0.88	13.59 ± 0.85	16.47 ± 0.78
LSD (0.05)		2.09	2.20	2.35	1.95

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability

Table 4.19. Effect of Varying Concentrations of Aqueous Extracts of Dried Shoots and Roots of Akidi on the Leaf Area of *Z. mays* Sown in Pots

	Treatments	2 WAS	4 WAS	6 WAS	8 WAS
		First Trial			
	100% w/v Aqueous Shoot Extract (ASE100)	23.64 ± 0.98	47.23 ± 1.28	110.59 ± 1.19	206.30 ± 1.03
	50% w/v Aqueous Shoot Extract (ASE50)	23.74 ± 1.08	50.75 ± 1.03	111.35 ± 1.02	228.11 ± 1.07
	25% w/v Aqueous Shoot Extract (ASE25)	23.90 ± 1.23	51.95 ± 1.05	154.22 ± 1.21	302.43 ± 1.15
	100% w/v Aqueous Root Extract (ARE100)	23.88 ± 1.14	37.76 ± 1.19	94.54 ± 1.22	245.52 ± 1.37
	50% w/v Aqueous Root Extract (ARE50)	23.76 ± 1.24	47.60 ± 1.08	107.34 ± 1.02	258.47 ± 1.27
	25% w/v Aqueous Root Extract (ARE25)	23.72 ± 1.08	52.42 ± 0.99	119.18 ± 1.05	309.45 ± 1.03
	Control (distilled water)	23.97 ± 1.04	64.90 ± 1.06	117.41 ± 1.02	215.17 ± 1.32
LSD (0.05)		2.84	2.81	2.82	3.02
		Second Trial			
	100% w/v Aqueous Shoot Extract (ASE100)	22.74 ± 1.17	46.15 ± 1.13	105.83 ± 1.14	204.57 ± 1.03
	50% w/v Aqueous Shoot Extract (ASE50)	22.73 ± 1.01	49.72 ± 1.24	109.32 ± 1.02	226.16 ± 1.38
	25% w/v Aqueous Shoot Extract (ASE25)	22.91 ± 0.40	50.80 ± 1.04	148.75 ± 1.06	302.02 ± 1.44
	100% w/v Aqueous Root Extract (ARE100)	23.51 ± 1.00	36.14 ± 1.13	92.50 ± 1.04	243.86 ± 1.05
	50% w/v Aqueous Root Extract (ARE50)	23.59 ± 1.03	44.91 ± 1.07	105.29 ± 1.08	255.03 ± 1.24
	25% w/v Aqueous Root Extract (ARE25)	23.66 ± 1.17	51.00 ± 1.19	116.89 ± 1.06	307.67 ± 1.02
	Control (distilled water)	23.86 ± 1.08	62.86 ± 1.14	115.42 ± 1.12	218.21 ± 1.15
LSD (0.05)		2.61	2.89	2.74	2.93

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability

Shelled maize weight

The highest shelled maize weight of 11.64 g for the first trial and 12.04 g for the second trial was obtained under the control treatment. These results were significant to be significantly ($P < 0.05$) higher than those of other treatments which ranged ranging between 5.60 g (ASE100) to 7.65 g (ARE25) in both trials (Table 4.20). The lowest shelled maize weight was recorded under ASE100 treatment with values 5.68 g (first trial) and 5.60 g (second trial).

100 - Seed weight of maize

The control treatments produced the heaviest weight as measured by 100-seed weights. The weights, 9.24 g (first trial) and 11.17 g (second trial) obtained, differed significantly from all other treatments in both trials. Also, the lowest seed weight, 4.95 g and 5.03 g weas recorded under ASE100 treatment for both trials (Table 4.20).

Dried shoot weight of maize

The dried shoot weight of maize was significantly affected by treatsments. The highest shoot weight (31.78 g) was recorded under ASE 25 which was significantly higher than all other values in the first trial and 30.89 g in the second trial which was also better than others in the trial. The least values 20.42 g and 20.02 g respectively for 1st and 2nd trial were recorded with ARE100 which indicated that the root extracts was more allelopathic than the shoot extract when applied at 100%.

Dried root weight of maize

As with the dried shoot, the highest root weights were recorded under the ASE 25 (11.90 and 11.60 g) in both trials, while the least values were observed under ASE 100 and ASE 50 (2.78, 4.94 g) respectively for the first trial and 2.66 g and 5.04 g respectively for the second trial. There were no significant ($P = 0.05$) difference between the dried root weight of maize treated with ARE 100 and ARE 50 (6.67 g and 6.95 g) respectively for the first trial and 6.57 g and 6.89 g respectively for the second trial when compared to the control treatments (7.95 g and 7.88 g) respectively for the first and second trial.

Table 4.20: Effect of varying concentrations of aqueous extracts of Akidi dried shoots and roots on the yield components *Zea mays* in pots

	Treatments	Fresh Weight (g)	Dehusked Weight (g)	Shelled Weight (g)	100 - Seed Weight (g)
			First Trial		
	100% w/v Aqueous Shoot Extract (ASE100)	45.48 ± 1.31	22.31 ± 1.20	5.68 ± 0.51	5.03 ± 0.52
	50% w/v Aqueous Shoot Extract (ASE50)	54.21 ± 1.09	36.75 ± 1.28	7.15 ± 0.73	5.40 ± 0.40
	25% w/v Aqueous Shoot Extract (ASE25)	63.83 ± 1.08	36.85 ± 1.24	7.41 ± 0.75	5.56 ± 0.69
	100% w/v Aqueous Root Extract (ARE100)	60.24 ± 1.12	33.59 ± 1.17	6.45 ± 0.78	5.76 ± 0.45
	50% w/v Aqueous Root Extract (ARE50)	52.80 ± 1.26	24.13 ± 1.18	7.17 ± 0.76	6.74 ± 0.87
	25% w/v Aqueous Root Extract (ARE25)	63.97 ± 1.21	30.46 ± 1.16	7.65 ± 0.66	6.78 ± 0.56
	Control (distilled water)	103.25 ± 1.01	66.50 ± 1.18	11.64 ± 0.78	9.24 ± 0.62
LSD (0.05		2.95	3.05	1.82	1.54
			Second Trial		
	100% w/v Aqueous Shoot Extract (ASE100)	43.81 ± 1.25	21.59 ± 1.04	5.60 ± 0.52	4.95 ± 0.41
	50% w/v Aqueous Shoot Extract (ASE50)	52.81 ± 1.11	35.96 ± 0.98	7.08 ± 0.66	5.35 ± 0.43
	25% w/v Aqueous Shoot Extract (ASE25)	61.81 ± 1.21	34.92 ± 1.06	7.39 ± 0.53	5.48 ± 0.31
	100% w/v Aqueous Root Extract (ARE100)	59.90 ± 1.26	32.77 ± 1.23	6.39 ± 0.58	5.68 ± 0.43
	50% w/v Aqueous Root Extract (ARE50)	51.73 ± 1.25	23.73 ± 1.03	7.10 ± 0.63	6.66 ± 0.49
	25% w/v Aqueous Root Extract (ARE25)	62.67 ± 1.06	28.96 ± 0.99	7.58 ± 0.62	7.10 ± 0.42
	Control (distilled water)	101.93 ± 1.11	64.84 ± 1.09	12.04 ± 0.72	11.17 ± 0.70
LSD (0.05		3.01	2.71	1.56	1.20

Values are mean ± standard error, n = 4
LSD (0.05) = Least significant difference at 5% level of probability

4.5.1. Effects of Planting Densities on Some Growth Parameters of *Akidi*

The effect of plant population of *akidi* on some growth parameter is presented in table 4.22. The vine increased with increasing density across the two trials with longest vines being 197.93 cm and 201.47 cm respectively for the two trials occurring as a population of 80,645 plants / ha (D5). There was an inverse relationship between the plant population and stem diameter. Diameter reduced with increasing population. The diameter did not vary from one population D1 to D3 significantly (P = 0.05) but were superior to population D4 and D5 which were equally similar in the second trial. The thickest stem was 11.59 cm while thinnest was 7.08 cm in the first trial and 12.10 cm and 7.93 cm in the second trial.

The shoot dry weight / plant weed dry weight / m^2 decreased with increasing plant population across trials. Weed dry weight was least in D5 (9.18 g and 9.02 g) respectively for the two trials. There were no significant variations in this parameter among treatments D2 to D4 across the two trials. As for the shoot dry weight / m^2, values increased with increasing population. The highest value of 73.76 g and 74.24 g were recorded respectively under the highest population (D5) from the two trials (Table 4.22).

Weed population reduction increased the plant populations. The highest reduction (81.13%) occurred under the highest population (D5) while the least (64.36%) occurred under the lowest population for the first trial and the trend is similar in the second trial (Table 4.22).

4.5.2: Floristic Enumeration of Herbaceous Plant Species Identified on the Plots of *Vigna unguiculata* Stocked at Varying Densities

The sum of twenty seven plant species from thirteen families was listed in the first trial. *Tridax procumbens* dominated with the highest RIV of 29.47% (D1); 30.46% (D2); 25.71% (D3); 25.89% (D4); 27.11% (D5) and 26.48% (D6) in the first trial (Table 4.23). *Ageratum conyzoides* and *Brachiaria deflexa* followed with RIV of 11.96% (D1); 16.39% (D2); 15.76% (D3); 17.67% (D4); 15.48% (D5) and 15.95% (D6). Species with low RIV were Corchorus *olitorius, Crotalaria retusa, Desmodium scorpiurus,* and *Sida acuta* with RIV of 2.10% each for D1. In the D2 treatment, *Desmodium scorpiurus* and *Stachytarpheta cayennensis* both had an RIV of 2.15% each. In the D3 treatment *Amaranthus cruentus,*

Table 4.21. Effect of Varying Concentrations of Aqueous Extracts of Dried Shoots and Roots of Akidi on Dry Weight of Z *mays* in Pots

	Treatment	Dried Shoot Weight (g)	Dried Root Weight (g)
	First Trial		
	100% w/v Aqueous Shoot Extract (ASE100)	23.46 ± 0.84	2.78 ± 0.28
	50% w/v Aqueous Shoot Extract (ASE50)	25.12 ± 0.75	4.94 ± 0.35
	25% w/v Aqueous Shoot Extract (ASE25)	31.78 ± 1.19	11.90 ± 0.66
	100% w/v Aqueous Root Extract (ARE100)	20.42 ± 0.96	6.67 ± 0.51
	50% w/v Aqueous Root Extract (ARE100)	25.96 ± 0.82	6.95 ± 0.65
	25% w/v Aqueous Root Extract (ARE100)	27.30 ± 0.85	11.71 ± 0.65
	Control (distilled water)	25.75 ± 1.15	7.95 ± 0.61
LSD (0.05)		2.42	1.34
	Second Trial		
	100% w/v Aqueous Shoot Extract (ASE100)	22.77 ± 0.87	2.66 ± 0.44
	50% w/v Aqueous Shoot Extract (ASE50)	24.94 ± 1.20	5.04 ± 0.36
	25% w/v Aqueous Shoot Extract (ASE25)	30.89 ± 1.10	11.60 ± 0.61
	100% w/v Aqueous Root Extract (ARE100)	20.02 ± 0.74	6.52 ± 0.87
	50% w/v Aqueous Root Extract (ARE100)	24.90 ± 0.94	6.86 ± 0.75
	25% w/v Aqueous Root Extract (ARE100)	26.70 ± 1.26	11.61 ± 0.74
	Control (distilled water)	25.16 ± 1.16	7.88 ± 0.79
LSD (0.05)		2.68	1.71

Values are mean ± standard error, n = 4

LSD (0.05) = Least significant difference at 5% level of probability

Table 4.22. Effects of Stocking Density of *Vigna unguiculata* on Its Vegetative Growth and Dry Weight of Other Plants at 10 weeks After Sowing.

