EVALUATION OF YIELD AND SUB-YIELD COMPONENTS OF COWPEA (*VIGNA UNGUICULATA* (L) WALP) ACCESSIONS

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INTEGRI PROCEDAMUS

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DECLARATION

I, Henry Kofi Mensah, hereby declare that this thesis submitted to the University of Ghana, Legon for the award of Master of Philosophy in Botany is my work and has not been submitted by me or any other person for a degree at any other University or institution of higher education.

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ABSTRACT

One hundred and eight cowpea accessions were evaluated for yield and sub-yield components at the Department of Plant and Environmental Biology. They consisted of 60 F2 segregating, 44 accessions as test materials and 4 controls. The controls were Asontem Wang Kae, Padituya and Kirkhouse from CSIR-SARI. Data collected comprised of morphological and phytochemical traits. Descriptive, multivariate and genetic component analyses were carried out to evaluate the extent of variation. Rank summation index and contrast analysis were performed to select the best performing accessions. For the morphological traits studied, semierect growth habit with frequencies of 64.78%, 43.75% and 51.45% which occurred in the test materials, controls and the entire population. The majority of the accessions in the test materials exhibited red seed coat colour (19.59%) whereas in the controls most of the accession showed cream seed coat (50%). Overall, the majority of the accessions exhibited cream seed coat colour with a frequency of 35.35%. The chi-square test of association between qualitative traits showed was 125 significant associations in the test materials whereas the controls only showed 3 significant associations. The overall population exhibited 162 significant associations. In the multiple correspondence analysis (MCA) terminal leaf shape, growth habit, pod curvature and raceme position mostly led to variation in the first dimension which accounted for inertia of 51.40%. Thirteen farmer and consumer-preferred traits were used in the MCA plot. Asontem, UG8 and UG30 had a close relationship with similar phenotypic classes in the first quadrant of the MCA plot. UG1 and UG81 were outliers and had a distant relationship with majority of the phenotypic classes of the selected traits. The test materials had a significantly higher mean than the controls for the following traits; number of pods per plant, number of locules, seed weight and seed yield but lower than the controls for the following traits; days to first flower, days to 50% germination, days to first mature pod and days to 50% mature pod. Furthermore, the test materials were significantly higher in mean concentration for the following amino acids; gallic acid and vanillic acid, glycine, l-histidine, l-aspartic acid, l-valine and l-methionine. A total of 191, 537 and 413 significant pairwise correlations were observed in the test materials, controls and entire population respectively for all quantitative traits. The multiple regression analysis revealed that the underlying determinant of yield was most influenced by yield and yieldrelated components in the test materials and controls with contributions of 100% and 36.67% respectively. Phytochemical traits made the highest contribution of 25.95% to influencing variation in yield for the entire population. The first six principal components in the morphological traits accounted for a total variability of 47.17%, 55.40 %, 42.99% in the test materials, controls and entire population respectively. The first three principal components in the phytochemical traits accounted for a total variability of 51.81%, 100 %, 53.14% of the total variation in the test materials, controls and entire population respectively. The biplot showed that the relationships among accessions and morphological, phytochemical and all traits explained 46.63% and 99.49 and 94.48 % of the total variance respectively. The canonical discriminant analysis grouped against yield showed that the first CV accounted for 17.19% and 40.82% for the respective morphological and phytochemical traits. The cluster analysis based on morphological and phytochemical traits clustered the 108 accessions into 7 and 6 major groups respectively. The genetic component studies showed that seed yield had a high genotypic (63.1%) and phenotypic (243.8%) variances but low heritability of 18.41% while phytochemical traits had high GCV (>20), PCVs (>20) and heritability (>80%). Based on the lowest RSI scores, the 10 best performing accessions with high yield potential among the population evaluated were UG84, UG24, UG44, UG69, UG47, UG14, UG70, UG66, UG36, UG102 . The marginal analysis revealed that no accession was significantly higher in yield than the overall mean. However, it confirmed cluster grouping of accessions based on trait similarities and dissimilarities.

DEDICATION

This thesis is dedicated to my family and to Professor Isaac Kwadwo Asante who has been a good mentor, father and friend.

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LIST OF ABBREVIATIONS

APL	-	Pod length
APW	-	Pod width
ASP	-	L-aspartic acid
BL	-	Branch length
BRC	-	Branch colour
D50F	-	Days to 50% flowering
D50MP	-	Duration to 50% mature pod
DFF	-	Number of anthesis at first flowering
DFMP	-	Duration to first mature pod
DLB	-	D-l-b-phenylalanine
DTG	-	Days to germination
EC	-	Eye colour
EP	-	Eye pattern
FC	-	Flower colour
GAL	-	Gallic acid
GH	-	Growth habit
GLY	-	Glycine
GP	-	Growth pattern
IPP	-	Immature pod pigmentation
ISO	-	Iso leucine
LBL	-	Lobe length
LC	-	Leaf colour

LIST OF ABBREVIATIONS (Cont'd)

LHIS		L-histidine
LLEU	-	L-leucine
LLYS		L-lysine
LM	-	Leaf marking
LMET	-	L-methionine
LN	-	Number of locules
LSER	-	L-serine
LT	-	Leaf texture
LTRY	-	L-tryptophan
LTYR	-	L-tyrosine
LVAL	-	L-valine
MPC	-	Mature pod colour
NAFF	-	Duration to first flower
NMB	-	Number of main branches
NNS	-	Number of nodes on main stem plant
NOL	-	Number of leaves
NPLNT	-	Number of pod per plant
NRPP	-	Number of racemes per plant
NSPP	-	Number of seeds per pod
PC	-	Pod curvature
PCA	-	P-coumaric acid
PDL	-	Peduncle length
PED	-	Peduncle colour

LIST OF ABBREVIATIONS (Cont'd)

PH	-	Plant height
PHN	-	Plant hairness
PP	-	Plant pigmentation
PPDN	-	Number of pod per peduncle
PSA	-	Percent seed abortion
PTC	-	Petiole colour
PTP	-	Pod attachment to peduncle
PV	-	Plant vigour
PWT	-	Pod wall thickness
QUE	-	Quercetin
RP	-	Raceme position
RUT	-	Rutin
SC	-	Seed coat
SCW	-	Seed crowding
SL	-	Seed length
SPS	-	Standard petal length
SPT	-	Splitting of testa
SS	-	Seed shape
ST	-	Seed thickness
STC	-	Stem colour
STL	-	Stipule length
STW	-	Stipule width
SW	-	Seed width

LIST OF ABBREVIATIONS (Cont'd)

SWGT	-	Seed weight
TLL	-	Terminal leaflet length
TLS	-	Terminal leave shape
TLW	-	Terminal leaflet width
TT	-	Twinning tendency
TTX	-	Testa texture
VAN	-	Vanillic acid
YLD	-	Yield

CHAPTER ONE

INTRODUCTION

1.0 General Introduction

Cowpea (*Vigna unguiculata* L. Walp.), is an important staple food legume and cheap source of protein for many poor Africans in the low-land humid and dry savannah tropics. It is an excellent substitute for animal proteins by resource-poor people and vegetarians because of its high seed protein content (about 25%) and rich amino acids (Boukar *et al.* 2011). Indeed, some cultivars with seed protein content of about 30%, close to that obtained for soybean (Glycine max) have been reported (Singh 2007; Santos *et al.* 2012). Immature pods, immature seeds and young leaves of cowpea are also used as vegetables (Umaharan *et al.* 1997), and its plant residues could be used as fodders and compost. Nigeria accounts for about 50% of total cowpea production in Africa with the production of about 6 million metric tons (FAO 2013). This high volume of production demonstrates the importance of cowpea cultivation as a component of Nigerian farming system and with cultivation expanding beyond the northern region traditionally known for the crop in recent times (Nwofia *et al.* 2006; Akande *et al.* 2012). However, farmers-traditional cultivars are known to be well adapted to the low input conditions, but generally poor in yield and highly susceptible to major diseases and pests. These production constraints are the main target of cowpea breeding programs both at the national and regional levels in sub-Sahara Africa. Although past research efforts have brought some improvement into farmer's yield, available statistics still indicate significant instability in yield across years (FAO 2013) and yield at farm-gate is far below optimum. In Ghana, the area under cultivation peaked in the year 2003 with 190,400 ha (MOFA, SRID, 2011). However, there have been slight reductions in the area under cowpea cultivation from then to 163,700 ha in 2010. Despite the decline in area, total cowpea grain production per annum has increased from 142,300 MT in 2004 to 219,300 MT in 2010. This is an indication of higher yields which may be due to adoption of combination of factors including better agronomic practices and higher yielding varieties. Cowpea consumption is higher than production in Ghana. There was import of 3,380 MT of cowpea grains which supplemented the country's production of 219,300 MT in 2010. This is, however, a tremendous improvement over the deficit of 1990 which was 113,000 MT (Al-Hassan and Diao, 2007). There is an urgent need to devise novel and workable solutions to achieve sustainable means of enhancing productivity in terms of agro-products and their nutritional composition to of cowpea to reduce the import deficit of cowpea locally and meeting the demand of the ever growing global human population.

In this study, 108 cowpea accessions which consisted of 56 segregating cowpea accessions at various stages of breeding, 48 cowpea collections and 4 breeders were evaluated for variability, genetic stability and selection indices of seed yield and yield components traits using variance component analysis, bivariate and multivariate analysis, rank summation index and marginal analysis approach in a search for cowpea accessions with high yield and high phytochemical content.

