TAXONOMIC DELIMITATION OF SPECIES OF *SENNA AND CASSIA* IN AHMADU BELLO UNIVERSITY, ZARIA

BY

FATIMA NURU GARBA

DEPARTMENT OF BOTANY,
FACULTY OF LIFE SCIENCES,
AHMADU BELLO UNIVERSITY,
ZARIA, NIGERIA

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BY

FATIMA NURU GARBA, B.Sc.BOTANY(ABU) 2010
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DEPARTMENT OF BOTANY,
FACULTY OF LIFE SCIENCES
AHMADU BELLO UNIVERSITY,
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AUGUST, 2018

DECLARATION

I declare that the work in this dissertation entitled "TAXONOMIC DELIMITATION OF SPECIES OF *SENNA* AND *CASSIA* IN AHMADU BELLO UNIVERSITY, ZARIA" has been carried out by me in the Department of Botany. The information derived from the literature has been duly acknowledged in the text and list references provided. No part of this thesis has been presented for another master degree at this or any other institution.

Garba Nuru Fatima	_____	_____
Name of student	Signature	Date

CERTIFICATION

This Dissertation entitled "TAXONOMIC DELIMITATION OF SPECIES OF SENNA AND CASSIA IN AHMADU BELLO UNIVERSITY, ZARIA" by Fatima Nuru GARBA meets all the regulation governing the award of Master's Degree of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Prof.A.K Adamu Chairman, Supervisory Committee Department of Botany Faculty of Life Sicence Ahmadu Bello University, Zaria	_____ Sign	_____ Date
Dr. B.Y Abubakar Member, Supervisory committee Department of Botany Faclty of Life Science	_____ Sign	_____ Date
Prof. I.O Iortsuun Head of Department Department of Botany Faculty of Life Science Ahmadu Bello University, Zaria	_____ Sign	_____ Date
Prof. S. Z. Abubakar Dean of Postgraduate Studies Ahmadu Bello University, Zaria	_____ Sign	_____ Date

DEDICATION

This work is dedicated to my husband, Dr. Aminu A. Ambi, my children, Hasoor, Huzaifah, Maimunatu and Suleiman and to my mother, Hajiya Habiba Garba.

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ABSTRACT

The foliar epidermal characters of species of *Senna*and *Cassia*whichincludes; *Senna alata* (L.) Roxb., *S. hirsuta* (L.) Irwin and Barneby, *S. obtusifolia* (L), *S. occidentalis* (L.), *S. siamea* (Lam.), *S. singueana* (L), *S. siberiana* (L) and *Cassia absus* were studied in Ahmadu Bello University, Zaria in search for useful taxonomic characters. Features such as leaf base, leaf apex, leaf shape and leaf texture were assessed for variances in morphological characters. Stomata and trichome studies (adaxial and abaxial)were conducted where the stomatal type, trichome type and stomata length, width and size were evaluated using a caliberated eye piece micrometer. For internal anatomy, histological technique was used.Acetolysis technique was adopted for flower bud studies. The scanning electron microscope was used for seedcoatsculpture study. All species were shruby except for *senna siamea* and *S. alata* which were trees. The stomata found were paracyticand anisocytic in *S. obtusfolia*and *S. occidentalis*, anisocytic in *S. siamea*while for *S. hirsutae and S siberiana*,they were paracytic all through. Therewasvariability in the stomatal length which was largest in *S.hirsutae*(2.22µm) and shortest in *S.siamea* (1.32µm). Thefrequencyof stomata was highest in *S. hirsutae* (42.75µm) and lowest *i*n *S.obtusfolia* (18.55µm). The pollen grains were radially symmetrical with few variations in length which was highest in *S.singueana* (27.20µm) and lowest in *C.absus*(1.58µm), width of pollen grain was widest in *S.occidentalis* (9.40µm) and in narrow *C.absus* (1.04µ). Based on surface sculpturing pattern: parallel crack was exhibited in *S. alata* and *S. siamea* while random cracks were seen in *S. siberiana* and *S. occidentialis*,*C. absus* had no cracks.For palisade cell number,the highest was observed in

S.hirsutae(39.20µm) and the lowest in *C.absus* (20.80µm). The thickness of the epidermis also varied, *C.absus* (28.88µm) had the thickest epidermis while lowest was in *S. siberiana* (6.35µm). Thedifference in stomatal, pollen and trichomefeaturesareofhigh taxonomicvaluein theclassificationofthesespecies. The study revealed that seed coat ornamentation within the genus shows considerable variation and can be helpful for taxonomic purposes. A dichotomous taxonomic key is hereby presented to aid the identification of the studied *Senna*and *Cassia* species. In conclusion,the similarities in structure of seedcoat and morphology showed interspecies relationship. They are placed in the same family due to similarities in morphology, while the differences in morphology led to speciation. The sculpturing details of the seed coat varied between species and have been able to show that they possess different cracks arrangement which can be used at both generic and species levels.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Ceasalpinoideae is a large sub-family of about 150 genera with 2000-3000 species of flowering plants in the order fabales (Eddy, 1997). The genus *senna* is native throughout the tropics with a few species extending in to the temperate regions.Many of them have economic importance for ornamental and natural medicine purposes, wood production, degraded area restoration (Kissmann *et al*., 1992) and also vegetable source. *Senna*comprises around 350 species and was divided into six sections: Psilorhegma, Chamaefistula, Senna, Peiranisia, Paradyction and Astroites(Irwin and Barneby, 1982; Randell and Barlow, 1998).

Taxonomic variability involving these genera are common due to mainly the high morphological similarities among them (Boonkerd *et al*., 2005).Irwin and Barneby (1981) subjected the genus to some nomenclatural and taxonomic changes that eventually led to the splitting of the genus into smaller genera viz: *Cassia, Senna* and *Chamaecrista* and they premise their work on the argument that while *Cassia* senso lato. is clearly an isolated group, the differences between the three groups are as large or even larger than those which delimit some genera elsewhere in the *Leguminosae*. However, Lock (1988) observed that series of problems have arisen because of the changes in name as many workers especially on the African flora would probably prefer to continue to use *Cassia* in its broad sense and this would within reason be acceptable if there was no overlap between floras of Africa and South America. Interestingly, many species of the genus are widespread in the tropics through dispersal or deliberate introduction hence confusionwill definitely set in as several

species will be given different names in different continents (Lock, 1988).In a nut shell, *Senna* Mill. is separated from *Cassia* Linn. On the basis of three adaxial stamens which are short and straight and the pedicels which have no bractioles, (Tucker,1996).

The taxonomy of *Senna* is of importance because of the medicinal value of the genus. The genus contains anthraquinones which varies from one species to the other, and may be poisonous if taken in excess hence the need for proper identification of the species. Some poisonous species are used to stupefy fish. Sadly, because of the apparent similarities between these species that are of ethnomedicinal importance, these species are used indiscriminately and many people might have used one species instead of the other. Therefore, there is need for proper taxonomic study of the genus to aid easy identification even when they are not in their fruiting period.

In West Africa, the genus contains about 22 indigenous species apart from those introduced (Hutchinson and Daziel,1958).ThenBurkill (1995) reported about 19 species in West African floristic region with the whole 19 species in Nigeria (Soladoye and Lewis, 2003) and at least 8 species in South Western Nigeria especially in Oyo and Ogun States.

Species delimitation is an integrative field that depends on increasingly diverse data types, yet it remains rife with arguments and opposing approaches.The use of leaf micromorphological and epidermal features has been found to be of immense interest in taxonomy and have been used by many authors in plant identification(Nwachukwu *et.al*, 2007). An excellent review of the application of morphological features in systematic studies was also seenin the works ofOlorede (1984), Edeoga and Eboka (2000) and Edeoga and Ikem (2001). Aworinde *et al*.,(2012) have used foliar epidermal features such as stomata and epidermal cells on ten species in the family

Sterculiaceae and discovered some stable taxonomic characters that were employed in classification and identification in spite of the remarkable morphological differences. Trichome types, densities and frequencies when used on the other hand canprovide good taxonomic evidence, Abdulrahman and Oladele (2004). According toDaniel(2005), leaf cuticle study is also becoming more important because taxonomists, drug industries, animal nutritionists, animal toxicologists and Police department have all found it useful in plant identification.

Studies have alsobeen carried out on pollen of this genus by Erdtman (1952), El-Ghazali (1989). Pollen morphological characters are often overlooked by many taxonomists due to the fact that they are small (0.3µm in diameter) for their identification (Faegri *et al,* 1989), and hence microscopic (both light and electron) techniques are prerequisite tools. Perven and carser (1998) studying the pollen grain of the subfamily Ceasalpinoideae in Pakistan concluded that the pollen morphology is significantly useful at the generic and specific levels.

Seed morphology has also been shown to provide useful characteristics for the analysis of taxonomic relationships in a wide variety of plant families (Zhang *et al*., 2005; Gontchaova *et al.,* 2009). In addition to gross morphology of seeds, sculpturing details of outer seed coat are quite variable between different species and can be of systematic importance, (Gohary and Mohammed,2007). Seed characteristics, particularly exomorphic features revealed by means of scanning electron microscope (SEM), have been used in resolving problems of systematics of species(Koul*et al.*,2000) and evolutionary relationships(Segarra andMateu, 2002).Seed coat morphology is usually stable and only a bit influenced by external environmental conditions while the seed develops and ripens within the fruit (Barthlott, 1981). Therefore, seed characters can provide useful data in the delimitation and

identification of species. The morphological features of different seed structures provide a wide range of structures which play an important role on the identification of taxa (Vaughan, 1968) and have been traditionally used to solve systematic and phylogenetic problems. Scanning electron microscopy is a powerful tool to achieve more accurate seed identification and could be used as a routine technique in the study of the spermoderm morphology (Brisson and Peterson, 1976).

1.2Statement of Research Problem

Taxonomy of*Senna* and *Cassia* species are puzzling because of the morphological variability, overlapping morphological characters and great range of similarities as well as ambiguous boundaries between taxa (Kumar *et al*., 2007, Soladoye *et al*., 2010).There are many related species of the genus *Senna* and *Cassia* which pose great challenges with respect to identification as such taxonomy delimitation of *senna* and *Cassia* species is important because of the medicinal values of the genushence proper identification of the species using epidermal structures, pollen grains as well as seedcoat sculpture would be helpful in delimiting them even when they are not in fruiting period (Aworinde *et al*.2012).

1.3Justification

Foliar anatomical features play an important role in distinguishing different groups of plants (Stace 1984). Foliar anatomical characters such as stomata and trichomes have been found instrumental in solving taxonomic problems. The taxonomic and phylogenetic significance of stomata and trichomes have long been recognized by various workers around the world, for example, Devi *et al*, (2013). Edeogu and Gomina (2001) and Edeogu and Mbaghu (2006) have used pollen attributes to establish evidence of relationship among different flowering plants in Nigeria. It is

used to provide basis for additional features for identification of plant species (Aftab and Parveen, 2006*). Senna* and *Cassia* species are used in south western Nigeria in treatment of diabetes and hypertension and this treatment is only recommended for short term use as abuse of *Senna* has been associated with organ failure (Vanderperren.,2005).Hence, this study is being designed to delimit these plant species and provide more taxonomic evidence to seperate the species.

1.4 Aim and Objectives of the Study

This research is aimed at studying the epidermal structures, pollen and seed coat morphology of some species of *Senna*and *Cassia* to elucidate the relationship among them for their taxonomic identification at species level.

The objectives of this study were to;

1. Delimit the species of *Senna*and *Cassia* in Ahmadu Bello University based on epidermal structuers.
2. Delimit the species of *Senna* and *Cassia* in Ahmadu Bello University based on pollen frequency and seedcoat sculpture.
3. Construct a Dichotomous Taxonomic Key for the identification of species of *Senna* and *Cassia* in Ahmadu Bello University.

1.5 Research Hypotheses

There is no significant difference in the;

1. Epidermalstructuresamong the various species of *Senna*and *Cassia* found in Ahmadu Bello University, Zaria.
2. Pollen frequency and seedcoat sculpture of species of *Senna*and *Cassia* found in Ahmadu Bello University,Zaria.

3. Taxonomic key constructed for the various species of *Senna* found in Ahmadu Bello University,Zaria.

CHAPTER TWO

2.0 LITERATURE REVIEW

Senna belongs to the genus *Senna*Mill, subtribe Cassiinae, tribe Cassieae, subfamily Caesalpinioideae (Leguminosae), family Fabaceae. The type species for the genus is *senna alexandrina*. The leaves are pinnate with opposite paired leaflets. The inflorescences are racemes located at the ends of branches or emerging from the leaf axils(Olorode, 1988).The flower is one of theconstant characters found in this genus despite its great diversity of forms. The flower has five sepals and five yellow petals. There are ten straight stamens which can be of different sizes, and some are staminodes. The fruit is a legume pod containing several seeds of varying length, size and may assume different shapes (Olorode, 1988).*Senna* species are pollinated by a variety of bees, especially large female bees in genera such as *Xylocopa*(Marazzi *et al.*,2006). Some species also have extrafloral nectarieson the leaves or flower stalks,which attract ants,but do not benefit pollinators. These ants probably deter herbivores (Marazzi *et al*.,2006). The yellow, nectar less flowers offer pollen as a reward to their pollinators, usually large female bees of different genera, for example, *Xylocopa* (Gottsberger and Silberbauer-Gottsberger, 1988)

2.1 Economic Importance of *Senna* and *Cassia* species

Demands of traditional herbal medicines are increasing day by day not only by the developing countries but also by the developed countriesthroughout the world. The demand is due to the increased acceptance of traditional herbal medicines, because of having no side effects, and as such modern people rely more on drug resources of

plant origin (Scholthof, 1999). So studies on the ethno-botany, ethnophytopathology and ethno medicinal uses of our wild medicinal plants and investigations regarding enhanced productivity of medicinal plants is one of the frontier areas of modern research. Ethnobotany is the study of the relationship between people and plants. Two major phenolic compounds Naringin and Apigenin (Scholthof, 1999), were identified in some fractions of Senna alata. The presence of these flavoniods in Senna alata may explain its wide use in ethnomedicine practice for the treatment of hypertension, sickle cell anemia and diabetes in South western Nigeria Senna have for millennia played a major role in herbalism and folk medicine. Alexandrian Senna (S. alexandrina) has long been traded commercially. Senna glycosides, or sennosides, are used in modern medicine as laxatives (Spiller,2003). Senna drugs contain the dried leaves of the type species S. alexandrina. Preparations are available in powders, granules, tablets, oral infusions, and syrups. It can also be available in combination with the dietary fiberpsyllium to add bulk to the bowel contents (Agarwal *et al*., 2010). The glycosides increase gastric fluid secretion and bowel motility, producing laxative action. The products are only recommended for short-term use, and chronic use and abuse of Senna has been associated with organ failure (Vanderperren, 2005).

Several *Senna* species are used as herbal remedies in Nigeria to treat various conditions and hemorrhoids(Ogunkunle *et al.,* 2006). Taxonomic relevance of vegetative anatomy in delimitation of taxa and establishment ofintergeneric or interspecific relationships is well reported (Tschan and Denk, 2012). Shifting taxonomic boundaries mark the history of traditional systematic treatments of *Senna*. These shifts are bestexplained by the difficult taxonomic interpretation of morphological variation in *Senna*. For example, the high degree of specialization

typical of the buzz-pollinated *Senna* flowers complicates the identification of traits that can be unambiguously used for taxonomic purposes.