Density (plant/m^2)	Vine Length cm/plant	Stem Diameter mm/plant	Shoot Dry Weight/plant (g)	Shoot Dry Weight (g) / m^2	Weed Dry Weight (g)	% Weed Reduction
First Trial						
D1 (30,121 plant per hectare)	127.55 ± 1.84	11.59 ± 0.86	12.46 ± 0.70	37.38 ± 1.08	17.34 ± 1.04	64.36
D2 (40,323 plant per hectare)	146.48 ± 1.23	10.11 ± 1.03	11.50 ± 1.02	46.00 ± 1.11	14.82 ± 0.91	69.54
D3 (50,000 plant per hectare)	158.00 ± 2.27	9.92 ± 0.91	10.15 ± 0.82	60.90 ± 1.67	12.34 ± 1.03	74.64
D4 (60,976 plant per hectare)	172.73 ± 1.43	8.90 ± 0.75	9.96 ± 0.81	69.72 ± 1.10	11.39 ± 0.87	76.59
D5 (80,645 plant per hectare)	197.93 ± 1.54	7.08 ± 0.62	9.22 ± 0.64	73.76 ± 1.27	9.18 ± 0.86	81.13
0 (Control)	-	-		-	48.66 ± 0.87	-
LSD (0.05)	4.44	2.21	2.11	3.31	2.40	
Second Trial						
D1 (30,121 plant per hectare)	130.25 ± 2.18	12.10 ± 0.97	12.74 ± 1.14	38.22 ± 1.17	28.23 ± 1.24	57.52
D2 (40,323 plant per hectare)	149.08 ± 1.73	11.79 ± 0.89	11.72 ± 0.91	46.88 ± 1.02	16.52 ± 0.93	75.14
D3 (50,000 plant per hectare)	162.96 ± 1.40	10.07 ± 0.95	10.65 ± 0.90	63.90 ± 1.19	15.47 ± 1.08	76.72
D4 (60,976 plant per hectare)	173.87 ± 1.42	8.21 ± 0.90	10.12 ± 1.06	70.84 ± 0.84	14.75 ± 1.17	77.81
D5 (80,645 plant per hectare)	201.47 ± 1.18	7.93 ± 0.88	9.28 ± 0.65	74.24 ± 1.05	9.02 ± 1.06	86.42
0 (Control)	-	-	-	-	66.46 ± 0.93	-
LSD (0.05)	4.23	2.40	2.46	2.77	2.77	

Values are mean ± standard error, n = 4

LSD (0.05) = Least significant difference at 5% level of probability

Corchorus olitorius, Setaria longiseta, Sesbania pachycarpa and *Stachytarpheta cayennesis* all had an RIV of 2.29% each. While in the D4 treatment, *Desmodium scorpiurus, Euphorbia hyssopifolia Phyllanthus amarus* and *Portulaca oleracea* all had an RIV of 2.11% each. In the D5 treatment, *Crotalaria retusa* and *Phyllanthus amarus* both had RIV of 2.41% each. In the D6 treatment, *Crotalaria retusa, Sesbania pachycarpa* and *Stachytarpheta cayennensis* had an RIV of 2.71% in the first trial experiment (Table 4.23).

The sum of twenty eight plant species from fourteen families was listed in the second trial. *Tridax procumbens* dominated with the highest RIV of 44.54% (D1); 35.94% (D2); 29.94% (D3); 39.40% (D4); 30.57% (D5) and 48.12% (D6) (Table 4.20). Species with low RIVs were *Corchorus olitorius* (D2) and *Vigna unguiculata* (D2) with RIV of 1.66% each for the second trial experiment (Table 4.24).

The herbaceous species taxa ranged between 11 to 17 and 13 to 19 for both trials. The D3 treatment had more taxa value of 17 species for the first trial with D5 treatment having the higher taxa value of 19 species (2nd trial) (Table 4.25). The individuals enumerated within the plots ranged between 103 to 170 (first trial) and 131 to 491 (second trial).

The Shannon – Wiener index of the herbaceous flora ranging between 1.81 to 1.93 (first trial) and 0.88 to 2.02 (second trial). Higher Shannon – Wiener index value of 1.93 was recorded for D4 treatment (first trial) and a value of 2.02 for the D5 treatments (second trial) (Table 4.25). The evenness index value ranged between 0.38 to 0.58 (1st trial) and 0.15 to 0.47 (2nd trial) (Table 4.25). Lowest evenness value of 0.38 was recorded for the first trial and a value of 0.15 for the second trial.The dominance index value ranged between 0.38 to 0.58 (1st trial) and 0.15 to 0.47 (2nd trial). Highest dominance index value of 0.27 for the first trial and0.65 for the second trial were recorded for D6 treatment.

Table 4.23: Relative Importance Value of Weed Species Encountered on Plots of *Vigna unguiculata* Stocked at Varying Densities (n = 8) - First Trial

S / N	Species Name	Family	D1	D2	D3	D4	D5	D6
1	*Ageratum conyzoides* Linn.	Asteraceae	11.96	16.39	15.76	17.67	15.48	15.95
2	*Amaranthus cruentus* Linn.	Amaranthaceae	-	-	2.29	-	-	-
3	*Boerhavia diffusa* Linn.	Nyctaginaceae	11.86	7.35	2.88	11.75	7.24	7.59
4	*Brachiaria deflexa* (Schumach) Robyns.	Poaceae	12.28	12.14	13.35	12.92	11.09	22.57
5	*Corchorus olitorius* Linn.	Malvaceae	2.10	-	2.29	-	-	-
6	*Crotalaria retusa* Linn.	Fabaceae	2.10	-	-	2.44	2.41	2.71
7	*Desmodium scorpiurus* (Swartz) Desvaux	Fabaceae	2.10	2.15	2.59	2.11	-	-
8	*Euphorbia heterophylla* Linn.	Euphorbiaceae	7.87	7.65	5.47	4.89	6.27	8.99
9	*Euphorbia hirta* Linn.	Euphorbiaceae	6.09	8.55	5.47	6.20	6.76	4.01
10	*Euphorbia hyssopifolia* Linn.	Euphorbiaceae	2.73	2.45	-	2.11	-	-
11	*Eleusine indica* (L.) Gaertn.	Poaceae	-	3.05	-	2.44	-	-
12	*Eragrostis atrovirens* (Desfontaines) Steudel	Poaceae	-	-	3.76	-	3.38	-
13	*Eragrostis tenella* (L.) P. Beauv.ex Roem. & Schult.	Poaceae	2.42	2.45	3.76	-	-	-
14	*Mitracarpa villosus* (Sw.) DC.	Rubiaceae	-	-	-	-	2.83	-
15	*Phyllanthus amarus* Schumach	Phyllanthaceae	4.51	2.45	-	2.11	2.41	3.14
16	*Portulaca oleracea* Linn.	Portulacaceae	-	-	-	2.11	-	3.14
17	*Rhaponticum repens* (L.) Hidalgo	Poaceae	-	-	2.59	-	-	-
18	*Setaria longiseta* P.Beauv.	Poaceae	-	-	2.29	-	-	-
19	*Sesbania pachycarpa* sensu auct.	Fabaceae	-	-	2.29	-	-	2.71
20	*Sida acuta* Burm F.	Malvaceae	2.10	-	-	-	-	-
21	*Solanum nigrum* Linn.	Solanaceae	-	-	-	2.44	-	-
22	*Spigelia anthelmia* Linn.	Loganiaceae	2.41	-	-	2.44	3.38	-
23	*Stachytarpheta cayennensis* (Richard) Vahl.	Verbenaceae	-	2.15	2.29	-	-	2.71
24	*Talinum fruticosum* (L.) Juss.	Talinaceae	-	-	4.59	-	-	-
25	*Tithonia diversifolia* (Hemsl.) A. Gray.	Asteraceae	-	-	3.76	-	-	-
26	*Tridax procumbens* Linn.	Asteraceae	29.47	30.46	25.71	25.89	27.11	26.48
27	*Vigna unguiculata* (L.) Walp.	Fabaceae	-	-	2.59	2.44	11.58	-

Table 4.24: Relative Importance Value of Weed Species Encountered on the Plots of *Vigna unguiculata* Stocked at Varying Density (n = 8) – Second Trial

S/N	Species Name	Family	D1	D2	D3	D4	D5	D6
1	*Ageratum conyzoides* Linn.	Asteraceae	8.16	9.06	12.60	13.81	13.64	10.48
2	*Amaranthus cruentus* Linn.	Amaranthaceae	-	3.31	2.32	-	-	-
3	*Boerhavia diffusa* Linn.	Nyctaginaceae	-	5.65	5.11	23.75	7.75	2.10
4	*Brachiaria lata* (Schumach.) C.E Hubbard	Poaceae	-	-	-	-	6.64	2.10
5	*Brachiaria deflexa* (Schumach) Robyns	Poaceae	5.37	8.90	13.77	26.42	5.91	3.32
6	*Corchorus olitorius* Linn.	Malvaceae	1.99	1.66	2.09	20.69	-	2.10
7	*Commelina benghalensis* Linn.	Commelinaceae	4.57	-	-	-	-	-
8	*Crotalaria retusa* Linn.	Fabaceae	-	1.88	-	5.07	5.17	-
9	*Desmodium scorpiurus* (Swartz) Desvaux	Fabaceae	-	-	-	20.69	-	-
10	*Euphorbia heterophylla*	Euphorbiaceae	4.57	5.42	9.29	4.27	5.54	4.51
11	*Euphorbia hirta*	Euphorbiaceae	4.17	5.88	4.88	21.84	2.95	4.71
12	*Euphorbia hyssopifolia* Linn.	Euphorbiaceae	-	-	-	2.33	-	-
13	*Eleusine indica* Linn.	Poaceae	-	-	-	1.94	-	2.20
14	*Eragrostis atrovirens* (Desfontaines) Steudel	Poaceae	-	-	-	-	2.59	-
15	*Eragrostis tenella* (L.) P. Beauv.ex Roem. & Schult.	Poaceae	-	-	-	-	-	2.10
16	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	4.17	-	-	-	2.95	-
17	*Momordica charantia* Linn.	Cucurbitaceae	-	3.31	-	-	-	-
18	*Phyllanthus amarus* Schumach	Phyllanthaceae	-	-	-	21.46	2.22	2.31
19	*Portulaca oleracea* Linn.	Portulacaceae	-	-	-	2.33	-	2.31
20	*Rhaponticum repens* (L.) Hidalgo	Poaceae	9.94	10.49	9.78	7.40	2.22	4.92
21	*Sesbania pachycarpa* sensu auct.	Fabaceae	4.17	3.54	2.09	1.94	-	4.40
22	*Solanum nigrum* Linn.	Solanaceae	-	-	-	21.08	-	-
23.	*Spigelia anthelmia* Linn.	Loganiaceae	-	-	-	3.89	4.81	2.20
24	*Stachytarpheta cayennensis*	Verbenaceae	-	-	2.32	-	-	2.10
25	*Talinum fruticosum* (L.) Juss.	Talinaceae	4.17	3.31	2.32	20.69	-	-
26	*Tithonia diversifolia* (Hemsl.) A. Gray.	Asteraceae	2.19	-	3.50	-	-	-
27	*Tridax procu8mbens* Linn.	Asteraceae	44.54	35.94	29.94	39.40	30.57	48.12
28	*Vigna unguiculata* (L.) Walp.	Fabaceae	1.99	1.66	-	20.69	7.03	-