1.2 Problem statement

With the world population expected to increase by up to 70% by 2050, the global community is faced with the constraint of providing safe and secure food supplies to an increasing number of people. The human population is projected to reach the 9.8 billion mark by 2030, bringing immense challenges in feeding the global populace (Tian *et al*., 2016; Pais *et al*., 2020). This will be a huge task, especially for the African continent, to handle in an era of climatic change and a growing population that will double by the year 2050 (Adedeji *et al*., 2020). Not only is the task of coping with this high human population growth rate in terms of the conventional agricultural production system daunting; it is also not environmentally/ecologically sustainable (Roell and Zurbriggen, 2020). In addition to the burgeoning human population, other factors that are posing threats to improvement in agricultural productivity include among others, climatic change, the loss of fertile agricultural land to urbanization, the challenges of phytopathogens and pests, abiotic challenges, high levels of salinity, and drought.

Annually, the plant is cultivated on 14.4 million hectares that produce 8.90 million tons (Food and Agriculture Organization of the United Nations, 2021) of cowpea seeds. The annual average production of cowpea is low compared to other grain legumes, primarily due to narrow genetic variability and the low yielding potential of existing genotypes (Raina *et al*., 2020). The consistent use of conventional breeding approaches has reduced genetic variability, which is the main prerequisite for crop improvement programs (Holme *et al*., 2019).

Despite all the previous efforts, there is still a big gap in cowpea improvement to identify the ideal varieties that have high yielding potential, high productivity and enhanced nutrition.

1.3 Justification

The rising increase in the global human population, impacts of climate change and armed conflicts within the sub-region and outside the region has led to decreasing land use for agriculture and agricultural related activities, destruction of crops and displacement of humans and animals. All these occurrences have accounted for increased famine and malnutrition among humans especially children and animal populations. The success of a crop improvement programme largely depends on the extent of variability available in the germplasm for various economic important characters (Vu *et al*., 2017). The conservation of genetic diversity is also an important task especially in the modern era where most of the crop species are facing genetic uniformity and effects of climate change. This makes these crops more vulnerable to both biotic and abiotic stresses. Therefore, concrete efforts need to be made towards effective characterization, evaluation, identification and then utilization of trait specific germplasm accessions. Keeping this view, the present study was aimed to study identify cowpea accessions with high yielding and high phytochemical content to help combat malnutrition, food insecurity, ensure food sustainability and effective land use.

1.4 Objectives of the study

1.4.1 Main objective

The main objective was to evaluate yield and yield components in cowpea accessions for high yield and high phytochemical content.

1.4.2 Specific Objectives

1. evaluate the extent of agro-morphological and phytochemical variability existing among cowpea accessions.
2. to determine the relationships existing between growth and vegetative, yield and yield-related, and phytochemical traits.
3. estimate genotypic and phenotypic variances as well as the heritability estimates of the agro-morphological and phytochemical traits.
4. Rank, identify and select superior cowpea accessions based on yield and yield components.

CHAPTER TWO

LITERATURE REVIEW

2.1 ORIGIN, DOMESTICATION AND DISTRIBUTION

Cowpea is known to be endemic in Africa. Cowpea belongs to the genus *Vigna*. The genus *Vigna* is a diploid consisting of twenty-two (22) chromosomes (Fatokun *et al.*, 2013). Cowpea is a member of the Leguminosae family's Phaseoleae tribe, which encompasses many of the significant warm-season grain and oil seed legumes (Timko *et al.*, 2007). Flight (1976) writes that carbon dating of certain specimens from Kimtampo rock shelter in Ghana showed the first indication of cowpea existence in West Africa. It is suggested that cowpea got its name from the fact that it used to be a major source of fodder for cows in the south-eastern United States and other regions of the world (Timko *et al.*, 2007). The genus *Vigna* consists of several species distributed into subgenera, namely *Ceratotropis*, *Haydonia*, *Lasiocarpa*, *Macrorhycha*, *Plectotropis*, *Sigmoidotropis* and *Vigna* (Marechal *et al.*,1978; Fatokun *et al.*, 2013). Because members of the *Vigna unguiculata* ssp dekindtiana group can be produced from farmed cowpea, it is assumed to be the immediate parent of these cultivated cowpeas (Ehlers & Hall, 1997).

For the domestication of cowpea in various locations of sub-Saharan Africa, several explanations have been offered (Ba *et al.*, 2004). Herniter *et al*. (2020) reported that Vavilov (1926) was the first to suggest Ethiopia as the main centre for cowpea domestication, with China and India as secondary centres. West Africa is a major hub of farmed cowpea varieties (Padulosi and Ng, 1997). West Africa as a major centre for cowpeas may be as a result of the fundamental variations that exist in cowpea grains grown by the locals. Cowpea has many names across the world. Cowpea is referred to as "*caupi*" in Brazil and "*wake*", "*ewa*", and "*niebe*" across West African countries while in the United States, it is referred to as black-eyed peas, southern peas, field peas, pinkeye, and crowders (Timko *et al.*, 2007). South-eastern Africa is said to be the major place of the diversity of wild *Vigna* species (Ehlers and Hall, 1997). Temperatures in subtropical zones are ideal for cowpea during summer while that of tropical zones supports cowpea growth all year (OECD, 2016).

2.2 THE BOTANY OF THE COWPEA PLANT

The cowpea *Vigna unguiculata* (L.) Walp. is an annual herbaceous legume cultivated for its edible seeds or fodder. Cultivated cowpeas are herbaceous annuals that are either erect, prostrate or climbing annuals with a tap root and virtually all are glabrous. They are mostly grown for grain but a small proportion (about 10%) are grown as green leafy vegetables and fodder in Africa or as fresh pods in eastern Asia (Boukar *et al.*, 2015). Cowpea V. unguiculata can grow up to 80 cm and up to 2 m for climbing cultivars. It has a well-developed root system. Germination is epigeal with the first pair of true leaves being simple and opposite and subsequent leaves being trifoliate with oval leaflets (6-15 cm long and 4-11 cm broad) and alternate. The papilionaceous flowers are born on racemose inflorescences at the ends of peduncles that arise from leaf axils and can be white, yellowish, pink, pale blue or violet in colour. Peduncles are stout and grooved and usually much longer than the leaves (2-20 cm long). Flowers are self-pollinating, arranged in raceme or intermediate inflorescences in alternate pairs. Flowers open in the early day and close at approximately midday, after blooming they wilt and collapse. Pollinating insect activities are beneficial in increasing the number of pod set, the number of seeds per pod or both; however, there are no recommendations for the use of pollinating insects on cowpeas (McGregor, 1976). For each inflorescence, flowers are sequentially produced in alternating pairs on thickened nodes at the tip with cushion-like extra-floral nectaries between each pair of flowers. The flower is large (standard is 2-3 cm in diameter), with a straight keel, diadelphous stamens (one free and nine fused), a sessile ovary with many ovules, and a style that is bearded along the inside and ends in an oblique stigma. Fruits are pods that vary in size, shape, colour and texture. They occur in pairs forming a V, mostly pending and vertical but may be erect, crescent-shaped or coiled. Usually yellow when ripe, but may also be brown or purple in colour. They are cylindrical, 2-6 cm long and 3-12 mm broad and contain 8-20 seeds. Seeds vary considerably in size, shape and colour.

They are relatively large, 2-12 mm long and weigh 5-30 g/100 seeds. Seed shape could be reniform or globular. The testa, the coat covering the grain may be smooth or wrinkled; white, green, red, brown, black, speckled, blotched, eyed (the hilum – central line – is white surrounded by a dark ring) or mottled in colour (Aveling, T., 1999; Heuzé *et al*, 2013). The corolla is yellowish-white to violetish-white with violet wings and mature seed colours vary from white through brown to black. Cultivated cowpeas are mostly indeterminate and some have the potential to produce multiple flushes of flowers (Gwathmey *et al*. 1992) that live for less than one year. The wild relatives of cowpeas, which are perennial, have fleshy roots and the capacity to re-sprout after a dry or cool season.

2.3 PRODUCTION

Cowpeas are produced across the world mostly as dry seeds. Africa is the home of cowpea production. The production of cowpea has increased due to researches and studies, which has helped develop cultivars that have much quality, invulnerable to some plant diseases and flourish early (Ehlers and Hall, 1997). The production of this grain legume is subjected to West African countries including Nigeria, Niger, Burkina Faso and Mali. In tropical and subtropical areas, cultivated cowpeas are grown as warm-season annuals (Hall, 2001). In the year 2014, Sub-Sahara Africa and Asia were the largest producers of the world's cowpea, contributing about 95 % of the total production (FAOSTAT, 2021; OECD, 2016). Cowpea dry grain output is the sole commodity that has previously been evaluated on a global scale (Timko *et al*., 2007). The cowpea yield in 2020 was estimated to be in the region of 9.8 million, while by 2030, the projected yield is expected to rise to 12.3millon tons (Boukar *et al*., 2016). In many years of cowpea production across the world, Nigeria has the highest estimated production followed by Niger and Brazil, respectively (Timko *et al*., 2007). The coastal countries of West Africa such as Ghana, Côte d'Ivoire (Ivory Coast) and Nigeria serve as a major point of trading providing a large market for highly rated cowpea grains in Africa. Cowpea can tolerate drought conditions; therefore most cultivars prefer planting cowpea over other grains (Duivenbooden *et al*. 2002). The production of cowpea has increased due to its high demand by the African population since cowpea serves as a major food in Africa (Horn and Shimelis ,2020)

