EVALUATION OF GROUNDNUT (*Arachis hypogaea* L.) GERMPLASM IN NIGER STATE FOR AGRONOMIC TRAITS

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ABSTRACT

Groundnut is an annual legume and one of the world's most important oilseed crops. In order to access the genetic diversity of groundnut in Niger state, a germplasm collection mission was undertaken to three agricultural zones of the state. These zones represent the major groundnut producing areas of Niger state. Fourty-five farmers were interviewed using a validated questionnaire. The germplasm collected were evaluated for agro morphological parameters at the experimental garden of Department of Plant Biology, Federal University of Technology Minna, Nigeria using Randomize Complete Block Design (RCBD) with three replicates. All the accessions were characterized into distinct genotypes base on agromorpholocal, fatty acid composition and pollen parameters. A total of thirty-seven (37) accessions of groundnut were collected from the farmers and six (6) improved varieties from Niger State Agricultural Development Project. The highest number (4) of groundnut accessions was collected from Lapai Local government while Gbako, Bida, Lavun, Paikoro, Agaie,Shiroro, Bosso, Kontagora and Katcha Local Government had 3 accessions each. Two accessions each were collected from Borgu, Rijau and Agwara Local Government. There were significant differences ($P<0.05$) for most of the parameters studied. Accession NG-SHI-036 had the highest plant height (35.33 cm). Accession NG-PAK-030 had the highest number of leaves (340.00) and accession NG-LAP-028 had the highest number of branches (16.00). Accession NG-AGW-009 had the least number of days to 50% flowering (27.33 days) and maturity (87.33 days). Accession NG-SHI-036 had the highest number of pod per plant (49.67); SAMNUT22 had the highest 100 seed weight (56.55g), 100 pod weight (132.70g) and shelling percentage (58.06 %). The result of pollen parameters revealed that SAMNUT26 had the highest pollen production (4803.33) and accession NG-SHI-036 had the highest percentage fertility (92.00%). The result of the pollen germinability revealed that in 10% and 20% sucrose concentration, NG-SHI-036 had the highest percentage germinability of 27.00% and 75.33% respectively. The dendrogram of the agro morphological parameters cluster the accessions into four major groups. Genotype NG-SHI-036 had the highest oil percentage (53.17%). Accessions NG-SHI-036, NG-GBA-014 and NG-LAV-024 were the best in terms of fatty acid composition. This study has provided some useful baseline information about important traits in the various groundnut accessions in Niger State. Such traits should be exploited for the improvement of the crop in the future.

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ABBREVIATION AND GLOSSARIES

ANOVA	Analysis of Variance
DMRT	Duncan Multiple Range Test
RMRDC	Raw Materials Research and Development Council
NBPGR	National Bureau of Plant Genetic Resources
IBPGR	International Board for Plant Genetic Resources
ICRISAT	International Crops Research Institute for Semi-Arid Tropics

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Groundnut (*Arachis hypogaea* L.) is well-known as peanut in North and South America (Gadhiya *et al*., 2014). It is an annual legume and one of the world's most significant oilseed crops (Upadhyaya *et al*., 2006; Mukhtar *et al*., 2013). The genus *Arachis* comprises of 80 described species and is partitioned into nine taxonomic sections:*Trierectoides, Erectoides, Procumbentes, Rhizomatosae, Heteranthae, Caulorrhizae, Extranervosae, Triseminatae and Arachis* (Rami *et al*., 2013). Groundnut is thirteenth in the world food crops position; it positions fourth in oil generation or palatable oil after soybean, rapeseed, and cottonseed and third vegetable most important protein (Food and Agricultural Organisation, 2017a).

Groundnut has been affirmed to have originated from South America and later spread to Brazil (Zhao *et al*., 2012). It was acquainted by Portuguese from Brazil to West Africa and afterward to South Western India in the sixteenth Century, in the present day; the groundnut is grown in practically every one of the nations of the world (Anjana *et al.,* 2016). It is grown in all continents with a complete region of 24.6 million hectares, and a production of 41.3 million tons (FAO, 2013). In Africa, about 11.7 million hectares of land is utilized for groundnut production and 10.9 million tons of yearly generation (FAO, 2013).

The importance of this crop cannot be overemphasised; it is utilized for diverse purposes; it is a good source of cooking oil, frying, salad, margarine and groundnut butter. It is a cash crop broadly developed in all the tropical and sub tropical locales of the world for direct use as nourishment, for oil, and for the high protein meal produced after oil extraction. The

seeds have palmitic, oleic and linoleic acids representing about 90% of total fatty acids at seed maturity (Engin *et al.,* 2018). Groundnut is significant sources of vitamins E, K, and B (the richest source of thiamine and niacin) and other basic minerals (Kassa *et al*., 2009). Groundnut cake after oil extraction is especially utilized for animal feeding with high protein content (Savage and Keenan 1994). It was reported that consuming groundnut at least four times a week demonstrated a 37% decreased danger of coronary heart disease (Suchoszek-Lukaniuk *et al*., 2011). Studies also indicated that groundnut contain anticancer activity with half hindrance of expansion of related leukemia cells (Hwang *et al*., 2008). Efforts have been made by several researchers to improve the quality and quantity of the available groundnut varieties. However, such efforts are yet to be well felt by the local farmers, especially in Niger state. There is therefore, a need to further broaden the genetic basis of the crop through the study of diversity of the crop in Niger state through collection and characterisation of the available germplasm.

1.2 Statement of the Research Problems

Under utilisation of vast potential of groundnut landraces has led to low genetic variability among varieties available to farmers. This low genetic variability remains one of the main challenges to groundnut improvement (Pasupuleti *et al*., 2013). According to Tulole *et al*. (2008), cultivation of low yielding varieties and poor seed supply are among the major constraints to increasing groundnut production.

In Niger state, attention has not been given to collection and evaluation of available groundnut landraces and information on the qualitative and quantitative properties of groundnut oils of cultivars grown in Niger state has not been adequately evaluated. In addition, Hassan and Ahmed, (2012) also noticed that the major focus of the breeding

program by the groundnut breeders has been on the improvement in yield and yield related traits. However, quantity and quality of oil in term of fatty acid has rarely been studied.

Pollen production, viability and germinability test of the groundnut genotypes have not been used to determine genetic variability among the accessions of groundnut grown in Niger state. There is therefore a need to develop better genotype (s) of the crop in order to encourage its cultivation for increased production of yield as well as enhancing its improvement in the state.

1.3 Justification for the Study

In crop improvement program, estimation of genetic diversity is a fundamental aspect for breeding highly productive cultivar and the genetic diversity present in a crop plays important role in improvement of crop (Tulole *et al*., 2008).Groundnut landraces are valuable as they possess huge treasures of genetic material which may prove valuable in the future crop development and improvement program (Ajeigbe *et al.,* 2014).

Moreover, previous research on groundnut in Niger State has dealt with economics analysis of groundnut (Animasahun, 2008) and functional characterisation of groundnut (Mustapha *et al.,* (2015). Collection and evaluation of germplasm have been found to be effective for selection of new varieties with desirable trait (Falusi, 2001; Assefa *et al.*, 2005; Kaizzi *et al*., 2006; Adjei-Nsiah *et al.,* 2007; Tulole *et al*., 2008; Daudu *et al*., 2015; Gado, 2018; Abubakar *et al.,* 2018). Knowledge of the genetic variability in a population and partitioning the variance into the components provides useful information for improvement of desirable traits (Zaman *et al*., 2011).

Due to rapid growth of population, groundnut yield is urgently required to increase, to meet food demand. In order to meet this demand, there is necessity for development of improved varieties (Engin *et al*., 2018).

The nutritional and storage qualities of groundnuts are determined by its fatty acids composition (Gulluoglu *et al*., 2016). Due to the high amount of oleic and linoleic acids in groundnut seed, quality of groundnut oil depend on their relative proportions (Hassan and Ahmed, 2012). Hence, fatty acid composition of groundnut oil determines its quality (Asibuo *et al.,* 2008a; Hassan and Ahmed, 2012; Ganapati *et al.*, 2014). Oils with high content of fatty acid (oleic acid) are less susceptible to oxidative changes during refining and storage (Win *et al*., 2011; Ganapati *et al.*, 2014). Nutritionally, a high content of linoleic acid is preferable because it is an essential fatty acid and has been known to lower total blood cholesterol and low-density lipo-protein levels (Asibuo *et al.,* 2008a).

The characterisation of germplasm is of immense significance for cultivar identification, description of accessions, establishment of diagnostic characteristics, identification of duplicates, development of interrelationship between, or among traits and between geographical groups of cultivars, identification of accessions with desirable agronomic traits and selection of entries for more precise evaluation; and also important in estimation of the extent of variation in the collection (Upadhyaya *et al.*, 2008).

1.3.1 Aim and Objective of the Study

1.3.2 Aim of the study

The aim of this study is to evaluate groundnut (*Arachis hypogaea* L.) germplasm in Niger State.

1.3.3 Objectives of the study

The Objectives of the study were to:

i. collect and characterize groundnut accessions using standard descriptor of groundnut.
ii. determine agromophological parameters of the accessions.
iii. determine pollen parameters of the accessions.
iv. quantify the fatty acid composition of the accessions.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Centers of Origin and Diversity of Groundnut

Groundnut which is also called peanut (*Arachis hypogaea* L.) originated from South America (Idoko and Sabo, 2014). The term 'groundnut' is used in Asia, Africa, Europe and Australia, while in North and South America it is commonly referred to as 'peanut'. The term 'groundnut' refers to the pods with seeds that mature underground; the connotation of 'peanut' is because this crop belongs to the family leguminoceae which includes also other crops such as peas and beans (Prasad *et al*., 2009).

The earliest archaeological records of groundnuts in development are from Peru, dated 3750-3900 years before present (BP). Groundnuts were generally spread through South and Central America when Europeans arrived at the continent, likely by the Arawak Indians. There is likewise archaeological affirmation of their reality from Mexico, dated 1300-2200 preceding present (PP). After European contact, groundnuts were scattered around the world. The Peruvian runner type was taken toward the Western Pacific, China, Southeast Asia and Madagascar. The Spanish acquainted the Virginia type to Mexico, through the Philippines, in the sixteenth century. The Portuguese at that point took it to Africa, and later to India, through Brazil. Virginia types evidently arrived at the South east United State (US) with the slave trade (Prasad *et al*., 2009; Chandran *et al.,* 2016; Audu *et al.,*2017).

2.2 Taxonomy of Groundnut

Groundnut (*Arachis hypogaea* L.) belongs to the family Leguminaceae (Amarasinghe *et al*., 2017). It belongs to the tribe *Aeschymanomeneae*, subtribe *Stylosanthineae,* it is a self-pollinating, indeterminate, annual herbaceous legume of genus and species *Arachis hypogea* that is derieved from a Greek words 'arachos' meaning 'weed' and 'hypogea' meaning 'underground chamber' (Adinya *et al.,* 2010).

It is isolated two subspecies, *hypogaea* and *fastigiata* Waldron. Every one of these species subspecies is additionally divided into botanical varieties; subsp. *hypogaea* into var. *hypogaea* and var. *hirsuta*, subsp. *fastigiata* Waldron into var. *fastigiata*, var. *vulgaris*, var. *peruviana* and var. *aequatoriana*. Just three botanical varieties, subsp. *hypogaea* var. *hypogaea*, subsp *fastigiata* var. *fastigiata* and var. *vulgaris* are generally cultivated in the Americas, Africa, and Asia (Ferguson *et al*., 2004). There are 80 species in the genus *Arachis* partitioned into nine sections: *Arachis, Caulorrhizae, Erectoides, Extranervosae, Heteranthae, Procumbentes, Rhizomatosae, Trierectoides,* and *Triseminatae* based on morphology and cross-compatibility relationships (Valls and Simpson, 2005).

Scientific classification of groundnut according to Prasad *et al*. (2009)

Kingdom:	Plantae
Unranked:	Angiosperm
Unranked:	Eudicots
Unranked:	Rosids
Order :	Fabales
Family:	Fabaceae
Subfamily:	Faboideae

Tribe: Dalbergieae

Genus: *Arachis*

Species: *A. hypogaea*

2.3 Biology of Groundnut

According to Prasad *et al.* (2009), most groundnuts are planted in single rows about 90-100 cm apart with about 20 seeds per meter in the row. The standard twin row system (two rows spaced 20 cm apart on 90 cm centers) is becoming common, as the twin row system regularly has less frequency of the tomato spotted wilt virus. Optimum planting depth for groundnut is about 5 cm for heavy soils and 6 cm for light soils. Planting further than 7.5 cm reduces percentage germination. If soil moisture is limited, irrigation before planting is recommended. Furthermore, in some places seeds are treated with *Rhizobia* to help nitrogen fixation. On the off chance that groundnuts are been planted either without precedent for another field, or after an extensive stretch, it is recommended to treat the seeds with an appropriate strain of *Rhizobia* (Prasad *et al*., 2009).

Groundnut emergence is intermediate between the epigeal (hypocotyl elongates and cotyledons emerge above ground as in soybean) and hypogeal (cotyledons remain below ground as in field pea). The hypocotyl elongates but usually stops before cotyledons emerge. Leaves are alternate and pinnate with four leaflets (tetra foliate). Groundnut can be erect or prostrate (15 - 61 cm) with a well-created taproot and numerous lateral roots and nodules (Madhan and Nigam, 2013). Groundnut pods are usually placed to a depth of 7 - 10 cm referred to as pod zone (Ademiluyi *et al.,* 2011).

Groundnut can reach the height of 30-50 cm tall, leaves are opposite, and pinnate with four leaflet; each leaflet is 1-7 cm long and 1-3 cm across (wide), the flowers are yellowish

orange with reddish veining, it grew underground to produced “pegs” which later develops to a matured groundnut pod; the pods are 3-7cm long containing 1-4 seeds (Krapovickas *et al*., 2007).

According to Kamara *et al*. (2011), groundnut being a yearly plant is having a main and remarkable characteristic of producing fruits underground. They reported that it is uncommon in that, after fertilization, the aerial flowers grow downwards and the ovary, at the end of the elongated stalk ‘peg’, enters the soil in a positive geotropic manner where the ovary at the tip of the peg develops into the pod containing seeds.

2.4 Production of Groundnut

Groundnut production globally accounts for approximately 42 million hectares with a total production of over 35 million tons (Rao *et al.,* 2013). Land area of groundnut planted or harvested worldwide significantly expanded to 26.5 million hectares in 2014 from 16.6 million acres in 1961 (FAO, 2017b). The USA recorded highest in groundnut yield per hectare, followed by China and Argentina. It suggests that the USA and Argentina are among the leading producers of groundnut mainly because of their significant return per section of land. By and large, in cutting edge economies, groundnut yield per section of land has expanded because of productive utilization of current innovation combined with use of improved seed. Be that as it may, the turnaround has been the situation in Africa as yield per hectare is low in nations, such as, Nigeria, Sudan and Tanzania (FAO, 2017 b).

In addition, more than half of the production areas of groundnut is centered in arid and semi-arid regions (Reddy *et al.,* 2003).

Nigeria is the largest groundnut producing nation in West Africa, representing 51 % of groundnut production in the region. The country contributes 10 % of total global

production and 39% to production in Africa (Ajeigbe *et al.,* 2014; Nahanga, 2017). Between 1956 and 1967, groundnut was the country's most important single export crop, exemplified by the acclaimed Kano groundnut pyramids. Groundnut possesses between 1.5 and 2 million ha of land in Nigeria, the main producing states include Niger, Kano, Jigawa, Zamfara, Kebbi, Sokoto, Katsina, Kaduna, Adamawa, Yobe, Borno, Taraba, Plateau, Nasarawa, Bauchi, and Gombe States (Alabi *et al*., 2013; Zekeri and Tijjani, 2013).

2.5 Ecology of Groundnut

Light, sandy loam soil is favoured for the production of groundnut. Temperature of 30°C is viewed as the ideal for fast germination and development of pods (Chandran *et al.,* 2016). The soil should also be light colored. This shows that it is relatively low in organic matter, which averts parasitic maladies. It additionally implies that the soil will not stain the pods, which can reduce the market value of the crop if it is sold in the pod. The pH ought to be 5.5 to 7.0 (slightly acidic to neutral). Groundnut cannot tolerate saline soils (Desmae and Sones, 2017).

The crop requires between 250 and 1,000 mm of rain during the developing time frame: very early maturing groundnut varieties need 250-400 mm; early varieties 300-500 mm; late maturing varieties 500-1,000 mm. In the event that the rainfall is above 1,000 mm at that point groundnut should be grown on ridges unless the soil is very well drained (Desmae and Sones, 2017). In addition, the ideal temperatures for growing groundnut should be between 25-30°C. Ideal Temperatures above 35°C are not favourable to groundnut production. Under lower temperatures, the germination is delayed; the delay in germination exposes the seeds to soil pathogen attack for a longer period. At temperature below 17° C, crop growth almost ceases. The limit for germination of groundnut is around

18 ºC, however, temperatures between 20 -30 ºC results in ninety-five percent (95 %) germination. Cooler temperature, particularly at night has been reported to also delay harvesting (Meena *et al.,* 2015). Groundnut ought not to be grown in territories of excess of 1,500 metres above sea level as the temperature is probably going to be low for groundnut and it will influence its production (Ajeigbe *et al*., 2014; Desmae & Sones, 2017).

2.6 Genetic of Groundnut

Comprehensive reviews on groundnut genetics covering inheritance, cytogenetics, combining ability, genotypic and phenotypic coefficients of variation, heritability, genetic gain, genotype-by-environment interactions and trait correlations were published (Nigam, 2014). Qualitative and quantitative inheritances of traits have been reported. Generally, majority of morphological (e.g. growth, branching, leaf, pod and seed traits), quality (protein and oil) and disease resistance (leaf spots, rust) traits were reported to have predominantly qualitative inheritance (Jakkeral *et al.*, 2013; Gangadhara and Nadaf, 2016). In addition, quantitative inheritances were also reported for some of the traits such as oil content and quality (Wang, *et al*., 2012; Shasidhar *et al.,* 2017; Wilson *et al*., 2017). Most of the economically significant traits such as yield, maturity and drought tolerance traits are quantitatively inherited (Ravi *et al*., 2011). The presences of genetic and non-genetic variances were reported for various traits (Reddy *et al*., 2011).

Low-to-high genotypic and phenotypic coefficients of variation,broad-sense heritability, genetic advance and genetic advance as percentage of mean have been reported for various traits including grain and pod yield, days to 50 % flowering and plant height, shelling percentage, specific leaf area (SLA) and number of pods per plant and 100-seed weight (Patil *et at*., 2014; John *et al.,* 2013).On account of attributes connections, grain and pod

yield were reported to be positively correlated among themselves and with traits such as shelling percentage, 100-seed weight, number of pods per plant and dry haulm yield (Padmaja *et al.,* 2013, Thirumala *et al*., 2014); also with drought-related traits such as harvest index (HI) (Upadhyaya *et al*., 2011). On the other hand, negative correlations were reported for grain and pod yield with early leaf spot (ELS) resistance parameters, days to first flowering and days to 50% flowering (Padmaja *et al.,* 2013, Nyadanu *et al.,* 2015). For quality traits negative correlations between protein content and oil content and between oleic acid and linoleic acid were reported by Sarvamangala *et al*. (2011).

2.7 Genetic Diversity of Groundnut

The degree and dispersion of genetic diversity in a plant species depends on its evolution and breeding system, ecological and geographical factors as well as anthropogenic influences (Wang *et al*., 2016). Numerous landraces and cultivars are restricted in various part of the nation (Mshelmbula *et al*., 2017).

It was perhaps Charles Darwin who originally noticed that domesticated species aggregate a remarkable amount of variation in a short time. Groundnut follows this pattern, and considering its very recent origin, there is remarkable large agromorphological diversity in groundnut (David *et al*., 2011). Based on this, two subspecies were recognized; *hypogaea* and *fastigiata*. These, in turn, have two (*hypogaea* and *hirsuta*) and three (*fastigiata*, *vulgaris*, and *peruviana*) botanical varieties, respectively (David *et al*., 2011; Garba *et al*., 2015). They further reported that the variety (A. *hypogaea* subsp. *hypogaea*var.*hypogaea*) has a long cycle, no flowers on the central stem, and regularly alternating vegetative and reproductive side stems. It is broadly present as landraces along the tributaries to the South of the Amazon River in Brazil and Bolivia. The modern agricultural types '*Virginia*' or

'Runner' exemplify this type. Also classified within subsp. *hypogaea*, but with more hirsute leaflets and even longer cycle, is the variety *hirsute Kohler* (Peruvian Runner). Nowadays, this variety is concentrated in the coastal regions of Peru, from where it extends to Central America and Mexico, Asia and Madagascar. The variability of this variety found in the Old World even recommends the probability of pre-Colombian contacts (Seijo *et al*., 2007).

The subspecies *fastigiata* Waldron has a shorter cycle, flowers on the central stem and regenerative and vegetative stems dispersed in a disarranged manner. The variety *vulgaris* C. Harz has its dispersion fixed on the bowl of the river Uruguay. For the most part, the fruits are two seeded, and the varieties relates to the horticultural type known as 'Spanish'. The variety *fastigiata* has fruits with multiple seeds and a smooth pericarp; this variety relates to the horticultural type 'Valencia'; centres of diversity are in Paraguay, and Central and North-Eastern Brazil extending to Peru. The other varieties *aequatoriana* Krapov and W.C. Gregory (Ecuador and North of Peru) and *peruviana* Krapov. and W.C. Gregory (Peru, North East of Bolivia and the Brazilian State of Acre) have fruits with multiple seeds, overwhelming reticulation of the pericarp and very restricted distributions (Seijo *et al*., 2007; David *et al*., 2011).