Table 4.25: Floristic Diversity of Herbaceous Plant Species Enumerated On the Plots of *Vigna unguiculata* Stocked at Varying Densities

Treatment	Taxa _ S	Individuals	Shannon _ H	Evenness e^H/S	Dominance _ D
			First Trial		
D1	15	152	1.87	0.43	0.22
D2	14	159	1.81	0.44	0.25
D3	17	170	1.86	0.38	0.24
D4	12	103	1.93	0.58	0.21
D5	11	115	1.72	0.51	0.24
D6	13	167	1.74	0.44	0.27
			Second trial		
D1	13	250	1.11	0.23	0.57
D2	14	220	1.50	0.32	0.39
D3	13	213	1.75	0.44	0.26
D4	14	136	1.87	0.47	0.26
D5	19	131	2.02	0.40	0.22
D6	16	491	0.88	0.15	0.65

NOTE: *Akidi* planting densities were as follows**:** D1 = 3 plants / m^2; D2 = 4 plants / m^2; D3 = 5 plants / m^2; D4 = 6 plants / m^2; D5 = 8 plants / m^2; D6 = 0 plants / m^2;

4.6.1. Effect of Different Interplant Spacing on Vegetative Parameter of Maize Crop in Ibadan, Nigeria

Plant height (cm)

Maize that received hoe-weeded control (MHW) treatment recorded the highest plant height of 231.59 cm for the first trial and 177.13 cm for the second trial,and the result differed significantly (P ≤ 0.05) when compared to other treatments, which ranged from 164.62 cm to 223.60 cm (first trial) and 143.81 cm to 176.25 cm (second trial). In the weedy check (MWC) treatment maize had the lowest height value of 164.62 cm and 143.81 cm for the 1st and 2nd trials, respectively (Table 4.26). Within the interplant spacing treatment, the M + A 20 had the highest maize height value of 212.36 cm and 171.50 cm for the first and second trial, respectively, and these were significantly (P ≤ 0.05) different from any other treatments.

Stem diameter (mm)

In the stem diameter encompassing all treatments, MHW had the highest stem diameter value of 15.31 mm (first trial) and 15.83 mm (second trial) and the result showed significant difference among the treatments used. While maize (50,000 plants/ha) weedy control (MWC) had the lowest stem diameter of 10.74 mm and 13.63 mm for first and second trial, which were significantly (P ≤ 0.05) lower when compared to other treatments used in the experiment (Table 4.22).

At maturity (60 days) of the test crop maize, within the maize and akidi interplant treatments, M + A 20 had the highest stem diameter of 14.78 mm and were not significantly different (P ≤ 0.05) from other akidi interplant spacing treatments, for the first trial. In the second trial, M + A 20 also had the highest stem diameter of 15.20 mm but it was significantly greater (P ≤ 0.05) than all other interplant treatments. Also there were no significant difference within M + A 30 and M + A 40 (Table 4.26).

Leaf area (cm^2)

The maize herbicide control had the highest mean leaf area value of 577.31 cm^2 and 517.73 cm^2 for the first and second trials, respectively. This was significantly different from all other treatmentsS that ranged from 315.46 cm^2 to 554.56 cm^2 (first trial) and 371.56 cm^2 to 461.27 cm^2 (second trial). The weedy control treatment had the lowest mean leaf area value of 315.46 cm^2 and 371.56 cm^2.

At maturity (60 days) of the test crop maize, within the maize and akidi interplant treatments, the M + A 20 interplant had the highest mean leaf area of 554.84 cm^2 for the first trial and 461.27 cm^2 for the second trial and were significantly ($P \leq 0.05$) higher than all other akidi interplant spacing treatments. The least mean leaf area of 508.08 cm^2 (first trial) and 394.05 cm^2 was recorded M + A 40 interplant, within the maize and akidi interplant treatments (Table 4.26).

Days to first tassel

In the first tassel days encompassing all treatments, the maize weedy control (MWC) reached its first tassel on the 49.75 day for the first and second trials, which showed significant difference amongst treatment used.

Within the maize and akidi interplant treatments, the M + A 20 and M + A 30 both reached their first tassel at 46.75 day and were not significantly ($P \leq 0.05$) higher than M + A 40 which tasseled on the 47.25 day for the first trial. The second trial showed the same trend, with M + A 20 and M + A 30 reaching their first tassel on the 46.50 day and these was not significantly higher than M + A 40 which reached its first tassel on the 47.25 day (Table 4.26)

Days to 50% tassel

In the 50% days to tassel encompassing all treatments, M + A 30 reached 50% tassel on the 51.50 days which was earlier than all other treatments and these findings were significantly ($P \leq 0.05$) higher when compared to other treatments used. Also there were no differences among other treatments, for the first trial.

Within the maize akidi interplant treatment, the M + A 30 plant per hectare per hectare were the earliest to reach 50% tassel on the 51.50 and 50.50 days for the 1st and 2nd trial, respectively. This was also observed to be significantly ($P \leq 0.05$) higher in the midst of other interplant treatments used for the study (Table 4.22). In the second trial, the weedy control (MWC) maize plants reached 50% tassel on the 53.50 day and it is significantly ($P \leq 0.05$) inferior compared with every other treatment used (Table 4.26).

Table 4.26. Effect of Different Interplant Spacing of Akidi on Vegetative Parameters of Maize in Ibadan, Nigeria (n = 16)

	Treatment	Maize Height (cm)	Stem Diameter (mm)	Leaf Area (cm)	Days to 1st Tasseling	Days to 50% Tasseling
			First Trial			
	Maize + Akidi (40,000)	204.63 ± 1.05	14.30 ± 1.07	508.08 ± 1.15	47.25 ± 0.55	52.00 ± 0.82
	Maize + Akidi (30,000)	210.68 ± 0.95	14.50 ± 1.10	547.41 ± 1.26	46.75 ± 0.29	51.50 ± 0.75
	Maize + Akidi (20,000)	212.36 ± 1.05	14.78 ± 1.07	554.84 ± 1.08	46.75 ± 0.73	52.00 ± 0.67
	Maize Hoe Weeded	231.59 ± 1.20	15.31 ± 1.11	542.69 ± 1.35	47.25 ± 0.29	52.50 ± 0.58
	Maize Herbicide Control	223.60 ± 1.06	15.10 ± 1.20	577.31 ± 1.51	47.25 ± 0.29	52.25 ± 0.73
	Maize Weed Control	164.62 ± 1.10	10.74 ± 0.71	315.46 ± 1.09	49.75 ± 0.73	53.00 ± 0.47
$LSD_{(0.05)}$		2.76	2.72	3.22	1.33	1.74
			Second Trial			
	Maize + Akidi (40,000)	156.60 ± 1.11	14.73 ± 1.07	394.05 ± 1.11	47.25 ± 0.55	51.75 ± 0.55
	Maize + Akidi (30,000)	168.25 ± 1.15	14.67 ± 0.92	431.34 ± 1.13	46.50 ± 0.75	50.50 ± 0.75
	Maize + Akidi (20,000)	171.50 ± 1.21	15.20 ± 0.75	461.27 ± 1.30	46.50 ± 0.58	51.75 ± 0.73
	Maize Hoe Weeded	177.13 ± 1.26	15.83 ± 1.16	413.99 ± 1.13	47.25 ± 0.29	52.25 ± 0.55
	Maize Herbicide Control	176.25 ± 1.16	15.28 ± 0.92	517.73 ± 1.19	47.25 ± 0.87	52.25 ± 0.29
	Maize Weed Control	143.81 ± 1.24	13.63 ± 0.85	371.56 ± 1.17	49.75 ± 0.55	53.50 ± 0.58
$LSD_{(0.05)}$		3.07	2.45	3.01	1.60	1.53

4.6.2. Effect of Different Interplant Spacing On Yield Components of Maize Crop in Ibadan, Nigeria

Fresh cob weight / plant (g)

The herbicide control (MHC) had the greatest fresh cob value of 190.68 g and 129.99 g for the first and second trial, respectively. These were significantly ($P \leq 0.05$) higher than all other treatments that ranged from 78.45 g to 171.14 g for first trial, and 73.02 g to 124.18 g for the second trial. The maize weedy control (MWC) treatment had the lowest cob fresh weight value of 78.45 g (first trial) and 73.02 g (second trial) and these showed significant difference when compared to other treatment used.

Within the interplant treatments, the highest cob fresh weight value of 171.1 g (first trial) and 124.18 g (second trial), were recorded under the M + A 40 treatment. This showed significant difference when compared with other treatments used in the experiment (Table 4.27).

Dehusked cob weight / plant (g)

The highest dehusked weight of 152.20 g (first trial) and 88.98 g (second trial) were obtained under the maize herbicide control (MHC). These were observed to be significantly higher at 5 percent confidence interval when compared to other treatment used ranging between 53.35 g to 125.00 g for first trial and 20.92 g to 67.76 g for the second trial.

Within the interplant spacing, the M + A 40 attained the highest cob dehusked value of 124.68 g and 62.04 g for the first and second trial, respectively. These were observed to be significantly (95% confidence level) higher among other akidi treatments used (Table 4.27).