2.4 CONSTRAINTS TO COWPEA PRODUCTION

According to (FAO,2006), about 6,991,174 tonnes of dry cowpea grains are produced annually worldwide on about 12,316,878 ha. Despite the importance of cowpea, its productivity in typical Sub Sahara Africa farmers' fields is very low, at less than 600 kg/ha compared with a potential grain yield of over 2000 kg/ha (Boukar *et al*., 2018). This is partly due to the use of unimproved varieties, inadequate application of inputs, and poor agronomic practices during crop production. Furthermore, cowpea production is constrained by many biotic and abiotic factors, including low soil fertility and a wide range of factors such as insects, diseases, parasitic weeds, and unavailability of improved seeds (Huynh *et al*.,2016; Bolarinwa *et al*., 2021; Rugare *et al*., 2015). According to Haggag *et al*. (2015) drought and soil salinity are major abiotic stress factors affecting crop production and food safety. In addition, drought and high temperatures are identified as key stress factors that the researcher should emphasize more about the effects of climate change on plants. Plant breeders and biotechnologists have been studying and trying to acquire knowledge and tools, to tackle challenges posed by climate change. The challenge in many is to produce sufficient food for the escalating population growth with limited water supplies and breeding for drought tolerance and water use efficiency (Haggag *et al*., 2015; Horn *et al*., 2015)

Water scarcity causes a significant reduction in agricultural productivity and can lead to total crop failure or reduce yield below 360 $kg \cdot ha^{-1}$. In addition, water deficit reduces leaf area index, chlorophyll content, number of pods per plant, and seed yield in cowpea (Bailey *et al*., 1990). Even though cowpea is regarded as a drought-tolerant crop and can grow under harsh climatic conditions with limited water, it is also affected by various climatic factors and often lead to low yields (Larweh *et al*., 2019) According to Carvalho *et al*. (2017), cowpea's growth period can range between 90 to 240 days, but this varies from variety to variety and climatic conditions. Bastos *et al*. (2011) reported that well-watered cowpea plants could produce more than 1000 kg grain ha^{-1} , while in Ghana, an average yield of 1.25 metric tons per hectare was observed in farmers' fields (Larweh *et al*. 2019). Insect pests are the most important yield-reducing biotic factors in cowpea production worldwide (Sindhu *et al*.,2019; Togola *et al*., 2020) The major insect pests of cowpea include aphids (*Aphis craccivora* Koch), flower bud thrips (*Megalourethras spotted* Trybom), pod borer (*Maruca vitrata* Fabricius), and pod sucking bugs (especially *Clavigra llatomentoscollis* Stal, *Riptortus identifies* Fabricius, *Anoplocnemis curvipes* Fabricius, and *Nezara viridula* Linnaeus) (Boukar *et al*., 2018). Most of the insect pests affect the crop in the field except storage pests such as weevils that destroy seeds in storage facilities, although infestation may occur while the crop is in the field (Souleymane *et al*., 2013). Significant losses due to *Striga gesnerioides* have been reported to range between 83% and 100%, especially in Sub-Saharan Africa (Omoigui *et al*.,2012). In some parts of Sub-Saharan Africa, such as the northern Guinea savanna of Nigeria and northern Namibia, 100% yield losses on farmer's fields were recorded mainly when susceptible local varieties were used (Horn and Laing, 2015; Omoigui *et al*.,2012).

2.5 USES AND ECONOMIC IMPORTANCE

The plantation of cowpea is a strategic way to reduce food insecurity in the world (da Silva *et al*., 2018).Cowpea is mainly used to supplement protein and vitamins containing foods. Cowpea is vital to the livelihoods of relatively impoverished people in tropical developing countries, especially where animal protein is scarce. It is considered the second most important legume feed grown (Asante, 1996). According to a household survey performed in Ethiopia, the cowpea grain is the most popular part of the cowpea for food in Ethiopia, notably in the states of Amhara, Oromia, and Tigray (Kebede & Bekeko, 2020). In herbal medicine, cowpea leaves serve as a high protein pot herb in many African and Asian countries (Kebede & Bekeko, 2020). The immature cowpea shoots and leaves are consumed as spinach and vegetables usually when dry (Alemu *et* *al.*, 2016). Cowpea residue is a significant source of feed for ruminant animals. Alemu *et al.* (2016) reported that cowpea leaves and grains are used to treat gastric discomfort, malaria and liver diseases by most farmers.

Cowpea is notable for its soil fertility management when intercropped with other cereal crops. Cowpea is important for traditional farming systems as it fixes atmospheric nitrogen, improves soil fertility, provides ground cover and suppresses weeds (Kyei-Boahen *et al.*, 2017; Beshir *et al.*, 2019). Cowpea is capable of fixing about 240 kg ha^{-1} of atmospheric nitrogen and making about 60–70 kg ha^{-1} nitrogen for succeeding crops when rotated (Kebede & Bekeko, 2020). Yusuf *et al.* (2009) reported that, in the Northern Guinea Savanna zone of Nigeria, cowpea genotypes fix about 13.9 to 40.3 kg ha^{-1} of atmospheric nitrogen. Sanginga *et al.* (2000) also reported about 13.1–31.9 kg ha^{-1} fixed nitrogen for eight cowpea genotypes in West Africa savanna. The differences in the amount of nitrogen fixed by the various cowpea genotypes reported by Yusuf *et al.* (2009) and Sanginga *et al.* (2000) were a result of the number of days required for the cowpeas to reach maturity (Kebede & Bekeko, 2020). The fixation of nitrogen in the soil helps them grow very well in poor soils with about 85% sand and less than 0.2% organic matter with lower levels of phosphorus (Fall *et al.*, 2003). Cowpea plants are shade tolerant and compatible which makes them grow together with some crops like maize, sorghum, cotton and sugarcane (Andargie *et al.*, 2013; Quaye *et al.*, 2009 ; Timko & Singh, 2008; Timko *et al.*, 2008). Cowpea grain and cowpea hay trade at the local and global level is a major contribution to the West African economy (Langyintuo *et al.* 2003; Timko *et al.*, 2007). Farmers usually sell cowpea grains in the local market to generate income. Aside from being sold as a dry grain, it is also processed by industries and stored in different containers.

Cowpea is a multi-purpose crop that is cultivated around the world. It is cultivated mostly for its seeds which are high in protein and rich in lysine and tryptophan. They serve as vegetables like green pods, fresh shelled green peas, shelled dry peas and leafy greens (Fall *et al.*, 2003). Their haulm serves as a source of feed for livestock. Cowpea plants can serve as soil erosion and green manure control (Andargie *et al.*, 2013; Quaye *et al.*, 2009; Timko & Singh, 2008; Timko *et al.*, 2008).

2.6 NUTRITION

Recent studies proved that malnutrition contributes to more than one-third of child's death in the world (Sharmila, 2022). This is due to the high rate of cereal-based meal consumption which is less nutritious, bulky but gives more energy (Amagloh, 2022). Legumes are considered foods that are rich in high protein and energy. Cowpea has been recommended as a required diet for the economically depressed communities in developing countries due to its high protein content to cause a reduction in the high prevalence of energy and protein malnutrition (Jayathilake *et al.*, 2018). Cowpea is low in fats but has high protein concentrations. Research programmes and the crossing of different varieties have increased the nutritional content of newly formed hybrids of cowpea. Cowpeas are a major part of diets throughout Africa, Latin America, and Asia, where they are particularly beneficial as sources of dietary protein to supplement cereals, starchy roots, and tubers (Phillips *et al.*, 2003). The existence of both heat-labile, heat-stable anti-nutrients and the intrinsic defiance to digestion of the primary globulins, restrict the nutritional quality of legume protein (Phillips *et al.*, 2003).

Cowpea has low energy density and contains about 23-32% protein, 50-60% carbohydrate and about 1% fats in dry weight. Yalçın (2007), reported that cowpea contains about 20.42–34.60% protein, 1.3% oil, 3.9% cellulose, 50–67% carbohydrates and 3.4 cal/g with the protein being rich in lysine and less amount of sulfur amino acids. The protein content in cowpea is about two-to-four-fold more than that in cereals and tuber crops. Essential minerals and vitamins are rich in cowpea. Cowpea serves as a natural complement food with cereals because it being rich in the amino acid called lysine. It is also a source of vitamins, flavonoids and also used as dietary fibre, as well as amino acids that serve great importance to the development of the human body. Certain specific or primary amino acids may cut across all cowpea grains but some amino acids may be specific to different varieties of cultivars. But deficient in methionine and cysteine as compared to animal proteins. It serves as a great source of health-promoting components like soluble and insoluble dietary fibre, minerals, phenolics and other functional compounds like vitamin B (Jayathilake *et al.*, 2018). Cowpea leaves contain minerals such as calcium, phosphorus and vitamin B (Maynard, 2008).

2.7 MORPHOLOGICAL CHARACTERIZATION AND EVALUATION

Cobbinah *et al.* (2011) studied about the hundred and thirty-four accession of cowpea from eight geographical origins in Ghana which were planted at two locations, Bunso (semi- deciduous forest) and Pokuase (coastal savanna) to evaluate their performance and to select those with desirable qualitative and quantitative characters for improvement. By 1986, about a total of 35,000 accessions of more than crop types have been multiplied and characterized. Like any other crop, cowpea breeding programme comprises important procedures. The first step involves breeders, collecting and evaluation of germplasm to select the parental lines or cultivars.

Genetic diversity in cowpea has been estimated using phenotypic, qualitative and quantitative agronomic traits that do not necessarily reflect real genetic relationships (Patil *et al.*, 2013). In addition, environmental conditions strongly influence the expression of these traits; hence, it limits the knowledge of the germplasm structure for specific ecological adaptations (Kameswara, 2004). It is vital to understand and manage the natural variability present in the landraces, which is a prerequisite for their genetic improvement.