At first, the extremely constrained DNA polymorphism present in *A*. *hypogaea* restricted the information that could be gained from molecular investigation. The primary examinations depended on isozymes and proteins, followed by Restriction Fragment Length Polymorphisms (RFLPs), Random Amplified Polymorphic DNA (RAPD) and Amplified Fragment Length Polymorphisms (AFLPs) (David *et al*., 2011). None of these marker frameworks were very informative in cultivated germplasm. More significant levels

of polymorphism were observed with micro-satellites, especially with longer TC motif repeats (Moretzsohn *et al*., 2009). Recently, numerous new microsatellite markers such Simple Sequence Repeated (SSR) have been created, and this has empowered the location of moderate degrees of genetic variation in A. *hypogaea* accessions and even intra-variety polymorphism (Tang *et al*., 2007; Varshney *et al*., 2009).

As a rule, two principal groups were observed, joining accessions of A. *hypogaea* sp. *fastigiata* '*fastigiata*'(Valencia type) and *fastigiata 'vulgaris*' (Spanish type) in one group, and *hypogaea 'hypogaea*' (Virginia and Runner types) and *Hypogaea'hirsuta'* (Peruvian runner) in a second group. Most often, these cultivars/lines have different varieties in their pedigrees and do not represent the varieties as well as landraces do (Cuc *et al*., 2008). Genetic diversity in groundnut represents the heritable variety inside and between populace (Wang *et al*., 2016).

2.8 Germplasm Characterisation and Evaluation

Germplasm can be defined as living genetic resources for example, seeds or tissues that are kept up for the purpose of plant breeding, preservation, and other research uses (Tripathi, 2017). Germplasm characterization and evaluation in a broad sense and in the perspective of genetic resources is the description of a specific accession. It covers the whole scopes of exercises beginning from the receipt of the new samples by the curator and growing these for seed increase, characterization and preliminary evaluation as well as for further comprehensive evaluation and documentation(De Vicente *et al*., 2005).

Characterization of genetic resources alludes to the procedure by which accessions are distinguished or separated (De Vicente *et al*., 2005). This distinguishing proof may refer to any distinction in the appearance or composition of an accession. In the concurred terminology of gene banks and germplasm management, the term‘characterization’ stands for the description, comprehension and recording of characters that are generally and exceptionally heritable, effectively observed by the eye and equally expressed in all the environments (De Vicente *et al*., 2005).

Characterisation of germplasm is constantly connected with evaluation of germplasm; however, germplasm evaluation deals with the estimation of the agronomic potential of an accession including quality parameters and reaction to different abiotic and biotic stresses (De Vicente *et al*., 2005). Evaluation of germplasm resources is important in distinguishing the fitting germplasm with a target trait for their further uses (Perrino *et al*., 1991). Genetic resources are very useful sources of variation for improving agricultural productivity. However, the protection of genetic resource only becomes significant if it acquires recognized value which can be assigned only through thorough evaluation of the germplasm for the critical genetic material (Perrino *et al*., 1991; De Vicente *et al*., 2005).

Simpson and Withers (1986) reported that the characterization of germplasm is the third phase of gene bank operations. The first phase has to do with the exploration and collection, the second stage gives more focus to improved multiplication techniques and storage ability. The third phase is focused on the characterization, evaluation and documentation due to the fact that distribution and utilization actions that contributes to the fourth phase depends on

the systematic knowledge of the value of the materials in the collection (Simpson and Withers, 1986). The methodology utilized for characterization or preliminary evaluation varies but they can be performed simultaneously with regeneration or reproduction. This is not the same with germplasm evaluation due to diverse environmental conditions required to complete the distinctive procedure (Simpson and Withers, 1986).

The International Board for Plant Genetic Resources (IBPGR, 1992) opinioned three main categories of evaluation of data: Characterization of morphological and agronomic descriptors of high heritability, preliminary evaluation on special agronomic character and secondary evaluation which has to do with several useful characters.

2.8.1 Purpose of characterisation and evaluation of germplasm

According to Rao and Hodgkin (2002) and NBPGR (2006), the purpose of germplasm characterization and evaluation are to:

a) describe accessions and establish accessions' investigative characteristics
b) classify accessions into groups utilizing sound means
c) assess interrelationships among accessions or among traits and among geographic groups of accessions
d) estimate the extent of variation in the genebank collection
e) identify duplicates in a collection
f) reveal potentially useful variability for further use in genetic enhancement of crops
g) determine phenotyping of genebank accession(s) of interest

2.8.2 Groundnut core collection

Very enormous collections of groundnut germplasm around the globe are being gathered in an effort to conserve the genetic variation of several species for further evaluation and usage. The world collection and assembly of groundnut genetic resource was upgraded through explicit collection campaigns in different groundnut growing locales of the world and in the centers of diversity in South America (Upadhyaya *et al.,* 2002). In this undertakings, various worldwide agencies for example, International Board for Plant Genetic Resources (IBPGR) and national projects for example, those of the nations of investigation and the United State Department of Agriculture (USDA) have worked together firmly prompting the foundation of the world's biggest store of groundnut germplasm at International Crops Research Institute for the Semi-Arid tropics (ICRISAT) and the United State of America (USA) under the United State Department of Agriculture (USDA) with 14,000 and 7545 accessions, respectively (Simpson, 1984). These collections give fundamental genetic stock to the international scientific community for further development of the groundnut. Beside the collection of the landraces of cultivated groundnut, endeavors were likewise made to gather unmistakable *Arachis* species. Williams (2001) talked about utilization of the geographic information system (GIS) for progressively viable examination, locate and conserve *Arachis* genetic resources depending on existing germplasm collections and topographical dissemination of genetic diversity within primary and secondary centers of diversity or origin.

2.9 Oil Composition of Groundnut

The supplement estimation of a groundnut product is firmly related with the fatty acid composition of its oil content, which additionally impacts its quality (Hassan and Ahmed, 2012; Ganapati *et al.*, 2014).The oil content of groundnut is different in both quantity and the relative proportion of fatty acids (Asibuo *et al.,* 2008[a]; Ganapati*et al. (*2014).

Twelve fatty acids have been reported in groundnut however, eight significant fatty acids amount to 98%of fatty acids in groundnut. Oleic acid, a monounsaturated fat, and linoleic acid, a polyunsaturated acid, amount to about 80% of the total fatty acid composition of groundnut (Asibuo *et al.,* 2008a). Ganapati *et al*., (2014) affirmed that the protein substance of groundnut is between 44 –56 %, oil 22 – 30 %, monounsaturated fats 45-50 %, poly unsaturated fats30-35 % and saturated fats17-18%. Hassan and Ahmed (2012) also reported that the oil content of groundnut is between 49.83-53.06 % with palmatic acid 9.95- 10.79 %, stearic acid 1.63-2.19 %, oleic acid 49.34-54.83 % and linoleic acid 28.08-34.23 %.

Oleic and linoleic fatty acid composition of groundnuts play a significant function in determining how advantageous groundnuts are for humans. For example, numerous authors have reported that groundnuts with high oleic to linoleic ratio are progressively helpful to individuals contrasted with 'typical' oleic groundnuts with a ratio of <2 (Achola*et al*., 2017). High oleic to linoleic proportion gives medical advantage (Garcia *et al*., 2006) and a great seed oxidative strength, hence broadened time frame of realistic usability (Janila *et al*., 2013). Likewise, groundnut oil is viewed as one of the healthy cooking oils; since the proportion of unsaturated to saturated fats is high (Johnson and Saikia, 2009; Achola *et al*., 2017).

Oleic acid (C18:1) has been found to be associated with several medical advantages, including; decreased risk of cardio vascular disease (CVD), by lessening the degrees of serum low-density lipoproteins (LDL) cholesterol; and keeping up of degrees of high-density lipoproteins (HDL), without causing huge weight gain (Barbour *et al*., 2015).

Monosaturated fatty acids (MUFAs) decline plasma triglyceride levels in comparison with carbohydrates and furthermore help in ruining the improvement of adrenoleuko dystrophy and reversing inhibitory impact of insulin generation (Vassiliou *et al*., 2009). It additionally has mitigating properties that actuate various pathways of invulnerable competent cells (Carrillo *et al.*, 2012). Polyunsaturated fatty acids (PUFAs) for example, linoleic (C18:2), are perceived for their susceptibility to oxidative rancidity, with the end goal that when heated at high temperatures makes it hazardous for human utilization (Isleib *et al*., 2006).

2.10 Importance and Uses of Groundnut

In some continents for example, Asia, Africa and South America, accounted for 97% of the global groundnut territory and 95% production industrially; the oil produce from the seed is utilized in manufacturing industries for the production of lubricants and other items such as shaving cream, soap and plastics (Alabi *et al*., 2013). In addition to the global analysis, Taru *et al.* (2010) reported that 50 percent of total groundnut production is used for oil extraction, 37% for confectionery use and 12 percent for seed production globally.

The seed cake, haulms (vegetable plant part) gives an extraordinary hay which has been used for livestock feed and fertilizer and shell have been used as filter for wallboard band insulators (Taru *et al.*, 2010).

Groundnut is a significant cash crop, a reasonable source of edible oil rich in omega-3 fatty acids, protein and vitamin E and its stover provides nutritious grain to domesticated animals, it provides income for farmers in developing nations (Holbrook and Stalker, 2003; Izge *et al*.,2007; Pandey *et al*., 2012).

Groundnut has also been rightfully described as natures masters piece of food values containing 36 to 54 percent oil with 21.36 percent protein and have an energy value of 2,363 KJ/100 g. The oil is rich in unsaturated fatty acid (80 percent), oleic acid and linoleic acid accounts for 38 to 58 percent and 16 to 38 percent, respectively. Among the immersed saturated fatty acids, palmatic acid is the most important one with the proportion of about 10 to 16 percent, higher iodine values (82 to 106) and refractive index values (1.4697 to 1.4719 ND20) demonstrating its susceptibility to oxidation. Raw groundnut oil have excellent dependability (Dharanguttikar and Borkar, 2014).

Abdurrahman *et al.* (2014) reported that groundnut as a legume plays an enormous function in feeding the world's people and animals, frequently in the third world nations, where they meet as much as two thirds of human dietary needs.

It was reported that consuming of groundnut at least four times each week demonstrated a 37% decreased danger of coronary illness (Suchoszek-Lukaniuk *et al*., 2011). Studies also indicated that groundnut contain anticancer activity with 50 percent inhibition of the proliferation of related leukemia cells (Hwang *et al*., 2008).

Groundnut oil has been reported to contained 47 % fat, 38.6 % protein, 1.8 % carbohydrate, 3.7 % crude fibre, 5.8 % moisture and 3.1 % ash (Atasie *et al*., 2009). They further added that the oil seed is an exceptional source of protein with high nutritional value. Groundnut

improves soil fruitfulness through nitrogen fixation, in this way expanding the productivity of other crops when used in rotation or in a cereal cropping system.

In Nigeria, groundnuts are processed into different products. Abdulrahaman *et al.* (2014) identified a few dishes prepared from groundnut in the three fundamental tribes of Nigeria namely; Yoruba, Hausa and Ibo. The dishes are groundnut oil, kulili, yaji, sisi pelebe, donkwa, kunu geda, chin-chin, groundnut soup, roasted groundnut. In northern part of Nigeria groundnuts are also cooked or boiled, processed into groundnut paste commonly known as groundnut butter, groundnut cake, salted groundnut and groundnut soup (Mustapha *et al*., 2015).

2.11 Constraints to Groundnut Production

Groundnut present significant opportunity to improve livelihoods and nutrition, but its production is subject to vital constraints. Ground production is constraints by lack of high yielding varieties, poor marketing, poor seed supply, unreliable rainfall, drought, pests and diseases (Tulole *et al*., 2008).

Lack of access to adequate quantities of enhanced seeds is one of the reasons for low groundnut productivity since it forces farmers to use low yielding varieties and recycled seed (Doss *et al.,* 2003, Simtowe *et al.,* 2010). There is likewise an absence of enthusiasm by business seed organizations to breed and sell seeds of self-pollinated crops, since it can be recycled by farmers thus making it uneconomic to breed them (Siambi and Kapewa, 2004).

Low precipitation and delayed drought during crop development period were reported to add to the low yields of groundnut production in most of the areas of Asia and Africa (Reddy *et al.,* 2003). Badiane (2001) reported that persistent droughts and insufficient

rainfall characterize one of the greatest problems on groundnut crop. Dulvenbooden *et al.* (2002) reported that groundnut production is outstandingly determined by rainfall. Awoke (2003) recognized absence of improved capital data source, absence of insurances and high financing cost as a portion of serious issues of groundnut production.

The overall agricultural production are falling apart thereby creating wide opening between demand and supply of food and makes the industries to import agricultural raw materials (Audu *et al*., 2017). They further added that, Government on its part moved its focus from agribusiness to the oil business, resulting to decrease in the production effectiveness and efficiency in Agricultural segment. The performance of Agricultural area has stayed below expectations; there is a wide breach between demand and supply of food in the nation. In spite the copious land and different resources in Nigeria, yield per hectare of groundnut has been decline over the years (Audu *et al*., 2017). Therefore output of groundnut has been declining bringing about varnishing of the well known groundnut pyramids during the 1960s (Nahanga, 2017).

Nigeria is the biggest groundnut producing nation in West Africa accounting for 51 percent of the production in the region (Ndjeunga *et al*., 2013). They added that the nation produces 10 percent and 39 percent of the World and Africa's total production respectively. preceding1980s, groundnut production declined significantly due to low yielding, poor seed supply, rosette incidence and drought (Ndjeunga *et al*., 2013).

Deficiencies of groundnut are experienced for both domestic and foreign markets farmers; they have lost stability of income as a result of poor output of groundnut. There is a setback of more than 90 percent of groundnut necessity by organizations associated in processing (Audu *et al*., 2017).

2.12 Growth and management of groundnut

2.12.1 Weeding

Groundnut does not contend well with weeds and yields will be brutally reduced if the crop is not effectively weeded, especially during the first 3-6 weeks after sowing (Ajeigbe *et al*., 2014). There is therefore a need for early weed control for better yield. The normally yield misfortune because of weeds has been accounted for 30 percent and may reach up to 60 percent under poor management practices. Sharma *et al*. (2015) additionally reported that when weeds are not controlled viably it will prompt overwhelming misfortune during harvesting by intermingling with and breaking pods from plants. It is therefore important to control weeds on groundnut fields using cultural, mechanical, physical or chemical methods, particularly during the first six weeks after sowing (Ajeigbe *et al*., 2014).

Haile and Keith (2017) reported that 2-3 weedings will be required, if the correct plant spacing has been observed. They added that if appropriate weeding is observed within the stated weeding period, the crop will cover the ground preventing weed growth. Crop rotation, good arrangement of the field, with profound turning of the soil, will help to ensure that the seed bed is weed-free (Haile and Keith, 2017). Hand weeding and hoeing are normally manual and cultural weed management methods which are good for groundnut (Devi *et al*., 2017**).** They further said that, the combination of physical and chemical methods by use of post-emergence herbicides is the best alternative for weed control at critical periods. Combination of physical and chemical methods by use of post-emergence herbicides like imazethapyr or quizalofop-p-ethyl (Bhatt *et al*., 2008) were recommended for controlling weeds effectively at later phases of crop growth and preservation of weed free environment at severe stages of crop growth (Sailaja *et al*., 2002).

2.12.2 Fertilizer requirement of Groundnut

Groundnut being an oilseed crop is most defenseless to phosphorus shortages, which thusly bring about nitrogen just as potassium insufficiency; fertilizer requirement of groundnut includes Single Super Phosphate (SSP) and gypsum essentially (Manan and Sharma, 2018).

The general fertilizer recommendation of NPK kg ha-1 is: 25 kg of N - 50 kg of Phosphorus pentoxide (P2O5) - 100 kg of Potassium oxide (K2O). However for realistic purposes two bags of NPK 15:15:15 in addition to two bags of Single Super Phosphate (SSP) and a bag of Muriate of Potash (MOP) can be applied per ha. If the groundnut crop follows a well-fertilized cereal crop at that point two bags of SSP might be adequate per ha. Application of 400 kg ha-1 gypsum at peak flowering/pegging stage both improves the seed filling and builds the oil content (Ajeigbe *et al*., 2014).

It has been hypothesized that the reaction of groundnut is higher to single superphosphate (SSP) application than to diammonium phosphate (DAP) due to the presence of Ca, S and trace elements in SSP. The single super phosphate fertilizer contains 12.5 percent sulphur, 16 percent Phosphorus pentoxide (P2O5) and 19 percent calcium and need to be utilized as a basal-dressing just by arrangement techniques (Manan and Sharma, 2018).

Due to shortage and significant expense of chemical fertilizer the utilization of poultry manure is an alternative which additionally have demonstrated beneficial outcome on the yield of groundnut (Ibrahim *et al*., 2016). Poultry manure is an outstanding source of organic manure which contains high nitrogen, phosphorous, potassium and other significant nutrients (Ibrahim *et al*., 2016).

2.12.3 Harvest of groundnut

Groundnut is an indeterminate plant, so the pod maturity is not homogeneous (Saxena *et al*., 2014). They further added that, in choosing the best harvest date, a farmer must explore his/her crops all the time, as the groundnut plant usually gives an indication of when to harvest. According to Ajeigbe *et al*. (2014) groundnut matured between 80-120 days; some of the indications of maturity according to Ajeigbe *et al*. (2014) are;

i. Pod colour: inner walls display a dark-brown colour as a result of darkening of the inner tissue of the hull. At the point when 75 percent of the pods of the selected number of plants have reached maturity by showing the dark discoloration, harvesting can begin. The external wall of the pods should show different shades on the inner cell layer when scraped with a blade. The colours are white on the immature and yellow pods, and orange, light brown or black on mature pods. Harvesting can be done when 70 percent of the pods show the other colours except white.
ii. Seed colour: the colour of seeds in the pods can likewise be utilized as a sign. Young, immature seed is usually white in colour and changes to pink and dull pink as the seed matures.
iii. Leaves: the leaves develop a yellow colour and are dry at the tips.
iv. Prevailing weather conditions: these can impact the assurance of the harvest date since they influence quality. Drought decides the harvest date when the soil is desiccated to such a degree that the plant withers and the seeds in the pods begin to shrivel and take on a ripe appearance. Such groundnuts must be harvested immediately.

Groundnut can be harvested either by hand pulling the whole plant (this is conceivable when there is sufficient dampness in the soil) or using a hoe or ox-drawn plow (usually used for spreading groundnut varieties on heavy soils and during dry conditions). This strategy is powerful in lifting the whole plant from soils, with low pod disease. The harvested plants ought to be shaken well to get rid of soil from the pods and kept upset with the pods facing upward for 2-3 days. This permits quicker drying of the pods and avert parasitic development (Saxena *et al*., 2014).

2.12.4 Drying and storage of groundnut

After the harvested groundnut plants are stacked in the field for couple of days for air and sun drying before stripping the pods, the pods are constantly dried till the moisture content is below 10 percent. This kept away from the advancement of aflatoxin brought about by yellow mold (*Aspergillus flavus*) and furthermore protects seeds practically. In smallholder farming, the harvested plants are as a rule taken home for drying. After cleaning and grading, the dry pods are stored in bags stacked up to 10bags high in separated stacks to allow free air flow or ventilation. The sacks should be piled on wooden planks, not directly on the floor to avoid damage from damp. Dusting the sacks before storing the pods help in protect the pods from numerous storage pests (Ajeigbe *et al*., 2014).

2.13 Cytology of Groundnut

Cultivated groundnut (*Arachis hypogaea*; AABB; 2n=4x=40) is known to be an allotetraploid in the *Arachis*segments (Laining *et al.*, 2016).This segment contains 31 species, including diploids (2n=2x=20), tetraploids (2n=4x=40) and aneuploids (2n=2x=18) (Pandey *et al*., 2012; Laining *et al.*, 2016). Cytogenetic proof shows that three types of genome exist in this area: the A genome, B genome and D genome. The A genome is

recognised by the presence of a small pair of chromosomes (chromosome) (Nielen *et al*., 2012) and the appearance of a heterochromatic band close to the centromeres after 4', 6-diamidino-2-phenylindole (DAPI) staining (Lavia *et al.,* 2009). Paradoxically, the previously mentioned highlights are missing in the B and D genomes (Seijo *et al*., 2004). The D genome bears an uneven karyotype with a few submetacentric and subtelocentric chromosomes as contrasted with the A and B genomes (Robledo and Seijo, 2008).