Grain weight / cob (g)

In the herbicide control (MHC) treatment maize attained the highest grain weight value of 57.45 g and 48.65 g for the 1st and 2nd trials, respectively. These results when compared with other treatment used for the study were found to be significantly higher at 95% percent confidence level. However, in the weedy control (MWC) maize recorded the least grain weight value of 13.95 g and 25.02 g for the

Table 4.27: Effect of Different *Akidi* Interplant Spacing On the Components of Maize in Ibadan, Nigeria (n=16)

Treatment	Fresh maize weight (g)/cob	Dehusked Maize Weight (g)/Cob	Shelled Maize Weight (g)/ Cob	100 - Seed Weight (g)	Grain Yield per t/ha	Yield as % of weedy control	Total Dry Weight (g)/Plant
			First Trial				
Maize + *Akidi* 20,000 (M1)	159.42 ± 1.11	118.54 ± 1.11	40.38 ± 1.03	12.31 ± 0.96	1.65 ± 0.95	288.57	65.46 ± 1.27
Maize + *Akidi* 30,000 (M2)	160.40 ± 1.12	119.95 ± 1.18	43.88 ± 1.03	12.53 ± 0.93	1.51 ± 0.87	310.00	69.76 ± 1.13
Maize + *Akidi* 40,000 (M3)	171.14 ± 1.01	124.68 ± 1.11	44.11 ± 1.06	12.93 ± 0.91	1.65 ± 0.95	315.71	85.05 ± 1.09
Maize Hoe Weeded (M4)	160.59 ± 1.28	125.28 ± 1.30	44.01 ± 1.11	12.59 ± 0.82	1.65 ± 0.95	314.29	68.14 ± 1.06
Maize Weed Control (M5)	78.45 ± 1.35	53.35 ± 1.03	13.95 ± 1.12	8.22 ± 1.06	0.52 ± 0.30	-	19.84 ± 1.10
Maize Herbicide Control (M6)	190.68 ± 1.18	152.20 ± 1.09	57.45 ± 1.08	13.10 ± 1.06	2.15 ± 1.24	410.00	79.91 ± 1.18
LSD $_{(0.05)}$	3.04	2.93	2.76	2.47			2.93
			Second Trial				
Maize + *Akidi* 20,000 (M1)	80.68 ± 1.10	58.25 ± 1.33	34.35 ± 1.18	14.19 ± 1.08	1.29 ± 0.74	137.60	60.72 ± 1.26
Maize + *Akidi* 30,000 (M2)	103.50 ± 1.28	51.91 ± 1.21	41.79 ± 1.23	14.80 ± 1.16	1.57 ± 0.90	167.20	70.83 ± 1.13
Maize + *Akidi* 40,000 (M3)	124.18 ± 1.12	62.04 ± 1.12	46.95 ± 1.07	15.27 ± 1.05	1.76 ± 1.02	188.00	84.68 ± 1.12
Maize Hoe Weeded (M4)	120.35 ± 1.04	67.75 ± 1.37	46.21 ± 1.16	14.99 ± 1.29	1.73 ± 1.00	184.80	64.60 ± 1.02
Maize Weed Control (M5)	73.02 ± 1.15	20.92 ± 1.04	25.02 ± 1.15	11.25 ± 1.06	0.94 ± 0.54	-	40.50 ± 1.38
Maize Herbicide Control (M6)	129.99 ± 1.33	88.98 ± 1.35	48.65 ± 1.17	15.52 ± 1.08	1.82 ± 1.05	194.40	74.76 ± 1.14
LSD $_{(0.05)}$	3.02	3.20	2.99	2.89			3.04

and second trial, respectively (Table 4.27). However, when compared amongst other treatment used it was observed to be significantly ($P \leq 0.05$) inferior.

Within the interplant spacing treatment, the M + A 40 attained the highest grain weight values of 44.11 g (first trial) and 46.9 g (second trial). These were significantly ($P = 0.05$) higher compared to other interplant spacings (Table 4.27). The lowest maize seed weight value of 8.22 g and 11.25 g were obtained from the weedy control (MWC) treatment for the first and second trials, respectively. These values were significantly lower than other treatments (Table 4.27).

Maize Biomass (dry matter) yield per plant (g)

At maturity (60 days) of maize, the M + A 40 had accumulated the highest maize biomass weight of 85.05 g for the first trial. This was significantly higher than other treatment used that ranged from 19.84 g to 79.91 g for the first trial (Table 4.27). In the second trial, the highest maize biomass value of 84.68 g was obtained which differed significantly compared to other treatments which ranged from 40.50 g to 74.76 g (Table 4.27).

4.6.3. Floristic Enumeration of the Different Treatments in Maize Cropping in Ibadan, Nigeria

Maize + *akidi* (40,000 plants / ha)

The sums of sixteen plants from twelve families were listed. *Ageratum conyzoides* dominated with the highest RIV of 34.21% (Table 4.28). *Brachiaria deflexa* followed with RIV of 18.10%. Species with low RIV were *Momordica charantia* and *Talinum fructicosum* with RIV of 0.87% each. The Shannon-Wiener index was 1.58, evenness index of 0.30 and dominance index of 0.32 for the first trial (Table 4.30).

In the second trial, the sum of 15 plants from twelve families were listed *Ageratum conyzoides* dominated with the highest RIV of 34.13% (Table 4.29). *Tridax procumbens* followed with RIV of 18.37%. Species with low RIV were *Boerhavia diffusa, Corchorus olitorius, Momordica charantia, Phyllanthus amarus* and *Sesbania pachycarpa* with RIV of 1.75% each. The Shannon-Wiener index was 1.81, evenness index of 0.41 and dominance index of 0.27 for the second trial (Table 4.30).

Maize + *akidi* (30,000 plants / ha)

The sum of fifteen plants from twelve families was listed. *Ageratum conyzoides* dominated with the highest RIV of 33.82% (Table 4.28). *Brachiaria deflexa* followed with RIV of 20.18%. Species with low RIV were *Talinum fructicosum,* and *Vigna unguiculata* with RIV of 0.76% each. The Shannon-Wiener index was 1.90; evenness index of 0.30 and dominance index of 0.34 were recorded for the first trial (Table 4.30).

In the second trial, the sum of fifteen plants from twelve families was listed. *Tridax procumbens* had the highest RIV of 28.57% (Table 4.29). *Ageratum conyzoides* and *Brachiaria deflexa* followed with RIV of 23.57% and 14.29%, respectively. Species with low RIV were *Boerhavia diffusa, Brachiaria lata, Desmodium scorpiurus, Euphorbia hirta, Ludwigia decurrens, Momordica charantia, Phyllanthus amarus and Spigelia anthelmia* with RIV of 2.14% each. The Shannon wiener index was 1.90, evenness index of 0.40 and dominance of 0.23 was recorded for the second trial (Table 4.30).

Maize + *akidi* (20,000 plants / ha)

The sum of nineteen plants from thirteen families was listed. *Sesbania pachycarpa* dominated with the highest Relative Importance Value (RIV) of 24.33% (Table 4.28). *Brachiaria deflexa and Indigofera hirsuta* followed with RIV of 13.84% and 13.79% respectively. Species with low RIV includes *Corchorus olitorius* and *Dactyloctenium aegyptium* which had RIV values of 0.68% each. The Shannon-Wiener index was 1.70, evenness index of 0.29 and dominance index of 0.30 was recorded for the first trial (Table 4.30).

In second trial, the sum of eleven plants from nine families was listed. *Tridax procumbens* dominated with the highest RIV of 34.45% (Table 4.29). *Brachiaria deflexa* and *Ageratum conyzoides* followed with RIV of 24.26% and 16.69% respectively. Species with low RIV were *Fimbristylis littoralis, Gomphrena celosioides, Rottboellia cochinchinensis* and *Tithonia diversifolia* with RIV of 1.93% each. The Shannon-Wiener index was 1.50, evenness index of 0.40 and dominance index of 0.30 was recorded for the treatment (Table 4.30).

Maize hoe – weeded control (MHW)

The sum of fifteen plants from eleven families was listed. *Ageratum conyziodes* had the highest RIV of 35.38%. *Brachiaria deflexa* followed with RIV 19.22%. Species with low RIV were *Corchorus olitorius, Dactyloctenium aegyptium* and *Talinum fructicosum* with RIV of 0.77% each. The Shannon-Wiener index was 1.44, evenness index of 0.28 and dominance index of 0.38 for the first trial (Table 4.30).

In the second trial, the sum of ten plants from eight families was listed. *Tridax procumbens* dominated with the highest RIV of 39.39% (Table 4.29). *Ageratum conyzoides* followed with RIV of 29.95%. Species with low RIV were *Boerhavia diffusa, Euphorbia hirta* and *Mitracarpus villosus* with RIV of 1.95% each. The Shannon-Wiener index was 1.27, evenness index of 0.36 and dominace index of 0.37 for the second trial (Table 4.30).

Maize (50,000) herbicide control (MHC)

The sum of eleven plants from nine families was listed. *Ageratum conyzoides* had the highest RIV of 36.78%. *Brachiaria deflexa* followed with RIV of 33.46%. Species with the lowest RIV were *Corchorus olitorius, Dactyloctenium aegyptium* and *Phyllanthus amarus* with RIV of 1.31% each (Table 4.28). The Shannon-Wiener index was 1.19, evenness index of 0.30 and dominance index of 0.39 for the first trial (Table 4.30).

In the second trial, the sum of seventeen plants from ten families was listed. *Brachiaria deflexa* had the highest RIV of 22.20%. *Tridax procumbens* followed with an RIV of 17.82%. Species with low RIV were *Crotalaria retusa, Indigofera hirsuta* and *Phyllanthus amarus* with RIV of 1.03% each (Table 4.29). The Shannon wiener index was 1.98, evenness index of 0.43 and dominance index of 0.20 for second trial (Table 4.30).

Maize (50,000) weedy control (MWC)

The sum of ninteen plants from eleven families was listed. *Brachiaria deflexa* had the highest RIV of 17.30%. *Euphorbia deflexa* followed with RIV of 15.29%. Species with the lowest RIV were *Indigofera hirsuta* and *Ludwigia decurrens* with an RIV of 1.07% each (Table 4.28). The Shannon wiener index was 2.42, evenness index of 0.59 and dominance index of 0.12 for the first trial (Table 4.30).

In the second trial, the sum of twenty one plants from ten families was listed. *Euphorbia hirta* had the highest RIV value of 13.66%. Species with the lowest RIV were *Ludwigia decurrens, Phyllanthus amarus* and *Sida acuta* with an RIV value of 1.13% each (Table 4.29). The Shannon wiener index was 2.65, evenness index of 0.68 and dominance index was 0.09 for the second trial (Table 4.30).

4.6.4.: Biomass Accumulation of Herbaceous (weed) Plants in Maize Cropping Study in Ibadan, Nigeria

Among all treatments, the maize weedy control check had the highest herbaceous biomass value of 126.30 ± 0.23 g for the first trial (Table 4.31) and 132.65 ± 0.43 g for the second trial. These were significantly ($P \leq 0.05$) different from all other treatments (Table 4.31). The maize (50,000 plants/ha) + akidi (40,000 plants/ha) had the lowest herbaceous biomass value of 6.63 ± 0.37 g for the first trial and 7.65 ± 0.05 g for the second trial. These were significantly ($P \leq 0.05$) lower than all other treatments which ranged from 8.70 ± 0.11 g to 126.30 ± 0.23 g for the first trial and 8.50 ± 0.04 g to 132.65 ± 0.43 g for the second trial.