2.7.1 Pigmentation

In the study by OO *et al.* (2022) Leaf colour of all genotypes were occurred as equivalent group having 23 genotypes with green and 23 genotypes with dark green leaf colour showing little variation among them. Measurement on leaf shape of all genotypes observed high variation i.e.hastate, sub-hastate, globose and sub-globose. 23 genotypes had globose, ten genotypes were hastate, 9 genotypes were sub-globose and four genotypes possessed subhastate leaves. Similar findings were also reported by Yadav *et al*. (2013) in Indian mustard; Kaur *et al*. (2017) in Vigna radiata; Kumar *et al*. (2016) and Bello *et al*. (2021) in cowpea. In flower colour, two categories classified among the genotypes i.e., purple and white. 25 genotypes had purple flowers and remaining 21 genotypes showed white flowers indicating there was little variation in 46 cowpea genotypes. Previous workers were similarly reported by Kaur *et al*. (2017) in Vigna radiata; Stoilova and Pereira (2013), Kandait *et al*. (2016) and Bello *et al*. (2021) in cowpea. Considering pod pigmentation at tip, all the 46 genotypes were classified into three categories which are small pigmented, complete and non pigmented. Majority of the genotypes (45) found no pigmentation, the genotype Pant Lobia 4 had small pigmentation and the genotype PGCP 68 completely pigmented. For pod shape, all the genotypes classified into three categories i.e. straight, slightly curved and curved. 23 genotypes had slightly curved pod, 21 genotypes had straight pod shape and the remaining two genotypes viz., GC 1712 and PGCP 67 had curved pod shape. It was revealed that there was little variation among the 46 cowpea genotypes according to pod characteristics. Similar findings were also reported by Katiyar *et al*. (2008), Kaur *et al*. (2017) in Vigna radiata; Yadav *et al*. (2013) in Indian mustard, Kumar *et al*. (2016) and Kandait *et al*. (2016) in cowpea. On the basis of seed colour, all the genotypes were grouped into three categories i.e. creamy, brown and black. 28 genotypes showed brown, 17 genotypes had creamy seed and the only PGCP 68 had black in colour. According to seed shape, three groups were occurred into rhomboid, ovoid and crowder shape. 28 genotypes showed rhom boid 14 genotypes had ovoid and the remaining four genotypes possessed crowder seed shape. All the genotypes were classified into five groups i.e. reddish brown, brown, tan/brown greenish and black for seed eye colour. The largest group had 30 genotypes of tan/brown eyed seed, eleven genotypes had greenish eyed seed, three genotypes possessed reddish brown in eye colour and two genotypes (SKAU 407 and PL 7) had black-eyed seed. It is suggested that the group patterns in seed colour, seed shape and seed eye colour had significant variation among the 46 genotypes of cowpea.

Similar findings were earlier reported by Katiyar *et al*. (2008), Kaur *et al*. (2017) in Vigna radiata; Yadav *et al*. (2013) in Indian mustard; Stoilova and Pereira (2013), Kumar *et al*. (2015), Kandait *et al*. (2016) and Bello *et al*. (2021) in cowpea.

2.7.2 Growth Habit

The major cowpea growth habits are: erect, semi-erect, prostrate, and climbing. Most cowpea plants are indeterminate in growth habit; however, some of the newly developed early maturing varieties have a determinate growth phenotype (Timko *et al.*, 2008).

Erect growth habit facilitates farming operations such as weeding, insecticide application, and harvest. It is needed for mechanization. A prostrate growth habit may contribute to weed control in ensuring ground covering. But, Wang *et al.* (2006) found that erect cowpea growth habit may be generally more competitive with weeds than semi-erect or prostrate growth habit. Moreover, prostrate growth habit complicates some farming operations and increase pods vulnerability (Abadassi, 2015). Uguru and Uzo (1991) studied three types of growth habit (decumbent, climbing and bushy) and found that two allelic pairs of genes condition growth habit. But, according to Matos Filho *et al.* (2014), Ribeiro *et al.* (2014) and Lackyan and Dalvi (2015), however reported that growth habit is monogenic. The materials used and the types of growth habit considered may explain the differences noted. Fery and Singh (1997) reported broad-sense heritability estimates for growth habit traits such as plant height, branch number, node number, stem diameter, leaf number, leaf area, and root length ranging from 0 to 0.98. Selection for some growth habit traits may, therefore, be effective in some cowpea populations.

2.7.3 Seed yield

Seed yield in cowpea is the product of components including the number of pods per plant, the number of seeds per pod, and the mean seed weight. Its heritability is low (Padi, 2008; Alidu *et al*., 2013). The mean number of pods per plant is the ratio of the number of pods harvested to the number of plants harvested. It is positively correlated with seed yield (Ajibade Morakinyo, 2000; Agbicodo, 2009, N'gbesso *et al* 2013; Millawithanachchi *et al.*,2015). Siddique and Gupta (1991) showed that additive gene effects were important in the genetic control of number of pods per plant. Ajibade and Morakinyo (2000) and Omoigui *et al.* (2006) reported low broad sense heritability estimates for the trait (0.20 for Ajibade and Morakinyo (2000) and 0.19 for Omoigui *et al.* (2006). However, Millawithanachchi *et al.* (2015) obtained high narrow-sense heritability estimates (0.61 to 0.88) in some crosses. The number of seeds per pod is obtained by counting. According to Ajibade and Morakinyo (2000) and N'gbesso *et al.* (2013), it is significantly and positively correlated with seed yield; but, Alidu *et al.* (2013) found that the two traits were not significantly correlated.

The number of seeds per pod is moderately or highly heritable (narrow-sense heritability estimates ranging from 0.41 to 0.7011 (Millawithanachchi *et al.*, 2015). The mean seed weight is determined after counting and weighing a number of grains. It is, according to Ajibade and Morakinyo (2000), positively correlated with seed yield; at the opposite, Alidu *et al.* (2013) and N'gbesso *et al.* (2013) did not find any significant correlation between the two traits. Lopes *et al.* (2003) found that seed weight was governed by five genes. The trait may be highly heritable (narrow-sense heritability estimates of 0.6047 or 0.7111). High and stable seed yielding cultivars are needed in all cowpea producing areas. The data summarized earlier show that number of pods per plant, number of seeds per pod and seed weight may be highly heritable in cowpea. Selection for those traits can, therefore, be effective. The three traits are significantly correlated with seed yield in some cases. It may be then possible to increase seed yield by selecting for number of pods per plant, number of seeds per pod or seed weight. Direct selection for seed yield may also be effective if appropriate methods are used.

2.7.4 Seed quality

In cowpea, seed quality traits include seed size, seed coat colour, seed coat texture, and cooking time. Cowpea seed size ranges from small to big. Ogunbodede and Fatunla (1985) proposed a digenic epistatic model for seed size. Karkannavar *et al.* (1991) identified a dominant gene that conditions big seed. According to Drabo *et al.* (1984) and Padi and Ehlers (2008), seed size may be highly heritable. Cowpea seed coat colour varies with variety. The common colours known include white, brown, cream, green, red, buff, and black. Drabo *et al.* (1988) found that seed coat colour was controlled by five genes whereas Egbadzor *et al.* (2014) reported that several genes may govern the trait. Four seed coat textures are usually distinguished in cowpea: smooth, rough, wrinkle, and loose. Kehinde and Ayo-Vaughan (1999), Singh and Ishiyaku (2000) and Mashi (2006) indicated that two pairs of genes govern seed coat texture in cowpea. Cooking time ranges from short to long. Mashi (2006) found that two genes control cooking time in the varieties he studied. He also reported high narrow-sense heritability estimates (0.58 to 0.85) for that trait. Seed quality is very important for consumers. All the consumers prefer short cooking time varieties to save time and energy. The other seed quality characteristics needed in tropical zone depend on the region and the destination of the grains. For example, cowpea varieties with large white or brown grains and rough seed coat is generally preferred throughout West Africa whereas varieties with medium brown or red grains and smooth seed coat are preferred in East Africa (Langyintuo, *et al.*, 2003; Mashi, 2006; Ifegwu and Ajetomobi, 2014). Abadassi (2015) indicated that selection for seed quality in cowpea may be efficient if seed quality traits are highly heritable and positively correlated with other important agronomic traits.

2.8 PHYTOCHEMICALS CHARACTERIZATION

The general polyphenols common to all cowpea varieties are phenolic acids and flavonoids (Avanza *et al.*, 2013). Phytochemicals such as terpenoids, alkaloids and fatty acid esters have been reported to be potent antioxidants that help in plant metabolism (Grassmann *et al.*, 2005). The polyphenolic content of cowpea tends to increase as the plant approaches maturity while the tannin content reduces (Chikagwa-Malunga *et al.*, 2009). Extracts of cowpea polyphenols have been reported to have strong anti-inflammatory activity, with potential benefits in the treatment of diabetes, cancer, and cardiovascular illnesses (Awika & Duodu, 2017; Avanza *et al.*, 2013)

2.8.1 Polyphenolic Compounds

Polyphenolic compounds are termed substances that have a benzene ring bearing one or more hydroxyl substituents including their functional derivatives (Siddique & Gupta, 1991). Some sources of phenols include grapes, olive oil, sorghum, beans, herbs and spices (Moure *et al.*, 2001). Phenolic compounds are generally classified into three based on their sizes, they include phenolic compounds, flavonoids and tannins (Siddique & Gupta, 1991; Karuri, 2010). Cowpea serves as a great source of phytochemicals like the phenolic compounds which are known to prevent diseases and promote good health. Anthocyanins are commonly found in the black and green cowpea phenotypes (Mustapha & Singh, 2008).

A significant difference has been proven based on the study of phenol compounds and their antioxidant capacities to exist between cowpea cultivars (Teka *et al.*, 2020; Oksana, 2015). The phenolic composition of cowpea varieties in storage has been proven to show variations as compared to that of freshly harvested samples. Ethiopia is a region known to have cowpea varieties but lacks information concerning their phenolic content and antioxidant capacity. Phenols are categorized into bound phenolic compounds and soluble phenolic compounds (Teka *et al.*, 2020; Oksana, 2015).