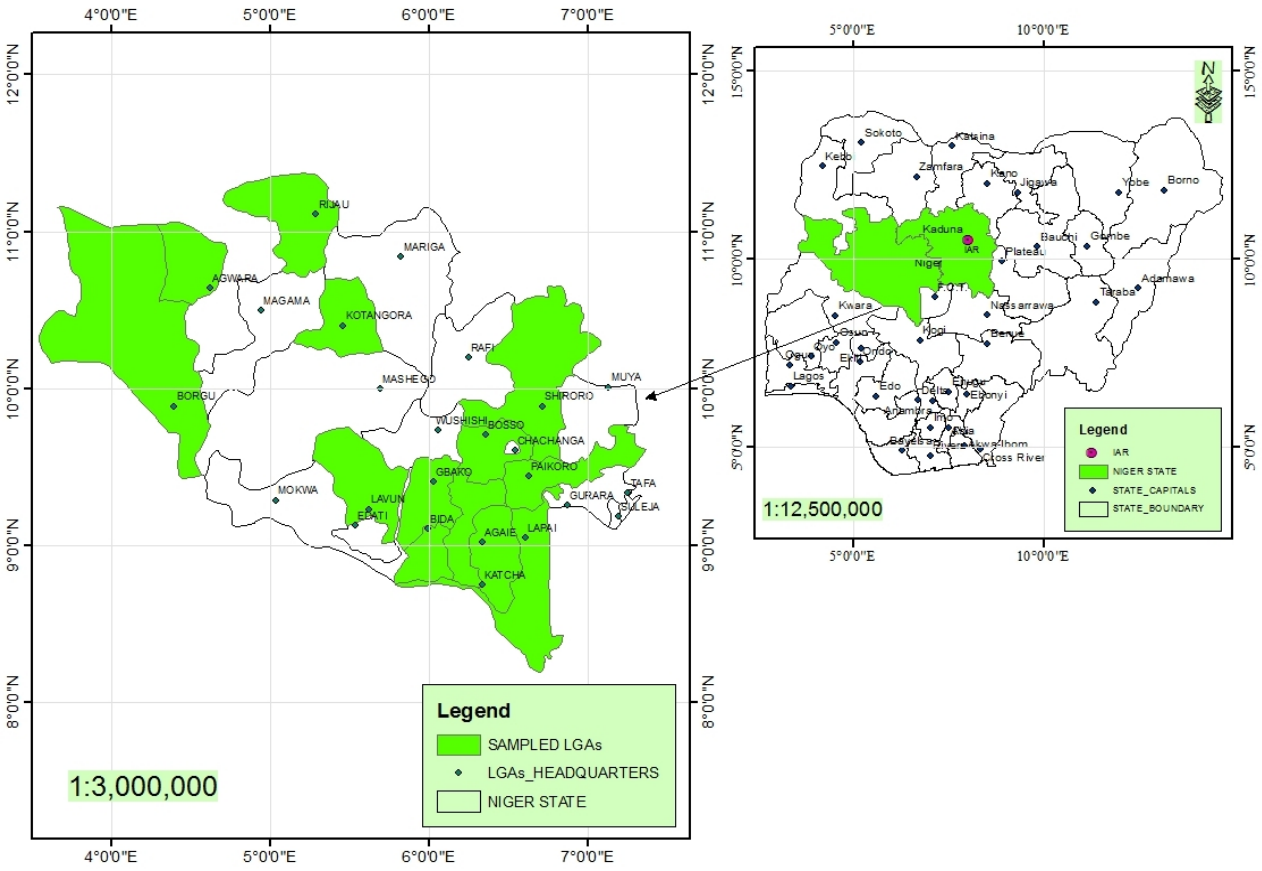
Cytogenetic and molecular information opined that the A and B genomes added to cultivated groundnut (Laining *et al.*, 2016). Physical mapping with 5S and 45S rDNA genes, genomic *in situ* hybridization (GISH) and molecular evolution studies of chloroplast DNA and 5S rDNA gave independent confirmation that *Arachis duranensis* (AA) and *Arachis ipaensis* (BB) were the parental genome donors of *A*. *hypogaea*. Hybridization of these two diploid species followed by a impulsive chromosome doubling was proposed as the device for the formation of cultivated groundnut (Grabiele *et al*., 2012).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Collection of Groundnut Seed Germplasm

A germplasm collection exploration was undertaken in collaboration with Niger state Agricultural Development Project (ADP) extension officer in attempt to collect the known groundnut genotypes from the farmers. Germplasm collection mission were undertaken to the three agricultural zones of Niger state. These zones represent the major groundnut producing areas of the state. The exploration covered 8 towns and 21 villages in 13 Local Government Areas of Niger state. The Local governments visited include, Gbako, Lapai, Bida, Lavun, Paikoro, Agaie, Shiroro, Bosso, Kontagora, Katcha, Borgu, Rijau and Agwara Local Government (Figure 3.1). Fourty-five farmers were interviewed using a validated questionnaire through an interpreter in some cases where language was a barrier and samples of groundnut accessions under husbandry were collected. A total of thirty-seven (37) accessions of groundnut were collected from the farmers and six (6) improved varieties were collected from Niger state Agricultural Development project (ADP). The study involved visits to farming villages and towns in the local government of the state. Expeditions were undertaken between July and August 2018, which corresponds to the period when the farmers were harvesting the crop. This was done in order to have a based gene pool to draw from. The seeds collected were packed and sealed in envelopes, each of them was given an entry number, information regarding the locality and local name were recorded. Some of the phenotypic characters observed were pod constriction, pod reticulation, pod beak, number of seed per pod, seed colour, primary seed colour, pod length, pod width, seed length and seed width.



Figures 3.1: Local Governments where the groundnut accessions were collected

3.2 Sorting and Characterisation of Groundnut Germplasm

Fourty three accessions of groundnut were collected and sorted based on the number of seed per pod, pod constriction, pod reticulation, pod length, pod width, seed length, and seed width in order to sort the accessions collected into distinct groups (genotypes). A number of characters were used according to the descriptor list of groundnut (IBPGR/ICRISAT, 1992). These characters include leaflet shape, leaflet colour, leaflet tip, leaflet surface, growth habit, and branching pattern. The data of the phenotypic characters mentioned were collected at maturity.

3.3 Experimental Site

Field experiments were carried out at the experimental garden of Department of Plant Biology, Federal University of Technology Minna, Niger state, Nigeria. Geographically, Minna is located in North-central geographical zone of Nigeria. Found within latitude 9^{o} 37'N and longitude 6^{o}33'E, covering a land area of 88 km^{2} with an estimated human population of 1.2 million. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20 ^{0}C, 61.00 % and 1334.00 mm, respectively. The climate presents two distinct seasons; a rainy season between May and October, and a dry season between November and April. The vegetation in the area is typically grass dominated Savannah with scattered trees.

3.4 Experimental Design

The accessions were grown in a Randomized Complete Block Design (RCBD) with three replicates. Groundnut accessions were grown on a ridge with intra spacing of 7cm and inter row spacing of 75 mm (IBPGR/ICRISAT, 1992). Threes (3) seeds were sown per hole and were later thinned to two at 2 weeks after seedling emergence.

3.5 Morphological Parameters

Morphological parameters were collected using the standard procedures and techniques of descriptors in the groundnut manual of IBPGR / ICRISAT (1992). Morphological parameters that were taken include,

i. Plant Height: Plant height was measured above the ground level to the terminal bud on the main axis using a meter rule. The data was collected at 2 weeks after planting and subsequently at 2 weeks interval.

ii. Number of Leaves: Number of leaves was counted at 2 weeks interval after planting by physical counting of leaves one after the other.

iii. Number of Branches: The numbers of branches were counted at 2 weeks interval after planting by physical counting of branches.

iv. Leaflet Length (mm): it was measured on the third leaf, apical leaflet, of the main stem when fully expanded; mean of 5 leaflets from different plants were recorded using meter rule.

v. Leaflet Width (mm): It measured on the third leaf, fully expanded apical leaflet, of the main stem, at its widest point, mean of 5 leaflets from different plants were recorded using meter rule

vi. Days to 50% flowering: It was determined visually by counting the number of days when 50% of the plants from the experimental units had at least one or two open flowers.

vii. Pod Length (mm): It was measured using thread and ruler and the mean of 10 matured pods were recorded.

viii. Pod width: It was measured using thread and meter ruler at the widest point and the mean of 10 mature pods were recorded.

ix. Seed Length (mm): It was measured with thread and ruler, the mean of 10 seeds were recorded.

x. Seed Width (mm): It was measured with thread and ruler, the thread was used at the midpoint and the avarage of 10 mature seeds were recorded.

xi. Seed Weight (g): weight of 100 random, mature and wrinkle-free seeds were taken using electric weighing balance.

xii. Number of pods per plant: Number of filled pods per plant was determined by counting the number of filled pods.

xiii. Shelling percentage (%): Shelling percentage was determined by dividing kernel weight by pod weight and multiplying it by 100.

$$\text{Shelling percentage} = \frac{\text{kernel weight (kg)}}{\text{Pod weight (kg)}} \times 100$$

3.6. Pollen Parameters

3.6.1 Pollen production

Pollen production study was carried out using modified method of Abubakar *et al*. (2015). Ten flower buds were selected from each accession and used in the study. The flowers were divided into two groups, each group contained anthers from 5 flowers in a small glass vial. One (1) ml distilled water was added into the vials and the anthers were thoroughly crushed with a glass rod into suspensions. A drop of each suspension was placed on a two-counting area of haemacytometric slide (0.1 mm in depth) and the slide was covered using a glass cover slip. Randomly placed pollens on the slide were viewed and counted from five large square areas of the haemacytometer counting area. Each treatment counted was replicated 5 times.

The average pollen grains per flower (P/F) and per anther (P/A) was determined using the formula below:

$$P/F = \frac{\text{Average pollen count x Volume of Fluids } (mm^3) \text{x dilution factor}}{\text{Number (10) of flower}}$$

Where Dilution factor = 0.10

$$P/A = \frac{\text{Pollen per flower}}{\text{Number of anther per flower}}$$

3.6.2 Pollen fertility test

Four (4) randomly selected plants from each genotype were used for pollen fertility study. Freshly opened flower buds were randomly collected early morning at 8.00 am. Matured anthers of the flowers were collected and squashed on a microscope slide. A drop of two percent (2 %) acetocarmine stain was added and covered with a glass cover slip and viewed with microscope. Poorly stained and shrunken matured pollen grains were counted and recorded as sterile pollens while deeply stained pollens were counted and recorded as fertile pollens (Daudu *et al*., 2017). For each of the genotypes, five slides were prepared and viewed from the micrographic fields. Percentage pollen fertility (PPF) was calculated using the method of Daudu *et al*. (2017), below:

$$PPF\ (\%) = \frac{\text{Number of Fertile pollen grains}}{\text{Total number of Pollen grains}} \times 100$$

3.6.3. Pollen germinability test

Sucrose solutions of different concentrations such as 0, 10 and 20 % were added to 1 % basic agar and used as medium for germinability test. The medium was dropped in petri dishes and pollens were sprinkled onto the medium gently and petri dishes were closed to prevent water loss of pollens. The Petri dishes were incubated at 30^0C for 24 hours. After

germination, pollens in the petri dishes were refrigerated until counted. Two petri dishes were used per sucrose concentration for each accession. Pollens were counted in each petri dish, they were considered as germinated if the pollen tube length was at least equal to or greater than the grain diameter (Abejide *et al*., 2014).

Percentage germinability was calculated using the method of Abejide *et al*. (2014), below

$$\text{Percentage Germinability} = \frac{\text{Number of germinated pollen grains}}{\text{Total number of the pollen grain}} \times 100$$

3.7. Fatty Acid Composition

A total of ten (10) accessions were selected based on the agromorphological clustering of the accessions at a genetic distance of 45 for fatty acid composition test.

3.7. 1 Determination of percentage oil content

A sample of 5 g grounded groundnut seed were weighed into the thimble which was covered with cotton wool and weight of an empty flat bottom flask was taken. Purified hexane of 2/3 was added into the flask and was fixed in the succillate apparatus on the heating mantle of 120 ^{O}C. Sample was allowed to boil for an hour while the extraction continued. After an hour, hexane was recollected by removing the thimble using distillation process. Afterward, the residue was dried in an adjusted oven to about 120 ^{O}C for 2-3 hours and kept in a descicator to cool. The flask was weighed and values were recorded (AOAC, 2005).

3.7.2 Determination of free fatty acid

A sample of groundnut oil of 1-2g was weighed in a beaker with the addition of 50mL of neutralised methylated spirit and 2-3 drops of phenolphthalein indicator which were later titrated with 0.1 normal sodium hydroxide solutions (NaoH to 0.1N) and titre values were obtained (AOAC, 2005).

$$\text{Percentage Free Fatty Acid (\% FFA)} = \frac{T \times N \times 28.2}{\text{Weight of Sample}}$$

28.20 = conversion factor of oleic acid
T= Titre value;
N = Concentration

3.7.3 Determination of fatty acid composition

The fatty acid methyl esters (FAME) were prepared using a reagent mixture of 10 mol methanol and 2.5 mol concentrated hydrochloric acid (37%). A sample of 2g of oil were placed in a small (50 mol) two-neck round-bottom flask equipped with a standard taper joint (19/38) and short condenser. Methanol of 7.5 mole was added to 1.5 mol of the previous reagent followed by 1.5 mol of toluene. The mixture was then heated at 65 °C for 1.5 hour. The heated mixture was transferred to a separatory funnel. Hexane of 15 ml and 10 mL distilled water were added to the mixture. The mixture was allowed until two distinct layers were observed. The upper layer was decanted and dried using anhydrous sodium sulphate Na_2SO_4 overnight. Afterwards 1 µL of the FAME was then injected into a gas chromatograph and values were recorded (AOAC, 2005).

3.8 Data Analysis

Data collected on morphological parameters, yield parameters, pollen parameters and fatty acid composition were subjected to analysis of variance (ANOVA) to determine the significance differences and Duncan Multiple Range Test (DMRT) was used to separate the means. All parameters were considered significant at $P \leq 0.05$. The results were presented in tables and data collected were run using the SPSS (version 20) computer program. The quantitative and qualitative data were pooled and unweighted pair group method with arithmetic averages (UPGMA) was used to construct a dendrogram to determine the relationship among the accessions

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Germplasm collection

The highest number of groundnut accessions was collected from Lapai Local government (4 accessions) followed by Gbako, Bida, Lavun, Paikoro, Agaie,Shiroro, Bosso, Kontagora and Katcha Local Government where 3 accessions were collected each. Mean while, 2 accessions each were collected from Borgu, Rijau and Agwara Local Government (Table 4.1). It was observed that some of these accessions showed some similarities in their phenotypic appearance. Genetic variations in pods and seed colours are shown in Plate I.

4.1.2 Pod and seed morphology

Distinct genetic variation was observed in the morphology of the fruit of the accessions in term of number of seed per pod, pod constriction, pod reticulation, pod beak and the size of the pods and seeds (Plate I). It was observed that 48.84 % of the accessions collected had deep pod constriction and 46.51 % had moderated pod constriction, 4.65 % had slight constriction. About 51.22 % had prominent pod reticulation, 44.19 % had moderate pod reticulation and only 4.65 % had slight pod constriction. It was also observed that 52.14 % had prominent pod beak, 2.33 % are very prominent, 32.56 % are moderate and 6.98 % had slight pod beak (Table 4.1). In addition, 88.37% had one colour and 11.63 % were variegated. The primary seed colours present include: pale tan (yellow-orange) [81.40 %], off white (yellow-white) [11.63 %] and dark red (6.98 %) [Table 4.1].

For the pod size, three pod length sizes were identified; small (20-25 mm), medium (26-30 mm) and big (31-40 mm). A total of 41.86 % are small, 41.86 % are medium, and 16.28 % were big in size (Table 4.1). Two pod width sizes were also identified; medium (9-15 mm) and big (16-20 mm), 81.40 % are medium while 18.60 % were big size. The seeds varied in their sizes both in length and in width (Table 4.1). Two groups of seed sizes were identified in length; small (10-15 mm) and big (16-20 mm). A total of 86.05 % are small in length while 13.95 % were big in length. Two groups of sizes were also noticed in seed width, small (25-30 mm) and big (31-40 mm); 18.60 % are big while 81.40 % are small in sizes (Table 4.1).

Table 4.1a: Sources and Description of Groundnut Germplasm in Niger State

S/NO	ACCESSION	LNA	PLC	LGA	NSP	POC	POR
1	NG-AGA-001	Kusha bologi	Kupafu	Agaie	1	7	7
2	NG-AGA-002	Yekiregi	Esa	Agaie	1	5	7
3	NG-AGA-003	Etwagutagi	Kusokpogi	Agaie	1	7	5
4	NG-BOS-004	Barna	Danzaria	Bosso	2	7	7
5	NG-BOS-005	Wata uku	Gwada	Bosso	1	7	7
6	NG-BOS-006	Wata uku	Bosso	Bosso	1	7	5
7	NG-BOR-007	Etwagutagi	Borgu	Borgu	1	7	5
8	NG-BOR-008	Kampala	Borgu	Borgu	1	5	5
9	NG-AGW-009	wata uku	Agwara	Agwara	1	7	7
10	NG-AGW-010	Kampala	Agwara	Agwara	1	5	5
11	NG-BDA-011	Gusha bologi	Bida	Bida	1	7	5
12	NG-BDA-012	Kusha guba	Gutata	Bida	1	7	7
13	NG-BDA-013	Kusha eyeko	Bida	Bida	1	5	5
14	NG-GBA-014	Patigici	Mamafu	Gbako	1	7	7
15	NG-GBA-015	Makwaci	Mamafu	Gbako	1	5	7
16	NG-GBA-016	Kusha eyeko	Kolonatsu	Gbako	1	5	5
17	NG-KAT-017	Kusha bologi	Katcha	Katcha	1	7	7
18	NG-KAT-018	Yekiregi	Idi	Katcha	1	5	7
19	NG-KAT-019	Kusha eyeko	Kakagbangi	Katcha	1	5	5
20	NG-KON-020	Kampala	Kontangora	Kontangora	1	5	5
21	NG-KON-021	Wata uku	Maraba	Kontangora	1	7	7
22	NG-KON-022	Etwagutagi	Kudu	Kontangora	1	7	7
23	NG-LAV-023	Kusha bologi	Danko Masalaci	Lavun	1	7	7
24	NG-LAV-024	Wawagi	Mafu	Lavun	1	7	7
25	NG-LAV-025	Gushako	Doko	Lavun	1	5	7
26	NG-LAP-026	Kwaso	Duma	Lapai	1	5	5
27	NG-LAP-027	Wata uku	Gana-Amadi	Lapai	1	7	7
28	NG-LAP-028	Kadala	Kawo	Lapai	2	7	7
29	NG-LAP-029	Yekiregi	Kosoti	Lapai	1	7	7
30	NG-PAK-030	Kampala	Paiko	Paikoro	1	5	5
31	NG-PAK-031	Yekiregi	Takunpara	Paikoro	1	5	7
32	NG-PAK-032	Wata uku	Makaje	Paikoro	1	7	7
33	NG-RIJ-033	Kampala	Rijau	Rijau	1	5	5
34	NG-RIJ-034	Wata uku	Rijau	Rijau	1	7	7
35	NG-SHI-035	Kwaso	Koboa	Shiroro	1	5	5
36	NG-SHI-036	Wata uku	Kuta	Shiroro	4	7	5
37	NG-SHI-037	Twagutagi	Kuta	Shiroro	1	7	7
38	SAMNUT21	Samnut 21	NSADP	NSADP	1	5	3
39	SAMNUT22	Samnut 22	NSADP	NSADP	1	5	5
40	SAMNUT23	Samnut 23	NSADP	NSADP	1	5	3
41	SAMNUT24	Samnut 24	NSADP	NSADP	1	5	5
42	SAMNUT25	Samnut 25	NSADP	NSADP	1	3	5
43	SAMNUT26	Samnut 26	NSADP	NSADP	1	3	5

LNA=Local name of the accession PLC=Place of collection LGA= Local Government NSDA= Niger State Agricultural Development Project.