At maize maturity, (10 weeks after sowing), within the maize and akidi interplant spacing treatments, the maize (50,000 plants/ha) + *akidi* (20,000 plants/ha) had the highest weed biomass value of 9.70 ± 0.24 g for the 1st trial and 9.65 ± 0.04 g for the 2nd trial. And these were significantly ($P \leq 0.05$) higher than other treatments. Compared to the weedy control, the weed biomass in each treatment ranged from 5.25% in M + A 40 to 28.39% in maize herbicide control (MHC) in the 1st trial, and from 5.77% in M + A 40 to 33.62% in MHC in the 2nd trial (Table 4.31). The weed control efficiency was lowest in the herbicide treatment (71.61% in the 1st trial and 66.38% in the 2nd trial) and highest in M + A 40 94.75% and 94.23% in the 1st and 2nd trials respectively (Table 4.31)

4.6.5. Biomass accumulation of *Vigna unguiculata* per plant in maize / *akidi* cropping study in Ibadan, Nigeria

At maturity, 10 WAS of maize + *akidi* (20,000 plants / ha) had the highest *akidi* biomass weight value of 62.71 g/plant for the 1st trial and 56.52 g/plant for the 2nd trial, respectively. And was significantly ($P \leq 0.05$) higher than all other *akidi* interplant treatments. The lowest *akidi* biomass value of 43.49 g/plant (1st trial) and

Table 4.28. Relative Importance Value (%) for Weed Sampled Within the Different Treatments in Maize Field in Ibadan, Nigeria (First trial)

S/N	Species name	Family	M + A 40	M + A 30	M + A 20	MHW	MHC	MWC
1	*Ageratum conyzoides* Linn.	Asteraceae	34.21	33.82	7.45	35.38	36.78	5.52
2	*Amaranthus spinosus* Linn.	Amaranthaceae	–	–	0.74	1.60	–	–
3	*Boerhavia diffusa* Linn.	Nyctaginaceae	6.01	5.22	5.41	7.56	4.36	4.63
4	*Brachiaria deflexa* (Schumach) Robyns	Poaceae	18.10	20.18	13.84	19.22	33.46	17.30
5	*Celosia argentea* Linn.	Amaranthaceae	–	–	–	–	–	2.15
6	*Corchorus olitorius* Linn.	Malvaceae	1.74	–	0.68	0.77	1.31	3.79
7	*Cleome viscosa* Linn.	Capparidaceae	–	–	–	–	–	1.36
8	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	–	–	0.68	0.77	1.31	–
9	*Desmodium scorpiurus* (Swartz) Desvaux	Fabaceae	8.34	7.60	3.25	6.70	5.81	14.73
10	*Euphorbia heterophylla* Linn.	Euphorbiaceae	7.35	6.08	5.28	4.88	10.16	15.29
11	*Euphorbia hirta* Linn.	Euphorbiaceae	3.30	4.36	4.06	3.78	–	1.07
12	*Indigofera hirsuta* Linn.	Fabaceae	–	2.27	13.79	2.51	2.76	2.15
13	*Ipomoea repens* (L.) Poiret.	Convolvulaceae	0.97	1.51	0.74	–	–	–
14	*Ludwigia decurrens* (DC.) Walter	Onagraceae	–	2.34	1.22	2.51	1.31	1.07
15	*Mimosa diplotricha* C.Wright.	Fabaceae	–	–	–	–	–	1.64
16	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	2.71	3.46	6.02	4.12	1.45	–
17	*Momordica charantia* Linn.	Cucurbitaceae	0.87	–	–	–	–	–
18	*anicum maximum* Jacq.	Poaceae	–	–	–	–	–	2.43
19	*Phyllanthus amarus* Schumach	Phyllanthaceae	1.84	2.27	4.46	–	1.31	1.64
20	*Portulaca olaracea* Linn.	Portulacaceae	2.13	2.99	1.62	2.94	–	2.43
21	*Sesbania pachycarpa* sensu auct./DC.	Fabaceae	0.97	–	24.33	–	–	4.07
22	*Talinum fructicosum* (L.) Juss.	Talinaceae	0.87	0.76	0.74	0.77	–	3.50
23	*Tithonia diversifolia* (Hemsl.) A. Gray.	Asteraceae	–	–	–	–	–	9.26
24	*Tridax procumbens* Linn.	Asteraceae	7.90	6.39	3.25	6.48	–	5.98
25	*Vigna unguiculata* (L.) Walp.	Fabaceae	2.71	0.76	2.43	–	–	–

Table 4.29: Relative Importance Value (%) For Weed Sampled within the Different Treatments in Maize Field in Ibadan, Nigeria (2nd trial)

S/NO	Species Name	Family	M + A 40	M + A 30	M + A 20	MHW	MHC	MWC
1	*Ageratum conyzoides* Linn.	Asteraceae	34.13	23.57	16.69	28.95	18.25	5.21
2	*Amaranthus spinosus* Linn.	Amaranthaceae	–	–	–	3.69	–	–
3	*Aspilia bussei* O.Hoffm. &Muschl.	Compositae	–	–	–	–	2.39	–
4	*Boerhavia diffusa* Linn.	Nyctaginaceae	1.75	2.14	–	1.95	–	2.87
5	*Brachiaria lata* (Schumach) C.E. Hubbard.	Poaceae	–	2.14	–	–	–	–
6	*Bracharia deflexa* (Schumach) Robyns	Poaceae	2.80	14.29	24.26	8.68	22.20	9.96
7	*Combretum hispidum* (M.A. Lawson) Jongkind	Combretaceae	–	–	–	–	–	2.57
8	*Commelina benghalensis* Linn.	Commelinaceae	5.24	2.86	3.87	–	5.30	1.74
9	*Corchorus olitorius* Linn.	Malvaceae	1.75	–	–	–	1.19	2.57
10	*Crotalaria retusa* Linn.	Fabaceae	–	–	–	–	1.03	2.57
11	*Desmodium scorpiurus* (Swartz) Desvaux.	Fabaceae	3.49	2.14	–	6.29	5.47	10.12
12	*Eleusine indica* (L.) Gaertn.	Poaceae	–	–	–	–	2.68	2.57
13	*Euphorbia heterophylla* Linn.	Euphorbiaceae	7.51	–	6.73	3.69	4.28	5.14
14	*Euphorbia hirta* Linn.	Euphorbiaceae	3.49	2.14	–	1.95	3.25	13.66
15	*Fimbristylis littoralis* Gaudich	Cyperaceae	–	2.86	1.93	–	3.58	–
16	*Gomphrena celosioides* Mart.	Amaranthaceae	–	–	1.93	–	–	–
17	*Indigofera hirsuta* Linn.	Fabaceae	3.49	–	–	–	1.03	1.13
18	*Ludwigia decurrens* (DC.) Walter	Onagraceae	–	2.14	–	–	–	–
19	*Mimosa diplotricha* C. Wright.	Fabaceae	–	–	–	–	–	3.78
20	*Mitracarpus villosus* (Sw.) DC.	Rubiaceae	5.76	4.29	2.40	1.95	3.41	3.70
21	*Momordica charantia* Linn.	Curcubitaceae	1.75	2.14	–	–	–	–
22	*Panicum maximum* Jacq.	Poaceae	–	–	–	–	–	8.83
23	*Phyllanthus amarus* Schumach	Phyllanthaceae	1.75	2.14	3.87	3.47	1.03	1.13
24	*Rottboellia cochinchinensis* (Lour.) W.D. Clayton	Poaceae	–	–	1.93	–	3.55	2.57
25	*Sesbania pachycarpa* sensu auct./DC.	Fabaceae	1.75	–	–	–	–	3.17
26	*Sida acuta* Burm. F.	Malvaceae	–	–	–	–	–	1.13
27	*Spigelia anthelmia* Linn.	Loganiaceae	–	2.14	–	–	–	–
28	*Tithonia diversifolia* (Hemsl.) A. Gray.	Asteraceae	–	–	1.93	–	3.55	6.04
29	*Tridax procumbens* Linn.	Asteraceae	18.37	28.57	34.45	39.39	17.82	9.52
30	*Vigna unguiculata* (L.) Walp.	Fabaceae	6.98	6.43	–	–	–	–

45.30 g/plant (2nd trial) was recorded for M + A 40 as shown in (Table 4.32). The *akidi* interplants raised the organic carbon to 2.4 – 2.7 from 1.8.

4.6.6. Soil analysis before and after the study

Soil physico–chemical analysis before the commencement of study was as follows; pH of 6.7; organic carbon of 1.8 g / kg; total nitrogen of 0.2 g / kg; average phosphorus of 15 kg and belongs to the sandy loam textural class (Table 4.33).

At the end of the study of maize and akidi interplanting, the soil pH ranged between 6.0 and 6.8, the sodium (Na) ranged between 0.5 Cmol / kg to 0.7 Cmol / kg, the potassium (K) ranged between 0.2 to o.3 Cmol / kg. The effective cation exchange capacity (ECEC) ranged between 8.2 Cmol / kg to 10.5 Cmol / kg, the organic carbon ranged between 1.6 to 2.7 g / kg while the total nitrogen ranged between 0.1 g / kg to 0.2 g / kg. The soils of all the treatment plots belong to the sandy loam textural class (Table 4.33). The organic akidi interplants raised the organic carbon to 2.4 – 2.7 from 1.8.

Table 4.30: Diversity indices of herbaceous plant enumerated on maize plot in Ibadan, Nigeria

Trial	Treatment	Taxa _ S	Shannon _ H	Evenness e^H/S	Dominance _ D
First	MA 20,000	19	1.65	0.29	0.30
	MA 30,000	15	1.51	0.30	0.34
	MA 40,000	16	1.58	0.30	0.32
	MHW	15	1.44	0.28	0.38
	MWC	19	2.42	0.59	0.12
	MHC	11	1.19	0.30	0.39
Second	MA 20,000	11	1.53	0.42	0.30
	MA 30,000	15	1.90	0.44	0.23
	MA 40,000	15	1.81	0.41	0.27
	MHW	10	1.27	0.36	0.37
	MWC	21	2.65	0.68	0.09
	MHC	17	1.98	0.43	0.20

NOTE: M +A 40 = Maize (50,000 plants / ha) + *Akidi* (40,000 plant / ha) ; M + A 30 = Maize (50,000 plants / ha) + *Akidi* (30,000 plant / ha); M + A 20 = Maize (50,000 plants / ha) + *Akidi* (20,000 plants / ha); MHC = Maize Herbicide Control (Maize (50,000 plants / ha); MWC = Maize Weedy Control (Maize (50,000 plants / ha); MHW = Maize Hoe–Weeded (Maize (50,000 plants / ha)

Table 4.31: Biomass accumulation of weeds plant species on the enumerated maize plot in Ibadan, Nigeria

Treatment	Weed biomass (g) 0.25 m^2	Weed dry weight as a percentage of weedy control / 0.25 m^2	Weed Control Efficiency (%)
	First trial		
Maize + *Akidi* (40,000)	6.6 ± 0.7	5.25	94.75
Maize + *Akidi* (30,000)	8.7 ± 1.0	6.89	93.11
Maize + *Akidi* (20,000)	9.7 ± 0.7	7.68	92.32
Maize Hoe Weeded	11.7 ± 0.8	9.28	90.72
Maize Herbicide Control	35.9 ± 1.7	28.39	71.61
Maize Weedy Control	126.3 ± 2.0	-	-
LSD (0.05)	3.23		
	Second trial		
Maize + *Akidi* (40,000)	7.7 ± 0.83	5.77	94.23
Maize + *Akidi* (30,000)	8.5 ± 0.78	6.41	93.59
Maize + *Akidi* (20,000)	9.7 ± 1.24	7.28	92.72
Maize Hoe Weeded	11.6 ± 0.93	8.75	91.25
Maize Herbicide Control	44.6 ± 0.96	33.62	66.38
Maize Weedy Control	132.7 ± 2.04	-	-
LSD (0.05)	3.06		