2.2Histological studies in *Senna* and *Cassia* species

During the past three decades, cell and tissue culture technique has emerged as a powerful tool for the study of an increasing number of basic problems in plant sciences, viz., cell and tissue developmental biology, physiology, biochemistry, pathology, genetics, molecular biology and for general applied aspects such as clonal propagation, haploid production, embryo culture, cell transformation with an ultimate objective of improving economically important plant species (Rani *et al*, 2001).The typesand thickening patterns of the xylem vessels, the presence or absence of homogeneous medullary rays, and difference in parenchyma cells are diagnostic features of taxonomic and quality control importance. According to the Indian literature,*Senna* plant has been described for its pharmacopeia uses. The whole plant is used to treat diarrhea and particularly the seeds, flower and fruits are used to treat skin diseases, fever,abdominal pain and leprosy (Asolkar *et al*. 1992). The root possess astringent, tonic, febrifugal, and purgative properties and therefore, is useful against cardiac disorders, biliousness, rheumatic condition, haemorrhages, wounds, ulcers and boils, tubercular glands and various skin diseases (Alam *et al*., 1990). Meanwhile, the flowers are eaten raw and it possess astringent, purgative, febrifugal and wound healing properties and a decoction of the flower is given for stomach troubles.Also *Cassia auriculata*is chiefly valued for the tannins present in the bark which is known as Avaram bark or Tangeedu bark in commerce is one of the best available barks in India. It is the principal indigenous bark, used in the South Indian tanneries for crust tanning. The bark is astringent and useful for gargles in sore throat, rheumatism, in enemas, eye diseases and diabetes. Its decoction is given in stomach

ache and the juice of fresh bark in dysentery. Recently it has been reported as a potent anticancer herb by Prasanna *et al*. (2009)

Senna occidentalis(L), commonly known as coffee senna,is native to tropical South America and found in almost entire Brazilian territory. It is frequentin orchards, wastelands, fields and roadsides and considered as a weed in several economically important crops (Machado, 1983). The medicinal action of *S. occidentalis*is recognized in some parts of the world, where the plant or its roasted seeds are used as expectorant. On the other hand, this species can be toxic when present in animal food and research has shown that it is one of the most important toxic plants of veterinary interest (Barbosa-Ferreira *et al*., 2005). Botanist are enjoying widespread use of *Senna* for treatment of several ailments, but still little known about their toxicity and safety issue which are always a concern. Investigations on functional plants provide evidence for the presence of substances that offer potential human health benefits. However, it should be a vital requirement to determine the toxic effects of some of the substances contained in the plants (Bellini *et al*.,2008). Toxicity is an expression of being poisonous, indicating the state of adverse effects led by the interaction between toxicants and cells. Thisinteraction may vary depending on the chemical properties of the toxicants and the cell membrane, as it may occur on the cell surface, within the cell body, or in the tissues beneath as well as at the extracellular matrix. The toxic effects may take place prior to the binding of the toxicants to the vital organs such as liver and kidneys. Hence, evaluation of toxic properties of a substance is crucial when considering for public health protection because exposure to chemicals can be hazardous and results to adverse effects on human being. In practice, the evaluation typically includes acute, sub-chronic, chronic, carcinogenic and reproductive effects (Asanteh, 2012).

Generally,studies have shown that *Senna* bark extracts are used for pharmaceutical purposes and in soaps, candy or perfumery (Hill,1952). A wide range of species and ecological adaptations makes atleast a handful of *Senna* suitable for any climate warmer than cool-temperate. The seeds of *S.occidentalis* are suitable for coffee. Economically, the roasted seeds are used to substitute coffee leaves contains certain chemicals such as saponins, antifungal antimicrobial while *S. alata*properties that aids in curing certain kinds of diseases e.g. Ogunkunle and Ladejobi (2006), in their work on ethanobotanical and phytochemical studies of some *Senna* species in Nigeria reported that *S. alata* is used to cure diseases caused by dermatocytes. *S. tora* are useful in leprosy, flatulence, colic, cough, bronchitis and cardiac disorder (Marmander, 2002).

2.3Palynological studies in *Senna* and *Cassia* species

Pollen or flower sperm is a fine to coarse powder consisting of micro gametophytes (pollen grains) which carry the male gamete of male seed plants(Wagner *et al*.,1990) palynology is the science that deals with the study of contemporary and fossil palynomorphs including pollen,spore,dinoflagelate cysts scolecodents together with particulate organic matter found in sedimentary rocks and sediments (Walker 1975). Palynology play important role in plant systematicand has great application in tracing the history of plant groups (Arogundade and Adedeji, 2009). The term 'palynology' was first coined by Hyde and William in 1945which relates to the study of pollen grains and spores (Aftab and Perveen 2006). Palynological studies have been carried in the genera Ceratonia (Ferguson,1980),Arabidopsis (Khan,2004), Ocimum spp.(Arogundade and Adedeji, 2009),Rumex spp.(Yasmin *et al.*, 2010). Likewise, different workers have studied different plant families such

asMalvaceae(Christensen,1986),Naucleeae (Kuanga *et al., 2008*),Leguminosae(Masih *et al*., 2005),Asteraceae (Zafar *et al.,* 2007). The pioneer palynological studies have been done by Erdtman (1952).The palynological attributes of plants have attracted the attention of many scientists,for example Nyananyo (1985) shows that palynology provides useful data for intrageneric class of the large genera of talineae on pollen morphology.Nyayanyo and olowokudejo (1986) also use seed coat morphology of *Talinum*and *Calandrinia*to produce more acceptable classification of the species in these taxa.

Similarly, Edeoga and Gomina (2001) have utilized pollen attributes to establish probable evidence of relationship between certain flowering plants in Nigeria. Edeoga and Ikem (2002*)* characterize*Boerhavia coccinea* by tricolpate pollen while *B.ejecta* and *B.diffusa* have alcopate pollen grains hence *B.cocceniac*ould be distinguished from other Nigerian collections of *Boerhavia* based on pollen character the variation in shape aperture, polar units' difference in wall sculpture of pollen grains have been used by many authors in the delimitation of various taxa (Edeoga *et al*.,1996,Angeles,1992,Mbagwu and Edeoga,2006).Morphometric studies have great importance and play significant role in distinct grouping or segregation of closely associated species.The significance of pollen morphology in the delimitation of various taxa and its importance to evaluate the systematic position of some species of Leguminosae including the genus *Cassia sensulato*have been provided by many authors such as Erdtman (1952) and El Ghazali (1989). Perveen and Qaiser (1998), studying the pollen grains of the subfamily Caesalpinioideae in Pakistan, concluded that the pollen morphology of the subfamily is significantly useful at the generic and specific levels. They recognized three pollen types on the basis of apocolpium, mesocolpium and tectum features.

Principal co-ordinate analysis and cluster analysis have also been found to producehierarchical classification of entities based on similarity matrix, distance matrix and dendrogram as Some studies have been performed ingenus,for example*Ficus* L. (Sonibare *et al*., 2004), *Acalypha* L., *Senna Mill*., *Indigofera*L. (Soladoye *et al*., 2010) and *Cassia*L., *Exacum* L., *Clerodendrum* L., *Caesalpinia* L. (Deshmukh *et al*., 2011, 2012, 2013) by taking an account of the morphological quantitative characters only.ChromosomalStudies also was carried out on karyotic and meiotic behavior and Studies of European populations as reported byDarlington and Wylie (1945) during the 30^{th} and 40^{th} of the last century indicated that the chromosome number of *S. occidentalis* was either 26 or 28. While Biondo *et al*. (2005) found only 2n= 28 chromosomes in populations native from the South of Brazil, while Castro *et al*. (2006) showed intraspecific variability (2n=26and2n= 28) in accessionsfrom the same region which agrees with Darlington and Wylie(1945).Chromosomenumbers in*Senna*species are usually 2n = 22, 24, 26 and28 (Biondo*et.al*, (2002); Souzaand Benko-Iseppon (2004). The basic number forthe genus is accepted to bex=14, however considered as a polyploid derivative ofx=7which isthe basic number for the subfamily Caesalpinioideae. The additional basic numbers ofx=13,12and 11, would have been derived by disploidyduring the evolutionary process (Goldblatt,1981).

2.4TheSeed Coat Structure

The seed coat (often referred to as testa) is the outer covering of every mature seed. It is therefore the main modulator of interactions between the internal structures of the seed and the external environment. Most seed coats exhibit complex and highly diverse morphology and anatomy, providing valuable taxonomic characters (Barthlott, 1981, 1990). These characters, especially the microstructural features of the seed

surface, can be useful for assessing phenetic relationships and delimiting taxa at various levels (Karcz *et al*., 2000).For a long time micrography of seedcoats was considered to be a conservative character of limited functional value; but with the advent of Scanning Electron Microscope SEM, studies of surface features of biological materials have gained impetus and the data so obtained have been utilized for taxonomic purposes and evolutionary interpretation(Heywood, 1971).

Recent SEM studies in seedcoats of leguminous plants reveal substantial diversity in topography (Brisson and peterson, 1976). Seed coat pattern of leguminous taxa studied by SEM need classification purpose mostly at or above the special level (Newell and Hymohitz, 1978) they have also been employed as genetic markers in hybridization programmes. A characteristic feature of Fabaceae is capacity to fixthe atmospheric nitrogen (N_2) by means of symbiosis with the nitrogen fixing bacteria. Therefore, these plants play an important ecological role. Woody legume seeds often poseimpermeable seed coats which require treatment before germination can take place, asit prevents water uptake, gaseous exchange and radicle emergence (Aguinagalde *et al.*, 1990).Scanning Electron Microscopy is apowerful tool to achieve more accurate seed identification, and could be used as a routine technique in study of the spermoderm morphology (Brisson andPeterson,1976).

Micro morphological features of seeds have long been employed as important tools in various scientific studies (Heywood,1971). However, most of the light microscopic features used are concerned with general shape and size rather than details of surface ornamentation (Dhara *et al*., 2011). Scanning Electron Microscope (SEM) provides deeper insight where gross morphology proves insufficient to analyse seed coat structure and surface sculpture.Seed characteristics,particularly exomorphicfeatures revealed by means of Scanning Electron Microscopy (SEM), have been used in

resolving problems of systematicof species by authors such as (Koul *et al*., 2000; Javadi, 2004) and evolutionary relationships by (Segarra and Mateu, 2002). Previous studies carried out on the Fabaceae family by scientists such as(Mallick *et al*. 2003; Johnson *et al*., 2004; Salimpour *etal*., 2007; Hosseinzadeh *et al*.,2008; Al-Ghamdi and Al-Zahrani, 2000; Ozbek *et al*., 2014; Kahraman *et al*., 2014)reported that the spermoderm characteristics are genetically determined and are the main source of intra or interspecific variation.

Morphological characteristics and SEM patterns of seed coat and leaf were described in seven taxa of genus Colutea (Pooyam, 2014). It was found that the discriminating seed characters by taxonomic entities were seed size, general shape, location of hilum, legume size and also leaf surface and microscopic texture of seed coat. In *Brassica*species, relatively numerous report concerning the seed coat structure have been published(Setia and Richa, 1989; Ren and Bewley, 1998).

Several recent studies of different seed coat characters have employed Scanning Electron Microscopy (SEM). For example, Koul *et al*. (2000) gave detailed descriptionsof seed morphology in 44 species of the subtribes Brassicinae, Raphaninae and Moricandiinae, and elucidated the phylogenetic relationships between taxa. More recently, Zeng *et al*. (2004) examined testa topographic patterns during seed development in the cultivated forms of these species. Gunn (1991) provided a morphological description of seeds including lens (which is a part of seed coat but modified) data for 148 species in the Caesalpinioideae. He reported that lens shapes were categorized as circular, elliptic, irregular, linear, oblong, punctiform, square, triangular or wedge shaped; the lens may be raised (a mound), flush or recessed. Hamly (1932) reviewed the structure of the legume seeds with emphasis to the role of the lens. He recorded that hard seeds of legumes become permeable

through the propensity of the lens palisade to split under pressure. Staden *et al*. (1989) reported that the lens is the limiting inbuilt point of weakness in absolutely hard seeds but the lens and testa should be regarded as an integrated system.Sahai (1999) investigated the details of structural diversity of lens in 14 species of *Cassia* in relation to taxonomic significance. She recorded that each species is characterized by its own lens. Moreover, shape, size and position of the lens in each species are genetically constant and serve as distinction from allied species of same genus. Sahai *et al*. (1997) carried out the macro- and micro morphology of seeds of 21 *Cassia* species and showed large variation in seed morphology.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Study Site

This research was carriedout at the Botany Department, Ahmadu Bello University (A.B.U.), Zaria (Altitude 610m above sea level, latitude 90˚2¹ to11˚32¹N and longitude 96º15¹'E to 98º60¹ E), Nigeria. Samaru lies in the Northern Guinea Savanna agro ecological zone of Nigeria with a mean annual rainfall of about 1100m. Rainfall is essentially between April - October and dry season between October -March. Hottest month is around March - April, and the mean daily Temperature is about 27^0C. The coldest Month is between November – Mid February (Geography Department, ABU, Zaria, 2018).

3.2 Plant Collection

Seven species of *Senna* were studied which include *Senna alata* (L.) Roxb., *S. hirsutae*(L.) Irwin and Barneby, *S. obtusifolia* (L.)Irwin and Barneby, *S. occidentalis* (L.)Link, *S. siamea* (Lam.) Irwin and Barneby, *S.singueana*(L),*S.siberiana*(L) and *C.absus*.The species were collected from different locations within the university premises.The names of the species and coordinates are provided in the table below;

Table 3.1: Location of *Cassia* and *Senna* species collected within Ahmadu Bello University, Zaria in 2016.

	Name of Taxa	Longitude	Latitude	Voucher Number	Site of collection
1	*Senna alata*	E007˚ 38.23	N11˚ 09.39	1236	Botanical Garden, ABU, Zaria.
2	*Senna siberiana*	E007˚ 39.40	N 11˚ 08.62	900218	Botanical Garden, ABU, Zaria.
3	*Senna obtusfolia*	E007˚ 38,79	N11˚ 09. 07	1370	ABU Press, Zaria.
4	*Senna hirsutae*	E007˚ 38.78	N11˚ 09. 22	7174	ABU Water Board, Zaria.
5	*Senna siamea*	E007˚ 36. 84	N11˚ 09. 39	900202	Botanical Garden, ABU, Zaria.
6	*Senna singueana*	E007˚ 39. 40	N11˚ 08.63	900109	Botanical Garden, ABU, Zaria.
7	*Senna occidentalis*	E007˚38. 84	N11˚ 09.06	1047	ABU Waterboard, ABU, Zaria.
8	*Cassia absus*	E007˚ 38.85	N11˚ 09.07	3106	ABU Press, ABU, Zaria.

3.3.1 Foliar Morphology

Fifty (50) samples of matured leaf per species was used for assessment of morphological character. Characters such as leaf texture, leaf shape, leaf base, leaf apex and leaf margin was observed and. Photomicrographs were taken using a Samsung HD camera model.

3.3.2Stomatal Study

The method of Pant and Verma (1974) was adopted for the stomatal and trichome studies. Fresh foliar materials were collected from mature plants in the study area. The leaves were fixed in 50ml formalin acetic alcohol (FAA) for 24 hours and washed in 70% ethanol. For mature stomatal types study, epidermal peels were obtained using a pair of sharp forceps on both surfaces of mature leaves after loosening the epidermis with a razor blade. The peels were placed on a microscope slide and stained with methylene blue and covered with a clean cover slip and observed under the microscope. Characters of upper epidermal cell number, lower epidermal cell number, upper epidermal cell pattern, lower epidermal cell pattern, stomata type, stomata number on both epidermal cell surfaces, stomata length on both surfaces, stomata width on both surfaces, stomata size on both surfaces and frequency were observed, measured and then multiplied by the calibration factorbefore recording. In addition, trichome type, number, length, width and size were observed, measured and recorded using a calibrated eye piece micrometer from 50 different epidermal cell peels. Photomicrograph was taken using a Samsung HD camera model A4CDNOC7000RDZ attached to a light microscope.