Table 4.1b: Sources and Description of Groundnut Germplasm in Niger State

S/N	ACCESSION	NSP	POC	POR	POB	SEC	PSC	POL	POW	SEL	SEW
1	NG-AGA-001	1	7	7	7	1	5	22.10	9.40	10.20	26.20
2	NG-AGA-002	1	5	7	5	1	5	25.80	11.60	12.80	27.10
3	NG-AGA-003	1	7	5	7	1	5	22.10	9.40	10.20	26.20
4	NG-BOS-004	2	7	7	7	1	5	39.60	11.60	10.20	26.20
5	NG-BOS-005	1	7	7	5	1	5	22.00	9.40	14.70	26.20
6	NG-BOS-006	1	7	5	7	1	5	22.00	9.40	10.20	26.20
7	NG-BOR-007	1	7	5	7	1	5	22.00	9.40	10.20	26.40
8	NG-BOR-008	1	5	5	5	2	1	26.00	17.10	14.30	33.80
9	NG-AGW-009	1	7	7	7	1	5	25.00	11.60	10.20	26.20
10	NG-AGW-010	1	5	5	7	2	1	26.00	17.10	14.30	33.80
11	NG-BDA-011	1	7	5	7	1	5	22.10	9.40	10.20	26.20
12	NG-BDA-012	1	7	7	7	1	5	22.10	9.40	10.20	26.20
13	NG-BDA-013	1	5	5	3	1	5	31.80	20.00	17.20	33.80
14	NG-GBA-014	1	7	7	7	1	5	22.10	9.40	10.20	26.20
15	NG-GBA-015	1	5	7	7	1	5	25.80	11.80	12.80	27.10
16	NG-GBA-016	1	5	5	3	1	5	31.80	20.00	17.20	33.80
17	NG-KAT-017	1	7	7	7	1	5	22.10	9.40	10.20	26.20
18	NG-KAT-018	1	5	7	5	1	5	25.90	11.60	12.80	27.10
19	NG-KAT-019	1	5	5	3	1	5	31.80	20.00	17.20	33.80
20	NG-KON-020	1	5	5	7	2	1	26.00	17.10	14.30	33.80
21	NG-KON-021	1	7	7	7	1	5	22.10	9.40	10.20	26.20
22	NG-KON-022	1	7	7	7	1	5	22.10	9.40	10.20	26.20
23	NG-LAV-023	1	7	7	7	1	5	22.10	9.40	10.20	26.20
24	NG-LAV-024	1	7	7	7	1	5	22.10	9.40	10.20	26.20
25	NG-LAV-025	1	5	7	5	1	5	25.80	11.60	12.80	27.10
26	NG-LAP-026	1	5	5	5	1	14	29.90	13.50	14.20	28.10
27	NG-LAP-027	1	7	7	7	1	5	22.10	9.40	10.30	26.20
28	NG-LAP-028	2	7	7	5	1	5	39.60	11.90	15.30	27.20
29	NG-LAP-029	1	7	7	5	1	5	25.90	11.60	12.80	27.20
30	NG-PAK-030	1	5	5	7	2	1	26.00	17.10	14.30	33.80
31	NG-PAK-031	1	5	7	5	1	5	25.90	11.60	12.80	27.20
32	NG-PAK-032	1	7	7	7	1	5	22.10	9.40	10.20	26.20
33	NG-RIJ-033	1	5	5	7	2	1	26.00	17.10	14.30	33.80
34	NG-RIJ-034	1	7	7	7	1	5	22.10	9.40	10.20	26.20
35	NG-SHI-035	1	5	5	5	1	14	29.90	13.50	15.30	27.20
36	NG-SHI-036	4	7	5	9	1	5	40.00	9.40	10.20	26.20
37	NG-SHI-037	1	7	7	7	1	5	22.21	9.40	13.90	26.20
38	SAMNUT21	1	5	3	7	1	5	29.90	12.00	11.90	26.20
39	SAMNUT22	1	5	5	7	1	5	25.60	9.40	10.10	26.20
40	SAMNUT23	1	5	3	5	1	14	26.00	12.10	11.30	26.20
41	SAMNUT24	1	5	5	5	1	5	22.10	9.40	10.20	26.20
42	SAMNUT25	1	3	5	5	1	5	29.10	120	11.60	26.20
43	SAMNUT26	1	3	5	5	1	5	23.50	9.40	10.01	26.04

NSP=number of seed per pod; POC=pod constriction; POR=pod reticulation;POB=pod beak
SEC=seed colour ; SEW=seed width (mm); SEL=seed length (mm); POL=pod length (mm)
PSC=primary seed colour; POW=pod width (mm); PSC 1=white; 5=pale tan; 14= Dark red
SEC 1=one colour; 2= variegated
(NSP 1=1-2; 4=2-3-4) POR &POB 3=slight; 5=moderate; 7=prominent; 9=very prominent
POC 3=slight; 5= moderate; 7=deep 9= very deep

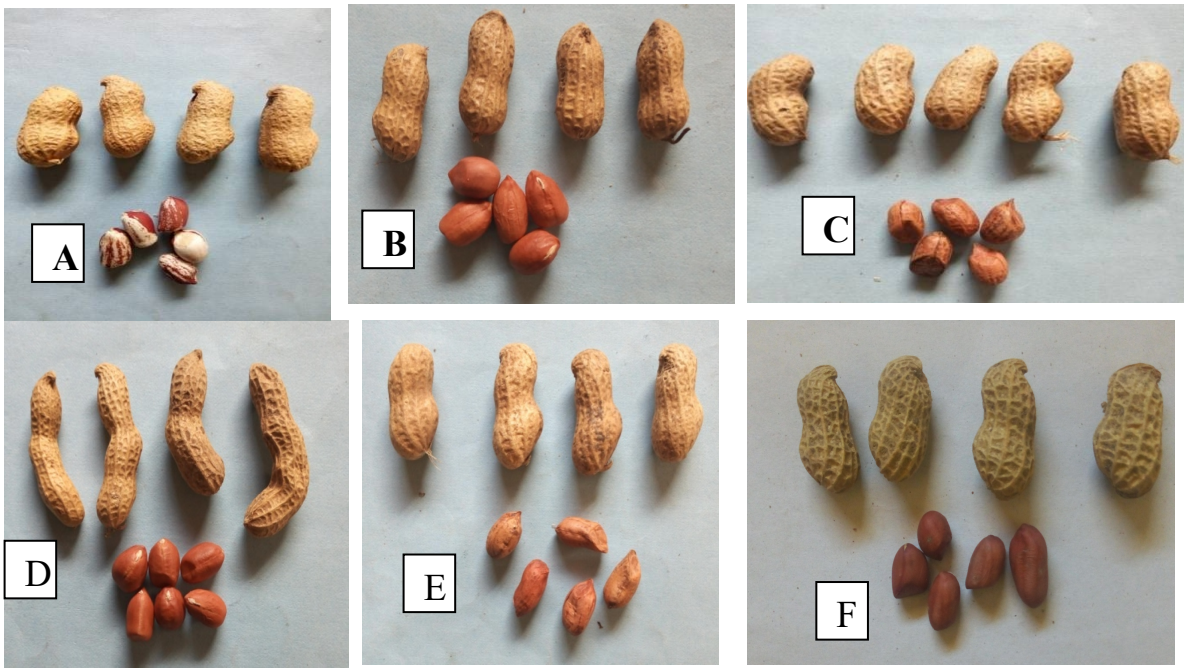


Plate I: Variation in Fruit size, colour, constriction, beak and reticulation

A: Accession with variegated seed colour and prominent pod beak
B: Accession with Moderate, beak and reticulation
C: Accession with pale tan and slight pod constriction, beak, and reticulation
D: Accession with seed greater than 2, very prominent pod beak, prominent pod constriction and reticulation
E: Accession with Moderate pod constriction.
F: Accession with dark red colour

4.1.3 Phenotypic traits of groundnut plant

Genetic variations were observed in the phenotypic character of the crop (Table 4.2). Two growth habits were observed in the accessions i.e. Erect and procumbent, 48.65 % of the accessions been erect and 51.35 % of the accessions procumbent in growth habit. It was also observed that all the accessions are almost glabrous on both sides of the surface in their leaflet. However, two major leaflet shapes was observed; 86.49 % are oblong-elliptic and 13.51 % are obovate. It was discovered that 94.59 % of the accessions had acute leaflet tip and 5.41 % had mucronate leaflet tip. It observed that all the accessions had entire leaflet margins (Table 4.2). Three leaflet colours were observed in the accessions; light green, dark green and green (Plate II). A total of 62.16 % were light green, 12.43 % dark green and 5.41 % are green in colour (Table 4.2). The two major branching patterns observed were alternative (51.35 %) and sequential (48.64 %) (Table 4.2).

For the size of the leaflet length, two sizes were identified small (30-50 mm) and large (51-70 mm) with about 97.29 % of accessions small and 2.70 % were in large size. Three leaflet width sizes were also identified small (20-25 mm), medium (26-30 mm) and big (31-40 mm). About 46 % of the accessions were small leaflet width size, 51.35 % medium and 2.70 % big size (Table 4.2).

Table 4.2 Phenotypic Traits of Groundnut Plant

S/N	ACCESSION	GH	LSU	LS	LT	LM	LC	BP	LL	LW
1	NG-AGA-001	2	1	4	2	1	2	1	49.50	27.20
2	NG-AGA-002	1	1	4	2	1	3	2	40.30	20.70
3	NG-AGA-003	2	1	4	2	1	2	1	49.90	30. 00
4	NG-BOS-004	1	1	4	2	1	2	2	40.40	20.90
5	NG-BOS-005	2	1	4	2	1	2	1	49.50	30.10
6	NG-BOS-006	2	1	4	2	1	2	1	49.60	27.20
7	NG-BOR-007	2	1	4	2	1	3	1	49.50	27.20
8	NG-BOR-008	1	1	10	2	1	3	2	40.20	20.30
9	NG-AGW-009	2	1	4	2	1	2	1	49.90	27.73
10	NG-AGW-010	1	1	10	2	1	3	2	40.20	20.30
11	NG-BDA-011	2	1	4	2	1	2	1	49.50	30. 00
12	NG-BDA-012	2	1	4	2	1	2	1	50.20	30.10
13	NG-BDA-013	1	1	4	2	1	3	2	40.30	20.40
14	NG-GBA-014	2	1	4	2	1	2	1	49.50	27.40
15	NG-GBA-015	1	1	4	2	1	3	2	40.32	20.70
16	NG-GBA-016	1	1	4	2	1	2	2	40.30	20.40
17	NG-KAT-017	2	1	4	2	1	2	1	49.70	27.40
18	NG-KAT-018	1	1	4	2	1	3	2	40.32	20.70
19	NG-KAT-019	1	1	4	2	1	2	2	40.30	20.40
20	NG-KON-020	1	1	10	2	1	3	2	40.20	20.30
21	NG-KON-021	2	1	4	2	1	2	1	49.50	27.20
22	NG-KON-022	2	1	4	2	1	2	1	49.50	31. 00
23	NG-LAV-023	2	1	4	2	1	2	1	49.50	27.20
24	NG-LAV-024	2	1	4	2	1	2	1	40.94	27.11
25	NG-LAV-025	1	1	4	2	1	4	2	40.32	20.70
26	NG-LAP-026	1	1	4	3	1	2	2	44.40	28.90
27	NG-LAP-027	2	1	4	2	1	3	1	49.60	27.30
28	NG-LAP-028	1	1	4	3	1	4	2	45. 00	20.90
29	NG-LAP-029	1	1	4	2	1	3	2	40.32	20.70
30	NG-PAK-030	1	1	10	2	1	3	2	40.20	20.30
31	NG-PAK-031	1	1	4	2	1	2	2	40.32	20.70
32	NG-PAK-032	2	1	4	2	1	2	1	50. 00	30. 00
33	NG-RIJ-033	1	1	10	2	1	3	2	40.20	20.30
34	NG-RIJ-034	2	1	4	2	1	2	1	49.80	30. 00
35	NG-SHI-035	1	1	4	2	1	2	2	40. 00	25. 00
36	NG-SHI-036	2	1	4	2	1	2	1	49.60	30. 00
37	NG-SHI-037	2	1	4	2	1	2	1	67. 00	29.20
38	SAMNUT21	1	1	4	3	1	4	1	49. 00	29.10
39	SAMNUT22	1	1	4	2	1	2	1	60. 00	30. 00
40	SAMNUT23	1	1	4	2	1	4	1	39. 00	10.90
41	SAMNUT24	2	1	4	2	1	3	1	50.40	30. 00
42	SAMNUT25	2	1	4	2	1	2	1	60.70	30.60
43	SAMNUT26	2	1	4	2	1	2	1	50. 00	30.40

GH= GROWTH HABIT
LS= LEAFLET SHAPE
BP= BRANCHING PATTER
LT= LEAFLET TIP
LC =LEAFLET COLOUR
LL= LEAFLET LENGTH (mm)
LW= LEAFLET WIDTH (mm)
LSU= LEAFLET SURFACE
LM= LEAFLET MARGIN

LC
2= Light green
3=Dark green
4= Green

LT
2= Acute
3= Mucronate

BP
1= Alternative
2= Sequential

GH
1=Erect
2=Procumbent

LS
4= Oblong-elliptic
10= Obovate

LM
1=Entire

LSU
1= Almost glabrous on both side of the surface

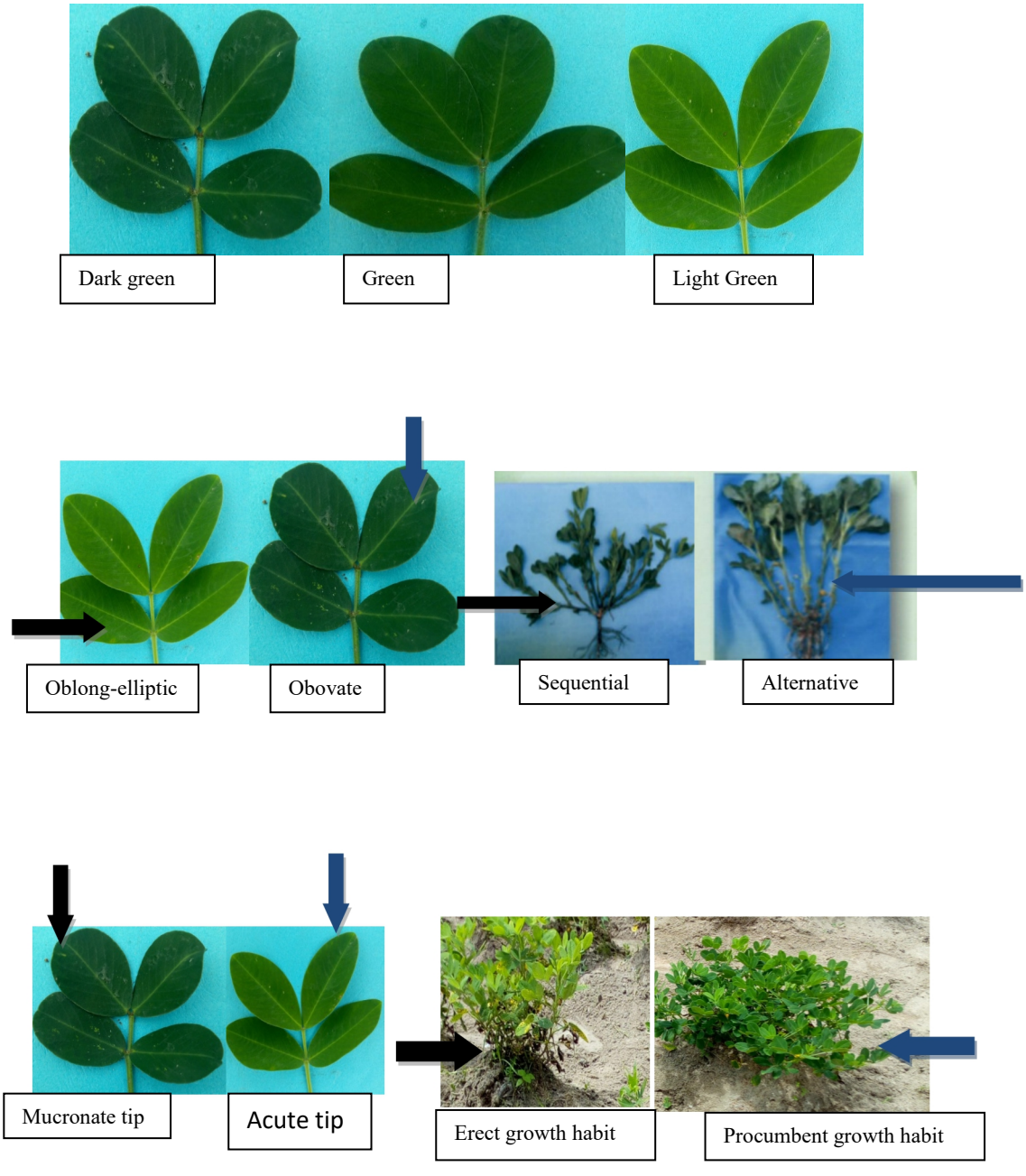


Plate II: Variation in phenotypic traits of plant.
Source: Field Photograph

4.1.3. Genetic variation in plant height of groundnut

Genetic Variation in plant height was observed among all the accessions for the period of data collection (Table 4.3). At week 2, the highest plant height (10.10 cm) was recorded for NG-AGW-09 which was not significantly different (P>0.05) from NG-SHI-037 (10.07cm) but significantly different (P<0.05) from all other accessions. The shortest plant height (4.20 cm) was recorded for NG-KON-020 and was not significantly different (P>0.05) from NG-KAT-018, NG-LAV-025, NG-LAP-028, and NG-RIJ-033 (4.23, 4.23, 4.37 and 4.37 cm respectively) but significantly different (P<0.05) from all other accessions. However, at week 4, the shortest plant height (6.70 cm) was recorded for NG-RIJ-033 and the value is not significantly different (P>0.05) from NG-KAT-18 (7.07 cm) but these values are significantly different (P<0.05) from all other accessions. The highest plant height (15.33 cm) was recorded for NG-BDA-012 and the value was not significantly different (P>0.05) with SAMNUT22 (15.03 cm); the highest plant height for SAMNUT22 continued to week 6, but the shortest plant height was recorded for NG-LAV-025 and NG-KAT-019 (9.33 cm and 9.47 cm respectively), these values were significantly different (P<0.05) from other accessions. At week 8, the shortest plant height (12.22 cm) was recorded for NG-KAT-019, this value was not significantly different (P>0.05) from NG-LAV-025 (13.00 cm) but significantly different (P<0.05) from all the other accessions. The highest plant height (35.33 cm) was recorded for NG-SHI-036, the value was not significantly different (P>0.05) from SAMNUT25, SAMNUT22, SAMNUT26, and SAMNUT24 (30.73, 31.77, 32.20 and 33.10 cm respectively) but significantly different (P<0.05) from all the other accessions (Table 4.3).

TABLE 4.3: Weekly variation in Plant height of groundnut accessions from Niger

S/N	ACCESSIONS	Week Two	Week Four	Week Six	Week Eight
1	NG-AGA-001	6.93±0.22^{efgh}	9.23±0.07^{bcde}	10.87±0.19^{abc}	20.60±0.71^{defg}
2	NG-AGA-002	9.10±0.06^{ij}	11.10±0.06^{defg}	12.63±0.41^{bcd}	21.03±0.55^{efgh}
3	NG-AGA-003	4.43±0.12^{ab}	8.17±0.03^{ab}	13.37±0.20^{bcde}	20.43±0.72^{cdefg}
4	NG-BOS-004	9.13±0.58^{ij}	11.17±1.47^{defg}	14.00±1.26^{cdef}	17.77±0.34^{abcde}
5	NG-BOS-005	11.30±0.15^{k}	13.00±0.25^{ghi}	15.23±1.27^{befg}	15.30±0.06^{abcd}
6	NG-BOS-006	7.53±0.48^{h}	10.57±0.47^{cdef}	14.73±1.21^{def}	15.27±1.47^{abc}
7	NG-BOR-007	7.00±0.29^{igh}	9.20±0.62^{bcde}	11.00±0.76^{abc}	20.80±1.96^{defgh}
8	NG-BOR-008	6.43±0.34^{defg}	9.07±0.64^{bcd}	13.00±0.29^{bcde}	15.80±1.32^{abcd}
9	NG-AGW-009	10.10±0.55^{j}	13.07±0.55^{ghi}	15.93±0.78^{efg}	20.33±0.34^{cdefg}
10	NG-AGW-010	6.43±0.38^{defg}	10.03±0.03^{bcde}	12.60±0.23^{abcd}	14.40±0.35^{ab}
11	NG-BDA-011	7.43±0.34^{gh}	9.03±0.03^{bcd}	11.00±0.29^{abc}	18.53±0.90^{abcde}
12	NG-BDA-012	8.53±0.47^{i}	15.33±1.67^{j}	19.80±1.35hig	20.37±1.58^{cdefg}
13	NG-BDA-013	7.67±0. 44^{gh}	10.33±0.17^{cde}	12.40±0.80^{abcd}	18.27±0.28^{bcde}
14	NG-GBA-014	7.17±0.60^{fgh}	10.53±0.03^{cdef}	14.87±0.19^{def}	25.77±1.33^{h}
15	NG-GBA-015	9.20±0.35^{ij}	11.17±0.03^{defg}	13.50±0.29^{cde}	17.17±0.66^{abcde}
16	NG-GBA-016	7.20±0.15^{gh}	11.13±0.07^{defg}	12.70±0.65^{bcd}	17.23±1.25^{abcde}
17	NG-KAT-017	7.17±0.17^{fgh}	11.53±0.03^{efg}	16.33±0.44^{efg}	24.73±0.32^{gh}
18	NG-KAT-018	4.23±0.15^{a}	7.07±0.23^{a}	10.20±0.70^{ab}	15.83±1.64^{abcd}
19	NG-KAT-019	4.73±0.50^{ab}	10.27±1.78^{cde}	9.47±2.27^{a}	12.22±3.61^{a}
20	NG-KON-020	4.20±0.15^{a}	7.40±0.15^{ab}	11.33±0.17^{abcd}	17.57±0.03^{abcde}
21	NG-KON-021	5.47±0.37^{bcd}	9.10±0.06^{bcd}	13.20±0.47^{bcde}	19.07±0.23^{bcdef}
22	NG-KON-022	5.90±0.15^{cde}	11.10±0.06^{defg}	17.33±0.44^{fgh}	24.27±0.12^{gh}
23	NG-LAV-023	4.43±0.12^{ab}	8.17±0.03^{ab}	13.33±0.17^{bcde}	24.40±0.25^{gh}
24	NG-LAV-024	5.57±0.09^{bcde}	11.17±0.03^{efg}	16.33±0.17^{rfg}	24.40±0.25^{gh}
25	NG-LAV-025	4.23±0.15^{a}	8.13±0.03^{ab}	9.33±0.170^{a}	13.00±0.06^{a}
26	NG-LAP-026	7.10±0.26^{fgh}	13.93±0.73^{hij}	16.83±0.49^{fg}	21.27±0.62^{afgh}
27	NG-LAP-027	5.10±0.40^{abc}	7.53±0.03^{ab}	11.43±0.18^{abcd}	15.27±1.12^{abc}
28	NG-LAP-028	4.37±0.19^{a}	9.10±0.06^{bcd}	12.40±0.65^{abcd}	19.40±0.21^{bcdefg}
29	NG-LAP-029	4.50±0.23^{ab}	10.40±0.49^{cdef}	13.87±0.73^{cdef}	24.07±3.58^{fgh}
30	NG-PAK-030	4.93±0.44^{abc}	10.43±0.33^{cdef}	12.20±0.70^{abcd}	14.47±0.32^{ab}
31	NG-PAK-031	4.67±0.12^{ab}	9.13±0.03^{bcde}	14.00±1.80^{cdef}	15.50±2.78^{abcd}
32	NG-PAK-032	6.00±0.06^{cde}	10.50±0.26^{cdef}	14.20±0.15^{cdef}	21.20±0.15^{efgh}
33	NG-RIJ-033	4.37±0.19^{a}	6.70±0.50^{a}	10.20±0.35^{ab}	17.20±1.82^{abcde}
34	NG-RIJ-034	6.73±0.32^{efgh}	10.07±0.98^{bcde}	13.50±1.50^{cde}	21.43±0.34^{efgh}
35	NG-SHI-035	6.10±0.50^{cdefg}	14.13±0.03^{hij}	15.90±0.21^{efg}	18.83±0.32^{bcde}
36	NG-SHI-036	5.30±0.15^{bcd}	11.33±0.13^{efg}	18.33±0.60^{ghi}	35.33±0.22^{i}
37	NG-SHI-037	10.07±0.29^{j}	13.60±0.95^{hij}	22.23±0.70^{j}	24.50±0.29^{gh}
38	SAMNUT21	6.57±0.30^{efgh}	12.40±0.40^{fgh}	14.43±0.07^{cdef}	18.17±0.44^{bcde}
39	SAMNUT22	6.73±0.13^{efgh}	15.03±0.03^{j}	21.53±0.48^{j}	31.77±0.28^{i}
40	SAMNUT23	6.13±0.03^{defg}	8.30±0.15^{abc}	12.03±0.87^{abcd}	16.02±0.76^{abcde}
41	SAMNUT24	5.93±0.44^{bcdef}	11.17±1.47^{efg}	18.57±3.44^{ghi}	33.10±1.95^{i}
42	SAMNUT25	6.70±0.47^{efgh}	13.10±0.06^{ghi}	20.43±0.38^{ij}	30.73±4.83^{i}
43	SAMNUT26	6.23±0.19^{defg}	14.73±0.32^{ij}	19.87±1.39^{hij}	32.20±2.91^{i}

Values are means ± standard error of mean. Values followed by the same superscript(s) within the same column do not statistically differ at the 5% level tested by DMRT.