However, more information on cowpea phenolics and antioxidant capacities is focused primarily on soluble phenolic fractions. Bound phenolic fractions are also abundant in legumes and covalently linked to the cell-wall matrix including cellulose, arabinoxylans and proteins by ester, ether and carbon-carbon bonds (Teka *et al.*, 2020). Polyphenols have been proven to occur in the free and bound forms in plants, most especially in whole grains like cereals and legumes. Phenolics and flavonoids have been proven to be more effective than Vitamin C, E and carotenoids. (Teka *et al.*, 2020; Oksana, 2015).

Flavonoids are referred to as plant secondary metabolites which play an essential role by protecting the plant. Even though some plants phenolics and flavonoids are classified as antinutrients, they serve also as natural antioxidants. Flavonoids can serve as antioxidants because of their molecular structure (Pandey & Rizvi, 2009). Their antioxidant and free radical scavenging activities results are based on the position of hydroxy groups and other features in the flavonoid structure (Ismael, 2015). The consumption of flavonoid-rich foods has been proven to protect against human diseases that are associated with oxidative stress. Cowpea seeds are known to be a good source of antioxidants. The total flavonoid content in cowpea have been proven to range from 0.95-0.36 mg quercetin equivalents g^{-1} (Avanza *et al.*, 2021). Flavanols and flavan-3-ols are termed as the main flavonoid subclasses observed in cowpea flour. Antioxidants are found mostly in the hull or the seed coat of the cowpea cultivar (Avanza *et al.*, 2021).

2.8.1.1 Phenols

Phenolic compounds are one of the most abundant and widely distributed groups of plant secondary metabolites, and they are responsible for a wide range of positive effects in a wide range of illnesses (Dalaram, 2015). Phenolic compounds are key secondary metabolites found in plants that play a vital role as an antioxidant resource (Vasantharaja *et al.*, 2019). These compounds are concentrated in the tegument of the cowpea which gives the seeds their typical colour (Avanza *et al.*, 2013). Polyphenols found in the plant matrix exist as both free and bound forms, mostly in cereals and legumes (Teka *et al.*, 2020). Bound phenols form is the dominating phenols contributing largely to the cowpea phenolic contents depending on the cowpea variety (Xiang *et al.*, 2019; Teka *et al.*, 2020). The bound phenolics are covalently bounded to the cell-wall matrix such as cellulose, hemicelluloses, lignin, pectin, and rod-shaped structural proteins by ester, ether, and carbon-carbon bonds (Acosta-Estrada *et al.*, 2014; Teka *et al.*, 2020). The covalently bounded bound phenolic compounds cannot be extracted into aqueous solvent mixtures (Perez-Jimenez & Torres, 2011). However, bound phenolic compounds can be extracted by acid, alkaline or enzyme hydrolysis together with the regular solvent extraction method (Tang *et al.*, 2016; Teka *et al.*, 2020). According to Adjei-Fremah *et al.* (2015) and Teka *et al.* (2020), cowpea phenolic contents are to date reported only as of the soluble portions, ranging from undetectable levels to 140 µg/g db. Phenolic acids in the soluble extracts contain hydroxybenzoic and hydroxycinnamic acid derivatives (Teka *et al.*, 2020). Previous research on the phenolic compounds and antioxidant proportions of cowpea cultivars revealed significant variances between the cultivars (Dalaram, 2015; Zia-Ul-Haq *et al.*, 2013). Kirigia *et al.* (2018) and Teka *et al.* (2020) reported that variations in the phenolic composition of cowpea varieties may be a result of the cowpea grain being put to storage as compared to the freshly harvested ones. These variations may also be due to genetic, the extraction method used and the environmental factors that affect the cowpea variety (Sombié *et al.*, 2018). P-coumaric acid is reported to be one of the dominant phenolic acids in the free fractions of cowpea seed (Cai *et al.*, 2003; Dueñas *et al.*, 2005).

2.8.1.2 Flavonoids

Flavonoid compound in plants constitutes an important group of polyphenolic compounds which has strong antioxidant potential and exerts many health benefits (Wang *et al.*, 2011). Flavonoids are a major source of dietary polyphenols in cowpea grains and have a well-documented antioxidant activity (Xiang *et al.*, 2019; Teka *et al.*, 2020). Flavonoids have a high potential for health benefits. According to research conducted by Teka *et al.* (2020), cowpea contains 4 to 22 % of soluble flavonoids. According to Nassourou *et al.*, (2016), previous epidemiological research showed that eating a diet high in flavonoids can protect against oxidative stress-related illnesses in humans.

2.8.1.3 Amino Acids

In nations with high rates of protein-energy malnutrition, legumes have been advocated as a protein source (Elharadallou *et al.*, 2015). Cowpeas are a good source of protein and nutrients at a reasonable cost (Chavan *et al.*, 1989). Characterization of specific storage proteins in legumes has received a lot of attention in recent years (Chan & Phillips, 1994). Lack of sulphur amino acids and the presence of anti-nutritional elements such as trypsin inhibitors are major limiting factors in the utilization of protein quality (Evans & Boulter, 1980). As a result, cowpeas must be properly prepared, especially when they are a major component of a young child's diet (Elharadallou *et al.*, 2015). Cowpea seeds had crude protein levels ranging from 18 % to 35 % depending on variety, and the protein in cowpeas was found to be lacking in methionine and tryptophan (Kachare *et al.*, 1987). Seed proteins were categorized according to their solubility in alkali (glutelins), salt solution (globulins), water (albumins), and alcohol (prolamins) (Chan & Phillips, 1994). The nutritional quality of total seed protein is greatly influenced by the relative proportions of each component in a seed (Chan & Phillips, 1994).

According to the WHO Technical Report Series (2007), it recommended the daily protein and amino acid requirements in adult human diet was as follows: histidine (10 mg/kg/day ≈ 10,000 ppb), Isoleucine (20 mg/kg/day ≈ 20, 000 ppb), leucine (39 mg/kg/day ≈39,000 ppb), lysine (30 mg/kg/day ≈ 30, 000 ppb), sulfur containing amino acids; Methionine (10 mg/kg/day ≈10,000 ppb) and cysteine (4 mg/kg/day ≈ 4, 000), aromatic amino acids; Phenylalanine and tyrosine (25 mg/kg/day ≈ 25, 000 ppb), threonine (15 mg/kg/day ≈ 15, 000 ppb), tryptophan (4 mg/kg/day ≈ 4,000 ppb) and valine (26 mg/kg/day ≈ 26, 000 ppb). Amino acids are classified as those that cannot be synthesized by the body and therefore must be obtained by the diet, called 'essential' (His, Ile, Leu, Lys, Met, Phe, Thr, Trp, and Val), and those that the body can produce, the so-called 'non-essential' amino acids (Asp, Asn, Glu, Ala, Ser, Cys, Tyr, Gly, Arg, Gln, and Pro).

2.8 INTERRELATIONSHIPS AMONG TRAITS IN VARIABILITY STUDIES

Bivariate and multivariate statistical tools have found extensive use in summarising and describing the inherent variation in the population of crop genotypes. Some of the tools that have found extensive application include principal component analysis (PCA), discriminant canonical analysis (DCA), and cluster analysis (CA). These techniques identify plant traits that characterise the distinctness among selected genotypes. They are often extended to the classification of a population into groups of distinct orders based on similarities in one or more characters, and thus guide in the choice of parents for hybridization (Ariyo, 1987; Nair *et al.*, 1998). The PCA has been used to partition observed agronomic variations in genotypes of many crops such as rubber (Omokhafe and Alika, 2000), rice (Nassir, 2002), and sesame (Mponda *et al.*, 1997).(what about cowpea) The canonical analysis is a tool used when it is of more interest to show differences between groups than between individuals (Labuschagne *et al.*, 2002). Graybosch *et al.* (1993) used canonical correlation to ascertain the extent to which a set of biochemical measurements were related to a set of quality measurements of wheat. Osborne *et al.* (1993) also employed the tool to discriminate between the different quality properties of breeding materials where differences between groups were of more significance than individual lines. Correlation and regression analyses are multivariate tools that help to study the interrelationships and inter-dependence among traits. While PCA and canonical variate analysis help to identify the traits with the highest variability, correlation and regression analyses help in the study of the relationships of the identified traits with yield and other traits, all in a bid to make the development of new varieties efficient and effective. Through correlation analysis, Islam *et al.* (2002) Tsegaye *et al.* (2006) showed that sweet potato yield is related to many traits. Since only few traits can be improved at a time during a breeding cycle, it becomes necessary to select few traits among those that impact yield. Multiple regression analysis is a good tool to study the individual contribution of many traits (independent traits) to the performance of a trait (dependent trait). This was demonstrated by Stathers *et al.* (2003) who identified marketable and unmarketable root weight and total number of roots as good yield components that could be used to improve the genotypes they evaluated.