Table 4.32: Biomass accumulation of cover crop (*V. unguiculata*) inter planted at different spacing regimes on the enumerated maize plots in Ibadan, Nigeria

	Treatment	*Akidi* biomass/0.25 m^2
	First trial	
	Maize + *Akidi* 20,000	62.7 ± 1.1
	Maize + *Akidi* 30,000	57.6 ± 1.3
	Maize + *Akidi* 40,000	43.5 ± 2.1
LSD (0.05)		4.28
	Second trial	
	Maize + *Akidi* 20,000	56.5 ± 1.9
	Maize + *Akidi* 30,000	52.1 ± 1.1
	Maize + *Akidi* 40,000	45.3 ± 1.8
LSD (0.05)		4.57

NOTE: M + A 40 = Maize (50,000 plants / ha) + *Akidi* (40,000 plant / ha) ; M + A 30 = Maize (50,000 plants / ha) + *Akidi* (30,000 plant / ha); M + A 20 = Maize (50,000 plants / ha) + *Akidi* (20,000 plants / ha); MHC = Maize Herbicide Check (Maize (50,000 plants / ha); MWC = Maize Weedy Control (Maize (50,000 plants / ha); MHW = Maize Hoe–Weeded (Maize (50,000 plants/h

Table 4.33: Analysis of the soil after study of maize and akidi interplant in Ibadan, Nigeria

TRT	pH	Particle size (g/kg)			Exchangeable bases (cmol /kg)				ECEC Cmol / kg	% base salt	OC (g / kg)	TN (g/kg)	Av P (m /kg)	Mn (mg / Cu)	Fe (mg / kg)	Cu (mg/ kg)	Zn (mg)	Textural Class
		Sand	Silt	Clay	Ca	Mg	Na	K										
Initial analysis	6.7	846.0	108.0	46.0	7.0	2.1	0.6	0.3	10.1	99.0	1.8	0.2	15	60	15.0	2.6	30.0	Sandy loam
MA 20,000	6.0	856.0	98.0	46.0	8.5	1.2	0.5	0.3	10.5	99.5	2.4	0.2	43	105	19.4	2.6	70.3	Sandy loam
MA 30,000	6.5	886.0	78.0	36.0	6.3	1.1	0.5	0.2	8.2	99.3	2.7	0.2	47	58	14.8	2.9	80.2	Sandy loam
MA 40,000	6.6	826.0	108.0	66.0	8.0	1.2	0.6	0.3	10.1	99.4	2.7	0.2	36	78	15.6	2.6	70.3	Sandy loam
MHW	6.5	866.0	88.0	46.0	6.6	1.9	0.7	0.3	9.6	99.3	1.8	0.1	27	56	19.1	2.9	50.1	Sandy loam
MWC	6.8	836.0	108.0	56.0	6.1	1.0	0.5	0.3	8.0	99.0	1.7	0.2	47	208	16.5	4.9	50.1	Sandy loam
MHC	6.3	836.0	98.0	66.0	7.7	1.1	0.5	0.2	9.6	99.5	1.6	0.1	26	48	16.5	3.1	56.3	Sandy loam

NOTE: M + A 40 = Maize (50,000 plants/ha) + *Akidi* (40,000 plant/ha); M + A 30 = Maize (50,000 plants/ha) + *Akidi* (30,000 plant /ha); M + A 20 = Maize (50,000 plants/ha) + *Akidi* (20,000 plants/ha); MHC = Maize Herbicide Control (Maize (50,000 plants/ha); MWC = Maize Weedy Control (Maize (50,000 plants/ha); MHW = Maize Hoe–Weeded (Maize (50,000 plants/ha)

Plate 4.3: Maize and *akidi* interplant plot

Plate 4.4: Maize weedy control (MWC) plot

CHAPTER FIVE

5.1. DISCUSSION

The survey revealed that the respondents involved in the cultivation of *akidi* belonged to the relatively active age group which is similar to Ndungu *et al*. (2004) who obtained that the production of leafy vegetable cowpea is largely by young farmers. Agricultural production can be effectively enhanced by young and active farmers than aged farmers, as they are more agile and receptive to new innovations that could likely improve their productivity. Both male and female cultivated *akidi* on their farms, which is an indication of the preference for the crop in the locality. However, inspite of this popularity the crops potentials as a suitable weed suppressant, is yet to be fully harnessed. Thus, there is need for farmer to deliberately cultivate akidi as a valuable interplant in conservation agriculture.

The researches showed most of the respondent were educated which is a great advantage. Uaiene *et al*. (2009) Observed that improved education increases farmers ' capacity to process data and discover necessary infrastructure to overcome restrictions to cultivation. An educated farmer has better perception, understands better and acts far quicker than their uneducated peers in response to new knowledges. Education also improves farmers ' allocating skills and makes them more effective in farm farming practices.

Generally, majority of the respondents cultivated akidi in mixtures with other legumes or crops. Mixed cropping is desirable for food security, augment returns, curtail pests and diseases amongst others lowered production cost (HLPE, 2016). It also allows the peasant farmers to enhance for enhancing their yield and diversify the use of their limited land resources. The survey also showed increasing popularity of *akidi*, possibly due its use as a valuable tool in conservation agriculture and weed management. The weed infestation observed by the respondents were moderate with the major weeds frequently observed by the respondents were of the Poaceae family; also *Ageratum conyzoides* was of moderate infestation as these were similar to the finding of Shave *et al*. (2017) in their study of weed composition in cassava and mucuna intercrop in Makurdi, Nigeria. The popular weed control method used by the respondents is hoe weeding. Majority of the respondents sourced their seeds from local vendors may due to preference for native biota. However, they are relatively small scale farmers inexperienced and with scattered farms. As observed, *akidi* was mostly interplanted interplanted with cassava, yam and then maize.

As observed, vast majority of the respondents cultivated *akidi* mainly for one or more of the benefits it can offer when used as a cover crop or live mulch. There was a reduction in the frequency of weed and pest infestation, the use of external input for the control of earth wearing away and soil productivity improvement. This agrees with the finding of Ekpo and Ndaeyo (2011) that *akidi* was observed to be promising in enhancing physical, chemical and microbiological constituents of the soil when intercropped with cassava. This can possibly boost subsequent crop yield. Chikoye *et al*. (2002) in their study also observed that *akidi* at high density could probably reduce weed interference at critical stage of cassava growth, (3 to 4 months). Majority of the respondents reported increase in crops grown in association with *akidi* which agrees with the findings of Okpara (2000) who reported a yield advantage when intercropping maize with *akidi* in Umudike, Nigeria. Numerous studies have revealed the benefits of interplanting legumes such as cowpea with maize (Akande *et al*., 2006); cassava and cowpea (Mohammed *et al*., 2006) and *akidi* and cucumber (Ekesoibi *et al*., 2015).

The seed germination studies showed that there is no dormancy in *Vigna unguiculata* (*akidi*) seeds, as they germinate readily under favourable conditions. The vigorous growth and excellent development of *akidi* could be linked to the fact that growth and development of legumes are greatly determined by their inherent characteristics (Cook *et al*., 2005). *V. unguiculata* seeds germinate readily, as well as establishes quickly due to its large seed and its relative resistance to moisture stress at shoot emergence and early plant vigour (Harrison *et al*., 2006). The observed rapid number of nodules produced by *akidi* without the specific requirement for rhizobium inoculation is peculiar to most tropical indigenous live mulch legumes.

Higher vine length observed in plants under reduced light intensities corroborates Sarr *et al*. (2015). Plant growing under reduced light situation responds to illumination stress by alloting more of their accessible carbon to shoot growth, resulting to some extent in longer vine length in search of more light. The higher vine length observed in low light plants was due to etiolation, as much of their nutrients were devoted to stem enlongation. According to Keller *et al*. (2011) stem enlongation of *Arabidopsis* sp. in reduced light situation was as a result of low red to far – red illumination proportion.

The better performance of *akidi* in cage with L_0 (100% light intensity) and L_1 (about 70% light intensity) confirmed *akidi* as a light loving plant. This is similar to Sarr *et al*. (2015) who observed that cowpea prefer high to moderate light intensity for optimum production. When light fell below 70%, growth was affected negatively as the plant became etiolated. This findings, agrees with Araujo *et al*. (2017), who reported elongated growth with shading. The reduction in the number of nodules under reduced illumination was due to the plants tending to preserve their carbon at the expense of symbionts (Kiers and Denison, 2014). The decline in the number and size of nodule with increasing shade shows *V. unguiculata* as a shade sensitive plants. This decline may be due to reduced availability of photosynthetic product. Woghiren and Awodoyin (2018) had reported that shading reduced nodule number, size and nitrogen fixation of *Vigna unguiculata*. Furthermore, Liu *et al*. (2011a) reported that, below 50% and 25% illumination intensities, leaf synthesis increased while the pod and seed yield greatly reduced in soybean. Polthane *et al*. (2011) studying the effect of low light intensity on soyabean growth and yield observed that low intensity of approximately 30% of full sunlight had drastic effect on yield.

The observed highest dry matter yield with high light situation than under the layers of net can be attributed to excellent photosynthesis-rate occasioned by superior surface area of the leaves and greater chlorophyll substance. The increase in dry matter accumulation in floras underneath high light probably may be due to more solar emission getting to the plants in the open than in the shade (Campillo *et al*., 2012).

Upon biomass separation, it was observed that perhaps the shoot had the highest dry weight in both the high and low light intensity, whereas the root has the lowest. The greater shoot weight in high light may be ascribed to greater leaves thickeness with decreased volume of spongy mesophyll cell (Tisne *et al*., 2008), thicker palisade tissue and better stomatal carbon dioxide transmission (Wuyts *et al*., 2012). Light can enhance the conversion of photosynthate to sink expansion and absorption rate which is greater under the sun resulting to a total rise in leaf development (Long *et al*., 2004).

Plants underneath shade have been able to grow vegetatively with maximum leaf production. The direct effect of light on temperature, which is a high light intensity, implies that high temperatures will lead to a reduction in cowpea node output (Porter, 2005). Ologundudu *et al*. (2013) observed that low temperature and photoperiod favoured the production of more leaves under shade condition, which may have been a mechanism formed by cowpea plants to increase total suface area for phoyosynthesis due to reduced leaf area.