4.1.3.2 Genetic variation in number of leaves of groundnut

The results observed for the number of leaves per plant in all the accessions showed some variations within the weeks (Table 4.4). At week 2, the least number of leaves (4.40) observed was recorded for NG-BDA-013. This value was significantly different ($P<0.05$) from other accessions. The highest number of leaves (52.00) per plant was recorded for NG-BOR-008 and this value was not significantly different ($P>0.05$) from NG-SHI-036 and NG-BOS-004 (52.00 and 52.00 respectively) but significantly different ($P<0.05$) from all other accessions. At week 4, the highest number of leaves (96.00) observed was recorded for NG-GBA-014. This value was significantly different ($P<0.05$) from all other accessions. The lowest number of leaves (56.00) was recorded for NG-BOS-004. This value was also significantly different ($P<0.05$) from all other accessions. However, at week 6, the lowest number of leaves (82.67) observed was recorded for NG-SHI-037. This value was significantly different ($P<0.05$) from all other accessions. The highest number of leaves (201.33) observed was recorded for NG-LAP-029. The value was significantly different ($P<0.05$) from all other accessions. At week 8, the accession with the lowest number of leaves per plant was recorded for NG-KAT-019 (113.33). This value was significantly different ($P<0.05$) from all the other accessions. The highest number of leaves (340.00) per plant was recorded for NG-PAK-030. This value was significantly different ($P<0.05$) from the other accessions (Table 4.4).

Table 4.4: Weekly Variation in Number of Leaves of Groundnut Accessions

S/N	ACCESSIONS	Week Two	Week Four	Week Six	Week Eight
1	NG-AGA-001	46.67±1.33^{cd}	68.00±0.00^{abcd}	130.67±16.71^{abcdef}	185.33±8.74^{bc}
2	NG-AGA-002	50.67±1.33^{cd}	68.00±0.00^{abcd}	148.00±6.11^{abcdef}	265.33±7.42^{defg}
3	NG-AGA-003	46.67±1.33^{cd}	66.67±1.33^{abcd}	116.00±8.33^{abc}	184.00±8.33^{bc}
4	NG-BOS-004	52.00±2.31^{d}	56.00±2.31^{a}	169.33±16.38^{bcdef}	285.33±16.38^{defgh}
5	NG-BOS-005	42.67±3.53^{bcd}	54.67±5.81^{ab}	94.67±22.64^{b}	174.67±22.64^{bc}
6	NG-BOS-006	45.33±4.81^{cd}	60.00±2.31^{abc}	155.33±13.48^{bcdef}	253.33±11.62^{defg}
7	NG-BOR-007	42.67±4.81^{bcd}	61.33±8.74^{ab}	96.67±23.73^{b}	164.00±24.33^{ab}
8	NG-BOR-008	52.00±10.58^{d}	84.00±12.17^{de}	186.00±29.14^{cdef}	300.67±29.36^{efgh}
9	NG-AGW-009	42.67±3.53^{bcd}	66.67±1.33^{abcd}	120.67±24.01^{abcd}	154.00±25.17^{ab}
10	NG-AGW-010	44.00±2.31^{bcd}	66.67±1.33^{abcd}	137.33±3.53^{abcdef}	297.33±3.53^{ab}
11	NG-BDA-011	46.67±1.33^{cd}	66.67±1.33^{abcd}	109.33±15.38^{ab}	142.67±17.94^{ab}
12	NG-BDA-012	46.67±3.53^{cd}	64.67±3.33^{abcd}	104.00±4.00^{ab}	201.33±4.81^{bc}
13	NG-BDA-013	4.40±0.40^{a}	76.00±10.07^{cd}	124.00±6.11^{abcde}	238.67±5.81^{cdef}
14	NG-GBA-014	44.00±2.31^{bcd}	96.00±0.00^{e}	122.67±2.67^{abcd}	236.00±2.31^{cd}
15	NG-GBA-015	45.33±4.81^{cd}	66.67±16.22^{abcd}	155.33±33.39^{bcdef}	260.67±19.88^{defg}
16	NG-GBA-016	46.67±3.53^{cd}	68.00±0.00^{abcd}	158.67±42.60^{abcdef}	205.33±32.69^{defg}
17	NG-KAT-017	44.00±2.31^{bcd}	62.67±1.33^{abcd}	151.33±7.51^{abcdef}	233.33±7.51^{bcd}
18	NG-KAT-018	45.33±4.81^{cd}	65.33±1.33^{abcd}	145.33±17.33^{abcdef}	264.00±16.17^{defg}
19	NG-KAT-019	45.33±8.74^{cd}	66.67±1.33^{abcd}	102.67±32.69^{ab}	113.33±41.40^{a}
20	NG-KON-020	44.00±2.31^{bcd}	69.33±1.33^{abcd}	116.00±2.31^{abc}	236.00±2.31^{cde}
21	NG-KON-021	44.00±2.31^{bcd}	66.67±1.33^{abcd}	158.67±7.42^{bcdef}	224.00±6.11^{bcd}
22	NG-KON-022	46.67±1.33^{cd}	72.00±0.00^{bcd}	181.33±1.33^{cdef}	252.00±2.31^{def}
23	NG-LAV-023	45.33±4.81^{cd}	68.00±0.00^{abcd}	142.00±31.90^{abcdef}	228.67±28.50^{bcd}
24	NG-LAV-024	45.33±4.81^{cd}	66.67±1.33^{abcd}	162.67±23.25^{bcdef}	233.33±22.19^{cd}
25	NG-LAV-025	40.00±4.00^{bcd}	65.33±1.33^{abcd}	196.00±6.11^{ef}	317.33±1.33^{gh}
26	NG-LAP-026	40.00±4.00^{bcd}	68.00±4.00^{abcd}	131.33±6.57^{abcdef}	303.33±0.67^{fgh}
27	NG-LAP-027	38.67±2.67^{bc}	66.67±1.33^{abcd}	102.67±11.39^{ab}	180.00±9.24^{bc}
28	NG-LAP-028	42.67±3.53^{bcd}	68.00±0.00^{abcd}	145.33±20.70^{abcdef}	262.67±21.46^{defg}
29	NG-LAP-029	42.67±3.53^{bcd}	66.67±1.33^{abcd}	201.33±1.33^{f}	238.67±1.33^{cdef}
30	NG-PAK-030	42.67±1.33^{bcd}	65.33±1.33^{abcd}	194.67±59.34^{ef}	340.00±40.07^{h}
31	NG-PAK-031	40.00±4.00^{bcd}	65.33±1.33^{abcd}	190.00±40.15^{def}	302.00±40.15^{fgh}
32	NG-PAK-032	38.67±1.33^{bc}	66.67±1.33^{abcd}	109.33±7.42^{ab}	224.00±6.11^{bcd}
33	NG-RIJ-033	32.00±4.62^{b}	80.67±15.33^{de}	123.33±28.48^{abcde}	227.33±35.14^{bcd}
34	NG-RIJ—034	46.67±1.33^{cd}	66.67±1.33^{abcd}	136.67±18.12^{abcdef}	251.33±17.94^{def}
35	NG-SHI-035	42.6±71.33^{bcd}	57.33±1.33^{abc}	150.67±17.33^{abcdef}	268.00±18.04^{defg}
36	NG-SHI-036	52.00±6.11^{d}	65.33±1.33^{abcd}	193.33±1.33^{def}	285.33±5.81^{defg}
37	NG-SHI-037	46.67±1.33^{cd}	66.67±1.33^{abcd}	82.67±8.74^{a}	184.67±1.33^{bc}
38	SAMNUT21	44.00±4.00^{bcd}	66.67±0.67^{abcd}	134.67±4.81^{abcdef}	238.00±4.16^{cdef}
39	SAMNUT22	46.00±2.00^{cd}	65.33±1.33^{abcd}	140.00±10.07^{abcdef}	222.00±10.07^{bcd}
40	SAMNUT23	38.67±1.33^{bc}	66.00±2.00^{abcd}	181.33±9.61^{cdef}	258.67±27.55^{defg}
41	SAMNUT24	41.33±1.33^{bcd}	62.67±3.53^{abcd}	114.00±14.47^{abc}	180.67±13.28^{bc}
42	SAMNUT25	37.33±1.33^{bc}	58.67±18.67^{abc}	94.67±4.81^{b}	178.67±4.81^{bc}
43	SAMNUT26	42.67±3.53^{bcd}	65.33±1.33^{abcd}	125.33±20.83^{abcde}	261.33±17.64^{defg}

Values are means ± standard error of mean. Values followed by the same superscript(s) within the same column do not statistically differ at the 5% level tested by DMRT

4.1.3.3 Genetic variation in number of branches of groundnut

The result obtained for the number of branches per plant in all the accessions showed genetic variations within the weeks (Table 4.5). At week 2, there is no significant difference ($P>0.05$) in all the accessions. At week 4, the least number of branches (4.00) was recorded for SAMNUT25 this value was significantly different ($P<0.05$) from all the other accessions. The highest number of branches was recorded for NG-AGA-003, NG-KAT-018 and NG-PAK-031 (5.33, 5.33 and 5.33) respectively. However, at week 6, the highest number of branches (11.00) was recorded for NG-PAK-030. This value was statistically different ($P<0.05$) from all the other accessions. The least number of branches (5.00) was recorded for NG-BDA-011 though the value was not significantly different ($P>0.05$) from NG-LAP-027 (5.00) but significantly different ($P<0.05$) from all other accessions. At week 8, the accession with the lowest number of branches (5.00) per plant was recorded for NG-BDA-011 and this value was not significantly different ($P>0.05$) from NG-LAP-027, NG-AGA-001, NG-AGA-003, NG-BOS-005 and NG-PAK-032 (5.00, 5.33, 5.33, 5.33 and 5.33) respectively; these values were significantly different ($P<0.05$) from all the other accessions. The highest number of branches per plant observed was recorded for NG-LAP-028 (16.00); this value was significantly different ($P<0.05$) from the other accessions (Table 4.5).

Table4.5: Weekly Variation in Number of Branches of Groundnut Accessions

S/N	ACCESSIONS	Week Two	Week Four	Week Six	Week Eight
1	NG-AGA-001	3.67±0.33^{a}	5.00±0.00^{bc}	5.33±0.33^{ab}	5.33±0.33^{a}
2	NG-AGA-002	4.00±0.00^{a}	5.00±0.00^{bc}	8.33±0.33^{abcde}	9.67±0.33cd
3	NG-AGA-003	3.67±0.33^{a}	5.33±0.33^{c}	5.33±0.33^{ab}	5.33±0.33^{a}
4	NG-BOS-004	3.67±0.33^{a}	5.00±0.00^{bc}	9.33±1.45^{cde}	11.00±1.00^{def}
5	NG-BOS-005	3.67±0.33^{a}	5.00±0.00^{bc}	5.33±0.33^{ab}	5.33±0.33a
6	NG-BOS-006	3.67±0.33^{a}	4.67±0.33^{abc}	7.00±0.58^{abcd}	7.33±0.33^{abc}
7	NG-BOR-007	3.67±0.67^{a}	4.33±0.67^{ab}	5.00±1.15^{a}	6.00±0.58^{ab}
8	NG-BOR-008	4.00±0.58^{a}	4.67±0.33^{abc}	10.33±1.67^{de}	13.33±1.67^{fg}
9	NG-AGW-009	3.67±0.33^{a}	5.00±0.00^{bc}	6.00±0.58^{abc}	6.67±1.20^{ab}
10	NG-AGW-010	3.67±0.33^{a}	5.00±0.00^{bc}	9.33±0.33^{cde}	12.00±1.00^{def}
11	NG-BDA-011	4.00±0.00^{a}	5.00±0.00^{bc}	5.00±0.00^{a}	5.00±0.00^{a}
12	NG-BDA-012	4.00±0.00^{a}	5.00±0.00^{bc}	6.33±0.67^{abc}	6.33±0.67^{ab}
13	NG-BDA-013	3.67±0.33^{a}	5.00±0.00^{bc}	7.67±0.33^{abcde}	9.67±0.33^{cd}
14	NG-GBA-014	3.33±0.33^{a}	5.00±0.00^{bc}	7.00±0.00^{abcd}	7.00±0.00^{abc}
15	NG-GBA-015	3.67±0.33^{a}	4.67±0.88^{abc}	7.33±0.67^{abcd}	13.00±2.00^{ef}
16	NG-GBA-016	3.67±0.33^{a}	5.00±0.00^{bc}	8.33±1.86^{abcde}	9.67±0.33^{cd}
17	NG-KAT-017	3.33±0.33^{a}	5.00±0.00^{bc}	7.00±0.00^{abcd}	7.33±0.33^{abc}
18	NG-KAT-018	3.67±0.33^{a}	5.33±0.33^{c}	8.67±1.67^{abcde}	12.67±1.76^{ef}
19	NG-KAT-019	3.67±0.67^{a}	4.67±0.33^{abc}	6.33±1.86^{abc}	6.33±1.86^{ab}
20	NG-KON-020	3.33±0.33^{a}	5.00±0.00^{bc}	6.67±0.33^{abc}	8.33±0.33^{bc}
21	NG-KON-021	3.67±0.33^{a}	5.00±0.00^{bc}	6.33±0.33^{abc}	7.00±0.00^{abc}
22	NG-KON-022	3.67±0.33^{a}	4.67±0.33^{abc}	6.67±0.33^{abc}	7.00±0.00^{abc}
23	NG-LAV-023	3.67±0.33^{a}	5.00±0.00^{bc}	6.00±0.58^{abc}	6.00±0.58^{ab}
24	NG-LAV-024	3.33±0.33^{a}	5.00±0.00^{bc}	6.00±0.58^{abc}	6.00±0.58^{ab}
25	NG-LAV-025	3.00±0.00^{a}	5.00±0.00^{bc}	9.00±1.00^{cde}	10.67±0.33^{cde}
26	NG-LAP-026	3.33±0.33^{a}	5.00±0.00^{bc}	8.00±0.58^{abcde}	15.67±0.33^{gh}
27	NG-LAP-027	3.00±0.00^{a}	5.00±0.00^{bc}	5.00±0.00^{a}	5.00±0.00^{a}
28	NG-LAP-028	3.33±0.33^{a}	5.00±0.00^{bc}	6.67±0.33^{abc}	16.00±0.00^{h}
29	NG-LAP-029	3.33±0.33^{a}	5.00±0.00^{bc}	7.00±0.58^{abcd}	10.33±0.33^{cde}
30	NG-PAK-030	3.00±0.00^{a}	5.00±0.00^{bc}	11.00±4.16^{e}	13.33±0.33^{fg}
31	NG-PAK-031	3.33±0.33^{a}	5.33±0.33^{c}	8.00±0.58^{abcde}	11.00±0.58^{def}
32	NG-PAK-032	3.67±0.33^{a}	5.00±0.00^{bc}	5.33±0.33^{ab}	5.33±0.33^{a}
33	NG-RIJ-033	3.33±0.33^{a}	5.00±0.00^{ab}	8.67±1.33^{bcde}	11.00±1.00^{def}
34	NG-RIJ-034	3.00±0.00^{a}	5.00±0.00^{bc}	6.33±0.33^{abc}	6.67±0.33^{ab}
35	NG-SHI-035	3.67±0.33^{a}	5.00±0.00^{bc}	9.00±1.00^{cde}	9.00±1.00^{bc}
36	NG-SHI-036	3.33±0.33^{a}	5.00±0.00^{bc}	8.00±0.00^{abcde}	8.33±0.33^{bc}
37	NG-SHI-037	3.67±0.33^{a}	5.00±0.00^{bc}	5.33±0.33^{ab}	6.33±0.33^{ab}
38	SAMNUT21	3.33±0.33^{a}	5.00±0.00^{bc}	8.33±0.33^{abcde}	11.33±0.67^{def}
39	SAMNUT22	3.67±0.33^{a}	5.00±0.00^{bc}	5.00±0.00^{a}	5.67±0.33^{ab}
40	SAMNUT23	3.33±0.33^{a}	5.00±0.00^{bc}	8.33±1.20^{abcde}	9.00±1.53^{bc}
41	SAMNUT24	3.00±0.00^{a}	5.00±0.00^{bc}	7.00±1.00^{abcd}	7.00±1.00^{abc}
42	SAMNUT25	3.33±0.33^{a}	4.00±0.58^{a}	5.33±0.33^{ab}	5.67±0.33^{ab}
43	SAMNUT26	3.67±0.33^{a}	5.00±0.00^{bc}	5.33±0.33^{ab}	6.00±0.58^{ab}

Values are means ± standard error of mean. Values followed by the samesuperscript(s) within the same column do not statistically differ at the 5% level tested by DMRT.

4.1.4. Yield parameters of groundnut

4.1.4.1 Day to 50 % flowering

The result obtained for day to 50 % flowering is presented in (Table 4.6). The shortest day to 50% flowering (27.33 days) was recorded for NG-AGW-009 this value was not significantly different (P>0.05) from NG-AGA-001, NG-AGA-003, NG-BOS-005, NG-BOS-006, NG-BOR-007, NG-BDA-012, NG-KON-022, NG-LAP-027, NG-PAK-032, NG-RIJ-034, NG-SHI-037, SAMNUT26, NG-LAV-023 and SAMNUT22 with 28.00, 28.33, 28.33, 28.33, 28.33, 28.33, 28.33, 28.33, 28.33, 28.33, 28.33, 28.67, and 29.00 days respectively but significantly different (P<0.05) from all the other accessions; NG-BDA-013 has the highest number in days to 50 % flowering (42.67 days), this value was significantly different (P<0.05) from all the other accessions (Table 4.6).

4.1.4.2 Days to maturity

The statistical analysis revealed that the accessions varied significantly at P≤0.05 in days to maturity. The least number of days to maturity (87.33) was recorded for NG-AGW-009. However, this value was not significantly different (P>0.05) from accession NG-AGA-001, NG-BOS-006, NG-AGA-003, NG-BDA-012, NG-KON-022, NG-LAP-027, NG-PAK-032, NG-BOS-005, NG-BOR-007, NG-SHI-037, NG-RIJ-034, NG-LAV-023, NG-BDA-011, NG-GBA-014, NG-KAT-017, NG-LAV-024, NG-SHI-036, and NG-KON-021 with 88.00, 88.00, 88.33, 88.33, 88.67, 88.67, 88.67, 89.00, 89.00, 89.00, 89.33, 89.67, 90.00, 90.00, 90.00, 90.00, 90.00, 90.00 and 90.33 respectively but significantly different (P<0.05) from all other accessions. The highest day to maturity was recorded for NG-BDA-013 (115.67) and the value was not significantly different (P>0.05) from NG-RIJ-033 (115.33) but significantly different (P<0.05) from all other accessions (Table 4.6).

4.1.4.3 Weight of 100 seed

Weight of 100 seed showed some interesting genetic variation among the accessions. The least weight of 100 seed (20.87g) was recorded for NG-SHI-036; this value was significantly different ($P<0.05$) from all the other accessions. The highest weight of 100 seed (56.55g) was recorded for SAMNUT22 this value was not significantly different ($P>0.05$) from NG-LAP-026 (54.72g) but significantly different ($P<0.05$) from all the other accessions (Table 4.6).

4.1.4.4 Weight of 100 pods

Weights of 100 pods per accession showed some interesting genetic variation (Table 4.6). The smallest weight of 100 pods (39.35g) was recorded for NG-KON-002; this value was significantly different ($P<0.05$) from all the other accessions. The highest weight of 100 pods (132.70g) was recorded for SAMNUT22; this value was significantly different ($P<0.05$) from all the other accessions (Table 4.6).