2.8 HERITABILIY

In breeding programmes for seed improvement, it is important to collect suitable information concerning the magnitude, variabilities within characters and their heritabilities (Omoigui *et al.*, 2006). Heritability refers to the degree to which a character is passed down from one generation to the next (Omoigui *et al.*, 2006). Heritability is usually based on the quantitative characters of seeds, which contributes most to the yield component of the crops. The components of variance estimation for a quantitative trait allows one to assess the magnitude to which genetics impacts the trait of plant species. The estimations may also have consequences for distinguishing between alternative models of selection and also, selecting a suitable model for trait analysis (Abney *et al.*, 2001). The extent of heritability determines the ease of selection for superior traits in crop improvement. Briggs and Knowles (1967) suggested that environmental variance is insignificant compared to genotypic variance in the effective selection process especially for seed yield. However, some researches have shown that some cowpea traits are influenced by environmental variability. Several researches have shown linkage between high heritability and genotypic variance as well as genotypic coefficient ofvariance. Abney *et al.* (2001) reported that additive variance alone may not necessarily provide an accurate picture of the impact of genetics on a trait. We must also include dominant variance and, as a result, the broad sense heritability of the desired characteristics. Previous research on heritability in cowpea has shown that the degrees of heritability and the genetic factors for a trait differ from place to place (Omoigui *et al.*, 2006). For the selection programme variation presented among the traits was taken into consideration which depends on the degree of heritability (Khan *et al.* 2021). To know the projected gain from selection, valuation of genetic advance with heritability can be a significant approach to crop improvement (Khan *et al.* 2021). Various research findings reported that the selection may be effective for a specific trait improvement using available genetic variation with the degree of heritability (Umar *et al.*,2014; Langat *et al.*, 2019). Consideration of both heritability and genetic advance is more effective over the solely use of heritability (Mazid *et al.*, 2013; Asfaw *et al.*, 2017). Malek *et al.* (2014) findings disclosed that higher phenotypic variance values than the genotypic variance for all traits indicates the trait expression is governed by the environment. The estimated genotypic coefficient of variation and phenotypic coefficient of variation values were categorized based on the suggested index of 0%-10% for low, 10–20% for moderate and ≥ 20% for high variation (Khan *et al*., 2021; Sabri *et al*., 2020; Usman *et al.*, 2014). Intermediate to strong genetic advance with heritability(broad or narrow sense)? was found for all yield-related traits except seed width and shelling %. This indicates that the traits have significant potential in the selection process due to low environmental influences (Meena *et al. (*2016). The improvement of the traits with low heritability and genetic advance can be a boost over heterosis breeding (Usman *et al.,* 2014). The relative differences between genotypic coefficient of variation and phenotypic coefficient of variation were higher for the traits plant height, seed width, days to 50% flowering, and seed length in cowpea. This indicates higher environmental effect and that the improvement of these traits will be difficult via direct selection. Contrarily the trait with a lower difference signals of lower by the environment. This may give desirable, strong and significant output in crop improvement programme, is supported by Umar *et al.(*2014) and Usman *et al*. (2014).

Direct selection can be effective considering traits with low relative differences (Fakuta *et al*., 2014). Considering the heritability and genetic advance index (Khan *et al*., 2020; John *et al*., 1955) as more than 60% for high, 30–60% for moderate, and 0–30% for low, were found in the traits biomass fresh weight per plant (Hb = 97.68% GA = 88.82%), biomass dry weight per plant (Hb = 89.91% GA = 106.66%), fresh pod weight (Hb = 99.55% GA = 93.54%), dry pod weight (Hb = 98.10% GA = 113.94%), seed weight (Hb = 98.42% GA = 122.01%) and yield (Hb = 98.10% GA = 113.94%) were highly heritable together with high genetic advance value(re-cast the sentence and simplify it for clarity). They recommended that for crop improvement direct selection can be effective based on traits with effect of additive genes; similar findings documented by the previous researchers (Langat *et al*., 2019; Onwubiko *et al*., 2019).

Low to moderate heritability and genetic advance values may hinder in the trait's improvement due to high environmental effects over the genetic effects (Ridzuan *et al.*, 2019). Effective selection can be only achieved in traits with higher genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance where the effect of additive genes is more robust than environmental effect (Usman *et al*., 2014).

CHAPTER THREE

MATERIALS & METHODS

3.1 Experiment site

The field work was conducted at the West African Centre for Crop Improvement Farms, University of Ghana from August 2020 to November 2020. The soil used was sandy-loamy. The weather conditions during experiment were also recorded. The wide range of temperature and relative humidity were from 22.3°C to 38.7°C and from 22% to 74%. The highest rainfall was 400.4 mm and found 4 rainy days during this experiment

3.2 Experimental planting materials

F_2, F_3 and F_4 seeds from a parental cross between the cowpea variety Golinga and a wild relative were used for the research. The seeds of the parents and segregating generations were provided by the Genetics Unit, Department of Plant and Environmental Biology, University of Ghana. As female genitor the cultivar Golinga (P1) was used and as male genitor the cultivar Wild (P2). The F_2, F_3 and F_4 generations were obtained by performing the $P_1 \times P_2$ cross and the self-fecundations of the F_1, F_2, F_3 and F_4 generations. The $P_1 \times P_2$ crossing was performed in 2019, at the IPA headquarters in Recife, PE. Successive self-fecundations from F1 to F4 were performed. Segregating generations were conducted by the single pod descent method from the F2 to F4 generation, when the lineages were opened. All seeds from the F1 generation were used to produce the F2 generation. From the F2 generation, the seeds from the harvested pods formed a bulk with the seeds from all plants of the same cross. From each bulk a sample was taken to be sown, composing the plants of the next generation. The remaining seeds from each cross were stored for future trials.). Fifty-six inbred lines at F_2 to F_4 stages of breeding and forty-three accessions as test materials stored at the Department of Plant and Environmental Biology Seed Bank were used in the present study. The test materials were segregated materials

Four controls which were used due to theirused due to their productive and commercial standard characteristics. The controls or controls were Asontem, Padi-tuya, Kirkhouse and Wan Kae. The controls were collected from Savannah Agricultural Research Institute (SARIproductive commercial standard characteristics. The controls or controls were Asontem, Padi-tuya, Kirkhouse and Wan Kae. The controls were collected from Savannah Agricultural Research Institute (SARI). fiftyand fiftyand fifty (Appendix 1).

3.3 Experimental design

The experimental design used for this experiment was complete block design (RICBD) with three to twelve replications used. There were seven blocks which contained 27 lines each. Each block measured 5 m × 1.8 m. An alley of 1 m was left between lines in each block and a 2 m alley was left between blocks. After every five-test material planted for each line, the four pure lines were introduced as checks. An accession was planted for each row, which comprised of three to twelve plants. The planting distance was 20cm x 30 cm.

3.4 Land Preparation, Planting and Fertilizer Application

The experimental field with sandy loam soil, was ploughed and harrowed, after which planting was carried out. Between three to twelve seeds were placed in each hole. Weeding was done using a hand hoe at 3 and 6 weeks after sowing. Cowpea plants were sprayed against insect pests using '*Attack*' insecticide at a rate of 600 mls/ha at 35,45, 55 and 65 days after sowing.

3.5 Data collection

3.5.1. Morphological data

Morphological data were collected on plants that survived 6 weeks after planting. Morphological characterization was conducted under the two broad areas qualitative and quantitative traits. The standard Descriptor for Cowpea by the International Board for Plant Genetic Resources (1983) was used.

3.5.1.1 Qualitative traits

Qualitative traits were observed in 108 accessions are presented in Table 1. Twenty-eight qualitative traits were studied. The phenotypic classes of the various traits were scored through observations and hand feeling. The qualitative traits were grouped under 13 growth and vegetative and 15 yield-related traits (Table 1).

Table 1: Qualitative traits measured in 4 pure lines (control), 56 segregating populations (F_2 - F_4) and 43 accessions

Characters	Trait	Abbreviation	Classes
Growth and Vegetative Traits (13)			
Pigmentation	**Stem colour**	**STC**	Extensive (Dark red with green extensions),
	Branch colour	**BRC**	Intermediate (Intermediate red with green
	Petiole colour	**PTC**	extensions), Moderate (Intermediate green),
	Plant pigmentation	**PP**	None, Solid (Dark green), Very slight (Pale green)
	Leaf colour	**LC**	Dark green, Intermediate green, Pale green
General plant characteristics	**Growth habit**	**GH**	Acute erect, Erect, Semi-erect, Intermediate, Semi–prostrate, Prostrate, Climbing
	Growth pattern	**GP**	Determinate, Indeterminate
	Twinning tendency	**TT**	None, Slight, Intermediate, Pronounced
	Plant hairness	**PHN**	Glabrescent, Short appressed hairs, Pubescent
	Plant vigour	**PV**	Non-vigorous, Intermediate, Vigorous, Very vigorous
Leaf characters	**Terminal leave shape**	**TLS**	Globose, Sub-globose, Sub-hastate, Hastate
	Leaf marking	**LM**	Absent, Present
	Leaf texture	**LT**	None, Slight, Intermediate, Pronounced
***Yield-related traits** (15)*			
Pigmentation	**Peduncle colour**	**PED**	Extensive (Dark red with green extensions), Intermediate (Intermediate red with green extensions), Moderate (Intermediate green), None, Solid (Dark green), Very slight (Pale green)
	Flower colour	**FC**	Purple, Yellow, Cream, White, Mauve
	Immature pod pigmentation	**IPP**	None, Pigmented tip, Pigmented sutures, Pigmented valves, green sutures, Splashes of pigment, uniformly pigmented
	Mature Pod colour	**MPC**	Black, Brown, Dark tan, Straw
	Seed coat	**SC**	Black, Brown, Cream, Cream with black patches, Grey, Purple, Red, White
	Eye colour	**EC**	Eye absent, Gray, Red
Flower characters	**Raceme position**	**RP**	Above canopy, Throughout canopy, Upper canopy
Pod characters	**Pod attachment to peduncle**	**PTP**	30^0-90^0 degrees from erect, Erect, Pendant
	Pod curvature	**PC**	Curved, slightly curved, Straight
	Pod wall thickness	**PWT**	Thin, Intermediate, Thick
Seed characters	**Seed crowding**	**SCW**	Crowded, Extremely crowded, Not crowded, Semi–crowded
	Splitting of testa	**SPT**	Absent, Present
	Seed shape	**SS**	Crowder, Kidney, Ovoid, Rhomboid, Globose
	Testa texture	**TTX**	Rough, Rough to wrinkled, Smooth, Smooth to rough
	Eye pattern	**EP**	Holstein group, Narrow eye, Small eye, Very small

3.5.1.2 Quantitative traits

Three to twelve plants per accession were randomly selected and used for quantitative trait measurements.