3.3.5Internal Anatomy

Histological technique as described by Drury and Wallington, (1980) was adopted. Small part of the leaf was fixed in Formalin Acetic Acid for 24 hours after which it was dehydraded in graded alcohol 30%,50%,70%,95% and absolute alcohol for 2 hours each then cleared in a mixture of alcohol and chloroform at different concentrations each for another 2 hours then left in pure chloroform overnight. Infiltration was then done wherelittle chips of paraffin wax was added at a time until it gels and kept in an open place until smell of the chloroform was no longer felt in the preparation. More chips of paraffin wax were added for 24 hours. This was then embedded into transverse section, trimmed and made into ribbons then mounted on the slides. Slides were dewaxed in xylene for 5 minutes and hydrated in absolute alcohol for 2 minutes,95%,70%,50% and 30% alcohol also for 2 minutes each and washed in water, then transferred into safranin stain for 30 minutes, washed again in water for 2 minutes before Counter staining in fast green stain for 2 minutes, washed in water for another 2 minutes and dehydrated in 30%,50%,70%, 95% and absolute alcohol 4 minutes.

Finally, the stained tissues were cleared in xylene for 2 minutes.The stained tissues were then mounted on a microscopic slides and sealed with Canada balsam. The slides were dried on slide drier until they are well dried then observed under the microscopeCharacters such as number of palisade cells, number of spongy cells, vascular bundles number were counted and recorded while other characters such as length and width of palisade and spongy cells, width of epidermal cells and distance between the lower and upper epidermis were measured with calibrated microscope and recorded.

3.4Palynological Studies

For palynological studies, acetolysis technique as described by Erdtman (1952) wasadopted, Flower buds of the different species of *Senna*and *Cassia*were collected in September,2015 except for *Senna siberiana* which was collected in March,2016 and placed separately in specimen bottles. 10ml of glacial acetic acid was added to each specimen bottle and taken to the laboratory. These flower buds were obtained within the University premises (Table 3.1). Flower buds in the specimen bottles was teased and transferred into a hand driven centrifuge machine and centrifuge slowly. The glacial acetic acid was then decanted after centrifuging and 5ml of acetolysis mixture (mixture of glacial acetic acid and concentration of H_2SO_4 (9:1) was added into a new centrifuge tubes.)

A glass rod was inserted into each tube stirred and transferred to a water bath.The tubes were heated at a temperature of 80^0C. Heating was stopped immediately when boiling point was reached. The mixture was then stirred. The tubes were transferred to a centrifuge machine and centrifuge at 2500 rpm for 5 minutes again. Reaction mixture was decanted and 10ml of water was added to the sediment. The tubes were shaken thoroughly until the mixture foams. The foam was removed by adding few drops of alcohol and centrifuged again and decanted. After decanting, the sediment was suspended in a few drops of a mixture of glycerine (10ml) and water (10ml) and left for 24 hours.The suspension was drained on a filter paper. A minute piece of glycerine jelly was fixed on a needle and allowed to touch the surface of the pollen bearing sediment. The jelly and the poliniferous material sticking to it were transferred to a slide and the pollen grains (after gentle heating to remove air bubbles) were examined under the microscope, sealing was done with colorless nail polish whereby a drop was transferred by means of hair brush to the margin of the covers

slip.The slide was turned upside down to allow the pollen grain and pollen fragment to settle on or near the cover slip. Characters such as pollen number, pollen length, pollen width of 30 pollen grains for each species collected from the study area was recorded. Calibrated microscope was used to measure pollen length and width.

3.5Scanning Electron Microscope Studies of seedcoat *Senna* and *Cassia* species

Air-dried, ripe, turgid seeds from natural population within the university premises were selected at random, cleaned in an ultrasonic cleaner for 10mins, fixed to specimen stubs with an adhesive and placed on a revolving disc of Joel Fine Coat Ion sputter (Joel, JFC 1100). Each seed was uniformly coated with 5nm thick gold. Specimen stubs were then fixed to the specimen holder of the SEM (Joel, JSM 840) and maintained at an acceleration potential of 10kv for 5seconds. The photomicrographs were taken. Characters such as seed color, seed shape were observed and noted down then seed coat sculpture was also taken using the camera attached to the machine.

3.6 Statistical Analyses

From the result, the means of all the characters were statistically compared by subjecting their replicated values to one-way ANOVA and thereafter, Duncan's Multiple Range Tests using 20.0 version of the computer–based SPSS to separate the means. Those characters whose means showed significant differences from these discriminant analyses at p 0.05 were regarded as being diagnostic among the species and were used to define homogenous groups within the genus. Standard deviation was calculated and a dendogram was plotted using SAS 9.1.3 to further delimit the species.

CHAPTER FOUR

4.0 RESULTS

4.1 Morphological Features of Studied species

The leaf morphological variation of all plants species are shown where The apex of the leaf was round in *S. alata* and acuminate in *Senna occidentalis*. Habit was all shrubby except *S. alata* and*S. siamea* that were eithershrubby or trees. The leaf shape was ovate in most species except *Senna siamea* that was linear. Leaf base was either acute or obtuse (Table 4.1). All studied species were amphistomatic, meaning stomata occurs on both surfaces.The stomata varied among the species with paracytic occurring in all except *Sennasiamea* and *Cassia absus*where only anisocytic stomata was observed. Both paracytic and anisocytic stomata were observed in the abaxial surface of *Senna alata,Sennaoccidentalis* and *Senna obtusfolia*(Table 4.2).

The epidermal cell shape found in the species was polygonal except in *Senna alata* and *Sennahirsutea* where irregular pattern was observed. Anticlinal wall found was wavy to straight in the studied species except *Senna siamea*that wasfound to becurved. The seed properties were also considered where the seed color varied, seed texture was smooth except in *Senna alata* and *Senna singueana*that were rough textured (Table 4.3).

Table 4.1: Leaf Morphological features of*Senna* and *Cassia*Species Studied in Ahmadu Bello University, Zaria in 2016

S/N	Taxa	Apex	Shape	Base	Habit	HausaName
1	*S.alata*	Round	Oblong	Oblong-Obov	Shrub/tree	Claskonbature
2	*S. siberiana*	Obtuse	Oblong	Round	Shrub	Gamafada
3	*S.hirsutae*	Acute	Ovate	Acute	Shrub	Asuta
4	*S.singueana*	Round/obtuse	Ovate	Obtuse	Shrub	Runhu
5	*S.siamea*	Micronulates	linear	Obtuse	Tree	Runhunbature
6	*S. obtusfolia*	Obtuse	Obovate	Acute	Shrub	Tafasa
7	*S.occidentalis*	Acuminate	Ovate	Acute	Shrub	Rai dore
8	*C.absus*	Obtuse	Ovate	Round	Shrub	Pidili

Table 4.2 Epidermal characters in *Senna* and Cassia species in Ahmadu Bello University, Zaria in 2016

S/N	Taxa	Epidermal cell shape		Anticlinal wall shape		Stomatal type	
		Adaxial	Abaxial	Adaxial	Abaxial	Adaxial	Abaxial
1	*S. alata*	Polygonal	Irregular	Straight	Curved	Anisocytic	Paracyticand anisocytic
2	*S. siberiana*	polygonal	Polygonal	Curved	Curved	Paracytic	Paracytic
3	*S. hirsutae*	Polygonal	Irregular	Wavy	Curved	Paracytic	Paracytic
4	*S. siamea*	Polygonal	Polygonal	Wavy	curved	Anisocytic	Anisocytic
5	*S. singueana*	Polygonal	Polygonal	Wavy	Straight	Paracytic	Anomocytic
6	*S. obtusfolia*	Polygonal	Polygonal	Wavy	Straight	Paracytic	Paracytic and anisocytic
7	*S. occidentalis*	Irregular	Polygonal	Wavy	Curved	Paracytic	Anisocytic and paracytic
8	*C. absus*	polygonal	Polygonal	Curved	Irregular	Anisocytic	Anisocytic

Table 4.3: Seed coat propertiesof *Senna* and *Cassia species* in Ahmadu Bello University, Zaria in 2016

S/N	Taxa	Seed color	Seed shape	Seed texture
1	*S. alata*	Dark brown	Rhomboidal	Rough
2	*S. hirsutae*	Grey brown	Oval	Smooth
3	*S. singueana*	Black	Oval	Rough
4	*S. siamea*	Brown	Bean shaped	Smooth
5	*S. occidentalis*	Brown	Oval	Smooth
6	*S. obtusfolia*	Green	Oval	Smooth
7	*S. siberiana*	Brown	Oval	Smooth
8	*C. absus*	yellow	Kidney shaped	Smooth

4.2 Epidermal Cell Features of *Senna*and *Cassia* species

The histology of epidermal cells of *Senna* and *Cassia* species is shown in Table 4.4. The Palisade Cell Number (PCN) was found to be highest in *S. hirsutae* (39.20μm) and *C. absus* (20.80μm) was the least respectively. The Palisade Cell Length (PCL) washighest in *S. siberiana* (88.88μm) and the lowest value was in*S. siamea* (12.56μm)

The widestin Palisade Cell Width was found in*S. alata* (9.78μm) and the narrowest was in *S. siamea* (3.11μm). There was no significant difference in Spongy Cell Number which was highest in*S. alata* (67.05μm) and *C. absus* (37.65μm) recorded the lowest value in SCN.

There was no significant difference in Spongy Cell Length (SCL). The longestSCL was observed in*S. obtusifolia* (25.25μm) and the narrowest in*S. singueana* (12.56μm). The Spongy Cell Width was also widest in *Senna alata* (10.88μm) and *S. siamea* (4.66μm) had the narrowest. The Epidermal Cell Thickness (ECT) was thickest in*C. absus* (28.88μm) and the thinnest in *Senna siberiana* (6.35μm) respectively. The Epidermal Cell Width upper (ECW) was widest in *S. siberiana* (20.07μm) while the Vascular Bundle Number (VBN) was highest in*S. hirsutae* (7.80μm).

Table 4.4: Epidermal cells features of *Senna* and *Cassia* species in Ahmadu Bello University, Zaria in 2016.

S/N	Plant species	PCN	PCL	PCW	SCN	SCL	SCW	ECT	ECW	ECL	VBN
1	*Senna obtusfolia*	29.75±1.21^{d}	54.51±1.27^{c}	9.07±0.33^{ab}	57.25±3.48^{b}	25.25±1.31^{a}	6.67±0.25^{d}	15.15±0.54^{d}	3.95±0.20^{c}	4.39±0.18^{c}	3.60±0.25^{d}
2	*Senna siamea*	32.35±1.14^{cd}	12.56±0.38^{e}	3.11±0.15^{d}	42.45±1.27^{cd}	14.63±0.57^{cd}	4.66±0.65^{e}	20.85±0.93^{bc}	3.11±0.15^{c}	3.11±0.15^{d}	4.50±0.24^{cd}
3	*Senna singueana*	33.70±1.1^{bcd}	15.28±0.56^{e}	6.48±0.25^{c}	48.65±1.23^{c}	12.56±0.51^{d}	5.83±0.24^{d}	22.53±0.96^{b}	3.43±0.14^{c}	3.43±0.14^{d}	4.80±0.21^{c}
4	*Senna occidentalis*	29.65±1.47^{d}	41.57±1.83^{d}	6.22±0.28^{c}	48.75±2.25^{c}	24.99±1.23^{a}	8.48±0.38^{bc}	19.17±0.69^{c}	4.01±0.25^{c}	4.73±0.22^{bc}	4.75±0.22^{c}
5	*Senna alata*	34.35±1.76^{bc}	37.81±1.09^{d}	9.78±0.44^{a}	67.05±2.55^{a}	21.43±0.92^{b}	10.88±0.51^{a}	8.74±0.54^{e}	10.94±0.78^{b}	0.00±0.00^{e}	0.00±0.00^{e}
6	*Senna siberiana*	37.80±0.84^{ab}	88.84±2.32^{a}	8.29±0.34^{b}	42.00±1.17^{d}	16.58±0.58^{c}	8.09±0.40^{c}	6.35±0.26^{e}	20.07±0.56^{a}	14.50±0.44^{a}	6.00±0.36^{b}
7	*Senna hirsutae*	39.20±2.31^{a}	62.42±2.50^{b}	8.61±0.33^{b}	63.75±2.72^{a}	21.37±1.01^{b}	9.26±0.33^{b}	7.64±0.63^{e}	0.00±0.00^{d}	14.57±0.73^{a}	7.80±0.62^{a}
8	*Cassia absus*	20.80±0.75^{e}	53.10±1.44^{c}	9.13±0.33^{ab}	37.65±1.81^{d}	23.83±0.99^{ab}	6.67±1.21^{d}	28.88±1.80^{a}	3.56±0.21^{c}	5.37±0.17^{b}	4.20±0.32^{cd}

Means with different superscripts along the column differed significantly ($P < 0.05$)

Key:

PCN=Pallisade Cell Number,PCL=Pallisade Cell Length, PCW=Pallisade Cell Width, SCN=Spongy Cell Number,SCL=Spongy Cell Length, SCW=Spongy Cell Width, ECT=Epidermal Cell Thickness, ECL=Epidermal Cell Length, VBN=VascularBundlesNumber ,±= Plus or minus standard error

4.3 Distribution of Trichome in the Leaves of *Senna*and *Cassia* Species

The trichrome distribution is shown in table 4.5, with the micrographs in plates 7a-10b. There was presence of non-glandular unicellular and unbranched trichome in all species except *S. obtusfolia* which had multiseriate trichomes.*S. siberiana* (83.85μm) had significant number per field of view in the upper surface and the least number was in *S. alata* (25.90μm). There was significant difference in length in the upper trichrome which was longest in *S. singueana* (25.13μm) and the shortest was in *S. siamea* (0.50μm).The trichome width was widest in *S. alata* (4.55μm) and narrowest in *S.siberiana* (1.68μm).

There was significant difference in the number per field of view in the lower trichome surface as *S. singueana* had a highest number of non-glandular unicellular unbranched trichrome recording (80.80μm). The least was recorded in *S. siamea* (3.74μm). Length was found to be longest in *Cassia absus*(24.57μm) and*S. siamea* (5.32μm) recorded the shortest length in the lower surface. The width was widest in *S. alata* (4.34μm) and*S. obtusfolia* (0.53μm) recorded the narrowest width.

Table 4.5: Distribution of Trichome in the Surfaces of *Senna* and *Cassia* Species in Ahmadu Bello University, Zaria in 2016

			UNICELLULAR			MULTICELLULAR		
S/N	Plant species	Surfaces	NPV	LT	WT	NPV	LT	WT
1	*S. obtusfolia*	Upper	14.70±1.72^{d}	18.31±2.38^{bc}	4.45±1.49^{a}	1.35±0.68^{c}	3.78±1.74^{bc}	0.81±0.35^{b}
		Lower	20.65±2.07^{c}	22.61±3.85^{a}	1.89±0.13^{bc}	2.05±1.11^{e}	6.58±2.65^{d}	0.53±0.23^{c}
2	*S. siamea*	Upper	20.95±2.74^{cd}	10.5±0.98^{d}	2.00±0.17^{b}	ND	ND	ND
		Lower	3.74±1.61^{e}	5.32±1.53^{c}	0.91±0.25^{d}	ND	ND	ND
3	*S. singueana*	Upper	46.80±1.88^{d}	25.13±2.00^{a}	2.42±0.13^{b}	ND	ND	ND
		Lower	80.80±3.53^{a}	22.68±1.87^{a}	1.96±0.11^{b}	ND	ND	ND
4	*S.occidentalis*	Upper	ND	ND	ND	ND	ND	ND
		Lower	11.10±0.73^{d}	19.18±1.27^{b}	3.96±0.15^{a}	ND	ND	ND
5	*S. alata*	Upper	25.90±2.63^{c}	20.65±1.05^{abc}	4.55±0.22^{a}	ND	ND	ND
		Lower	26.60±2.23^{b}	16.38±0.87^{b}	4.34±0.25^{a}	ND	ND	ND
6	*S. siberiana*	Upper	83.85±4.43^{a}	17.50±1.20^{c}	1.68±0.07^{c}	ND	ND	ND
		Lower	47.65±3.60^{a}	14.84±0.88^{c}	1.47±0.05^{b}	ND	ND	ND
7	*S.hirsutae*	Upper	14.70±1.89^{d}	22.89±2.31^{ab}	1.71±0.19^{b}	ND	ND	ND
		Lower	12.90±1.22^{d}	22.61±2.08^{a}	1.51±0.12^{c}	ND	ND	ND
8	*C. absus*	Upper	39.9±3.34^{b}	15.75±0.99^{c}	1.96±0.15^{b}	ND	ND	ND
		Lower	40.6±1.55^{b}	24.57±1.48^{a}	1.79±0.19^{b}	ND	ND	ND

Means with different superscripts along the column differed significantly($P < 0.05$)

KEY;

NPV=Number per view, LT=length, WT=width, ± Plus or minus standard error, ND= not detected

4.4 Distribution of Stomata in the Leaves of *Senna* species

The components of stomata in various sampled species of plants are shown in Table 4.6, with the micrographs in plates 1a-6b. *S. obtusifolia* (25.60μm) had the highest number with*C. absus* (11.05μm) been the least in the upper surface respectively. In the lower surfaces, *S. hirsutae* (42.75μm) recorded the highest NPV value and the least was *S.siberiana (3.12-0.02*μm*). Senna siberiana*(166.95μ) had highest NE contents in the upper surfacewhere *C. absus* (51.05-1.92μm) recorded the lowest. The number of epidermal cell in lower surfaces of plants species was highest in *S. siamea* (162.40μm) and the least in *C. absus* (70.9-1.96μm). Upper surfaces of *S. hirsutae* (6.00μ) had the longest SL while *S. siamea* (4.20μm) had the least. *Senna hirsutae* (2.22μ) recorded significantly longest SL also in the lower surface while *S. siamea* (1.32μm) recorded the least.