4.1.4.5 Number of pods per plant

Number of pod per plant showed genetic variations among the accessions. The highest number of pods per plant (49.67) was recorded for NG-SHI-036, this value was significantly different ($P<0.05$) from all the other accessions. The least number of pods per plant (11.67) was recorded for NG-KAT-019 and was not significantly different ($P>0.05$) from NG-BOR-007 but significantly different ($P<0.05$) from all the other accessions (Table 4.6).

4.1.4.6 Shelling percentage

Shelling Percentage also showed a unique variation, the highest shelling percentage (58.06 %) was recorded for SAMNUT22; this value was significantly different ($P<0.05$) from all the other accessions. The least shelling percentage (30.44 %) was recorded for NG-SHI-036, this value significantly different from all the other accessions (Table 4.6).

Table 4.6: Yield Parameters of Groundnut Accessions

S/N	ACCESSION	DFF	DTM	WHS	SHE%	NPPP	HWP
1	NG-AGA-001	28.00±0.00^{a}	88.00±1.53^{a}	30.89±0.21^{d}	45.33±0.33^{d}	19.00±3.61^{ab}	71.62±1.23^{d}
2	NG-AGA-002	39.00±0.00^{cd}	111.67±0.88^{c}	32.03±0.45^{def}	45.67±0.33^{de}	32.67±3.71^{e}	72.3±1.52^{ef}
3	NG-AGA-003	28.33±.033^{a}	88.33±0.88^{a}	32.32±0.25^{d}	45.67±0.33^{de}	17.67±2.03^{ab}	74.73±0.47^{e}
4	NG-BOS-004	39.00±0.00^{cd}	111.67±0.88^{c}	32.74±0.30^{d}	45.67±0.33^{de}	34.33±9.39^{cde}	119.98±1.53^{k}
5	NG-BOS-005	28.33±0.33^{a}	89.00±0.58^{a}	43.20±0.27^{g}	47.50±0.25^{f}	17.00±3.51^{ab}	75.28±1.59^{e}
6	NG-BOS-006	28.33±0.33^{a}	88.00±1.53^{a}	23.96±0.16^{b}	32.37±0.09^{b}	27.67±1.86^{abcd}	53.37±0.66^{b}
7	NG-BOR-007	28.33±0.33^{a}	89.00±0.58^{a}	25.55±0.22^{b}	43.18±0.04^{c}	16.67±2.19^{a}	53.84±0.39^{b}
8	NG-BOR-008	40.00±0.00^{cd}	115.00±0.58^{de}	47.64±0.62^{h}	51.18±0.03^{g}	38.00±3.21^{cdefg}	93.25±0.47^{g}
9	NG-AGW-009	27.33±0.00^{a}	87.33±1.45^{a}	25.75±0.21^{b}	43.19±0.04^{c}	25.00±1.15^{abc}	57.72±0.16^{c}
10	NG-AGW-010	40.00±0.00^{cd}	115.00±0.58^{de}	43.74±0.10^{g}	47.49±0.31^{f}	37.67±2.73^{cde}	117.63±0.95^{j}
11	NG-BDA-011	31.33±0.3^{b}	90.00±0.58^{a}	25.88±0.19^{b}	43.19±0.04^{c}	24.67±5.55^{abc}	56.70±0.50^{b}
12	NG-BDA-012	28.33±0.33^{a}	88.33±0.176^{a}	25.14±0.29^{b}	43.19±0.04^{c}	19.00±2.31^{ab}	50.12±0.27^{b}
13	NG-BDA-013	42.67±0.38^{e}	115.67±0.33^{e}	52.85±0.39^{j}	56.42±0.29^{h}	25.00±2.08^{abc}	105.87±0.98^{g}
14	NG-GBA-014	31.00±0.00^{b}	90.00±0.58^{a}	24.74±0.40^{b}	43.19±0.04^{c}	23.67±2.33^{abc}	53.87±0.55^{b}
15	NG-GBA-015	40.33±.33^{d}	112.67±0.33^{cd}	28.27±0.32^{bc}	45.15±0.04^{d}	29.33±1.76^{abcd}	66.19±0.45^{c}
16	NG-GBA-016	39.00±00^{cd}	111.00±1.00^{c}	43.01±0.27^{g}	47.39±0.31^{f}	19.67±0.33^{ab}	92.9±41.16^{g}
17	NG-KAT-017	31.00±0.00^{b}	90.00±0.58^{a}	25.09±0.36^{b}	43.25±0.09^{c}	21.67±4.33^{abc}	51.30±0.43^{b}
18	NG-KAT-018	39.33±0.33^{cd}	112.00±0.58^{c}	29.86±0.38^{cd}	45.16±0.03^{d}	29.67±2.03^{bcde}	81.90±0.41^{f}
19	NG-KAT-019	40.00±0.00^{cd}	115.00±0.58^{de}	43.13±0.27^{g}	47.38±0.36^{f}	11.67±7.31^{a}	72.34±1.46^{e}
20	NG-KON-020	40.00±0.00^{cd}	115.00±0.58^{ed}	28.88±0.14^{c}	45.41±0.35^{d}	23.00±2.65^{abc}	118.89±0.37^{ijk}
21	NG-KON-021	31.00±0.00^{b}	90.33±0.33^{a}	26.55±0.22^{bc}	43.44±0.28^{c}	20.67±3.84^{ab}	39.35±0.39^{a}
22	NG-KON-022	28.33±0.33^{a}	88.67±0.88^{a}	28.84±0.34^{c}	45.15±0.04^{d}	27.00±5.69^{abcd}	63.93±0.58^{c}
23	NG-LAV-023	28.67±0.33^{a}	89.67±0.33^{a}	27.72±0.25^{bc}	45.22±0.10^{d}	21.67±3.84^{abc}	58.27±1.11^{c}
24	NG-LAV-024	31.67±0.33^{b}	90.00±0.00^{a}	28.81±10.25^{c}	45.03±0.03^{d}	22.33±2.33^{abc}	60.16±1.28^{c}
25	NG-LAV-025	39.33±0.33^{cd}	112.00±0.58^{c}	33.76±0.25^{d}	46.11±0.05^{e}	40.33±1.33^{defg}	72.88±0.17^{e}
26	NG-LAP-026	40.00±0.00^{cd}	115.00±0.58^{de}	54.72±0.22^{l}	56.51±0.37^{h}	39.00±2.52^{cdefg}	116.33±0.76^{j}
27	NG-LAP-027	28.33±0.33^{a}	88.67±0.88^{a}	23.78±0.23^{d}	32.30±0.06^{b}	17.33±1.45^{ab}	50.16±0.33^{b}
28	NG-LAP-028	39.67±0.33^{cd}	112.00±0.58^{c}	40.90±0.25^{f}	47.48±0.26^{f}	29.67±0.33^{bcde}	114.96±0.22^{j}
29	NG-LAP-029	39.00±0.00^{cd}	111.67±0.88^{c}	33.05±0.22^{d}	46.38±0.37^{e}	26.33±4.10^{abc}	74.97±0.60^{e}
30	NG-PAK-030	40.00±0.00^{cd}	115.00±0.58^{de}	37.16±0.28^{e}	47.48±0.26^{f}	26.33±5.90^{abc}	82.02±0.64^{f}
31	NG-PAK-031	39.00±0.00^{cd}	111.67±0.88^{c}	32.82±0.33^{d}	46.09±0.04^{e}	38.33±8.^{21cdefg}	73.94±0.69^{e}
32	NG-PAK-032	28.33±0.33^{a}	88.67±0.88^{a}	28.83±0.26^{c}	45.14±0.±0.13^{d}	20.33±1.33^{ab}	64.90±0.22^{c}
33	NG-RIJ-033	40.33±0.33^{d}	115.33±0.33^{e}	49.10±0.33^{i}	51.15±0.05^{g}	21.00±3.79^{ab}	114.76±0.74^{i}
34	NG-RIJ-034	28.33±0.33^{a}	89.33±0.33^{a}	32.00±0.59^{d}	46.08±0.07^{e}	27.00±4.36^{abcd}	64.96±0.39^{e}
35	NG-SHI-035	40.00±0.33^{cd}	115.00±0.58^{de}	41.70±0.64^{f}	47.09±0.02^{f}	33.00±3.21^{bcde}	106.83±0.63^{h}
36	NG-SHI-036	31.00±0.00^{b}	90.00±0.58^{a}	20.87±0.23^{a}	30.44±0.31^{a}	49.67±1.45^{g}	68.58±0.29^{d}
37	NG-SHI-037	28.33±0.33^{a}	89.00±1.00^{a}	26.51±0.25^{bc}	43.52±0.29^{c}	18.00±0.58^{ab}	58.16±0.16^{c}
38	SAMNUT21	39.00±0.00^{cd}	111.67±0.88^{c}	37.00±0.18^{e}	43.46±0.32^{c}	43.33±2.33^{efg}	79.86±0.66^{e}
39	SAMNUT22	29.00±0.58^{a}	94.00±0.58^{b}	56.55±0.20^{l}	58.06±0.03^{i}	41.67±2.03^{efg}	132.70±0.36^{k}
40	SAMNUT23	38.33±0.33^{c}	105.33±0.33^{b}	35.04±0.30^{e}	46.38±0.31^{e}	43.67±2.40^{efg}	88.95±0.16^{f}
41	SAMNUT24	38.33±0.33^{c}	110.33±0.33^{c}	39.56±2.25^{ef}	47.11±0.03^{f}	39.67±4.33^{defg}	67.61±0.48cd
42	SAMNUT25	38.67±0.33^{cd}	111.33±0.33^{c}	39.15±0.13^{f}	47.10±0.02^{f}	29.33±3.38^{abcde}	111.92±0.53^{h}
43	SAMNUT26	28.33±0.33^{a}	94.33±0.67^{b}	37.58±0.23^{e}	47.14.±0.01^{f}	45.67±2.40^{fg}	90.57±1.02^{g}

Values are means ± standard error of mean. Values followed by the same superscript(s) within the same column do not statistically differ at the 5% level tested by DMRT.

SHE%= Shelling Percentage (%) DTM= Days to Maturity

NPPP= Number of Pod per Plant WHS= Weight 0f 100 seed (g)

HWP=100 Weight of Pod (g)

4.1.5 Principal component analysis

Principal component analysis of quantitative and qualitative characters were grouped into 18 components, which accounted for the entire (100%) variability among the studied accessions (Table 4.7). The significant Eigen value (EV) were recorded for the first eighteen components with the value 2551.87, 694.52, 162.76, 79.08, 73.65, 35.77, 20.02, 9.98, 6.97, 6.47, 3.74, 2.77, 1.44, 0.70, 0.50, 0.38, 0.30 and 0.12 for PC 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18 respectively. The first two (2) principal components contributed 88.91 % of the variability. A total of 100 % variability was recorded at the eighteen (18) components among the evaluated groundnut accessions. The variability in PC1 (69.89 %) was mainly due to the contribution of number of leaves while 100 weight of pods contributed the major trait to PC2 (19.02 %). Pod width contributed significantly to the variability in PC7, PC8 and PC12 (Table 4.7). Leaflet length, shelling percentage, number of pod per plant, leaflet width, number of branches, leaflet shape, seed length, and seed color influenced the variability in PC3,PC4, PC5, PC6, PC11, PC13, PC14, and PC15 respectively (Table 4.7). PC9 and PC10 trait variability were influenced by pod length. Pod reticulation contributed majorly to the variability in PC16 and PC17. Seed width and pod constriction contributed majorly to100 % trait variability in PC18 (Table 4.7).

Table 4.7: Principal Component Analyses of Groundnut Accessions

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8
WHS	0.01	0.27	-0.05	0.46	0.37	0.09	0.23	0.17
SHE %	-0.04	-0.17	-0.02	0.60	0.40	0.20	0.07	-0.38
NPPP	0.11	0.08	0.44	-0.19	0.56	-0.6	0.04	0.07
HWP	0.12	0.92	-0.02	-0.07	-0.05	0.14	-0.06	-0.21
PH	-0.02	0.03	0.38	-0.25	0.23	0.43	0.07	0.1
NL	0.98	-0.13	0.01	0.06	-0.07	0.08	0.00	0.01
NB	0.04	0.03	-0.07	0.10	-0.01	-0.10	-0.03	0.20
GH	-0.02	-0.05	0.09	-0.06	0.00	0.18	-0.07	0.00
LS	0.01	0.03	-0.06	0.00	-0.08	0.07	0.22	-0.12
LSU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LT	0.00	0.00	0.00	0.01	0.01	-0.01	-0.03	0.04
LC	0.00	0.00	-0.01	0.00	0.00	-0.08	-0.03	-0.06
BP	0.00	0.00	-0.02	0.01	-0.01	-0.01	0.03	0.02
LL	-0.06	0.06	0.69	0.44	-0.54	-0.16	0.09	-0.02
LW	-0.02	-0.03	0.25	0.02	0.07	0.49	-0.12	0.51
NSPP	0.00	0.00	0.02	-0.04	0.00	-0.01	0.05	0.03
PB	0.00	-0.01	0.05	-0.06	-0.02	0.08	0.05	-0.18
PC	-0.01	-0.01	0.04	-0.02	0.01	0.04	-0.07	-0.07
PR	0.00	-0.01	0.03	-0.02	0.00	0.03	-0.07	-0.12
SC	0.00	0.02	0.02	0.02	0.05	0.01	0.05	-0.09
PSC	0.01	0.01	0.03	0.06	0.09	0.05	-0.28	0.16
PL	0.00	0.12	-0.21	0.32	-0.02	-0.2	-0.55	0.32
PW	0.00	0.07	-0.17	0.03	-0.04	-0.09	0.56	0.44
SL	0.00	0.04	-0.09	0.05	-0.07	-0.09	0.06	0.24
SW	0.00	0.04	-0.13	0.02	-0.10	-0.01	0.37	0.06
EV	2551.87	694.52	162.76	79.08	73.65	35.77	20.02	9.98
%VA	69.89	19.02	4.46	2.17	2.02	0.98	0.55	0.27
%CUV	69.89	88.91	93.37	95.54	97.55	98.53	99.08	99.36

LS= leaflet shape PC= pod constriction %VA= percentage variance EV= eigen value LT = leaflet tip PSC= primary seed colour GH= growth habit LSU= leaflet surface PR= pod reticulation %CUV = percentage cummulative variance PB= pod beak PL= pod length (mm) LC = leaflet colour NSPP= number of seed per pod WHS= weight of 100 seed LM= leaflet margin SC= seed colour SHE%= shelling percentage NPPP= number of pod per plant HWP=100 weight of pod LL= leaflet length (mm) BP= branching pattern PW = pod width (mm) PH= plant height SL= seed length (mm) NL= number of leaves SW=seed width(mm) LW= leaflet width (mm) NB= number of branches

Table 4.7: Continued

	PC 9	PC 10	PC 11	PC 12	PC 13	PC 14	PC 15	PC 16	PC 17	PC 18
WHS	-0.19	-0.37	-0.33	-0.41	0.19	-0.02	-0.01	-0.02	-0.08	-0.04
SHE %	0.13	0.22	0.23	0.31	-0.16	0.00	-0.06	0.09	0.00	0.05
NPPP	-0.10	0.16	0.07	0.09	0.09	0.09	-0.03	0.05	0.02	0.01
HWP	-0.02	0.1	0.12	0.17	-0.09	-0.04	-0.02	0.07	0.01	0.01
PH	0.66	-0.03	-0.07	-0.18	-0.07	0.10	-0.09	-0.16	-0.02	0.05
NL	0.02	0.00	-0.05	0.00	-0.01	0.01	0.01	-0.01	-0.01	0.00
NB	0.24	-0.06	0.66	-0.35	0.12	-0.42	0.01	0.16	0.10	-0.04
GH	0.03	0.02	-0.06	0.21	0.57	0.07	-0.09	0.43	-0.17	-0.27
LS	-0.02	0.18	0.25	-0.07	0.38	0.26	-0.14	-0.28	-0.05	-0.25
LSU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LT	0.00	0.01	0.09	-0.02	0.04	-0.11	0.02	-0.07	0.00	0.11
LC	0.03	0.08	0.09	-0.14	0.12	-0.10	0.14	-0.04	-0.03	-0.39
BP	0.01	-0.01	0.02	-0.03	-0.07	0.08	-0.14	0.04	0.28	-0.22
LL	0.05	-0.04	-0.03	0.02	0.00	-0.01	0.00	-0.03	0.01	0.00
LW	-0.47	0.33	0.14	0.04	-0.06	-0.03	0.08	0.07	0.10	-0.01
NSPP	-0.01	-0.06	0.09	-0.02	-0.05	-0.13	0.09	0.18	-0.01	0.30
PB	0.01	0.03	0.03	0.03	0.32	-0.10	0.18	-0.01	-0.35	0.13
PC	0.07	-0.05	-0.08	0.06	0.27	-0.16	0.37	0.16	-0.08	0.43
PR	0.14	-0.14	-0.19	0.00	0.01	0.03	0.09	0.54	0.54	-0.18
SC	0.03	0.12	0.03	-0.15	-0.11	0.23	0.84	-0.10	0.06	-0.23
PSC	0.00	-0.64	0.29	0.44	0.13	0.20	0.12	-0.29	0.13	-0.04
PL	0.34	0.36	-0.22	-0.01	0.18	0.14	0.00	-0.11	0.02	0.07
PW	0.25	0.08	-0.14	0.49	-0.02	-0.28	0.14	-0.02	-0.01	-0.15
SL	0.10	-0.12	0.21	-0.06	-0.3	0.52	0.00	0.45	-0.48	-0.01
SW	0.00	0.12	0.14	-0.07	0.27	0.43	-0.02	0.01	0.43	0.43
EV	6.97	6.47	3.74	2.77	1.44	0.70	0.50	0.38	0.30	0.12
%VA	0.19	0.18	0.10	0.08	0.04	0.02	0.01	0.01	0.01	0.00
%CUV	99.55	99.72	99.83	99.9	99.94	99.96	99.97	99.99	99.99	100

4.1.6 Cluster analysis

Groundnut accessions were assessed for qualitative and quantitative traits using cluster analysis. On the basis of their similarities, the accessions were clustered into four major groups, with cluster I containing 11 (25.58 %) of the genotypes which was subdivided in to Ia (1 genotype) and Ib (10 genotypes), 1 (2.33 %) in cluster II, 21 (48.84 %) in cluster III and this group was subdivided in to IIIa (16 genotypes) and IIIb (5 genotypes) and10 (23.26 %) in cluster IV which was also subdivided in to IVa (6 genotypes) and IVb (4 genotypes) . Accession NG-AGA-001 and NG-AGA-003 were strongly associated with one another and distinctly cluster in cluster Ib while the accession SAMNUT25 exists as an entity in Ia. In cluster II, accession NG-KAT-19 is entirely different from all other accessions, in Cluster IIIa NG-KON-022 and NG-RIJ-034 were strongly associated with one another and distinctly clustered. Furthermore, in cluster IIIa accessions NG-GBA-014 and NG-KAT-017 have a distinct cluster. In IIIb NG-BDA-013 and NG-RIJ-033 were also associated with one another. Similarly, in cluster IVa, NG-SHI-035 and NG-LAP-NUT-028 showed a close association and in cluster IVb accessions NG-LAV-025 and NG-PAK-031 were closely similar among the other accessions (Figure 4.1).