The allelopathic impacts of aqueous botanicals from shoot and root of akidi caused significant inhibitions in the germination of *Z. mays* seeds and in the sprouting of radicle and plumule. With the increasing concentration of botanicals, the inhibition level in both botanicals improved, indicating that the impacts of the botanicals are concentration dependent. The results revealed that the growth of the plumule and radicle in the extract – treated seeds were retarded when measured against the control treatment. Previous findings had shown that allelochemicals retard germination of seeds by preventing nutrient hydrolysis and cell division (Irshad and Cheema, 2004), and causes considerable decrease in the growth of plumule and radicle of diverse crops (Turk and Tawaha, 2003). Futhermore, Rice (1979) observed that the reaction of plants to allelochemicals is concentration dependent as well as susceptibility of the receiving target plant. Thus, their action may hypothetically be inhibitory, neutral or stimulatory.

As observed, seed germination of *Z. mays* was more adversely affected by 100% w/v shoot aqueous extract (ASE100) of *Vigna unguiculata* than seedling growth. There was significant variation in the radicle and plumule length in the *Z. mays* germination study, but the radicle length was more negatively affected when compared with the control treatment. These responses might be due to the fact that the radicle is more sensitive to allelochemicals during seed germination (Dorning and Cipollini, 2006). This also agrees with previous studies that the leaves in the above-ground shoots possess more allelochemicals than other organs (Turk and Tawaha, 2003), also, most of the time allelochemicals are present in water soluble state (Turk *et al*., 2003), and roughly all innate allelochemicals in plants above-ground material are drained into soils by water (Turk *et al*., 2003). Futhermore, Hassan and Samy (2007) reported that germination percentage decreased with increased levels of Calotropis procera leaf extract in a number of plants like barley, cucumber, fenugreek, and wheat. The phytochemical screening of *akidi* shoots and roots revealed that the shoots are richer in phytochemical contents than roots.

Plants in high density (80,645 plants per hectare) plots grew significantly longer than plants at other test densities. At high density the amount of light that reached individual plants was reduced, due to shading which caused etiolation, a situation whereby plants rapidly grow longer vine in order to reach the light. It is a negative response to stress, a mechanism described as helioplastic response of shade intolerant plants to light stress. The result may imply that *Vigna unguiculata* can only withstand moderate shade thereby confirming with previous research, that shading in legumes are typically responsible for longer growth, reduced specific leaf weight (SLW) and increased leaf area by unit weight (Tardieu, 2013). With the imposition of reduced light, much of the nutrient resource allotted to growth, were probably exploited in cell elongation which resulted in enhanced vine length at the expense of growth in the stem diameter.

The strong inverse relationship between the shoot biomass per plant and density indicates an intense intra-specific competition for space. This competition is attributed to the imposed high density that resulted in limited space. By being of the same species the plants had similar ecological requirements and occupied the same niche space (Pocheville, 2015). Thus, the low dry matter yield per plant in the high density plots (D5) could have been as a result of intraspecific competition. According to Liebman and Davis (2009), when two or more crops are growing simultaneously each constituent crop should enjoy sufficient space in order to fully exploit cooperation between the crops. The vast amount of plants per unit area, accounted for the low shoot dry matter yield per plant in the high density plots (D5).

The high reduction effect of increasing *Vigna unguiculata* density on weed biomass when compared to the control, as observed in this study could possibly indicate that *V. unguiculata* could serve as a ′smother plant`, effectively suppressing the growth of weed seedlings when grown at a density range of 50,000 plants per hectare to 80,645 plants per hectare. The best density is 80,645 plants per hectare. The plot with *V. unguiculata* at varying densities were able to shade weeds out of solar radiation, with resultant marked reduction in photosynthesis and hence low biomass production. According to a report by Dada (2010), cowpea based mixtures were found to deny weeds of solar radiation. Awodoyin and Ogunyemi (2005) in their assessment of the effect of proximity of neighbours on the performance and weed smothering ability of *Senna obtusifolia* reported strong negative correlation coefficient (r = -0.93) between stocking density and weed biomass; and that the highest density (200 plant /

m^2) was significantly better than other treatments in weed control. The above observation can be ascribed to better land coverage in the plots with higher *Vigna unguiculata* density.

The maize + *akidi* (20,000 plants / ha) and maize + *akidi* (30,000 plants / ha) reached its first tasseling earlier than all other treatments. However, the maize + *akidi* (30,000 plants / ha) reached its 50% tasseling earlier than all other treatments. The maize weedy check reached its first tasseling at a much later day. This delay observed in the weedy check may have been due to inter - specific competition between the maize crops and the weeds for the space, nutrient, light and water.

Although, there was an insignificant decline in the yield of maize interplanted with *akidi*, when compared with control treatments, however, the 100-seed weight of maize + *akidi* (40,000 plants / ha) was very close to what was obtained in the control plots. The relatively high maize yield from the plot of maize + *akidi* (40,000 plants / ha) may possibly be ascribed to the incorporation of the legume crop community which might have reduced competition from other weeds and enhanced soil fertility status. This was also evidenced in the soil analysis which revealed that maize + *akidi* (40,000 plants / ha) had high nitrogen content than all the other plots at the end of the experiment. The M + A 40 treatments effectively suppressed weed due to its speedy cover. The competition between akidi and maize may be less because they have different rooting depth and pattern, maize in the upper soil layer and *akidi* in the deeper soil layer. The high seed yield of the sole cropped maize, relative to the yield of maize in *Vigna unguiculata* – based crop interplant, was probably due to absence of competition between maize and other crop(s) for growth resources (air, water, nutrients, light), unlike what obtained in the interplant treatments, where there was interspecific competition for the limited agglomeration components. This complements the result of Flores-Sanchez *et al*. (2013), in which plant density was found to have had strong affect on intra and inter-specific competition on maize grain yield. According to Ndakidemi (2006), competition between mixtures is a key issue affecting yield as compared to mono-cropping. Also, a study carried out by Agboola and Fayemi (1971) observed a reduction in maize production when mucuna (*Mucuna utilis*) was intercropped with maize, whereas cowpeas (*Vigna sinensis*) and greengram (*Phaseolus aureus*) had minimal effect on maize and were themselves able to withstand maize shade.

The maize + *akidi* (40,000 plants / ha) plot also did better in″smothering″ weeds, as the weed dry weight was less than what was obtained from other treatments. There was better land coverage in maize plots inter-planted with *V. unguiculata* which resulted in cutting off weeds from solar radiation. The shading led to a marked reduction in the ability of the weeds to photosynthesize, and hence low biomass accumulation. The least value of weed biomass consistently recorded in the plots of maize and *V. unguiculata* interplant, suggests smothering of weeds by *akidi*. The highest weed biomass was recorded at weedy control (MWC). Weed dry weight is a vital tool to authenticate the impact of weed management on crops and their associated weeds. This agrees with the findings of Mashingaidze (2004) on maize – beans intercropping, who observed a reduction in weed dry weight by 55 – 66 percent when planted at a density of 222,000 plants/ha for beans equivalent to 33 percent of maize density (37,000 plant/ha). In a report by Bilalis *et al*. (2010), intercropping maize with leguminous vegetables significantly decreased weed density relative to maize monocrops. This is attributed to the reduced illumination available in maize legume intercrop for weeds. This brings about a decrease in weed density and weed dry weight when compared to mono crop. Rao (2000) claimed that a kilogram of weeds usually correlates to one kilogram of crop yield loss in the field.

In this study, the ability of *V. unguiculata* to effectively suppress weeds may have been either through interception of light from reaching the soil surface or by inhibiting weed growth by the release of allelochemicals. The laboratory analysis revealed that *V. unguiculata* has high secondary metabolite in the shoot and root. Previous studies revealed that cover crops could smother weeds either by decreasing resource accessibility (Ngouajio and Mennan, 2005) or by impairing the growth of weed through the secretion of allelochemicals (Reberg-Horton *et al*., 2005). Cover crop can help to alter prevalence of weed interference, via denying weeds the opportunity to use water, light, nutrients as well as soil (Ngouajio and Mennan, 2005) and the structure of weed vegetation (Wright *et al*., 2003). The ecosystem of soil microbes can be changed by the leftover parts of cover crops or increase microbial diversity, ensuring better soil micro-organisms predation of weeds and decreased weed seed potency (Ngouajio and McGiffen, 2002). This could also influence weed population flux (Jordan *et al*., 2000).

The treatment plots were dominated with species in the Asteraceae, Fabaceae and Poaceae families. The abundance of the Asteraceae and Poaceae families may be due to the fact that they are the largest families of the dicotyledons and the monocotyledons. The major weeds encountered in the treatment plot comprised of all categories of weeds which are grasses, broad leaves and sedges. This findings agrees with the result of Taah *et al*. (2017) in which they observed the Asteraceae, Fabaceae and Poaceae families to be the most prominent families in a cassava and legume intercropping system.

An augumentation of soil minerals was observed after the study, as the nitrogen and available phosphorus levels in the soil of maize and *akidi* interplant treatments increased. The increase in total N and available phosphorus at the end of the crop cycle can be attributed to the soil organic matter (SOM) boost. This agrees with the findings of Oroka (2012) that plant residues have high potential of improving soil fertility and enhancing soil resilience, as well as agronomic productivity. This is because soil organic matter is paramount in sustaining other soil quality factors. The decline observed in the exchangeable bases in some treatments could be attributed to exhaustive uptake of the exchangeable cations by the crops (maize and *akidi*) as these exchangeable bases are indispensible in the nutrition of plants. Besides, this decrease in the exchangeable bases can be as a result of loses due to leaching resulting from low organic matter content in sole maize plots. The soil pH of the maize and *akidi* interplant study was found to be slightly acidic, a range which is optimal for most vegetables and row crops. According to Shehu *et al*. (2018) in a study conducted in northern Nigeria, to evaluate variation in maize yield reaction to nutrient application, they also observed a pH range of 5.5 - 7.0 within the various study sites. Also, Dugje *et al*. (2009) in their study of cowpea production in West Africa observed that cowpea performed optimally at a pH range of 6.0 – 7.0. The soil of the maize and *akidi* interplant in this study was found to belong to the sandy loamy textural class, which favours the cultivation of maize and cowpea in conformity to a report by Dugje *et al*. (2009) who recommended that cowpea should be cultivated on a sandy loam to clay soils.

CHAPTER SIX

6.0. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Weed infestation is a major constraint in maize cropping systems which has made it difficult to meet the increasing global food demand. Before now, fallow was used in the management of weed as well as soil fertility restoration; however, human population increase has made it impossible to continue with this method. Thus, in order to mitigate these challenges of dwindling soil fertility and increasing human population studies were carried out to ascertain the potential of *akidi* as a cover crop in the management of weed in maize cropping systems in Ibadan. The results obtained from the various experiments are as follows;

1. From the survey of farmers in two Agricultural Development Programme (ADP) Blocks in Ebonyi State, it was observed that the cultivation of *akidi* is popularly in mixture with other legumes or crops. Majority of the respondents who were successful farmers were in their active age and had tertiary education, which could have accounted for their high level of success. The farmers obtained reduced weed infestation and pest and diseases incidence with intercropping with *akidi*.
2. In the two ADP Blocks, *akidi* was interplanted with cassava, yam and maize, though it could be planted as a sole crop. This is an indication of the compactibility of *akidi* with various cropping systems.
3. *Akidi* has the ability to control soil erosion and improve yield of crops planted in association due to soil covering growing pattern and being a legume which auguments soil nitrogen as evidenced by increased nitrogen and phosphorus levels in the soil at the end of the experiment.
4. The nitrogen fixing ability of the plant (due to its nodule production) may make it an ideal green manure plant to restore fertility of degraded cropland.
5. *Akidi* ability to secrete allelochemicals can possibly make the plant a good ″smother″ plant when used as a cover crop, thereby suppressing weeds on crop fields.
6. *Vigna unguiculata* performed better under 100% and 69% of light intensity. Below 69% light intensity resulted in plants becoming etiolated, as well as a

reduction in the number and size of nodules. The plant can therefore tolerate the reduced light under the maize canopy and can therefore be used as interplant to suppress weeds and revitalize the soil.