There was no significant difference in SW value in the lower leave surfaces of all the sampled plants species.The widest and the narrowest Stomatal width (SW) value was obtained in *S. hirsutae* (1.51μm) and *S. obtusifolia* (0.85μm) respectively. The Pollen length (PL) value of the upper leave surface was longest in *C. absus* (3.05μm) while *S. siamea* (1.80μm) had the least. Similarly, Pollen length concentration in the leave lower surface did not differ significantly among the plants species; *S. occidentalis* (1.42μm) was the longest, while *S. alata* (0.83μm) had the shortest.

The Pollen width (PW) value in the upper surface was widest in *S. singueana* (3.83μm) with *S. siamea* (1.15μm) having the narrowest. PW value in lower surfaces of plant species did not differ significantly.

The widest and the narrowest SW value was obtained in *S. hirsutae* (1.51μm) and *S. obtusifolia* (0.85μm) respectively. The PL value of the upper leave surface was longest in *C. absus* (3.05μm) while *S. siamea* (1.80μm) had the shortest. Similarly, PL concentration in the leave lower surface did not differ significantly among the plants species; *S. occidentalis* (1.42μm) was the widest, while *S. alata* (0.83μm) had the least.

The pollen width value in the upper surface was widest in *S. singueana* (3.83-0.17μm) with *S. siamea* (1.15μm) having the narrowest. PW value in lower surfaces of plant species did not differ significantly.

Stomatal size of the upper surface of *S. occidentalis* (21.42μm) was biggest and *S. siamea* (9.68μm) had the smallest Stomatal size. The Stomatal size in the lower surface was biggest in *S. hirsutae* (340-0.21μm) and the smallest Stomatal size value was obtained in *S. obtusifolia* (1.36μm).The upper surface pollen size of *S. hirsutae* (4.80μm) was biggest. The pollen size of the all the lower leave surfaces of plants species did not differ significantly but it was largest in *C. absus* (0.78μm), while *S. alata* (0.32μm) had the lowest value

Table 4.6: Distribution of Stomata in the Leave Surfaces of *Senna and Cassia* Species in Ahmadu Bello University, Zaria, 2016

S/N	Plants species	Surfaces	NPV	NE	SL(µm)	SW(µm)	PL(µm)	PW(µm)	S-Size(µm)	P-Size(µ)
1	*S. obtusfolia*	Upper	25.60±2.02^{a}	141.25±7.08^{b}	4.83±0.25^{c}	2.60±0.14^{de}	2.35±0.13^{c}	1.40±0.09^{bc}	13.34±1.21^{c}	3.33±0.35^{b}
		Lower	18.55±1.56^{bc}	126.15±1.80^{b}	1.56±0.09^{d}	0.85±0.04^{a}	0.99±0.07^{a}	0.34±0.00^{b}	1.36±0.12^{c}	0.33±0.02^{c}
2	*S. siamea*	Upper	20.40±1.92^{ab}	153.80±7.71^{ab}	4.20±0.26^{d}	2.25±0.18^{e}	1.80±0.14^{d}	1.15±0.05^{c}	9.68±1.31^{c}	2.06±0.20^{c}
		Lower	18.35±2.30^{bc}	162.4±4.69^{a}	1.32±0.09^{e}	1.32±0.51^{a}	1.22±0.51^{a}	0.37±0.02^{b}	1.94b±0.88^{bc}	0.44±0.88^{a}
3	*S. singuena*	Upper	10.15±0.60^{c}	83.95±4.59^{d}	1.87±0.07^{e}	1.36±0.10^{f}	5.52±0.32^{a}	3.83±0.17^{a}	2.13±0.18^{d}	0.22±0.02^{d}
		Lower	4.05±0.36^{d}	85.79±2.49^{d}	1.70±0.07^{c}	0.86±0.05^{a}	0.71±0.02^{a}	0.39±0.02^{b}	1.39±0.14^{c}	0.26±0.02^{d}
4	*S. occidentalis*	Upper	25.85±2.88^{a}	155.9±9.19^{ab}	5.75±0.16^{ab}	3.70±0.15^{a}	2.75±0.14^{bc}	1.48±0.09^{b}	21.42±1.15^{a}	4.07±0.35^{ab}
		Lower	22.85±1.76^{b}	158.1±7.62^{a}	1.96±0.06^{bc}	1.39±0.07^{a}	1.42±0.50^{a}	0.54±0.05^{a}	2.72±0.16^{bc}	0.68±0.16^{a}
5	*S. alata*	Upper	19.25±1.43^{b}	145.5±9.64^{ab}	5.35±0.20^{bc}	3.13±0.17^{bc}	2.50±0.13^{c}	1.30±0.08^{bc}	16.95±1.25^{b}	3.31±0.34^{b}
		Lower	22.35±1.64^{b}	107.45±6.51^{c}	1.9±0.06^{c}	1.09±0.05^{a}	0.83±0.04^{a}	0.38±0.02^{b}	2.12±0.13^{bc}	0.32±0.13^{c}
6	*S. siberiana*	Upper	20.20±1.07^{ab}	166.95±7.88^{a}	5.05±0.15^{c}	2.55±0.14^{de}	2.63±0.17^{bc}	1.18±0.08^{c}	13.05±0.91^{c}	3.30±0.48^{b}
		Lower	3.12±0.02^{e}	79.34±3.54^{e}	1.53±0.05^{d}	0.72±0.04^{a}	0.57±0.01^{a}	0.34±0.01^{b}	1.04±0.10^{d}	0.24±0.01^{d}
7	*S. hirsute*	Upper	21.55±1.90^{ab}	105.20±3.06^{c}	6.00±0.18^{a}	3.48±0.19^{ab}	3.00±0.14^{b}	1.55±0.10^{b}	21.33±1.63^{a}	4.80±0.46^{a}
		Lower	42.75±1.87^{a}	126.60±9.25^{b}	2.22±0.08^{a}	1.51±0.07^{a}	1.16±0.05^{a}	0.57±0.05^{a}	3.40±0.21^{a}	0.69±0.08^{a}
8	*C. abrus*	Upper	11.05±0.45^{c}	51.05±1.92^{e}	5.65±0.17^{ab}	2.95±0.15^{cd}	3.05±0.14^{b}	1.30±0.08^{bc}	16.90±1.19^{b}	4.03±0.37^{ab}
		Lower	15.25±0.73^{c}	70.9±1.96^{d}	2.14±0.08^{ab}	1.12±0.07^{a}	1.16±0.07^{a}	0.53±0.06^{a}	2.52±0.24^{abc}	0.78±0.24^{a}

Means with different superscripts along the column differed significantly (P<0.05)

KEY;

NPV=NumberPerView,S-Size=Stomatal Size,P-Size=Pore size,NE=Number of Epidermal Cell,SL=Stomal length,PW=Porewidth ,SW=Stomatal width,PL=Pore length,± Plus or minus standard error

4.5 Pollen Grain features in*Senna*and *Cassia* species in Amadu Bello University, Zaria in 2016

Table 4.7 shows the distribution of pollen grain per sampled plants with the micrographs in plates 14-17. There was significant variation in pollen grain distribution among the sampled plants species. The number per field of view (NPV) was significantly largest in *S. singueana* (45.85μm) while *S. siberiana* (8.65μm) had the lowest. The Length (L) of pollen grain in *S. singueana* (27.20μm) was longest while *C. absus* (1.58μm) had significantly lowest length.*S. occidentalis* (9.40μm) had the widest width among the species and the narrowest was that of *C. absus* (1.04μm).

Table 4.7: Pollen Grain features in *Senna* and *Cassia* species in Ahmadu Bello University Zaria in 2016

S/N	Plant species	NPV (Mean±SE)	L (Mean±SE)	W (Mean±SE)
1	*Senna obtusifolia*	8.70±0.51^{e}	2.94±0.16^{cd}	7.58±0.46^{bc}
2	*Senna siamea*	20.50±1.23^{c}	3.29±0.05^{cd}	9.15±0.18^{a}
3	*Senna singueana*	45.85±2.21^{a}	27.20±0.64^{a}	6.65±0.34^{c}
4	*Senna occidentalis*	18.05±1.61^{c}	3.67±0.64^{c}	9.40±0.43^{a}
5	*Senna alata*	31.95±1.97^{b}	2.59±0.34^{d}	4.45±0.25^{d}
6	*Senna hirsutae*	16.65±1.66^{cd}	2.82±0.11^{cd}	6.85±0.27^{c}
7	*Cassia absus*	13.25±0.89^{d}	1.58±0.07^{e}	1.04±0.08^{e}
8	*Senna siberiana*	8.65±0.42^{e}	10.88±0.58^{b}	7.91±0.35^{b}

Means with different superscripts along the column differed significantly ($P < 0.05$)
Key:
NPV=Number Per View, L=Length, W=Width, ± Plus or minus standard error.

4.6 Seed Coat Studies in *Senna*and *Cassia*Species found in Ahmadu Bello University,Zaria in 2016

Images obtained from the scanning electron microscope (SEM) at different levels of magnification for*Senna* and *Cassia*species seed coat without treatment is shown in Plates 4.1-4.8. The major differences in the two generic seed coat noted was the pattern of cracks which differed among the species. Arrows indicate the cracks and point of attachment on the surface of the seed coat.The cellular shapes may be of considerable diagnostic and systematic advantage. Epidermal cells of seed coats of the sampled *Senna* species exhibited random arrangement or arrangement in parallel rows. They exhibit cracks arrangement in parallel rows in the following species:*Senna alata* and *Senna siamea*, while others were randomly cracked as observed in*Senna siberiana* and *Senna occidentalis*. Most of the cracks in *Senna alata* had their origin from point of attachment (hilum) with other branches coming out in the same pattern. The parallel cracks arrangements in *Sennasiamea* were interconnected with one another. *Senna siberiana* pattern was distinct with one major crack in which some branches interconnected in random arrangement. *Senna occidentalis* had major cracks that were connected by minor cracks in somewhat parallel pattern.

The crack shapes in *Senna obtusifolia* was parallel but has branches at each major crack. The smaller branched cracks in *S. obtusifolia* were consistent on all the major ones and had the characteristics of branching also. *Senna singuena* had only one major crack on its entire surface with a point of attachment (hilum) on it. There was no crack on the surfaces of *Cassia absus* and *Senna hirsutae*. The former had some gyrated pattern on its seed coat, while the later was generally rough and uniform.

The variations among the species was used to construct the dichotomous Taxonomic key below;

1Trees-----2

1. Shrubs-----4

2.Leaflets linear------ *Senna siamea*

2.Leaflets ovate------3

3.Seed colour black----- *Senna singueana*

3.Seed colour white-----4

4.Fruit hairy------ *Senna hirsutae*

4.Fruit not hairy----5

5.Seed obovate------ *Cassia absus*

5.Seed Oval-------6

6. Abaxial Trichomes glandular and multicellular----7

6.Adaxial Trichomes non glandular and multiseriate------*Senna obtusfolia*

7. Adaxial Trichomes non glandular and unicellular------ *Senna alata*

7.Adaxial Trichomes and glandular multicellular-----8

8.Abaxial Stomata anomocytic-------9

8.Adaxial and Abaxial Stomata paracytic----*Senna siberiana*

9.Epidermal cell irregular

9.Epidermal cell polygonal--------*Senna occidentalis*

Dendogram of the morphological characters placed the species into two clusters. This shows that some of the species are more closely related to each other than others. For example, *Senna siberiana* and *Senna hirsutae* were seen to be more closely related due to posseessions of certain characters that varies them others like seed colour, seed shape, seed texture, habit, leaf shape and leaf base. Also *Senna obtusfolia* and *Sennaoccidentalis* are closely related as they shared characters such as leaf base, habit, seed texture and seed shape.

Senna alata and *Senna siamea*were alsofound to be closely related in that they share characters like habit, seed colour and both had paracytic stomata on both abaxial and adaxial surfaces. Although, *Cassia absus*clustered with*Senna alata* and *Senna siamea* it varied in seed shape, seed colour, leaf apex, leaf base and leaf shape. *Senna singueana* was in a different group because of some characters that are different from the remaining species for example, seed colour, seed texture and leaf apex. The existence of two clusters is an indication that these plant species are not monophyletic.

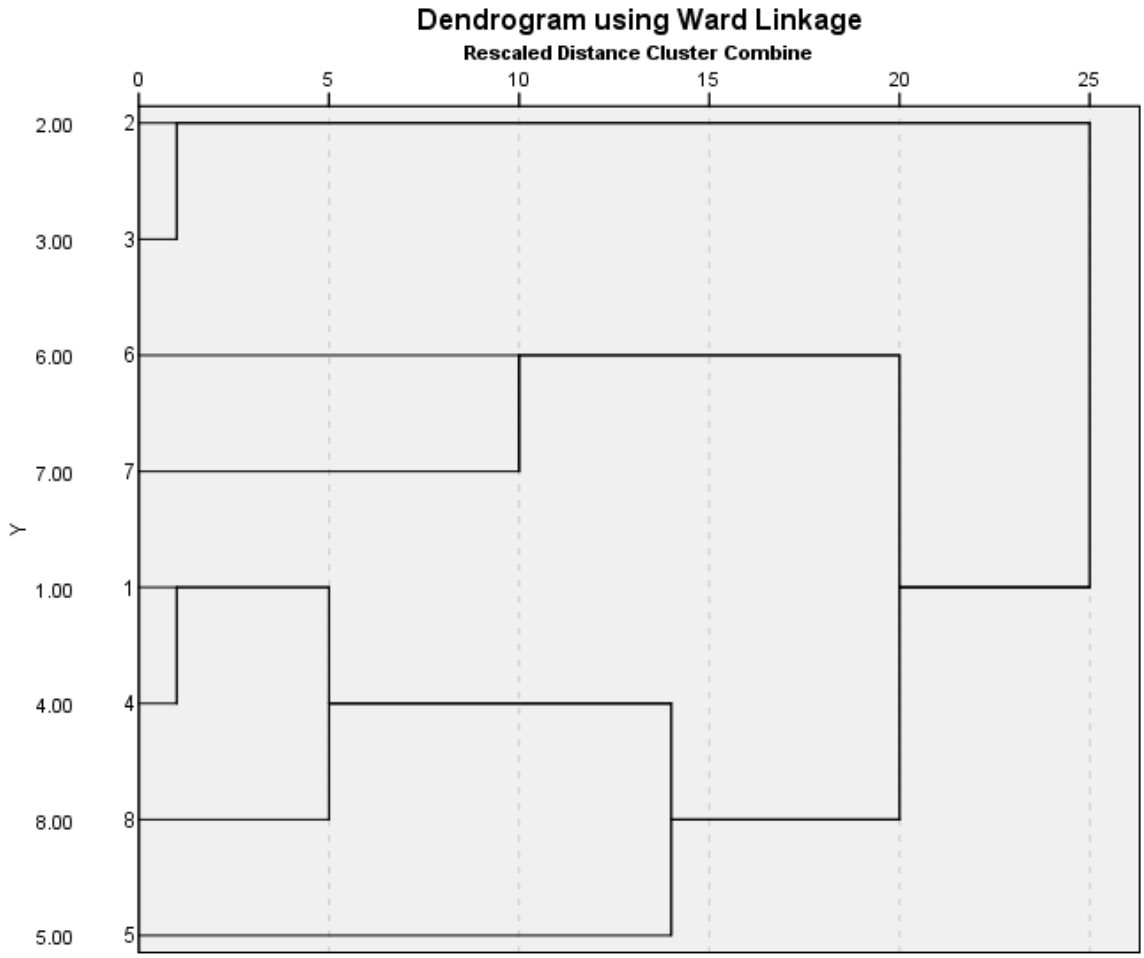


Figure 4.1 shows dendogram of leaf morphological characters of Senna and Cassia species in Ahmadu Bello University, Zaria which separates the plants into two clusters.