Growth and Vegetative traits

Mean days to germination (DTG)

The mean of the number of days from planting to the time of germination was calculated and recorded.

Mean number of leaves *(NOL)*

The number of leaves of three to twelve plants per accession was counted and the mean was calculated and recorded six weeks after planting (6 WAP)

Mean number of branches *(NOB)*

The number of branches of three to twelve plants per accession was counted and the mean was calculated and recorded 6 WAP.

Mean leaf length *(TLL)*

Leaf length was taken using a 30-centimetre rule. The mean was evaluated and recorded 6 WAP.

Mean leaf width *(TLW)*

Leaf length was measured by using a 30-centimetre rule to measure the broadest part of the leaf. Mean width was calculated and recorded six WAP.

Mean stipule length *(STL)*

The stipule length was measured by using a 30-centimetre rule. The mean was calculated and recorded six WAP.

Mean stipule width *(STW)*

Stipule width was measured by using a 30-centimetre rule. The broadest part of the measured and the mean was calculated and recorded six WAP.

Number of nodes on main stem plant *(NNS)*

Number of nodes per plant were counted and the mean was calculated and recorded six WAP.

Mean number of main branches *(NMB)*

Number of main branches per plant per accession were counted and the mean was calculated and recorded six WAP.

Mean branch length *(BL)*

Branch length was measured by using a 30-centimetre rule from the node to the tip of the branch. The mean was calculated and recorded six WAP.

Mean plant height *(PH)*

Plant height was measured from the first node to the apex of the plant. Measurement was done by using a 30-centimetre rule. Mean plant height was calculated and recorded six WAP.

Yield and yield-related components

Phenological traits

Number of days to first flowering *(DFF)*

Number of days to first flowering was recorded for each accession.

Mean number of days to 50% flowering *(D50F)*

Number of days to 50% flowering was recorded per accession and the mean was calculated.

Number of days to first mature pod *(DFMP)*

Number of days to first mature pod was recorded per accession.

Mean number of days to 50% mature pod *(D50MP)*

Number of days to 50% mature pod was recorded per accession and the mean was calculated. The mean number of days to first matured pod per accession was calculated and recorded.

Yield-related traits

The three to twelve plants randomly selected for the previous measurements were used.

Mean standard petal length (*SPZ*)

Standard petal length of three flowers from three to twelve plants randomly selected plants per accession was measured by using a 30-centimeter rule. The mean was calculated and recorded.

Mean keel/lobe length *(LBL)*

The keel/lobe length was taken by using a string and measured on a 30 cm rule. Measurement was done by placing the string on the keel/lobe measuring from the base to the keel apex and stretching it on the 30 cm rule. The mean keel/lobe length was evaluated and recorded.

Mean number of racemes per plant *(NRPP)*

The number of racemes of three plants per accession were counted and the mean was calculated and recorded.

Mean peduncle length *(PDL)*

The length of the peduncle of three plants per accession was measured using a 30-centimetre rule from the node to the tips of the peduncle. The average peduncle length of three to twelve plants per accession was calculated and recorded

Yield traits

Mean pod length *(APL)*

Three (3) pods per accession were measured using a string from the stylar end to the point of attachment of the pod to the stalk. The string was stretched on a 30-centimetre rule and the pod length recorded in centimetres. The mean pod length and its standard errors of three pods were determined and recorded.

Mean pod width *(APW)*

The pod width was taken by measuring the width of the same three pods used to measure the pod length. The measurement was done using a 30-centimetre rule. The mean pod width of three pods was calculated and recorded.

Mean number of pods per plant *(NPLNT)*

The number of pods of three plants per accession was obtained by counting both the matured and the young pods and the mean number of pods of three plants per accession were calculated

Mean number of pods per peduncle *(PPDN)*

The number of pods per peduncle of three plants per accession was obtained by counting both the matured and the young pods per peduncle. The mean of three plants per accession was calculated.

Mean number of locules per pod *(LN)*

Three pods were examined for number of locules per pod. Locules in the pod were recorded by counts. Three pods were split along the dorsal sutures by the hand and ovules were counted starting from the stylar end to the basal end. Counts were taken for the total number of locules per pod. The measurement was done using the three matured pods for each accession and the mean locules per three pods were calculated and recorded

Mean percent seed aborted *(PSA)*

Three pods were used to determine the mean percentage seed set for each pod, total number of the mean number of seeds aborted in three pods were calculated and recorded.

Mean number of seeds per pod *(NSPP)*

Three pods per accession were split by hand and the number of seeds in each pod per was counted. The mean number of seeds in the three pods were calculated and recorded.

Mean number of seeds per plant *(NSPPL)*

Three to twelve plants were selected and the number of seeds in each pod per accession was counted. The mean number of seeds of three plants per accession was calculated and recorded.

Mean seed length (*SL)*

Micrometre screw gauge was used to measure the length of 10 randomly selected seeds for each accession. The mean of seed length of ten seeds were determined and recorded.

Mean seed width *(SW)*

Micrometre screw gauge was used to measure the width of 10 randomly selected seeds for each accession. The mean of seed width of ten seeds was calculated and recorded.

Mean seed thickness *(ST)*

Micrometre screw gauge was used to measure the thickness of 10 randomly selected seeds for each accession. The mean seed thickness of ten seeds was determined and recorded.

Mean seed weight *(SWGT)*

One hundred seeds in each accession were weighed separately using an electronic balance. The mean seed weight of one hundred seeds per accession was calculated and recorded.

Mean yield (*YLD*)

Yield was estimated by extrapolating the weight of the seed in kilogram by hectares. This is given as: Yield = Weight (kg) / Area (h)

3.5.2 Phytochemical Characterization

3.5.2.1 Polyphenols

Preparation of Sodium Carbonate Concentration

A 50 ml volumetric flask was filled with 20 ml distilled water. A weight of 6.25 g of sodium carbonate was weighed and dissolved in the distilled water. The solution was boiled, allowed to cool and then a few crystals of sodium carbonate were added. The solution was made to stand for 24 hours and then filtered. Distilled water was added to reach the 25 ml mark.

Extraction of Samples for Phytochemical Studies

About 20 cowpea seeds from pods of each of the plants harvested were ground into powder using the mortar and pestle. A mass between 0.25 g and 0.5 g of the flour was weighed and poured into McCartney tubes. Between 10 ml and 20 ml of 100% ethanol was added and shaken. The bottles were covered with aluminium foil and allowed to stand for 24 hours. After 24 hours, the sample in solution was filtered and the filtrate was stored in tightly covered Mc Cartney tubes at a temperature of 4^0C in the fridge.

Determination of Phenolic Component

Extract of the pulverized seeds for each plant was analyzed for phenolic compounds using the Folin-Ciocalteau method. After the 24hour period, 1ml of each extract was measured into a measuring cylinder and then topped to 10 ml with distilled water in test tube. Twenty microliters (20 µl) of the xolution was pipetted into cuvettes. A volume of 1.58 ml of solution r and 100 µl Folin-Ciocalteu reagents were measured with a measuring cylinder and a 100 µl micropipette and added to the solution. The solution was shaken to mix. A volume of 300 µl of sodium carbonate was pipetted and added to the solution after 5 minutes and shaken. The solution was placed in the oven for 30 minutes and allowed to stand for 90 minutes. The absorbance at 765 nm was determined against a blank by using the spectrophotometer. The concentration for the phenolic compounds for each accession was determined from the linear equations of the standard curves.

Determination of Flavonoid Content

The modified aluminium chloride colourimetric procedure was used. A volume of 100 µl of each extract of a sample was pipetted and added to 500 µl of distilled water and 30 µl of 5% sodium nitrite in cuvettes. The resulting solutions were made to stand for 5 minutes after which 30 µl of aluminium chloride was added. Six minutes later, 200 µl of sodium hydroxide and 110 µl o distilled water were added to the solution and vortexed. The absorbance of the solution for each accession was read at a wavelength of 425 nm for each sample using the spectrophotometer. The concentration for each compound was calculated using the equation of the respective standard curves and the results expressed as mg/l of extract.

Standard Curves

The standard curves used for the determination of polyphenolic compounds concentrations are presented in Table 1.

Table 2: Polyphenolic compounds and their standard curves

Polyphenolic compounds	**Standard equations**
Gallic acid	y = 0.0012x – 0.0065
Vanillic acid	y = 0.0019x – 0.0026
p-coumaric acid	y = 0.0726x – 0.0874
Rutin	y = 0.007x + 0.062 y
Quercetin	y = 0.0008x + 0.1099 y

3.5.2.2 Determination of the amino acid content

The standard solution was prepared by weighing 2.5 mg of the standard compound into 25 ml of ethanol and diluted to a concentration of 100 ppm. A mixed standard solution of 10 ppm was prepared from the stock solution which was diluted to 1ppm as the working solution. A weight of 0.5 g of cowpea flour was extracted in 20 ml of 100 % ethanol.

The extracts of the cowpea seeds were analyzed for their amino acids content. The extracts were filtered through filter paper and a funnel into Mc Cartney tubes. The extracts were later transferred into smaller tubes and sent to Ghana Standards Authority. The following eighteen (18) amino acids were analyzed: l-cysteine, glycine, l-serine, l-histidine, l-aspartic acid, l-lysine, trans-4-hydroxy-l-proline, dl-threonine, l-threonine, d-proline, l-valine, l-methionine, l-asparagine, isoleucine, l-leucine, l-tyrosine, d-l-b-phenylalanine and l-tryptophan.

3.6 Data analysis

The descriptive statistics were used to provide the percent frequency distribution of qualitative traits, summary statistics, Pearson chi-square test of association using Stata 15. The summary statistics revealed means which were further subjected to the Z-test to measure significant differences between the group, test materials and controls. Pearson chi-square test of association was used to measure the association between qualitative traits.