7. The smothering effect exhibited by *Vigna unguiculata* was probably due to its better land coverage at higher densities, denial of solar radiation to the weeds, as well as the secretion of allelochemicals.
8. *Vigna unguiculata* was able to suppress the growth of weed seedling at higher densities range of 50,000 – 80,645 plant per hectare.
9. The shoot and root extracts of *Vigna unguiculata* brought considerable inhibitions in the germination of *Zea mays* seeds and in the growth of radicle and plumule of seedlings. The maize seed germination was retarded with increasing extract concentrations, hence growth was concentration dependent.
10. The 100% shoot and root aqueous extracts of *Vigna unguiculata* reduced the vegetative growth of *Zea mays* seedlings more than any other treatments. This did not have serious effect on the grain yield.
11. The phytochemical screening showed that shoots were richer in secondary metabolites such as phenolic, flavonoid, tannins, and glycosides.
12. The high vegetative and yield components observed in the maize on herbicide check and maize hoe weeded plots, can be adduced to the absence of *Vigna unguiculata*, hence no interspecific competition.
13. Although, there was a slight reduction in the yield of maize interplanted with *akidi*, when compared with control treatments, the 100 - seed weight of maize + *akidi* (40,000 plants / ha) was very close to what was obtained in the control plots.
14. The maize + *akidi* (40,000 plants / ha) performed better than all other interplant spacing treatment in the entire yield component, as compared with herbicide control check (MHC) and maize hoe weeded (MHW).
15. The maize + *akidi* (40,000 plants / ha) plot did better in″smothering″ of weeds, as the weed dry weight was less than what was obtained from other treatments.

6.2 Recommendations

From the results obtained from this study, the following recommendations are hereby made.

i. *Akidi* could be adopted as an effective interplant for weed, pests and diseases control in maize cropping systems.

ii. On the average, light intensity of ≥ 69% is recommended as ideal in maize and akidi interplant in maize cropping, in order to avoid its interference with maize performance.

iii. *Akidi* at a planting density of 80,645 plants per hectare should be adopted as ideal for weeds suppression.

iv. Maize + *akidi* (40,000 plants / ha) is recommended for high maize yield and adequate weeds suppression in maize cropping system.

CONTRIBUTION TO KNOWLEDGE

1. The study has revealed that although farmers in the southeastern Nigeria cultivated akidi on their farms for the grains, numerous additional benefits including weed reduction and soil enrichment are derivable from the cropping system.
2. Light intensity of 70% enhanced shoot dry weight and number of root nodules of *akidi* cowpea.
3. *Akidi* cowpea effectively smothered weed, in arable crop land at 40,000 plant / hectare.
4. *Akidi* can tolerate some degrees of shading; it can be adopted as interplant to control weeds in maize cropping systems and its nodulating ability will enhance the nitrogen status of the soil.
5. The interplanting of maize with akidi will reduce the use of herbicide and nitrogen fertilizer thus protecting the environment against degradation and ensuring the health of the ecosystem.

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APPENDIX 1: Total monthly rainfall (mm), temperature (^{O}C) and relative humidity (%) during the period of study (2014 – 2016)

	2014			**2015**			**2016**		
	R (mm)	T (^{OC})	RH (%)	R (mm)	T (^{O}C)	RH (%)	R (mm)	T(^{OC})	RH (%)
January	6.6	31.9	69.5	0.0	23	90.0	0.0	27.5	90.0
February	28.4	31.3	62.0	39.7	25	87.0	0.0	29.5	87.0
March	189.6	29.5	72.5	143.1	25	89.0	242.8	29.0	88.0
April	246.3	28.9	77.5	134.1	25	90.0	344.6	29.5	88.0
May	321.9	28.2	79.0	344.3	24	88.0	383.5	26.0	82.0
June	233.7	27.5	86.0	222.3	21	91.0	423.8	26.5	89.0
July	157.9	26.4	91.0	123.3	23	90.0	106.2	26.5	90.0
August	139.4	25.1	91.5	141.5	23	90.0	89.2	25.5	89.0
September	139.4	26.0	90.5	320.5	22	88.0	645.7	26.5	91.0
October	450.7	27.0	85.5	503.2	23	89.0	556.3	27.5	88.0
November	51.8	27.8	82.5	42.2	33	90.0	75.4	29.0	89.0
December	0.0	28.6	65.5	0.0	33	72.0	9.2	28.0	87.0
Total	1965.7	-	-	2014.2	-	-	2876.7	-	-
Mean	-	25.8	79.4	-	25.0	87.8	-	27.6	88.2

*Where R is rainfall, T is temperature, RH is Relative Humidity.

Source: Meteorological section of National Horticultural Research Institute, Ibadan.

APPENDIX 2: POTENTIALS OF AKIDI (*Vigna unguiculata*) AS COVER CROP IN THE MANAGEMENT OF WEEDS SOIL FERTILITY IN MAIZE CROPPING SYSTEM IN EBONYI STATE, NIGERIA

Dear Respondent,

My name is Imuwahen Aimufua WOGHIREN. I am a Ph.D. student in the Department of Crop Protection and Environmental Biology, Faculty of Agriculture and Forestry, University of Ibadan. I am using this questionnaire to seek information on how *Vigna unguiculata "akidi"* is being used in the management of weeds and soil fertility in EBONYI State.

You are required to provide information on *Vigna unguiculata* with respect to weed and soil management in your farming enterprise. Please note that there are no wrong or right answers. All information provided will be treated with utmost confidentiality and your identity will never be revealed to any other person. Thank you.

A. Demographic characteristics of respondents.

Instruction: Please write or tick as appropriate.

1. Local Government Area ----------------------

2. Sex: Male ☐ Female ☐

3. Age ------------- (Please write your actual age in years)

4. Marital status: Single ☐ Married ☐

5. What is the size of your household?

   (a) 2 (b) 3 (c) 4 (d) 5 and above

6. When was the first time you planted *V. unguiculata* on your farm?

   (i) 1 year ☐ (ii) 2 years ☐iii) 3 years ☐) 4 years ☐

   (v) 5 years and above ☐

7. How did you get the seed for planting *V. unguiculata* in your farm? (a) From nearby farms☐ (b) From local vendors ☐c) From other States (specify) ☐

8. Has it multiplied in number over the years? Yes ☐ No ☐

9. Highest Level of education (Please tick the appropriate box)

No formal education ☐ Primary ☐ Secondary ☐ OND ☐

NCE ☐ HND/B.SC/B.A ☐ Others ☐

10. What is your primary occupation?

Farming ☐ Civil service ☐ Trader ☐ Artisan ☐ Transporter ☐

Others specify -------------

11. What is your secondary occupation if any? ------------------------

B. Enterprise characteristics

1. How many years have you been cultivating ″akidi″ ? -------------------

2. How many farm locations do you have ″akidi″ cultivated? -------------------

3. What is the average size of your farms? -----------------------

4. Where is your farm located? (Please give name of town or village)

....

5. What is the main crop you grow on your farm? Maize ☐ Cassava ☐ Vegetables ☐ Yam ☐ Cocoyam ☐ Cocoa ☐ Others specify ----- -------------

6. How do you manage / control weeds on your farm?

(a) Biological (b) Chemical (c) Physical (d) others (specify)

7. If biological do you use insects to control weeds?

Yes ☐ No ☐

8. If you make use of chemical, which herbicide do you use?

(a) Paraquat (b) 2,4-D (C) Glyphosate (round up) (d) Others

9. Do you control weed physically by ………………..?

(a) Hand weeding (b) Hoe weeding (c) Both (d) Any other means

10. Is the rate of growth or spread of weeds on your farm rapid? Yes or No

If yes, how rapid? High ☐ Moderate ☐ Low ☐

11. What type of weeds is frequently noticed / common on your farm

(a) *Tridax procumbens* (b) *Ageratum conyzoidies* (c) *Chromoleana odorata*

(d) *Panicum maximum* (e) *Bracharia deflexa* (f) Other specify

…………………

12. Have you planted *Vigna unguiculata* (ahuje) on your farm before?

Yes ☐ No ☐

13. If yes, how do you cultivate it in your farm?

(a) Sole crop (b) Mixture of other legumes (c) Interplant with other crops
(d) Others (specify) ☐

14. Does ″akidi″ have any form of dormancy? Yes ☐ No ☐

15. Does ″akidi″ require special treatment before planting? Yes ☐ No ☐

16. If yes what did you observe? ………………………………………………..

C. Purpose of planting ″Akidi″ crop in maize cropping

1. Do you deliberately cultivate ″akidi″ for weed control?

Yes ☐ No ☐ Not Applicable ☐

If yes, how did you go about it

………………………………………………………..

2. When Akidi is used to suppress weed, what is the weeding frequency in plots inter-planted with Akidi compared to plots not inter-planted with Akidi?

Daily ☐ Weekly ☐ Monthly ☐

3. When Akidi is interplanted with maize, what is the frequency of pest infestation?

Daily ☐ Weekly ☐ Monthly ☐

4. Are maize / plant interplanted with Akidi more susceptible to pest attack?

Daily ☐ Weekly ☐ Monthly ☐

5. Do you plant Akidi in your farm to control erosion?

Daily ☐ Weekly ☐ Monthly ☐

6. Do you use Akidi as a green manure on your farm?

Daily ☐ Weekly ☐ Monthly ☐

D. *Vigna unguiculata* growth performance with other crops

1. When inter-planted with other maize, does the *V.* unguiculata affect your crop yield?

Yes ☐ No ☐

If yes, how was the yield?

Very high ☐ High ☐ Moderate ☐ Low ☐

2. When planted in association of other crops, is *V. unguiculata* beneficial to your crops in terms of yield?

Yes ☐ No ☐

If yes, explain? --

3. When Akidi is inter-planted with maize, does it hinder growth of maize?

Yes ☐ No ☐

4. When Akidi is inter-planted with maize, does it promote rapid maize growth?

Yes ☐ No ☐

5. Does inter-planting with *Vigna unguiculata* increase the growth of the subsequent crop planted on the farm?

Yes ☐ No ☐

If yes,

Is the yield, High ☐ Low ☐

6. Does inter-planting with *Vigna unguiculata* increase the yield of the subsequent crop planted on the farm?

Yes ☐ No ☐

If yes,

Is the yield, High ☐ Low ☐