I. *Senna siberiana, Senna hirsutae, Senna obtusfolia and Senna occidentalis*

II. *Senna alata, Senna siamea, Senna singueana and Cassia absus*.

Keys; 1*: Senna alata* 2*: Senna siberiana* 3*:Senna hirsutea* 4:*Senna siamea* 5:*Senna singueana* 6:*Senna obtusfolia* 7:*Senna occidentalis* 8:*Cassia absus*

CHAPTER FIVE

5.0 DISCUSSION

The significant difference in palisade cell, spongy cell and vascular bundle numbers was due to difference in measurements of both palisade and spongy cells. The variance in epidermal cell thickness and epidermal cell length may be due to genetic make up of the plants species as well as environmental conditions like sunlight which may be responsible for the variation in epidermal cell shapes and these variations might be of taxonomic importance in identification of the species.

microscopic examination provides vital data to aid the correct identification and description of the plant species. Spongy cell and palisade cell are almost always found togetherand thus according to Buckley and Farquhar, (2004), palisade acts to propagate light across the leaf into the spongy mesophyll, which then scatters light, then adaxial illumination (passing first through palisade) would result in fluorescence deeper into the leaf.

The high Spongy Cell Number (SCN) observed in *S. alata* could have been as a result of higher palisade cell width noted earlier. This may also be due to the fact that *S. alata* had the largest leaf area among the studied species.Daniel*et al.* (2005) did not record significant differences in mean palisade cell lengths between leaf types of their sampled plants, but had spongy mesophyll cells to be smaller in *Picea rubens* (both sun and shade) than in *Rhododendron catawbiense* leaves.Evans and Vogelmann (2003) reported a similar resultfor the profiles of ^{14}C fixation through spinach leaves in relation to light absorption and photosynthetic capacity through leave structure.

According toDalin *et al*, (2008), trichome density and morphology vary among species, population and within individual plants and that trichome density evolve as a result ofresponse to several environmental factors as plants with high trichome density are expected in areas that are dry or cold and the ultraviolet radiation is intense. Metcalf and Chalk, (1979) are also of the opion that trichome frequency and size are environmentally controlled as species within same genera vary with respect to trichome number and size. The trichome numberproduced and density vary also genetically with several species Dalin *et.al*, (2008). Saheed and Illoh (2010) also reported the presence of unicellular trichomes in Senna Mill.Marin*et al.* (2008) made similar observation on the stem, leaves, and calyx with numerous short and elongated non-glandular trichomes where they reported that Elongated non-glandular trichomes were especially densely distributed on the stem and on the margins of the leaves, while short nonglandular trichomes were densely distributed on the adaxial side and on the main vein of the *Thymuslykae* leaf.Ascensa*et al*. (1999) also reported glandular trichomes on the leaves and flowers of *Plectranthus ornatus*.

Non-glandular trichomes associated with cystolith bodies in the basal portion and with partially calcified walls, called cystolith-hairs, are widely distributed in *Senna* and *Cassia* species and responsible for the wrinkled leaf surface as the case of *S. singueana*. This study is agreement with studies carried out by Metcalfe and Chalk (1957) and Machado*et al*. (2006) who were able to observe that the morphology and the distribution of glandular trichomes in *Cordia verbenacea* were similar to those described for other species of the genus, being always uniseriate, with unicellular secretory head and a typical shape. Despite the variation in the number of stalk cells and in the size of the head cells,

glandular trichomes could be classified as globular or reniform, according to the morphology of the head cell.

Pollen morphology plays an important role in taxonomy of *Senna* and *Cassia* species. In the eight species studied, the shape of the pollen grain was circular which can be important for identification at the family level. This circular orientation of the pollen grain is as a result of being pollinated by insects especially bees. Walker and Doyle (1975) noted that at maturity, pollen is anasulcate (as observed at the tetrad stage) and the long and wide aperture had prominent margins. It has a globose-euprolate shape at presentation in open anthers.The studied species were found to have 3 colporate (tricolporate) type of pollen grain. It has been found that the taxa having tricolporate pollen grains reveals their advanced status whereas taxa with polyad or colpate type of pollen grains shows its primitive status in the evolutionary scaleWalker and Doyle (1975).

In addition to paracytic stomata, *Senna siamea* and *Cassia absus*were found to haveanisocytic stomata. Metcalf and Chalk,(1979) reported the occurance of paracytic stomata in *Mimosaceae* family. The diversity of stomata types on the same surface of an organ indicates its weakness in using stomata as a taxonomictool(Kidwai and Pant1964), however, Gopal (1970) is of the opinion that the most frequent stomata type can be used as a taxonomic character. Genome and environmental factors like sunlight, shade and habitat have been found to have profound influence on the distribution pattern of stomata Plant Biology,(2015) and that stomata index in the same leaf at different position and areas provides interesting information about frequency, distribution and function.

Paul *et. al*,(2013) are of the opion that leaves with small but more numerous stomata as in the case of *Senna occidentalis*exhibit faster absolute rate of response of stomata conductanse to water vapor and this principle may be used in the selection of plants in improved agricultural qualities. According to Buckley and Mott, (2013) The leaves of plants growing in wet soil possessed larger with less numerous stomata per unit area than did corresponding leaves from plants grown in dry soils.*Senna hirsutea* has the highest length which according to Abubakar *et al*.(2011), may be an indication of efficient gaseus exchange as increased stamata lenght ensures efficient gaseus exchange that affect the efficiency of photosynthesis of the plant species and that such features ensure high adaptability to new environment. There was also variation in stomata pore length, width and size which are believed to be affected by physiological activities of the guard cells Abubakar *et al*, (2011).

The frequency of stomata was found to be higher in the upper than lower surface in the studied species. The preponderance of stomata on the upper than lower surface is a mechanism to reduce water loss through transpiration (Adegbite, 2008). Several ecological factors may influence this distribution very strongly (For example, humidity, wind, position of the leaf on the stem).The number of upper epidermal cell was also generally high compared to lower surface in all the plants species. High epidermal cells that are associated with upper stomata may be due to their location in the leave which is directly in contact with the sun light.Exposure to direct sun rays could lead to development of thicker epidermal cells as noted in all the species. Stomata are, therefore, important regulators of the global atmospheric environment, and the developmental fate of epidermal cells to differentiate or not into a pair of mature guard cells is also

intimately linked to environmental cues. Alsothe gene HIC (high carbon dioxide) encodes a negative regulator for the development of stomata in plants (Gray*et al*., 2000).

In this study, its also been shown that *S. siamea* and *C. absus* also have some relations in that they have polygonal epidermal cells and anisocytic stomata but differ in anticlinal wall type. *S. obtusfolia*can easily be distinguished from the other species of *Senna* by presence of glandular multicellular trichomes *S. occidentalis* and *S. hirsutae* also share some characteristics with epidermal cells been polygonal, paracytic stomata, morphological characteristics also like acute base, ovate leaf shape, acute apex and oval seed shape (Saheed and Illo,2010).Results obtained from the present study have been found congruent with that of Ogundipe *et al*. (2009)and shaheen (2010) who made the same discovery in the genus *Senna* Mill.

The major variation in seed coat of *Senna* and *Cassia* species was crack in their cellular structures. The cracks were arranged in either parallel or random in all the sampled plants species, some were smooth with an uneven crack and minute- deep depression. Variation in seed coat arrangement could be helpful in knowing more about the cellular differences of the sampled *Senna* and *Cassia* species in Zaria. Parallel crack arrangement was noted in *S. alata* and *S. siamea*with minute interconnected cracks. This is probably the indication of the closeness in the phylogeny. *Senna siberiana*and *S. occidentalis* were also randomly cracked. Irregularly rippled pattern on seeds has also been documented in some species of spine scent *Acacia* (Shaheen 1995). In addition, valuable taxonomic evidence has been obtained from studying seed characteristics under SEM in some species of *Cassia* and *Senna* as well as some species of Caesalpinioideae (Hussein *et al.* 2002). Seed coat sculpturing consists of repetitive units calledsurface cells. Special forms

of these surface cells are the result of differential thickening in their walls (Denford and Karas, 1974). The hilum was also visible in some species as *S. singueana* and *C. absus* which indicates the point of attachment.Similar explanation could be responsible for their similarity in arrangement.

Mia and Paul (1995) reported the seed coat anatomy of 14 species of sect. They assigned Microcarpiam to two groups: (1) those with a uniformly thin (plesiomor- phic) endotesta *L. alata, L. Ianceolata, L. linearis, L. sufruticosa, L. pilosa, L. polyearpa, L. ravenii,* and *L. sphaerocarpa*; and (2) those with a thick (apomorphic) endotesta L. *microcarpa, L. curtissii, L. simpsonii, L. glandulosa, L. linifolia,* and *L. stricta*. This grouping agrees only partly with the groupings based on capsule wall structure. Their grouping agrees only partly with the groupings based on capsule wall structure, while the cellular structure of seed coat was not captured in their study.

CHAPTER SIX

6.0 Summary, Conclusions and Recommendations

6.1 Summary

A study on the leaf epidermis of*Senna* and *Cassia*species in Ahmadu Bello University, zaria was undertaken for a useful taxonomic characters. Leaf epidermal characters such as type of stomata, types of trichome, epidermal cell shape, stomatal length and width and trichome length and width were evaluated. Stomata were paracytic in nature with varying length and width making them to be of great significance in determining the relationship among species. Also the pollen morphology of the species was studied using a light microscope and the pollen were found to be radially symmetrical and species also showed variability in length, width and density. The similarities in structure showed interspecies relationship and reason for them to be in the same family while differences showed the reason for them to exist as distinct species.

Seed shape, seed color, surface texture and seed coat pattern was studied using the scanning electron microscope where two major types of cracks were found in the species whereas some had no cracks on their surface. Seed colored also varied significantly among species from brown to grey and dark brown while seed surfaces were smooth.

The species were found to posses both palisade and spongy cells with varying length; the number of vascular bundle varied among species so also was the epidermal thickness. Variations recorded in some of the characters studied may be to the genetic make up indicating how those characters are of taxonomic importance.

6.2 Conclusions

Based on the findings of the study, it can be concluded that significant variations were observed where species recorded paracytic stomata with the highest found in *Sennaoccidentalis*(25.85±2.58) and lowest in *Senna siberiana*(3.12±0.02) highest frequency in trichome been seen in *Senna siberiana*(83.85±4.43) and the lowest in *Senna alata* (3.74±1.61)

Pollen frequency was also found to be significant in *Senna singueana*(45.85±2.21) and lowest in *Senna siberiana* (8.65±0.42). Seedcoat sculpture also differed significantly among the species where *Senna alata* had parallel crack while *Senna occidentalis* was randomly cracked. A dichotomous taxonomic key was constructed to further delimit the species. For the epidermal study, highest frequency was in *Senna hirsutea* (39.20±2.31) and lowest in *Cassia absus* (20.80±0.75).

Based on the results in this study,

- The sculpturing details of the seed coat varied between species and have been able to show that they possess different cracks arrangement which can be used at both generic and species levels.
- The morphological features of the leaves revealed vital information which may play an important role in identification of species.
- The similarities in structure showed interspecies relationship and reason for them to be in the same family while differences showed reason for them to exist as distinct species

6.3 Recommendations

The morphology of the studied species revealed the presence of both paracytic and anisocytic stomata hence molecular studies can further be carried out to provide more information on their taxonomy. Furthermore, pollen grain study using scanning electron microscope can also be done in order to provide detailed structures of the pollen grains of other *Senna* species in Ahmadu Bello University.

REFERENCES

Abdul Rahaman A.A and Oladele F.A. (2004). Types, densities and frequencies of trichomes in some Nigerian vegetable species. *NigerianJournal of Pure and Applied Science.*19(2)1653–1658.

Abubakar, B. Y, S. Muazu, A.U. Khan andAdamu A.K(2011). Morpho-anatomical variation in some accession of moringa oleifera Lam. From Northern Nigeria African *Journal of Plant Sciences*,5(12): 742-748

Adegbite A.E.(2008). Leaf epidermal studies in Three Nigerian species of *Aspilia* (Heliantheae-Asteraceae) and Two hybrids. *Nigerian Journnal of Bot*any,8: 25-33.

Aftab, R. and Perveen, A. (2006). A palynological study of some cultivated trees from Karachi. *Pakistan Journal of Botany,*38(1): 15-28.

Agarwal, V. and Bajpai, M. (2010).Pharmacognostical and biological studies on *Senna*& its products: an overview.*International Journal of Pharmacuetical and Biological Sciences*1(2) 1-10.

Aguinagalde, I. Perezgarcia, F and Gonzalez A.E. (1990). Flavonoids in seed coats of *Colutea* species-ecophysiological aspects. *Journal of Basic Microbiology*, 30: 547–553.

Alam, M.M. Siddiqui, M.B. and Hussian, W. (1990). *Treatment of diabetes through herbal drugs in rural India*,61: 240-242.

Al-Ghamdi, F.A and Al-Zahrani R.M. (2000). Seed morphology of some species of TephrosiaPers. (Fabaceae) from Saudi Arabia. *Identification of species and systematic significance*. Feddes Repert.121: 59–65.

Angeles, G. (1992). The periderm of plodded and non plodded Ludungia octovalis (onagraceae). PAWA-BULL,.13: 195-200

Arogundade, O. and Adedeji, O. (2009). Pollen grain morphology of three species and a variety of *Ocimum* L. (Lamiaceae) in South- Western Nigeria. *Journal of Science and Technology*, 29 (3) 1-7.

Asante-Duah, K. (2012) *Public Health Risk Assessment for Human Exposure to Chemicals* (illustrateded.); Kluwer Academic Publishers: Dordrecht, The Netherlands, Volume 6.35-58

Ascensa, O. L., Mota, L. and Castro. D. M. M. (1999). Glandular Trichomes on the Leaves and Flowers of *Plectranthus ornatus*: Morphology, Distribution and Histochemistry. *Annals of Botany,* 84: 437-447.

Asolkar, L.V., Kakkar, K.K. and Chakre, O.J. (1992). *Second Supplement to Glossary of Indian Medicinal Plant with Active Principles*; Publication and Information Directorate: New Delhi, India, Volume I, Pp.177.

Aworinde, D.O. Ogundairo, B.O. Osuntoyinbo, K.F and Olanloye, O.A (2012) Foliar epidermal characters of some *Sterculiaceae*species in Nigeria. *Bayero Journal of Pure and Applied Sciences*,5(1):48–56.