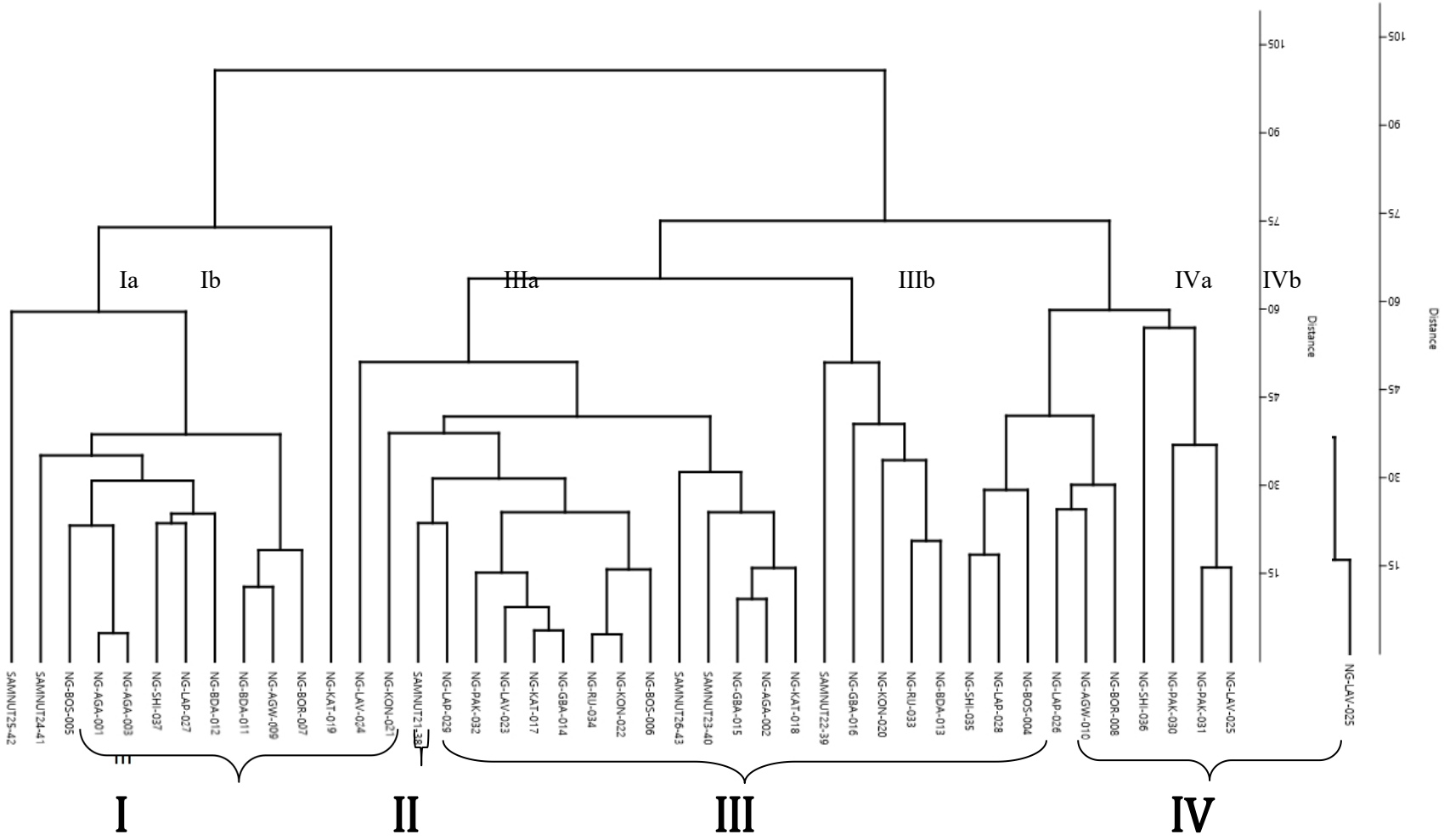


Figure 4.1: UPGMA Dendrogram of the Groundnut Accessions Based on Quantitative and Qualitative Parameters

4.1.7 Oil, free fatty acid and fatty acid composition among the selected genotypes of groundnut from Niger state.

Variations were observed in percentage oil, free fatty acid and fatty acid composition for the groundnut accessions (Table 4.8). Highest percentage oil was observed in accessions NG-LAV-024 (53.21%) which was not significantly different ($P>0.05$) from NG-SHI-036 (53.17%) and NG-GBA-014 (53.09 %) but significantly different ($P<0.05$) from all other accessions. NG-KAT-019 (46.02%) recorded the least percentage oil which was significantly different ($P<0.05$) from all other accessions. There was no significant difference ($P>0.05$) in free fatty acid and stearic acid in all the accessions. The least palmatic acid was recorded for SAMNUT26 (9.95 %) and the value was significantly different from all other accessions. Meanwhile, the highest palmatic acid was recorded for accession NG-SHI-036 (12.35 %). This value was significantly different ($P<0.05$) from all other accessions. The least oleic acid was recorded for NG-KAT-019 (41.98 %); this value was significantly different ($P<0.05$) from all other accessions. The highest percentage of oleic was recorded for NG-SHI-036 (63.03 %) which was not significantly different ($P>0.05$) from NG-BGA-014 (62.98 %), NG-LAV-024 (62.88 %) and NG-BOS-005 (62.58 %) but significantly different ($P<0.05$) from all other accessions. The least linoeic acid was recorded for NG-SHI-036 (17.63 %) which was not significantly different ($P>0.05$) from NG-GBA-014 (17.68%), NG-LAV-024 (17.78 %) and NG-BOS-005 (18.08 %) but significantly different ($P<0.05$) from the other accessions. The highest linoeic acid was recorded for NG-KAT-019 (38.68 %). This value was significantly different ($P<0.05$) from all other accessions (Table 4.8).

Table 4.8: Oil, Free Fatty Acid and Fatty Acid Composition among the selected Genotypes of Groundnut from Niger State

ACCESSION	% OIL	FFA %	PAA %	STA %	OLA %	LIA %
SAMNUT26	51.03±0.60^{de}	0.86±0.60^{a}	9.95±0.60^{a}	3.23±0.60^{a}	51.53±0.60^{c}	29.13±0.60^{b}
NG-KAT-019	46.03±0.60^{a}	1.29±0.60^{a}	10.87±0.60^{ab}	2.05±0.60^{a}	41.98±0.60^{a}	38.68±0.60^{d}
NG-GBA-014	53.09±0.60^{f}	1.02±0.0 ^{a}	11.53±0.60^{ab}	2.93±0.60^{a}	62.98±0.60^{d}	17.68±0.60 ^{a}
NG-GBA-015	49.55±0.60^{cd}	0.89±0.60^{a}	10.98±0.60^{ab}	2.98±0.60^{a}	43.58±0.60^{ab}	37.08±0.60^{cd}
NG-KON-020	48.24±0.60^{bc}	0.96±0.60^{a}	10.78±0.60^{ab}	2.58±0.60^{a}	43.08±0.60^{ab}	37.58±0.60^{cd}
NG-SHI-035	50.22±0.60^{d}	1.03±0.60^{a}	10.79±0.60^{ab}	2.95±0.60^{a}	43.57±0.60^{ab}	37.09±0.60^{cd}
NG-LAV-024	53.21±0.60 ^{f}	1.18±0.78^{a}	11.55±0.60^{ab}	2.97±0.60^{a}	62.88±0.60^{d}	17.78±0.60 ^{a}
NG-SHI-036	53.17±0.60 ^{f}	1.45±0.60^{a}	12.35±0.60^{b}	3.28±0.60^{a}	63.03±0.60^{d}	17.63±0.60 ^{a}
NG-LAV-025	47.06±0.60^{ab}	1.26±0.60^{a}	10.85±0.60^{ab}	2.08±0.60^{a}	44.28±0.60^{b}	36.38±0.60^{c}
NG-BOS-005	52.50±0.60^{ef}	1.96±0.17^{a}	11.73±0.58^{ab}	2.98±0.60^{a}	62.58±0.60^{d}	18.08±0.60 ^{a}

Values are means ± standard error of mean. Values followed by the same superscript(s) within the same column do not statistically differ at the 5% level tested by DMRT.

% groundnut Oil = Percentage oil

FFA= Free Fatty Acid

PAA = Palmatic Acid

STA = Stearic Acid

OLA = Oleic Acid

LIA = Linoeic Acid

4.1.8. Pollen parameters

4.1.8.1 Pollen production

The result of pollen production is presented in Table 4.9. Statistical analysis showed some variation in the number of pollens produced by the accessions studied. Accession NG-KAT-019 recorded the least number of pollen per flower (3500.00) which was not significantly different ($P>0.05$) from NG-BOS-05 (3751.67) but significantly different ($P<0.05$) from all the other accessions. Accession NG-KAT-019 recorded the least number of pollen per anther (226.67). This value was significantly different ($P<0.05$) from all the other accessions. SAMNUT26 recorded the highest number of pollen per flower (4803.33) and highest number of pollen per anther (573.33). This value was significantly different ($P<0.05$) from the other accessions.

4.1.8.2 Pollen fertility test

The result of percentage pollen fertility and sterility is presented in Table 4.9 and depicted in Plate III. The result showed that there was a clear variation among the genotypes in terms of pollen fertility and sterility. The genotype NG-SHI-036 had the highest pollen fertility (92.00%) and the least sterile pollens (8.00%). This value was significantly different ($P<0.05$) from all the other accessions. Genotype NG-KAT-019 (75.33 %), NG-GBA-015 (75.33 %) and NG-BOS-005 (75.33 %) had the least percentage in pollen fertility with percentage sterility of 24.67 % each. These values were not significantly different ($P>0.05$) from genotype NG-GBA-014 (76.00 %), NG-LAV-25 (76.67 %), NG-KON-020 (77.00 %) and NG-SHI-035 (77.67%) with 24.00 %, 23.33 %, 23.00 % and 22.33 % pollen sterility respectively (Table 4.9).

4.1.7.3 Pollen germinability

The result of pollen germinability is shown in Table 4.9 and depicted in Plate IV. The accessions showed unique variations in response to percentage pollen germinability to different sucrose concentration (0, 10, and 20 %). The 0 % sucrose concentration recorded 0 results in all the accessions. In 10 % sucrose concentration NG-BOS-005 recorded the least percentage germination (5.00 %). This value was significantly different ($P<0.05$) from all the other accessions. Accession NG-SHI-036 recorded the highest percentage germination (27.00 %). This value was significantly different ($P<0.05$) from all the other accessions.

In 20 % sucrose concentration, accession NG-SHI-036 had the highest germination percentage (75.33 %). This value was significantly different ($P<0.05$) from all the other accessions. Accession NG-KAT-019 recorded the least germination percentage (33.67 %) but was not significantly different ($P>0.05$) from NG-GBA-015 (36.67 %), NG-KON-020 (36.67 %), NG-GBA-014 (37.00 %), and NG-BOS-005 (37.00 %). These values were significantly different ($P<0.05$) from all the other accessions (Table 4.9).

Table 4.9: Pollen Parameters

ACCESSION	FRT	STR	PPF	PPA	GM 0%	GM 10%	GM 20%
SAMNUT26	87.33±1.45^{c}	12.67±1.45^{b}	4803.33±8.74^{c}	573.33±1.64^{c}	0.00±0.00^{a}	22.33±1.45^{cd}	62.33±1.45^{d}
NG-KAT-019	75.33±0.33^{a}	24.67±0.33^{d}	3500.00±2.68^{a}	226.67±3.33^{a}	0.00±0.00^{a}	10.33±0.33^{ab}	33.67±1.86^{a}
NG-BGA-014	76.00±0.58^{a}	24.00±0.58^{d}	4000.00±5.00^{ab}	430.00±1.49^{bc}	0.00±0.00^{a}	11.00±0.58^{c}	37.00±058^{a}
NG-GBA-015	75.33±0.33^{a}	24.67±0.33^{d}	4003.00±3.5^{ab}	443.33±2.63^{bc}	0.00±0.00^{a}	10.33±0.33^{ab}	36.67±0.88^{a}
NG-KON-020	77.00±0.58^{a}	23.00±0.58^{d}	4013±1.53^{ab}	426.67±1.53^{bc}	0.00±0.00^{a}	12.00±0.58^{c}	36.67±1.20^{a}
NG-SHI-035	77.67±1.20^{a}	22.33±1.20^{d}	4213.67±1.74^{abc}	450.00±2.87^{bc}	0.00±0.00^{a}	12.67±1.20^{c}	44.67±5.17^{b}
NG-LAV-024	76.67±0.67^{a}	23.33±0.67^{d}	4631.67±3.98^{bc}	416.67±1.67^{b}	0.00±0.00^{a}	10.33±0.33^{ab}	43.67±1.86^{b}
NG-SHI-036	92.00±3.46^{d}	8.00±3.46 ^{a}	4669.00±8.10^{bc}	433.33±6.67^{bc}	0.00±0.00^{a}	27.00±3.46^{d}	75.33±0.33^{e}
NG-LAV-025	82.00±1.53^{b}	18.00±1.53^{c}	4006.67±6.60^{ab}	360.00±3.12^{b}	0.00±0.00^{a}	18.33±3.28^{c}	53.67±1.86^{c}
NG-BOS-005	75.33±0.33^{a}	24.67±0.33^{d}	3751.67±7.18^{a}	376.67±3.93^{b}	0.00±0.00^{a}	5.00±1.73^{ab}	37.00±1.53^{a}

Values are means ± standard error of mean. Values followed by the same superscript(s) within the same column do not statistically differ at the 5% level tested by DMRT.

FRT= Fertile
STR= Sterile
PPF= pollen Production per Flower
PPA= Pollen Production Per anther
GM0= Germination Percentage with 0% Concentration
GM10% = Germination Percentage with 10% Concentration
GM20% = Germination Percentage with 20% Concentration

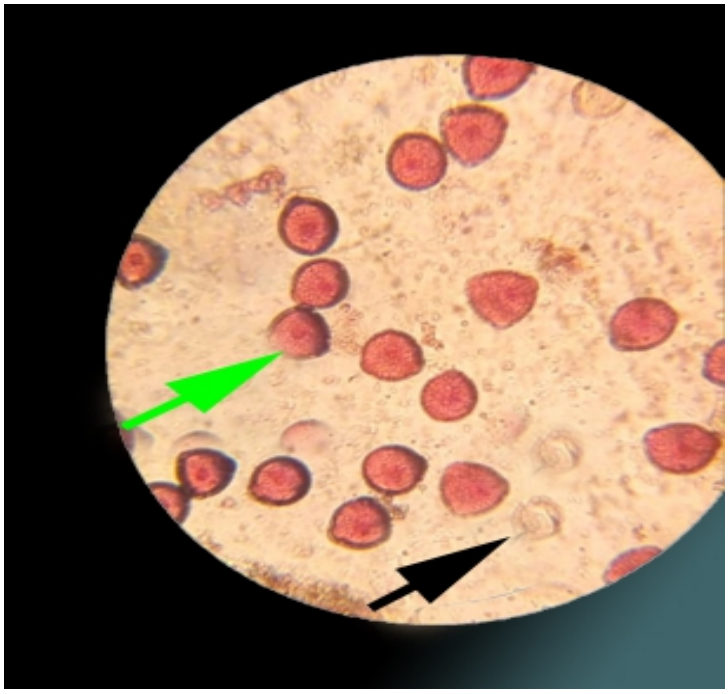


Plate III: Black arrow shows sterile pollen, green arrow shows normal pollens with deep stain in NG-SHI-036. X 400 Magnification.
Source: Field Photograph

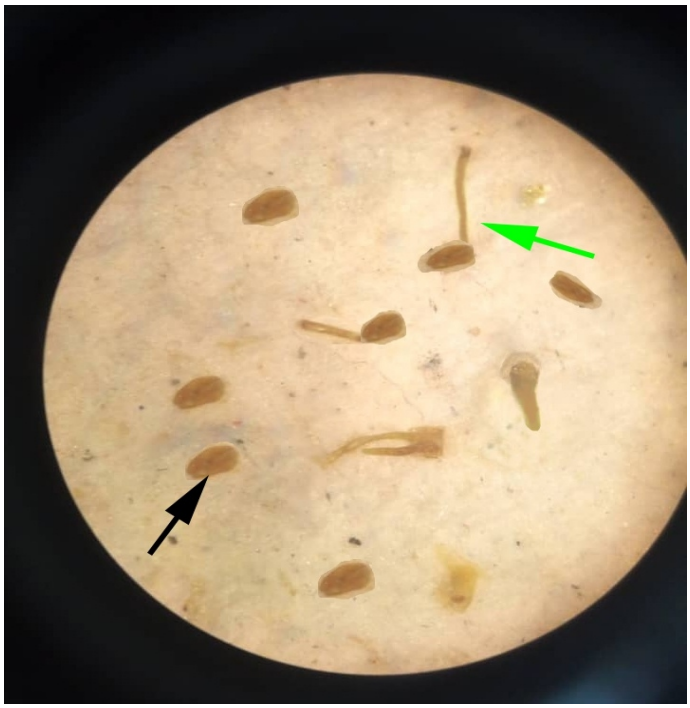


Plate IV: Green arrow shows germinating pollen, black arrow shows non germinating pollen of accession NG-GBA-015. X 400 magnification
Source: Field Photograph

4.1.9 Pearson linear correlation of some morphological and yield parameters

The results of the correlation analysis of some of agronomic traits of groundnut are shown in Table 4.10. The result showed that number of leaves was positively and highly significantly (P≤0.01) correlated with number of branches (0.960), days to 50 % flowering (0.971), days to maturity (0.974), number of pods per plant (0.957), weight of 100 seeds (0.936) and shelling percentage (0.943). The result further showed that number of branches was positively and highly significantly (P≤0.01) correlated with days to 50% flowering (0.959), days to maturity (0.952), number of pod per plant (0.916), weight of 100 karnel (0.924) and shelling percentage (0.922). The result also showed that days to 50% flowering was positively and highly significantly (P≤0.01) correlated with days to maturity (0.998), Number of pods per plant (0.935), weight of 100 seeds (0.966) and shelling percentage (0.973). Days to maturity was positively and highly significantly (P≤0.01) correlated with number of pod per plant (0.937), weight of 100 seeds (0.969) and shelling percentage (0.975). Number of pod per plant was positively and highly significantly (P≤0.01) correlated with weight of 100 seeds (0.915) and shelling percentage (0.889). Result also showed that weight of 100 seeds was positively and highly significantly (P≤0.01) correlated with shelling percentage (0.959). Plant height was highly significantly (P≤0.05) correlated (0.187) with 100 weight of pods (Table 4.10).

Table 4.10: Pearson linear Correlation of some Morphological and Yield Parameters

	NOB	NOL	PLH	DFF	DTM	NPP	WHS	SHE	HWP
NOB	1								
NOL	0.960**	1							
PLH	0.072	0.047	1						
DFF	0.959**	0.971**	0.033	1					
DTM	0.952**	0.974**	0.029	0.998**	1				
NPP	0.916**	0.957**	0.043	0.935**	0.937**	1			
WHS	0.924**	0.936**	0.021	0.966**	0.969**	0.915**	1		
SHE	0.922**	0.943**	0.018	0.973**	0.975**	0.889**	0.959**	1	
HWP	0.101	0.036	0.187*	0.062	0.051	0.073	0.133	0.037	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

NOB= Number of branches
NOL= Number of Leaves
PLH = Plant Height
DFF= Days to 50% Flowering
DTM= Days to maturity
NPP= Number of pod per Plant
SHE% = Shelling percentage
WHS = Weight of Hundred Seeds
HWP= Hundred Weight of pods

4.1.8.2 Pearson linear correlation of yield parameters and fatty acid composition

The result of the correlation analysis of yield parameters and fatty acid composition of groundnut oil is presented in Table 4.11. The result showed that oleic acid was negatively and highly significantly (P≤0.01) correlated with days to maturity (-0.964) and 100 weight of pod (-0.664). Linoeic Acid was positively and highly significantly (P≤0.01) correlated with days to maturity (0.962) and 100 weight of pod (0.660). The percentage groundnut oil was negatively and highly significantly (P≤0.01) correlated with days to maturity (-0.836) and 100 weight of pod (-0.519). The result showed that stearic acid was positively and highly significantly (P≤0.05) correlated with oil (0.426) and also highly significantly (P≤0.01) correlated with free fatty acid (0.685); oleic acid was positively and highly significantly (P≤0.01) correlated with percentage groundnut oil (0.876) and also highly significantly (P≤0.05) correlated with palmatic acid (0.440), Linoiec acid was negatively and highly significantly (P≤0.01) correlated with percentage groundnut oil (0.839) and oleic acid (0.989), linoiec acid was negatively and highly significantly (P≤0.05) correlated with palmatic acid (-0.430).

Table 4.11: Pearson Linear Correlation of Yield Parameters and Fatty Acid Composition

	DFF	DTM	WHS	SHE	NPPP	HWP	OIL	FFA	PAA	STA
DFF	1									
DTM	0.107	1								
WHS	0.954**	0.059	1							
SHE	0.940**	0.090	0.889**	1						
NPPP	0.869**	-0.016	0.820**	0.712**	1					
HWP	0.050	0.630**	0.074	0-.014	0-.012	1				
OIL	-0.164	-0.836**	-0.146	-0.133	-0.032	-0.519**	1			
FFA	-0.247	-0.128	-0.218	-0.197	-0.222	-0.056	0.100	1		
PAA	-0.222	-0.335	-0.231	-0.127	-0.198	-0.352	0.345	0.330	1	
STA	-0.274	-0.270	-0.264	-0.278	-0.179	-0.087	0.426*	0.685**	0.121	
OLA	-0.112	-0.964**	-0.084	-0.057	-0.008	-0.664**	0.876**	0.180	0.440*	0.29
LIA	0.062	0.962**	0.035	0.010	-0.038	0.660**	-0.839**	-.163	-0.430*	-0.28

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

DFF= Days to 50% Flowering
DTM= Days to maturity

NPPP= Number of pod per Plant
SHE = Shelling percentage
WHS = Weight of Hundred Seeds
HWP= Hundred Weight of pod
FFA= Free Fatty Acid
PAA = Palmatic Acid
STA = Stearic Acid
OLA = Oleic Acid
LIA = Linoeic Acid

4.2 Discussion

The highest number of groundnut accessions was collected from Lapai Local government (4 accessions) followed by Gbako, Bida, Lavun, Paikoro, Agaie,Shiroro, Bosso, Kontagora and Katcha Local Government where 3 accessions were collected each. Mean while, 2 accessions each were collected from Borgu, Rijau and Agwara Local Government. The result from the diversity indicated that Niger State has great diversity of the groundnut genetic resources. This can be supported by RMRDC (2018) who affirmed that the studied areas in this research have great groundnut raw material in Niger state. About 75% of farmers from all the local governments prefer accessions with moderate pod constriction, moderate pod beak, and moderate pod reticulation. This is because such accessions can stay in the field for a long period of time even after maturity without germinating. Anjana *et al*. (2016) reported that some accessions of groundnut germinate after maturity when not harvested; this could be due to the variation in seed dormancy (Asibuo *et al*., 2008b). In addition, farmers also mentioned that besides serving as a food condiment, preferred accessions are characterized by high oil content and market value than the other accessions. Quite numerous accessions were obtained from major groundnut cultivated areas of Niger State. This is an indication that Niger state has great diversity of the crop genetic resources.

The genetic variations observed in the phenotypic character of pods and seeds were similar to the results obtained by Amarasinghe *et al*. (2017) who observed 20-35 mm pod length, pod width (6.00- 18.00 mm), seed length (10-20 mm), pod constriction, pod reticulations, pod peak, and seed colors. Garba *et al*. (2015) also reported similar result with the observation recorded in this study but there was a difference in pod width. Garba *et al.* (2015) observed the maximum size of 15.20 mm while this research recorded 20.00 mm as maximum pod width. The difference observed could be attributed to the number of accessions studied; they studied less number of accession compare to this research. This is supported by Mukesh and Lal, (2017) who affirmed that, studying of few accessions of groundnut may result to low genetic variability.

Significant genetic variation observed among the accessions of groundnut in vegetative and yield parameters could be an indication of high genetic variability in the crop in Niger state. It was observed that there was high genetic diversity with regard to morphological and agronomic traits in the groundnut accessions collected. These further support the fact that, Niger state is among the leading groundnut producing states in Nigeria. Zekeri and Tijjani, (2013) and RMRDC, (2018) affirmed that Niger State is among the major groundnut producing states in Nigeria. The diversity could mainly be attributed to diverse genetic makeup and agro climatic conditions in the state. The accessions from different regions were sometimes closely related and accessions from the same region had different genetic background. The germplasm represents important source of genetic diversity that is expected to be useful in prospective breeding programs. The achievement in genetic improvement of the crop depends on the available diversity of the crop and its genetic resources (Makinde and Ariyo, 2010).

The variations observed in the growth habit were in line with the report of Madhan and Nigam, (2013) who affirmed that groundnut can be erect or procumbent. However, the procumbent growth type is most preferred as it is associated with high pod yield (Sevgi *et al*., 2008). Similar genetic variations observed in leaflet length, leaflet width, leaflet shape, leaflet colour, leaflet margin and leaflet surface have been reported by Krapovickas *et al*. (2007), Jakkeral *et al*. (2013), Patil *et al*. (2014), Garba *et al*. (2015), Gangadhara and Nadaf, (2016). The genetic variation observed provides opportunity for plant breeders to develop new and improved cultivars with desirable characteristics.

The significant differences observed in plant height are indication of genetic variability that exists in the crop. The height of the groundnut is heritable and is influenced by the genetic content of the genotype. The high value of plant height recorded in the NG-SHI-017, SAMNUT22, SAMNUT24, SAMNUT25 and SAMNUT26 was in line with the report of Krapovickas *et al*., (2007) who affirmed that groundnut height can be 30-50 cm. Though the highest plant height observed was different from the result obtained by Amarasinghe *et al*. (2017) who observed 29.13 cm and this research observed 35.33cm as the highest plant height; a difference of 6.20 cm. Janila *et al*. (2013) opined that, the higher plant height suggest them as a potential parents for inclusion in future breeding programs aimed at improving plant height and other agronomic aspects of groundnut. In addition, Dharanguttikar and Borkar, (2014) also opined that direct selection based on physiological characters would be considered for further breeding programme and will help in selecting high yielding genotypes in groundnut.

The important differences observed in the number of leaves are signs of genetic variability in the crop. The number of leaves in a crop plays important roles in the yield of a plant, as the

leaves are photosynthetic site of the plant. The number of leaves observed was in line with the observation of Dharanguttikar and Borkar, (2014). Number of genotypes such as NG-PAK-30, NG-PAK-031, NG-BOR-008, NG-LAV-025 and NG-LAP-026 recorded higher number of leaves which could bring about high yield. The significant number of leaves observed suggests the genotypes as potential parents for inclusion in future groundnut breeding in Niger State. Janila *et al*. (2013) had opined that, high number of leaves in groundnut suggests them for inclusion for future groundnut breeding program aiming at improving the number of leaves for a high yield.

The significant differences observed in number of branches are evidence of genetic variability present in the crop. The number of branches is highly heritable and this is influence by the genetic content of genotype of the crop. The high number of branches observed in NG-PAK-30, NG-PAK-031, NG-BOR-008, NG-LAV-025 and NG-LAP-026 influence the number of leaves. The number of branches observed was in line with the report of Zaman *et al*. (2011), Amarasinghe *et al*. (2017) and Engin *et al*. (2018). The significant number of branches observed suggests the genotypes as potential parents for inclusion in future groundnut breeding in Niger State.

Variations that were observed in the yield parameters among the accessions studied such as days to 50 % flowering, days to maturity, number of pod per plant, weight of 100 pod, weight of 100 karnel and shelling percentage opined the presence of genetic variability among the genotypes. Genetic variations and inheritance of day to 50 % flowering, days to maturity, number of pod per plant were reported by Zaman *et al*. (2011), Amarasinghe *et al*. (2017) and Engin *et al*. (2018).

The least and the highest number of day to 50 % flowering observed in NG-AGW-009 (27.33) and NG-BDA-015 (42.67) respectively were similar to the result obtained by Engin *et al*. (2018). However, the result was different from the observation of Garba *et al*. (2015) who observed 29 days for maximum number of day to 50% flowering. The variation could be attributed to environmental influence on the expression of traits (Zaman *et al*., 2011) and the numbers of accessions studied (Mukesh and Lal, 2017), as studying of few accessions may result to low genetic variability. Accessions with least number of days to 50 % flowering matured early compare with the accessions with high number of days to 50 % flowering. Anjana *et al*. (2016) also observed that accessions with least days to 50 % flowering mature early.

The highest number of days to maturity observed in genotype NG-BDA-013 (115.67) and the least number of days to maturity observed NG-AGW-009 (87.33) collaborated with the report of Ajeigbe *et al*. (2015) and Chandran *et al*. (2016). Accessions with highest days to maturity also have high number of days to 50 % flowering. This is supported by Mukesh and Lal, (2017) who affirmed that, groundnut genotypes with long period of maturity also have a long period to days to 50 % flowering and vice versa.

Variations observed in weight of 100 kernels in genotypes corroborated with the work of Sushree *et al*. (2017) who observed the range of 4.88- 67.65 g for weight of 100 kernel. The observation of 100 weight of pod was in line with the report of Garba *et al*. (2015). The least number of pods per plant observed in genotype NG-KAT-019 (11.67) and the highest observed in genotype NG-SHI-036 (49.67) was in agreement with the report of Amarasinghe *et al*. (2017). However, Richard *et al*. (2017) observed a higher number of pods per plant (72.00) while Sushree *et al*. (2017) observed a lower number of pods per plant (23.87).

The result obtained for the least shelling percentage observed in genotype NG-SHI-036 (30.44%) and the highest shelling percentage observed in SAMNUT22 (58.06 %) agreed with the result observed by Richard *et al*. (2017). It was observed that the higher the shelling percentage the more the seed weight. The result supported the findings of Jeyaramraja and Fantahun, (2014) who affirmed that a higher shelling percent indicates more seed weight.

The high percentage cumulative variance obtained in the first two components depicts a huge variation within the germplasm. The result was in agreement with findings by Balota *et al.* 2012, Albert, 2014 and Olalekan *et al.* 2017 who reported high diversity in the crop. However, the result contradicts the observation of Makinde and Ariyo, (2010) who recorded a lower cumulative variance within the first two components. This could be attributed to the number of the genotypes studied as this research had higher number of genotypes. High cumulative variance was also recorded in other crops (Ogunniyan and Olukojo, 2015, Abubakar *et al*. 2018). The high variability in the crop could be attributed to the mode of reproduction of the crop that is mostly autogamous with a low level of cross pollination. Several authors (Hamrick *et al*., 1990; Garba *et al*. 2015) reported that highly autogamous mode of reproduction promotes inter-population heterogeneity and allows good adaptation to the environment, in addition to plant-to-plant heterogeneity in the population.

Grouping of the accessions in to four clusters with each cluster group containing accessions from different local governments and sources proves that there was no association between pattern of clusters and geographical distribution of accessions. Clustering of accessions in the same cluster showing close similarity could be attributed to trans-boundary movement of the crop by farmers and adapted to the environment after years of cultivation. This is supported by Engin *et al*. (2018) and Abubakar *et al*. (2018) who had previously reported that accessions

may cluster based on their geographical origin or genetic differences and further small clusters could be based on similar characteristics, pedigree relation or close era of cultivation within the main group.

The variation observed in the percentage oil was supported by the statement of Aruna and Nigam (2009) who reported that groundnut oil varies between 40-60 %. Gulluoglu, *et al.* (2016) also reported 43.71-51.55 % oil content in groundnut. Oils with high content of monounsaturated fatty acid (oleic acid) are less susceptible to oxidative changes during refining and storage. Nutritionally, high content of linoleic acid is preferable because it lower total blood cholesterol and low-density lipo-protein levels and also more susceptible to oxidative rancidity than oleic (Kratz *et al*., 2002). The percentage of free fatty acid in the oil is an indication of their level of quality; and free fatty acid exceeding 5 % makes it unhealthy for human consumption (Kratz *et al*., 2002). Therefore, groundnut oil with free fatty acid less than 5 % is valuable for food. The variation observed in stearic acid, oleic acid, linoleic acid, palmatic acid agrees with the report of Asibuo *et al*. (2008a). Accessions such as NG-SHI-036, NG-GBA-014, NG-LAV-024 and NG-BOS-005 had high oleic to linoleic ratio and according to Achola *et al*. (2017) groundnuts with high oleic to linoleic ratio are more beneficial to humans compared to 'normal' oleic. Garcia *et al*. (2006) also affirmed that high oleic to linoleic ratio confers health benefits.

The pollen production observed (3500.00-4803.33) was in line with the observation of Prasad *et al*. (1999) who reported 2,800.00-4,389.00 pollen per flower in groundnut. However, the maximum number of pollen observed in this research was higher compare to the observation of Prasad *et al*. (1999). This could be attributed to the groundnut exposed to short episodes of heat stress by Prasad *et al*. (1999). The pollen production per anther observed in other

legumes such as soybean (Koti *et al*., 2004) was similar to the observed pollen. The high percentage fertility observed (75.33-92.00 %) in the accessions is an indication of high pollen viability in groundnut. The viability observed was similar to the observation of Husain *et al*. (2008) who earlier reported viability of 60.60-96.00 %. It was also observed that accessions with high pollen fertility have high yield. It was observed that 0% sucrose concentration does not produce results. Abejide *et al*. (2014) had earlier reported 0 % germination in 0 % sucrose concentration and suggested that too low and high concentration of sucrose in medium can affect pollen germination negatively. However, the result observed in 10 % and 20 % concentration was similar to the observation of Kakani *et al*., (2002). The pollen germinability result was also observed to be generally lower than the percentage fertility. This is an indication that not all fertile pollens will germinate *In vitro*. Kakani *et al*. (2002) found similar results in their experiments emphasizing that pollen grain evaluation through the staining method seems to express the germination potential but not its occurrence hence higher percentage fertility than percentage germinability. Husain *et al*. (2008) had earlier reported that the extent of germinability achieved depends on the experimental success in determining the most favorable medium for germinability.

Correlation of particular traits with other traits and with yield was significant in indirect selection of the genotypes for yield improvement (Mukesh and Lal, 2017). Significant and positive Correlation between traits suggests that these traits can be improved simultaneously in a breeding programme (Kumara *et al*., 2015). This is due to the fact that it shows communal relationship among characters and selection for one will translate to selection and improvement of the other (Mukesh and Lal, 2017). The significant positive correlation recorded between number of leaves and number of branches suggests that plant with more

branches produced more leaves. Significant positive correlation between number of branches and number of pods per plant was an implication that more number of branches produced more number of pods per plant. The positive correlation of days to 50 % flowering with days to maturity implies that the early flowered plant matured early and vice versa. Weight of 100 seed positively correlated with shelling percentage; suggests that higher shelling percent produces more seed weight. The implication of significant positive correlation of days to 50 % flowering with number of pods per plant is that, longer days to 50 % flowering produces more number of pods per plant and vice versa. Days to maturity positively significantly correlated with number of pod per plant, weight of 100 kernel and shelling percentage, indicated that the more days to maturity produces more number of pod per plant, more weight of 100 seed and more shelling percentage.

Mukesh and Lal (2017) observed similar correlation results between number of leaves, number of branches, days to 50 % flowering, shelling percentage, weight of seeds and number of pods per plant in groundnut. Correlation analysis determines communal relationship with no regard to their relative significance.

The implication of the negative correlation of percentage oleic acid with days to maturity and 100 weight of pod is an indication that the more days to maturity the less percentage oleic acid and less 100 weight of pod. Significant positive correlation of percentage linoeic acid with days to maturity and 100 weight of pod imply that the more percentage linoeic acid the more days to maturity and more 100 weights of pods. Significant negative correlation of percentage groundnut oil with days to maturity and 100 weight of pod is an indication that, the more days to maturity, the less percentage groundnut oil. The significant positive correlation of percentage stearic acid with percentage oil and percentage free fatty acid indicated that the

more percentage oil, the more percentage stearic acid and percentage free fatty acid. The significant positive correlation of percentage oleic acid with percentage groundnut oil and percentage palmatic acid is an indication that the more percentage oil, the more percentage oleic acid and percentage palmatic acid. The implication of percentage linoiec acid negatively correlated with percentage groundnut oil and percentage oleic acid is that, the more percentage oil, the less percentage linoiec acid, and the more percentage oleic acid, the less percentage oil. The implication of percentage linoiec acid negatively correlated with percentage palmatic acid implies that, the more percentage linoiec acid, the less percentage palmatic acid. The result of the correlation was similar to the observation of Asibuo *et al.* (2008a); Hassan and Ahmed (2012) and Ganapati *et al*. (2014).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The germplasm exploration revealed that some of the accessions showed some genetic variations in pod and seed morphology. It was also observed that about 75% of farmers prefer accessions with moderate pod constriction and moderate pod beak. The research revealed that the best performing accessions in agro morphological parameters are NG-SHI-036, SAMNUT26, SAMNUT21, SAMNUT22, SAMNUT24, NG-LAV-025, NG-LAP-026, NG-PAK-031 and NG-BOR-008. In pollen fertility, accession NG-SHI-036, NG-LAV-025 and SAMNUT26 are the best while in pollen production and germinability accession, NG-SHI-036 and SAMNUT26 are the best. Accession NG-SHI-036, NG-GBA-014 and NG-LAV-024 were considered the best accessions in terms of good fatty acid composition.

This study has provided some useful baseline information about the various groundnut germplasm in Niger State. It also supports that Niger state is blessed with many groundnut genotypes. The agromorphological characterisation of the studied germplasm provides knowledge on the traits that might be important to the plant breeders. The Cluster obtained

from agromorphological characterization gave an opportunity for separating the accessions in to different morphotypes. Such separation will support gene bank curator with information with regard to the appropriate site for collection and the proper methods for management. The cluster obtained gives a sense of the association among accessions and could help in selection of parents needed to maintain adequate diversity in the breeding program.

5.2 Recommendations

1. Accessions with high yield and high nutritional values such as NG-SHI-036, SAMNUT26, NG-LAV-025, NG-GBA-015 and NG-SHI-035 should be recommended for multi-locational trial to determine the stability of the genotypes.
2. Further studies should be carried out to assess the genetic diversity of the accessions using molecular markers.
3. Studies should be carried out on the amino acid composition of the groundnut accessions for proper selection of elite genotype(s) with high protein value.
4. Further studies should be carried out on those agro-morphological parameters that show greater diversity for selection and improvement of the crop in Niger state.

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Anova: Plant Height

		Sum of Squares	Df	Mean Square	F	Sig.
WEEK TWO	Between Groups	396.770	42	9.447	30.352	0.000
	Within Groups	26.767	86	.311		
	Total	423.537	128			
WEEK FOUR	Between Groups	609.544	42	14.513	13.735	0.000
	Within Groups	90.873	86	1.057		
	Total	700.417	128			
WEEK SIX	Between Groups	1327.912	42	31.617	12.163	0.000
	Within Groups	223.547	86	2.599		
	Total	1551.459	128			
WEEK EIGTH	Between Groups	3920.055	42	93.335	14.062	0.000
	Within Groups	570.818	86	6.637		
	Total	4490.873	128			

APPENDIX A

APPENDIX B

Anova :Number of Leaves

		Sum of Squares	Df	Mean Square	F	Sig.
WEEK TWO	Between Groups	6559.179	42	156.171	3.711	.000
	Within Groups	3619.627	86	42.089		
	Total	10178.806	128			
WEEK FOUR	Between Groups	6359.690	42	151.421	1.670	.023
	Within Groups	7800.000	86	90.698		
	Total	14159.690	128			
WEEK SIX	Between Groups	127096.806	42	3026.114	2.430	.000
	Within Groups	107117.333	86	1245.550		
	Total	234214.140	128			
WEEK EIGTH	Between Groups	313447.814	42	7463.043	6.875	.000
	Within Groups	93354.667	86	1085.519		
	Total	406802.481	128			

APPENDIX C

Anova: Number of Branches

		Sum of Squares	Df	Mean Square	F	Sig.
WEEK TWO	Between Groups	9.535	42	0.227	0.681	0.915
	Within Groups	28.667	86	0.333		
	Total	38.202	128			
WEEK FOUR	Between Groups	6.620	42	0.158	0.968	0.536
	Within Groups	14.000	86	0.163		
	Total	20.620	128			
WEEK SIX	Between Groups	307.953	42	7.332	2.365	0.000
	Within Groups	266.667	86	3.101		
	Total	574.620	128			
WEEK EIGTH	Between Groups	1145.488	42	27.274	14.599	0.000
	Within Groups	160.667	86	1.868		
	Total	1306.155	128			

APPENDIX D

Anova: Yield Parameters

		Sum of Squares	Df	Mean Square	F	Sig.
DFF	Between Groups	3694.202	42	87.957	96.978	0.000
	Within Groups	78.000	86	0.907		
	Total	3772.202	128			
DTM	Between Groups	17927.690	42	426.850	235.315	0.000
	Within Groups	156.000	86	1.814		
	Total	18083.690	128			
NPP	Between Groups	11023.550	42	262.465	6.409	0.000
	Within Groups	3522.000	86	40.953		
	Total	14545.550	128			
SHE	Between Groups	3349.277	42	79.745	575.507	0.000
	Within Groups	11.917	86	0.139		
	Total	3361.194	128			

DFF = Days to 50% flowering, DTM = Days to maturity, NPP = Number of pod per plant, SHE= Shelling percentage

APPENDIX E

Anova : Pollen Parameters

		Sum of Squares	Df	Mean Square	F	Sig.
FERTILE	Between Groups	917.467	9	101.941	17.576	0.000
	Within Groups	116.000	20	5.800		
	Total	1033.467	29			
STERILE	Between Groups	917.467	9	101.941	17.576	0.000
	Within Groups	116.000	20	5.800		
	Total	1033.467	29			
P/F	Between Groups	4788021.467	9	532002.385	3.182	0.015
	Within Groups	3343949.333	20	167197.467		
	Total	8131970.800	29			
P/A	Between Groups	203230.000	9	22581.111	3.755	0.007
	Within Groups	120266.667	20	6013.333		
	Total	323496.667	29			
GM10 %	Between Groups	1179.867	9	131.096	14.406	0.000
	Within Groups	182.000	20	9.100		
	Total	1361.867	29			
GM20%	Between Groups	5044.533	9	560.504	42.249	0.000
	Within Groups	265.333	20	13.267		
	Total	5309.867	29			

P/F= Pollen production per flower, P/A= Pollen Production Per anther, GM10% = Germination with 10% concentration, GM20% = Germination with 20% concentration

APPENDIX F

Anova: Fatty Acid Composition

		Sum of Squares	Df	Mean Square	F	Sig.
OIL%	Between Groups	189.852	9	21.095	19.472	0.000
	Within Groups	21.667	20	1.083		
	Total	211.519	29			
FFA	Between Groups	2.935	9	.326	.282	0.972
	Within Groups	23.108	20	1.155		
	Total	26.043	29			
PAA	Between Groups	11.938	9	1.326	1.234	0.330
	Within Groups	21.500	20	1.075		
	Total	33.438	29			
STA	Between Groups	5.033	9	.559	.516	0.846
	Within Groups	21.667	20	1.083		
	Total	26.699	29			
OLA	Between Groups	2562.760	9	284.751	262.847	0.000
	Within Groups	21.667	20	1.083		
	Total	2584.427	29			
LIA	Between Groups	2562.760	9	284.751	262.847	0.000
	Within Groups	21.667	20	1.083		
	Total	2584.427	29			

OIL% = Percentage oil FFA= Free fatty acid PAA= Palmatic acid STA= Stearic Acid OLA= Oleic acid LIA= Linoic acid

APPENDIX F

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

SCHOOL OF LIFE SCIENCES

DEPARTMENT OF PLANT BIOLOGY

GERMPLASM COLLECTION DATA SHEET FOR GROUNDNUT

1.Collection Number ☐ 2.Accession Number ☐

3. Crop Species

_____

4. Collector (s) _____5. Date

_____

6. State of Collect of Collection _____7. Local Government Area_____

8. Village/District _____9. Precise Locality_____

10.
Altitude_____Latitude_____Longitude_____

11. Soil Type_____

12. Precipitation: < Normal ☐ Normal ☐ > Normal ☐

13. Sample Source: Field ☐ Store ☐ Market ☐ others ☐

14. Local Name _____15. Type/Race_____ 16. Ethnic Group _____

17. Donor's Source: Own ☐ Local ☐ Market ☐ Others ☐

18. Cultural Practices: Rain-fed ☐ Irrigated ☐ flooded ☐

19. Planting Date_____ 20. Harvesting _____

21. preferred Type: _____

22. Diseases: _____

23. Insect Susceptibility: Susceptible ☐ Resistant ☐

24. Types of Insects_____

25. Agronomic Source: Very Poor ☐ Poor ☐ Average ☐ Good ☐ Very Good ☐