Barbosa-Ferreira M. Dagli M.L, Maiorka P.Cand GorniakS.L (2005). Sub-acute intoxication by *Senna occidentalis* seeds in rats. *Food Chemistry Toxicology*;43:497-503.

Barthlott, W. (1981). Epidermal and seed surface characters of plants: systematic applicability and some evolutionary aspects. *Nordic Journal Bot*any 1, 345–355.

Barthlott, W. (1990). *Scanning electron microscopy of the epidermal surface in plants*. In: Claugher, D. (Ed.), Scanning Electron Microscopy in Taxonomy and Functional Morphology. Clarendon, Oxford, 69–94.

Bellini, M.F. Cabrioti, L.N. Terezan, A.P. Jordao, B.Q. Ribeiro, L.R. and Mantovani, (2008) M.S. Cytotoxicity and genotoxicity of Agaricus blazei methanolic extract fractions assessed using gene and chromosomal mutation assays. *Genetics and. Molecular Biology*., 31, 122-127.

Biondo, E., Miotto S.T.S., Schifino-Wittmann M.T. and Castro B. (2002). *Cytogenetics and Cytotaxonomy of Brazilian Species ofSenna* Mill. (Cassieae – Caesalpinioideae – Leguminosae). *Caryologia*,58:152–163

Boonkerd, T., Pechsri S. and Baum, B.R. (2005). *A taxon study of Cassia sensu lato* (*Leguminosae – Caesalpinioideae: Cassieae: Cassiinae*) in Thailand. *Plant Systematics and Evolution.*252:153–165.

Brisson, J.D. and Peterson, R.L. (1976). A critical review of the use of scanning electron microscopy in the study of the seed coat. In: *Proceedings of the Workshop on Plant Science Applications of the SEM-IIT Research Inst. Chicago*, vol. 7(2): 477–495.

Buckley, T. N. and Mott, K. A. (2013)."Modelling stomatal conductance in response to environmental factors"*Plant, Cell and Environment*,36: 1691–1699.

Buckley, T.N and Farquhar, G.D. (2004). A new analytical model for whole-leaf potential electron transport rate. *Plant, Cell & Environment*,27: 1486–1502.

Burkill,H. M.(1995). TheUsefulPlantsof West Tropical Africa,Edition2, Volume3,RoyalBotanicGardens,Kew. London.150-167

Castro, B. Biondo, E. Schifino-Wittmann, M.T. and Miotto, S.T.S. (2006). Estudos cromossômicos em espécies da subfamília Caesalpinioideae (Leguminosae) do sul do Brasil: confirma¸c˜ao decontagens prévias edetec¸c˜ao de variabilidade intra-específicaem *Senna occidentalis* (L.) Link.*RevistaCientíficaRural*, 11:130–134.

Christensen, P.B. (1986). *Pollen morphological studies in the Malvaceae*.Grana, 25: 95-117.

Dalin, P. Jon, A. Christer,B. Pirita, H. and Katri, K.(2008) Leaf trichome formation and plant resistance to herbivory book chapter Pp4

Daniel, M. Herbat (2005) *technology-concept and scope*. Current Science. 88(9):1369-1370.

Daniel, M. Johnson, W.K. Smith, T. Vogelmann, C.and Craig, R. B. (2005). Leaf architecture and direction of incident light influence mesophyll fluorescence profiles. *Americal Journal of Botany*, 217:489-498.

Darlington, C.D. and Wylie, A.P. (1945). *Chromosome Atlas of Flowering Plants*. George Allen e Unwin LTD, London.

Denford K. E and Karas, I. (1974). Some observation on the seed coat structure within the genus *Epilobium*. *Experientia* 30: 1144-1147.

Deshmukh, S.A. (2011). Morphometrics of genus *Cassia* L. from Kolhapur District.*The Bioscan*, 6(3): 459-462.

Deshmukh, S.A. Chavan, S.R. and Gaikwad, D.K. (2012). Morphometric Studies in the genus*Clerodendrum* L. *Current Botany*, 3(5): 41-44.

Deshmukh, S.A. Labhane, N.M. Waghmare, M.B. Chavan, S.R. and Gaikwad, D.K. (2013). Morphometric studies in the genus *Caesalpinia* L. from Kolhapur distirct. Research and Reviews: *Journal of Botany*,2(1): 25-28.

Devi, N.J. Padma, Y. Narasimhudu, C.L. and Raju, R.R.V. (2013). Diversity of stomata and trichomes in *Euphorbia* L. – I. *Bangladesh Journal of Plant Taxonomy*.20(1): 27-38.

Dhara, G. Susy A. Neeta P. (2011). Morphological and micromorphological characterization of some legume seeds from Gujarat, India. *Environmental and Experimental Biol*ogy. 9: 105–113.

Drury, R. A. and Wallington, E. A (1980). *Carleton's Histological Technique*. fourth Edition. Pp 432.

Eddy, M. Q. (1997). Taxonomic significance of foliar epidermaldermotypes and floral trichomes in some taxa of cuban indigofera L.(Fabaceae).*Polibotanica*, 6:1-8

Edeoga, H.O and Eboka A.U. (2000) Morphology of the leaf epidermis and systematics in some *Dissotis* species Benth (Melastomataceae). *Global Journal of Pure and Applied Science*.6:371-374.

Edeoga, H.O and Ikem C.L. (2001). Comparative morphology of the leaf epidermis in three species of *Boerhaavia* L. Nyctagininaceae. *Journal of Plant Anatomy and Morphology*.1:14-21.

Edeoga, H. O and Gomina, A. (2001) Nutritional values of some non conventional leafy vegetables of Nigeria. *Journal of Economic and Taxonomic Bot*any. 20.7-15.

Edeoga, H. O. and Ikem, I. C (2002). Structural morphology of the pollen grains in the three Nigerian species of *Boerhavia* L. *New Botany*, 29. 89-95

Edeoga, H. O. Ogbebon, N. O. and Amayo, A. C. (1996). Pollen morphology of some Nigerian species of Aneilmia R. Br. And Luduigia L. New BA., 23: 223-231

El Ghazali, G.E.B. (1989). *A Study on the Pollen Flora of Sudan*, with Special Reference to Pollen Identification. PhD thesis, University of Bergen (Norway), 362.

Erdtman, G. (1952). *An Introduction to Palynology*: Pollen Morphology and Plant Taxonomy Angiosperm (Almqvist and Wiksell. Stockholm) Pp 539.

Evans,J. R. and Vogelmann T. C. (2003). Profiles of ^{14}C fixation through spinach leaves in relation to light absorption and photosynthetic capacity. *Plant, Cell and Environment*, 26: 547-560.

Faegri, K. Iversen, J. Kaland, E.P. and Krzywinski, K. (1989). *Textbook of Pollen Analysis*, IV. Edition.The Blackburn Pres, New Jersey, USA.Pp 328.

Ferguson, I.K. (1980). *The pollen morphology of Ceratonia* (Leguminosae: Caesalpinioideae). Kew Bulletin, 35(2): 273-277.

Gohary, I. and Mohammed A.H. (2007). Seed morphology of *Acacia* in Egypt and its taxonomic significance. *International Journal of Agricultural Biology*.9: 435–438.

Goldblatt, P.(1981) — *Cytology and the phylogeny of Leguminosae*. R. M. Polhill and P.H. Raven (Eds.),"Advances in Legume Systematics", Royal BotanicalGarden Kew, 2: 427-463.

Gontcharova, S. B.Gontcharova A. A. Yakubov V.V. and Kondo K. (2009). *Seed surface morphology in some representatives of the genus Rhodiola sect*. Rhodiola (Crassulacea) in Russian Far East. Flora204: 17–24.

Gopal, B. V. (1970) Structure and development of stomata on vegetative and floral organs of some *Amaryllidaceae.Annals of Botany* 34:737-749.

Hamly, D.H. (1932). Softening of the seeds of *Melilotus alba.* Botanical Gazette 96:345-375.

Hussein, I. F Khalifa,S.F.I. Ghareb, A and Fawzy, N.(2002) Taxonomic importance of seed characteristics of some species of *Senna* and *Cassia* (Subfamily-*Ceasalpiniodeae*).*Egyptian Journal of Biotechnology* 12(2):248-265.

Gottsberger, G. and Silberbauer-Gottsberger, I. (1988). *Evolution of flower structures and pollination in neotropical Cassiinae* (Caesalpiniaceae) *species*. *Phyton*, 28 (2): 293−320.

Gray, J. Holroyd, G. van der Lee, F. Bahrami, A, Sijmons, P. Woodward, F. Schuch, W. and Hetherington, A (2000). "The HIC signalling pathway links CO_2 perception to stomatal development". *Nature,*408: 713–716.

Gunn,C.R, (1991).Friuts and seeds of Genera in the subfamily Ceasalpiniodeae(fabaceae).1st Edition,U.SDepartment of Agriculture,Agricultural Research Service,Washington D.C.1-408.

Hetherington, A. M. and Woodward, F. I. (2003). *The role of stomata in sensing and driving environmental change*. *Nature*, 424:901–908.

Heywood, V.H. (1971). The characteristics of the scanning electron microscope and their importance in biological studies, In: Scanning Electron Microscopy: Systematic and Evolutionary Applications.*The Systematics Association*(Special Volume). (4) 1-16.

Hill, F. A. (1952). Economic Botany. McGrawHillBooks Company, NewYork, pp.560.

Hosseinzadeh, Z., Pakravan, M., Tavassoli, A. (2008). Micromorphology of seed in some Vicia species from Iran. *Rostaniha* 9: 96–107.

Hutchison, J. and Dalziel, J. M. (1958). Flora of West Tropical Africa. (I) 2. The Whitefraius press Ltd. London. Pp 276.

Irwin, H. S. and Barneby, R. C. (1982). Review of Cassinae in the New World. Memoirs of the New York Botanical Garden, 35: 1 – 918.

Irwin, H. S. and R. C. Barneby (1981). *Cassieae*.*In Advances in Legume Systematics* (R. M. Polhill and P. H. Raven Eds) *Royal Botanical Gardens*, Kew.Part 1: 97 – 106.

Javadi, F. and Yamaguchi H. (2004). A note on seed coat and plumule morphological variation in the genus *Cicer* (Fabaceae). *Scientic Report of the Graduate School of Agriculture and Biological Sciences* 56: 7–16.

Johnson, L.A. Huish K.H. Porter J.M. (2004). Seed surface sculpturing and segregated and its systematic significance in Gilia(Polemoniaceae) genera. *InternationalJournal of Plant Sciences.*165: 153–172.

Kahraman, A. Chidire H. and Dogan M. (2014) Anatomy, macro- and micromorphology of Lathyrus sect. Nissolia (Fabaceae) and their taxonomic significance. *Proceedings of National Acadamy of Science, India. Biological Sciences* 84: 407–417.

Karcz, J. Weiss, H. and Maluszynska J. (2000). Structural and embryological studies of diploid and tetraploid Arabidopsis thaliana(L.) Heynh. *ActaBiologica Cracoviensia Series Botanica* 42(2): 113–124.

Khan, R. (2004). Studies on the pollen morphology of the genus *Arabidopsis* (Brassicaceae) from Pakistan. *Pakistan Journal of Botany*,36(2): 229-234.

Kidwai, P. and Pant D.D (1964). Diversity in the development and organization of stomata in the *Phylanodiflora* (L) Green.Current science 33:653-654.

Kissmann, K.G. and Groth D. (1992). *Plantas infestantes e nocivas*. BASF Brasileira S.A., S˜ao Paulo, 798 pp.

Koul, K.K. Ranjna N. and Raina S. N. (2000). Seed coat microsculpturing in *Brassica* and allied genera (Subtribe Brassicinae, Raphanine, Moricandiinae). *Annals of Botany*.86: 385–397.

Krassilov, V. A. (2004). "Macroevolutionary events and the origin of higher taxa". In Wasser, Solomon P. *Evolutionary theory and processes: modern horizons: papers in honour of Eviatar Nevo*. Dordrecht: Kluwer Academic Publication. Pp. 265–289.

Kuanga, Y. Kirchoff, B. Tang, Y. Liang, Y. and JingPing, L. (2008). Palynogical characters and their systematic significance in *Naucleeae* (*Cinchonoideae, Rubiaceae).Review of Palaeobotany and Palynology*, 151: 123-135.

Kumar A, Tripathi, V. and Pushpangadan, P. (2007). Random amplified polymorphic DNA as marker for genetic variation and identification of *Senna surattensis* Burm, f. and *Senna sulfurea* DC. Ex Collad. *Current Science*, 93(8) 1146-1150

Lock, J. M. (1988). *Cassia* sen. Lat. (Leguminosae – Caesalpiniodeae in Africa). *KewBulletin*, 43 (2): 333 – 342.

Machado E.G. (1983). Efeitos da presen¸ca de sementes de fedegoso (Senna occidentalis L.) como impureza na alimenta¸c˜ao de frangos de corte. Disserta¸c˜ao (Mestrado), Escola Superior de Agricultura “Luiz de Queiroz”, Universidade de S˜ao Paulo, Piracicaba, Brasil.

Machado, S. R. Gregório, E. A. and Guimarães, E. (2006). Ovary peltate trichomes of *Zeyheria Montana* (Bignoniaceae): developmental ultrastructure and secretion in relation to function. *Annals of Botany*, 97:357-369.

Mallick, D.K. and Sawhney S. (2003). Seed coat ornamentation in wild and cultivated lentil taxa. *Phytomorphology* 53: 187–195.

Mamandhar, N. (2002). Plants and people of Nepal.Timbers press-oregun. 8: 5192-5276

Marazzi, B. Endress, K.P. de Queiroz, L.P.and Conti, E.(2006). "Phylogenetic relationships within *Senna* (Leguminosae, Cassiinae) based on three chloroplast DNA regions: patterns in the evolution of floral symmetry and extrafloral nectaries". *American Journal of Botany* 93 (2): 288–303.

Marin, M. Budimir, S. Janošević, D. Marin, P. D. Duletić-Laušević, S. and Jaljević-Grbić, M. L. (2008). Morphology, Distribution, and Histochemistry of Trichomes of *Thymus lykae* Degen and Jav. (Lamiaceae). *Archive of Biological Science, Belgrade*, 60 **(**4): 667-672.

Masih, T. Khan, M., Meo, A.A. and Akhtar, T. (2005). Palynological studies of some genera of Leguminosae. *Journal of Science and Technology*, 29(1): 19.

Mbagwu, F. N and Edeoga, H. O. (2006). Palynological studies on som Nigerian species of *Vigna savi*. *Journal of Biological Sciences.,* 6. 1122-1125.

Metcallfe, C.R and Chalk, L. (1957). *Anatomy of the dicotyledons*. Volume 2. Oxford University Press, Oxford, Pp 276.

Metcallfe, C.R and Chalk, L. (1979). Anatomy of Dicotyledons (2 Edition).Volume 1.Oxford University press, Oxford. Pp 276.

Mia, M. and Paul J. K. (1995). Character analysis of the seed coat in spiranthoideae and orchidoideae, with special reference to the *diurideae* (orchidaceae). *American Journal of Botany*, 82(11): 1443-1454.

Mott, K. A. (2009). Opinion: *Stomatal responses to light and CO_2 depend on the mesophyll.Plant Cell Environment*, 32:1479–1486.

Newell, C. A and Hymowitz, T. (1978) Seedcoat variation in *Glycine* wild, subgenus *Glycine,* Leguminaceae by SEM; *Brittonia*.30:76-88

Nwachukwu, C.U, Mbagwu F.N and Onyeji A.N. (2007). Morphological and leaf epidermal features of *Capsicum annuum* and *Capsicum frutescensSolanaceae*. Nature and Science.5(3):54-60.

Nyananyo, B. l (1985). Pollen morphology in Talinea (portulaceae) Sensumcneil. *Biology of Africa*, 2:41- 46

Nyananyo, B. l. and Olowokudejo, J. O (1986). Taxonomic studies in the genus *Talinum* (portulaceae) in Nigeria. *Wildenowia Berlin* 15: 455-463

Ogundipe, O.T. Kadiri, A.B. and Adekanmbi, O.H. (2009). Foliar epidermal morphology of some Nigerian species of *Senna* (Caesalpiniaceae). *Indian Journal of Science and Technology* 2(10): 5-9.

Ogunkunle, A. T. J. and Ladejobi, T. A. (2006). Ethnobotanical and phytochemical studies on some species of *Senna* in Nigeria.*African Journal of Biotechnology* **5** (21), 2020-2023.

Olorode, O. (1984). *Taxonomy of West African flowering plants*. Longman Group Limited. The Book Project, Obafemi Awolowo University, Ile-Ife, Nigeria.

Ozbek, F, Ufuk Ozbek M. and Ekici M. (2014). Morphological, anatomical, pollen and seed morphological properties of *Melilotus bicolor* Boiss.& Balansa (Fabaceae) endemic to Turkey. Australia. *Journal of Crop Sciences*.8: 543–549

Pant, D. D and Verma B.K (1974). Taxonomy of the genus *Ephedra*. Significance of stem and leaf epidermis and cuticle. *Botanical Journal of Linnean Society.*,69; 287-308.

Paul, L. D. Ray, H.F. and Peter J.F. (2013) Smaller, faster stomata: scalling of stomatal size rate of response and stomatal conductance. *Journal of Experimental Botany* 64(2) 495-505.

Perveen, A and Qaiser, M. (1998). *Pollen flora of Pakistan- X*. Leguminosae (subfamily: Caesalpinioideae). *Turkish Journal of Botany*,22: 145-150.

Pooyam, P., Ghahremaninejad, F. and Assadi M. (2014). A synopsis of the genus *Colutea* (Fabaceae) in Iran. *Edinburgh Journal of Botany*. 71: 35-49.

Prasanna, R. Harish, C.C. Pichai R. Sakthisekaran, D. and Gunasekaran, P (2009). Anti-cancer effect of *Cassiaauriculata* leaf extract *in vitro* through cell cycle arrestand induction of apoptosis in human breast and larynxcancer cell lines, *Cell Biology International* 33 127-134.

Rani, G. Arora S and Nagpal, A. (2001).Micropropagation of *Tagetes erecta* L. through nodal segments, *Journal of theIndian Botanical Society* 80;77-80.

Randell, B. R. and Barlow, B. A. (1998). In: A. S. George (executive editor). Australian Government Publishing Service: Canberra, Australia. *Flora of Australia*, 12: 89-138.

Ren, C.W. and Bewley, J.D. (1998). Seed development, testa structure and precocious germination of Chinese cabbage (Brassica rapasub. pekinensis). *Seed Science Research* 8:385–397.

Sahai, K. Kaur, H. and Pal, A. (1997). Macro and micromorphological seed characteristics of some *Cassias* pecies and their taxonomic significance. *Phytomorphology* 43: 273–279.

Sahai, K. (1999). Structural diversity in the lens of the seeds of some *Cassia* L.(Caesalpinioideae) species and its taxonomic significance. *Phytomorphology*. 49: 203–208.

Saheed, S.A. and Illoh, H.C. (2010). A taxonomic study of some species in *Cassiinae* (Leguminosae) using leaf epidermal characters. *Notulae Botanicea Horticulture Agrobotanici Cluj -Napoca*38(1): 21-27.

Salimpour, F. Mostafavi, G. and Sharifnia F. (2007). *Micromorphologic study of the seed of the genus Trifolium*, section Lotoidea, in Iran. *PakistanJournal of Biological Sci*ences. 10: 378–382.

Shaheen, A.M (1995). Morphological and cytogenetical variations in the ecological population of *Acacia* Mill in Egypt, Ph.D. Thesis, South Valley University, Aswan Faculty of Science, Egypt. pp 163

Scholthof, K.B.G. (1999). A role for plant pathology inpublichealth? *Emerging Infectious Diseases*5: inpress. [http://www.cdc.gov/eid].

Segarra, J.G. Mateu, I. (2001). Seed morphology of *Linaria* species from eastern Spain identification of species and taxonomicimplications. *Botanical Journal of Linnean Soc*iety 135, 375–389

Segarra, J.G. Mateu I. (2002). Seed morphology of *Linaria* species from Eastern Spain: identification of species and taxonomic implications. *Botanical Journal of Linnean Society.*135: 375–389

Setia, R. C. and Richa, R. (1989). *Anatomical studies on siliqua wall and seed coat development inBrassica juncea*(L.) Czern and Coss. *Phytomorphology*39: 371–377.

Soladoye, M.O and Lewis, G.P. (2003). A checklist of Nigerian legumes CENRAD, 12-14.

Soladoye, M.O. Onakoya, M.A. Chukwuma, E.C. and Sonibare, M.A. (2010a). Morphometric study of the genus *Senna* (Mill) in South-Western Nigeria. *AfricanJournal of Plant Science*, 4 (3): 44-052.

Soladoye, M.O. Sonibare, M.A. and Chukwuma, E.C. (2010b). Morphometric study of the genus *Indigofera* L. (Leguminosae-Papilionoideae) in South-Western Nigeria. *International Journal of Botany*, 6 (3) 343-350.

Sonibare, M.A. Jayeola, A.A and Egunyomi, A (2004). A Morphometric analysis of the genus *Ficus* Linn. (Moraceae). *African Journal of Biotechnology* 3 (4): 229-235.

Souza, M.G.C. and Benko-Iseppon, A.M.(2004) —Cytogenetics and chromosome banding patterns in Caesalpinioideae and Papilionoideae species of Para, Amazonas, Brazil. *Botanical Journalofthe Linnean Society*, 144: 181-191.

Spiller, H. (2003). "Skin breakdown and blisters from senna-containing laxatives in young children". *The Annals of Pharmacotherapy*, 37 (5):636–9.

Stace, C.A. (1965). *Cuticular studies as an aid to plant taxonomy*. Bulletin of British Museum. *Natural History of Botany 4:1-78.*

Stace, C.A. (1984). The taxonomic importance of the leaf surface. *In:* Heywood, V.H. and Moore, D.M. (Eds), Current Concepts in Plant Taxonomy. Academic Press, London, pp. 67-94.

Staden,J.V. Manning, J.C and Kelly, K.M. (1989).Legume seeds,the structure and function equation. In; Advances in Legume Biology, Stirton,C.H and J.L Zarucchi(Eds),Monographs on systematic Biology,Missouri,USA; 417-450.

Tschan, G.F. and Denk, T. (2012). Trichome types, foliar indumentum and epicuticular wax in the Mediterranean gall oaks, Quercussubsection Galliferae (Fagaceae): implications for taxonomy, ecology and evolution. *Botanical Journal Linnean Society*.169: 611-644.

Tucker, S. C.(1996) — Trends in evolution of floral ontogeny in Cassia sensu stricto, Senna, and Chamaecrista *(Leguminosae: Caesalpinioideae: Cassieae: Cassiinae);*a study in convergence. *American Journal of Botany* 83 (6): 687-711.

Vanderperren, B. (2005). Acute liver failure with renal impairment related to the abuse of *Senna* anthraquinone glycosides.*The Annals of Pharmacotherapy* 39(7-8): 1353-57.

Vaughan, J.G. (1968). *Seed anatomy and taxonomy*. *Proceedings of Linnean Society* London. 79, 251–255

Wagner, I. O. Woodhouse, R. P.and Walter, D. R. (1990). *Pollen grains, their structures, identifications and significance in science and medicine*. Mcgraw Hills. New York. Pp 574.

Walker, J. W. and Doyle, J. A. (1975). Bases of angiosperm phylogeny palynology. *Annals of the Missouri Botanical Garden*, 62:664-723.

Walter, I. W. (1976). Evolution of exine structure in the pollen of primitive Angiosperms. *American Journal of Botany*, 61: 8-10

Yasmin, G. Khan, M.A. Shaheen, N. Hayat, M.Q. Ali, S. and Shahid, A. (2010). Taxonomic implications of pollen morphology of seven species of Rumex L., from Pakistan. *Pakistan Journal of Botany,* 42(3): 1435-1442.

Zafar, M. Ahamad, M. and Khan, M.A. (2007). Palynology of family Asteraceae from floraof Rawalpindi- Pakistan. *International Journal of Agriculture and Biology*, 9(1): 156-161.

Zeng, C.L. Wang, Liu, A.H. and Wu, X.M. (2004). Seed coat microsculpturing changes during seed development in diploid and amphidiploid *Brassica* species. *Annals of Botany* 93: 555–566.

Zhang, Z.Y. Yang, D.Z. Lu, A.M. and Knapp, S. (2005). Seed morphology of the tribe *Hyoscyameae* (Soloanaceae). *Taxon* 54: 71–83.

Appendix I

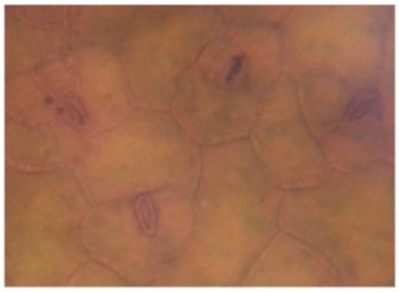


Plate 1a: Abaxial Surface of *Cassia absus* showing anisocytic stomata with polygonal epidermal walls using mg 40x

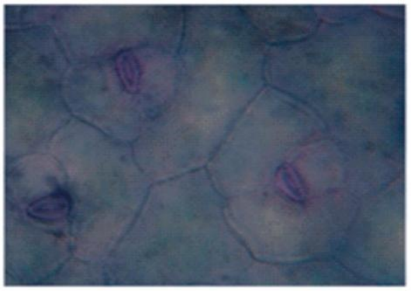


Plate 1b: Adaxial Surface of *Cassia absus* showing anisocytic stomata with polygonal epidermal walls using mg 40x

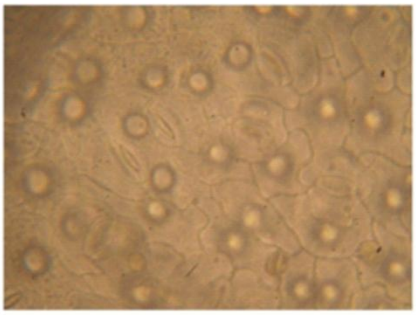


Plate 2a: Abaxial Surface of *Senna alata* showing anisocytic stomata with polygonal epidermal walls using mg 40x

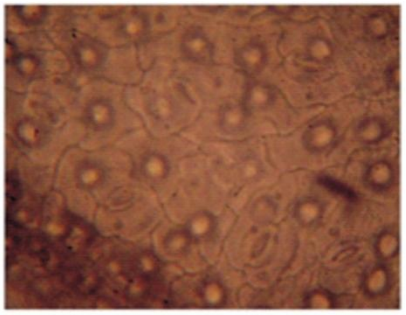


Plate 2b: Adaxial Surface of *Senna alata* showing anisocytic stomata with polygonal epidermal walls using mg 40x

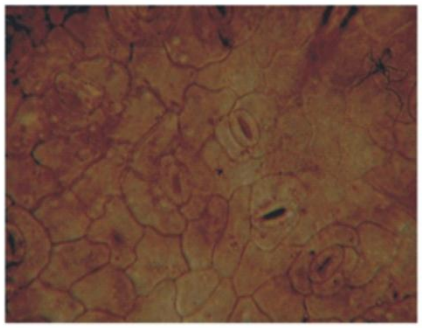


Plate 3a: Abaxial Surface of *Senna siamea* showing anisocytic stomata with polygonal epidermal walls using mg 40x

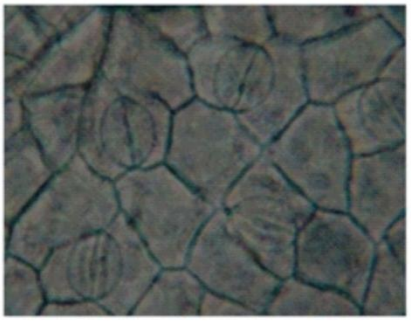


Plate 3b: Adaxial Surface of *Senna siamea* showing anisocytic stomata with polygonal epidermal walls using mg 40x

Appedix II

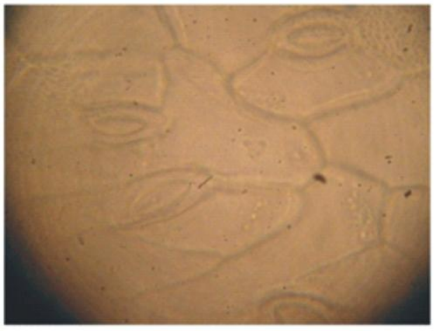


Plate 4a: Abaxial Surface of *Senna siberiana* showing *para*cytic stomata with polygonal epidermal walls using mg 40x

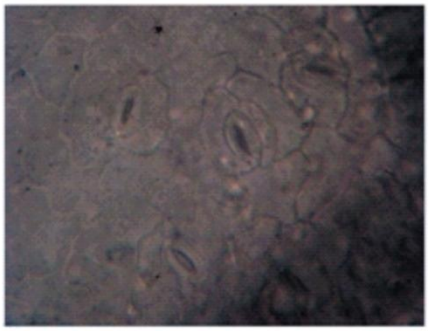


Plate 4b: Adaxial Surface of *Senna siberiana* showing *aniso*cytic stomata with polygonal epidermal walls using mg 40x

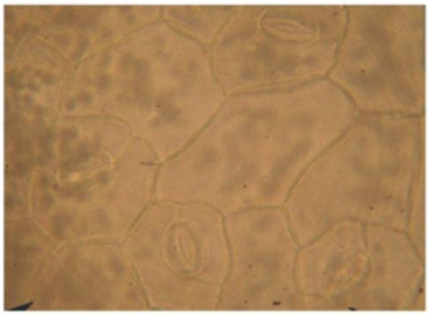


Plate 5a: Abaxial Surface of *Senna Obtusfolia* showing paracytic stomata with polygonal epidermal walls using mg 40x

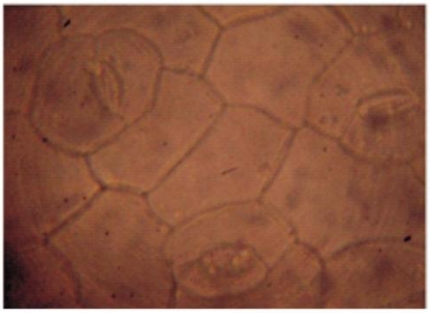


Plate 5b: Adaxial Surface of *Senna Obtusfolia* showing paracytic stomata with polygonal epidermal walls using mg 40x

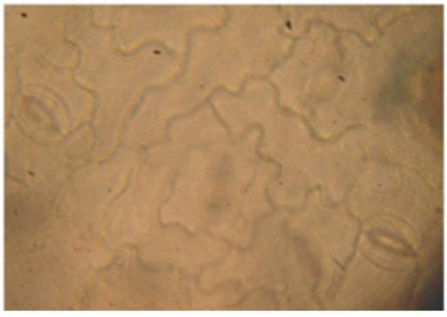


Plate 6a: Abaxial Surface of *Senna hirsuta* showing *aniso*cytic stomata with *Curved*l epidermal walls using mg 40x

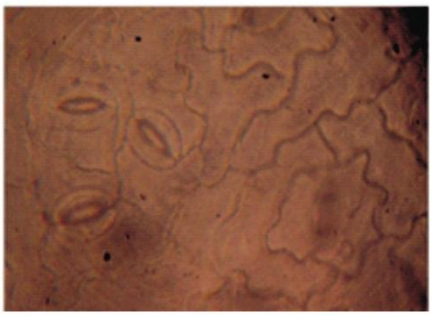


Plate 6b: Adaxial Surface of *Senna hirsuta* showing paracytic stomata with irregular epidermal walls using mg 40x

Apendix III

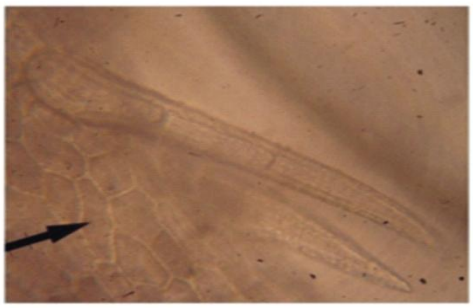


Plate 7a: Adaxial Surface of *Senna obtusfolia* showing Non-glandular Multicellular trichome using mg 40x

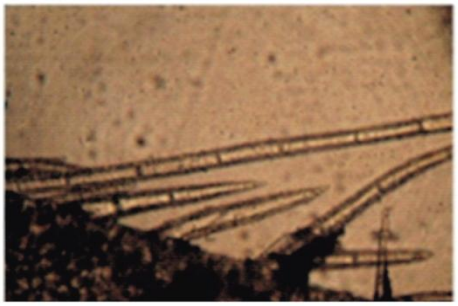


Plate 7b: Abaxial Surface of *Senna obtusfolia* showing Non-glandular Multicellular trichome using mg 40x

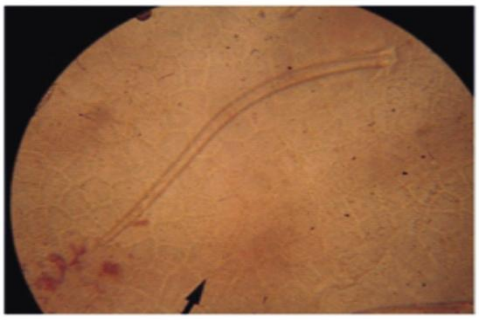


Plate 8a: Adadxial Surface of *Senna siberiana* showing Non-glandular Unicellular trichome using mg 40x

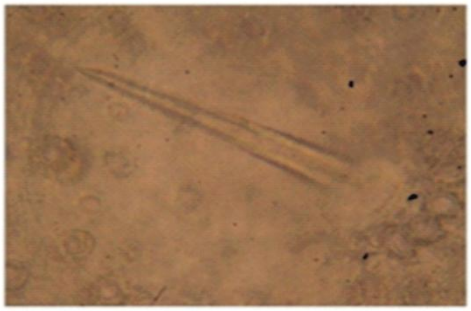


Plate 8b: Abaxial Surface of *Senna siberiana* showing Non-glandular trichome using mg 40x

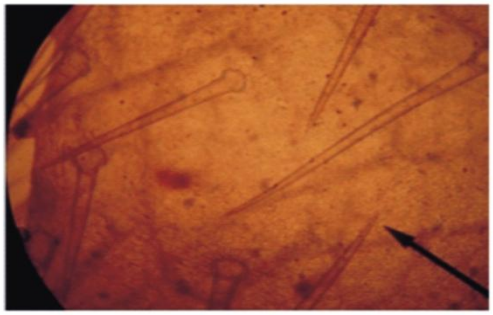


Plate 9a: Adaxial Surface of *Senna hirsuta* showing Non-glandular trichome using mg 40x

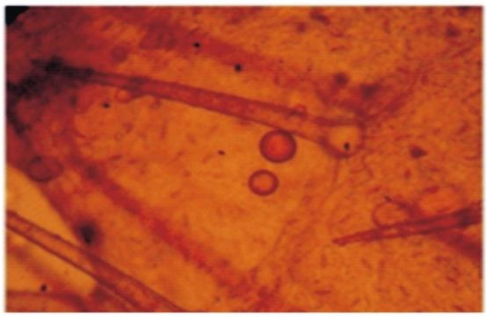


Plate 9b: Abaxial Surface of *Senna hirsuta* showing Non-glandular trichome using mg 40x

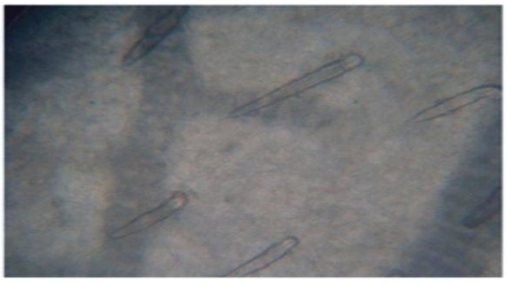


Plate 10a: Adaxial Surface of *Senna occidentalis* showing Non-glandular trichome using mg 40x

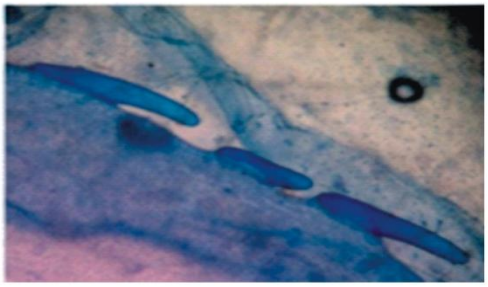


Plate 10b: Abaxial Surface of *Senna occidentalis* showing Non-glandular trichome using mg 40x

Appendix IV



Plate 11a: Adaxial Surface of C*assia absus* showing Non-glandular trichome using mg 40x

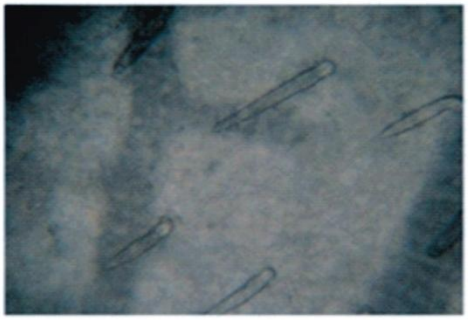


Plate 11b: Abaxial Surface of *Cassia absus* showing Non-glandular trichome using mg 40x



Plate 12a: Adaxial Surface of *Senna siamea* showing Non-glandular trichome using mg 40x



Plate 12b: Abaxial Surface of *Senna siamea* showing Non-glandular trichome using mg 40x

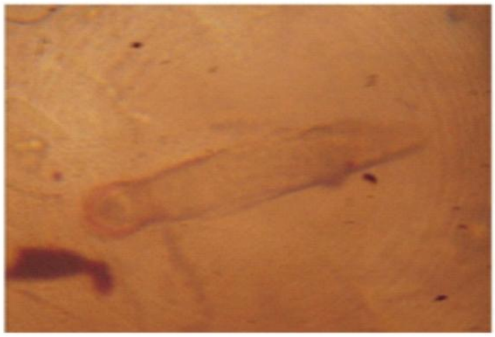


Plate 13a: Adaxial Surface of *Senna alata* showing Non-glandular trichome using mg 40x



Plate 13b: Abaxial Surface of *Senna alata* showing Non-glandular trichome using mg 40x

Appendix V



Plate 14: *Senna siamea* showing tricolporate pollen grain 40x mg



Plate 15: *Senna alata* showing tricolporate pollen grain 40x mg



Plate 16: *Senna hirsutae* showing tricolporate pollen grain 40x mg

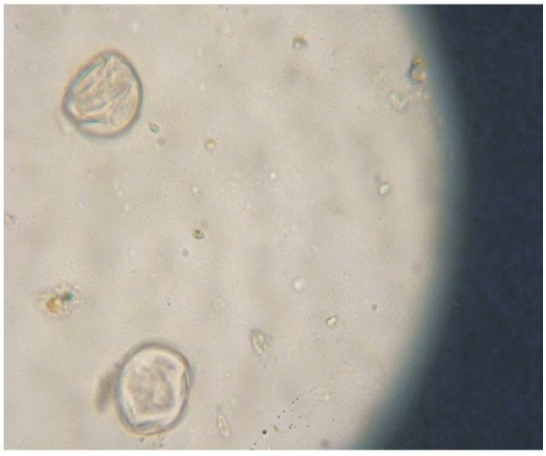
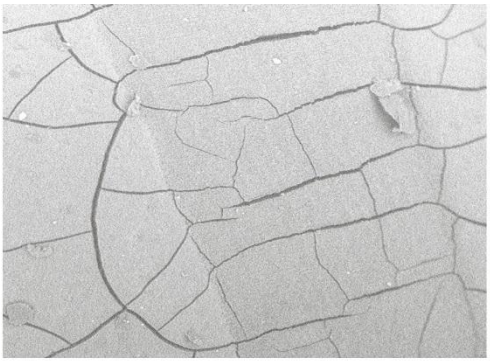
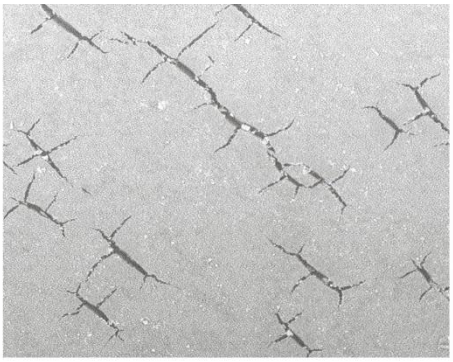


Plate 17: *Senna Obtusfolia* showing tricolporate pollen grain40x mg

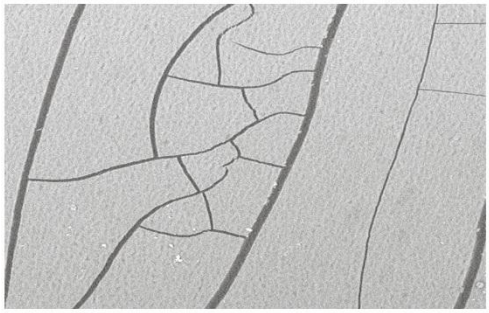
Appendix VI



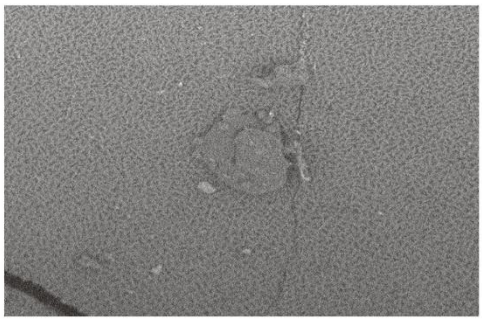
Senna Occidentalis **Seed coat x500μm Showing cracks in parallel pattern**



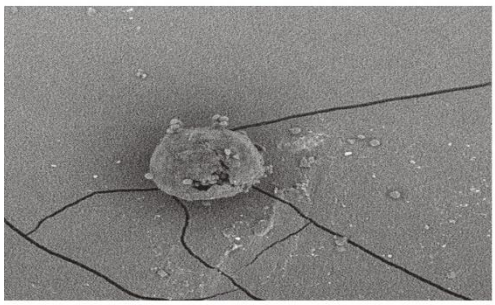
Senna obtusfolia **x500μm showing smooth rugea with minor branching**



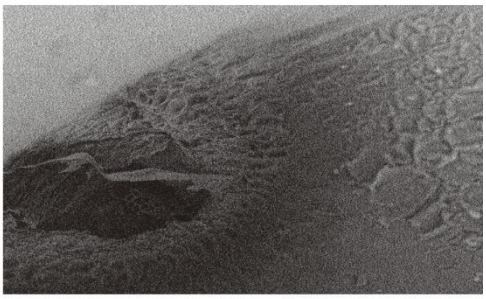
Senna siamea **seed coat x500μm showing inter connected cracks**



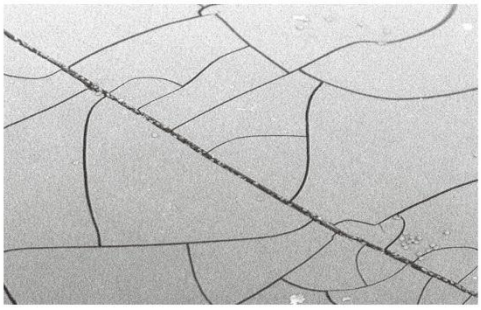
Senna singuena **x500μm showing the hilium and a major crack**



Senna alata **x500μm showing the hilium (point of attachment)**



Senna absus **x500μm showing the hilium on a rough surface**



Senna arereh **x500μm showing branched interconnected randomly**

Appendix VII

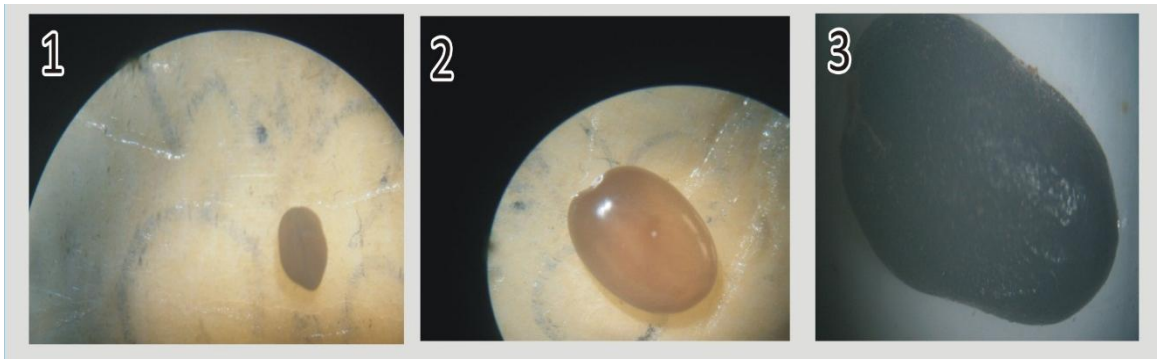


Plate 25 :*Senna hirsutae* seed x10 mg

Plate 26: *Senna siamea* seed x10 mg

Plate 27: *Senna siberiana* seed x10mg

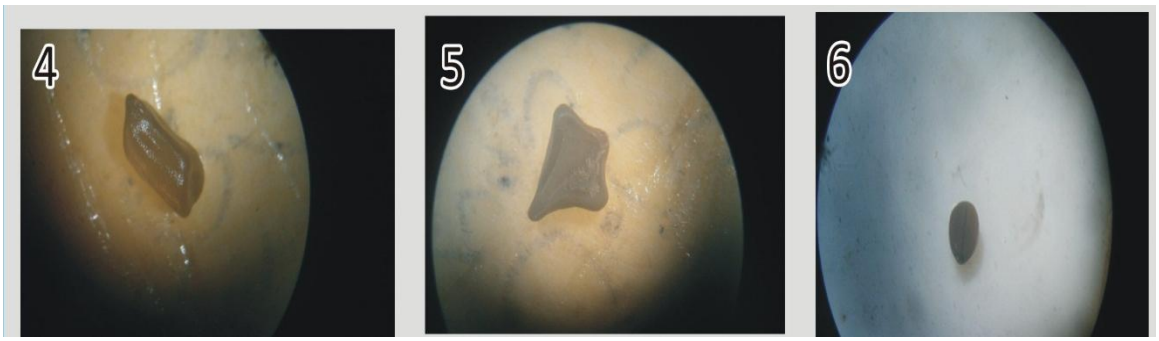


Plate 28: *Senna obtusfolia* seed

Plate 29: *Senna alata* seed x10 mg

Plate 30: *Senna occidentalis* seed x10 mg

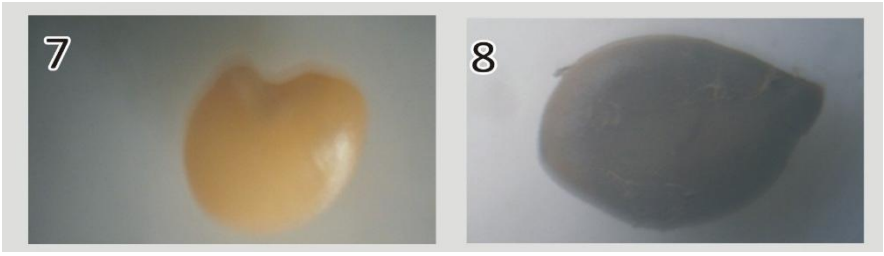


Plate 31:*Cassia absus* seed x10 mg

Plate 32:*Senna singueana* seed x10 mg