3.6.1 Bivariate & multivariate analysis

Pairwise correlation analysis, multiple regression, canonical linear discriminant analysis, principal component, principal component biplots, multiple correspondence analysis, cluster analysis were carried out using Stata 15.

Pairwise correlation analysis was used to establish the relationships that exist between quantitative traits. Multiple regression analysis was employed to determine the individual contribution of growth and vegetative traits, yield and yield-related traits and phytochemical traits to the underlying variation in yield (dependent variable). Principal Component Analysis (PCA) for quantitative traits was employed to determine the percentage contribution of each trait to total genetic variation. The principal components (PCs) with eigenvalues >1 was selected, and traits that had coefficients >0.3 were considered to have significantly contributed to variability. Biplots were plotted to compute similarity values to show the relationship among the accessions and traits.

Multiple correspondence analysis (MCA) was carried out using the burt matrix approach and standard normalization method for qualitative traits to determine the percentage contribution of each qualitative trait to total genetic variation. The following thirteen potential farmer and consumer-preferred traits: growth habit, mature pod colour, seed coat colour, eye colour, raceme position, pod attachment to peduncle, pod curvature, pod wall thickness, seed crowding splitting of testa, seed shape, testa texture and eye pattern were selected for MCA coordinate plot using coordinates of the first two dimensions.

Discriminant Canonical analysis was used to ascertain which set of growth and vegetative, yield and yield-related and phytochemical traits discriminated against yield (Osborne *et al.*, 1993; Graybosch *et al.*, 1993; Labuschagne *et al.*, 2002). Cluster analyses were performed using Minitab version 17 to group observations using the method of Ward's minimum variance distance. A dendrogram was plotted from the computed similarity values to show the relationship among the accessions. The accessions were grouped based on the similarity between agronomic and phytochemical traits.

3.6.2 Genetic Parameter Analysis

The 'R studio' software was used to test the significant differences using the analysis of variance (ANOVA) procedure at the level of LSD; P≤0.05. This analysis was done to identify the uniqueness among the accessions and estimate the effects of environment and genotype on morphological and phytochemical traits. Genotypic variance, phenotypic variance and environmental variance (Burton & De vane, 1953) with their corresponding coefficients of variation (Singh & Chaudhary, 1985) were used to estimate variability among the cowpea genotypes. The following formulae were adapted from Belay & Fischa (2020).

1. **Genotypic Variance**

   $GV = (MSg - MSe)r,$

   where *MSg* = Mean Square of genotypes, *MSe* = Mean Square of error (environmental variance or $\delta^2 e$), and *r* = number of replications;

2. **Phenotypic Variance,**

   $PV = GV + MSe/r$

   where *GV* = Genotypic Variance, *MSe* = Mean Square of error; and *r* = number of replications;

3. **Genotypic Coefficient of Variation**

   $GCV = \sqrt{GV}\ /x \times 100$

   where *GV* = Genotypic Variance and x =grand mean of the character;

4. **Phenotypic Coefficient of Variation,**

   $PCV = (\sqrt{PV})/x \times 100$

   where *PV* = Phenotypic Variance and *x* = mean of the character.

5. **Broad sense heritability** (H^2) of all the traits was calculated using the formula described by Allard (1960):

$H^2 = [(\sigma^2 g) / (\sigma^2 p)] \times 100$

where $\sigma^2 g$ and $\sigma^2 p$ are genotypic and phenotypic variances respectively.

6. **Genetic Advance** (*GA*) for selection intensity (K) at 5% was also estimated based on Allard (1960) as follows:

   $GA = K\sigma p H^2$,

   where, *GA* = expected genetic advance,

   K = the standardized selection differential at 5% selection intensity (K=2.063),

   σp = is phenotypic standard deviation on mean basis and

   H^2 = heritability in broadsense.

7. **Genetic advance as percentage of population means** (*GAM*) was also estimated with the methods described by Johnson, *et al.* (1955):

   $GAM = KH(GCV)$

   where *K* = the standardized selection differential at 5% selection intensity (K=2.063)

   H = heritability and (*GCV*) = genotypic coefficient of variation

8. **Relative differences** (***RD%***) was estimated using the formula

   $(\mathrm{RD}) = \frac{PCV - GCV}{GCV} x\ 100\%$ (Khan *et al.*, 2020)

3.6.3 Selection Index

3.6.3.1 Based on rank summation index (RSI)

Pairwise correlation coefficients were estimated for all traits to define the traits of a positive or negative association with yield. The traits which were positively and significantly associated with yield were used to compute rank summation index (RSI). Mulumba and Mock (1978) reported that using formula of RSI method, were accessions studied were first ranked using average values of the traits positively correlated with yield (here, 1 = topmost and 108 = lowermost), consequently, the ranked values of traits were summed to estimate the total performance of individual accessions. In this way, the accession with the lowest RSI score indicates superior yield and phytochemical content potential.

3.6.3.2 Based on contrast analysis

A generalized linear model prediction method for contrast analysis in STATA 14 was used. Contrasts analysis is used to answer questions about the way a categorical variable relates to the response. Contrast analysis was carried out to further select cowpea accessions with significant differences, with the grandmean as the reference point for the traits studied. This was done by the following steps

1. First, a one-way ANOVA analysis was carried out between traits (Independent variable) and means of accessions (factor variable as default base group). The command in Stata was computed as ***oneway trait accessions***
2. Further, a linear regression model was computed between traits (Independent variable) and accessions (factor variable as default base group).
3. Finally, a contrast and linear hypothesis test after estimation of the linear regress model were executed, where the factor term computed were the accessions as the variable for the main effect term contrasted against the differences from the grandmean. The output measured each mean value of traits in each accession against the grandmean which was the base category for each trait. Accessions that revealed contrast values and mean at $P<0.05$

were selected as significantly lower (-) or higher (+) than the grandmean. The command in Stata was computed as ***contrast g.accessions***

CHAPTER FOUR

RESULTS

4.0 RESULTS

4.1 Variability in morphological qualitative growth and vegetative traits.

The frequency distribution of the different classes of qualitative growth and vegetative traits are presented in Table 3.

4.1.1 Pigmentation

4.1.1.1 Stem colour

Stem colour was classified into six character states namely: *extensive, intermediate, moderate, none, solid and very slight* forms. *Very slight* and *none* were predominant in the test materials (19.59%) whiles *none* was predominant in the controls (33.83%). *Very slight* stem colour was dominant in the entire population (70.63%).

4.1.1.2. Leaf colour

Leaf colour was classified into three character states as: *dark green, intermediate and pale green*. *Dark green* was predominant in the test materials (66.15%) while in the controls, *dark green* leaf colour had equal frequency with intermediate green (43.75%). *Dark green* leaf colour was dominant in the entire population (51.95%).

4.1.1.3 Branch colour

The trait branch colour was classified into six character states namely: *intermediate, extensive, solid, moderate, none and very slight* forms. *Intermediate* branch colour was predominant in the test materials (19.76%) and controls (33.33%)

4.1.1.4 Petiole colour

Petiole colour was classified into six character states namely: *intermediate, extensive, solid, moderate, none and very slight* forms. *Intermediate* was predominant in the test materials (18.56%) whiles *very slight* was predominant in the controls (50.00%).

Table 3: Percentage distribution of morphological qualitative vegetative traits in 108 cowpea accessions

Characters	Traits	Character state	Test materials	Control	Entire population
Pigmentation	Stem colour	Extensive	13.40	0.00	4.91
		Intermediate	15.64	33.12	5.66
		Moderate	16.32	0.00	5.97
		None	**19.59**	**33.83**	7.17
		Solid	15.46	0.00	5.66
		Very slight	**19.59**	33.04	**70.63**
	Leaf colour	Dark green	**66.15**	**43.75**	**51.95**
		Intermediate green	22.16	**43.75**	35.85
		Pale green	11.68	12.50	12.2
	Branch colour	Extensive	15.98	0.00	5.85
		Intermediate	**19.76**	**33.33**	**28.36**
		Moderate	16.67	8.33	11.38
		None	15.46	27.08	22.83
		Solid	14.43	0.00	5.28
		Very slight	17.7	31.25	26.29
	Petiole colour	Extensive	16.32	0.00	5.97
		Intermediate	**18.56**	0.00	6.79
		Moderate	16.67	25.00	21.95
		None	14.43	25.00	**36.98**
		Solid	16.49	0.00	6.04
		Very slight	17.53	**50.00**	22.26
General plant characters	Growth habit	Climbing	9.45	0.00	3.46
		Erect	0.52	31.50	20.00
		Prostrate	25.09	0.00	9.18
		Semi-erect	**64.78**	**43.75**	**51.45**
		Semi-prostrate	0.17	25.00	15.91
	Growth pattern	Determinate	46.05	12.50	24.78
		Indeterminate	**53.95**	**87.50**	**75.22**
	Twinning tendency	Extensive	0.34	0.00	0.13
		Intermediate	16.15	16.67	16.48
		None	14.78	8.33	10.69
		Pronounced	10.14	4.17	6.35
		Slight	**58.59**	**70.83**	**66.35**
	Plant hairness	Glabrescent	35.05	33.33	33.96
		Pubescent to hairsute	29.21	**66.67**	**52.96**
		Short appressed hairs	**35.74**	0.00	13.08
	Plant vigour	Intermediate	23.02	**37.50**	**32.20**
		Non-vigorous	24.4	20.83	22.14
		Very-vigorous	25.77	20.83	22.64
		Vigorous	**26.8**	20.83	23.02
Leaf characters	Terminal leaf shape	Globose	43.47	**50.00**	**47.61**
		Hastate	0.00	25.00	15.85
		Sub-globose	**54.98**	25.00	35.97
		Sub-hastate	1.55	0.00	0.57
	Leaf marking	Absent	48.97	31.25	37.74
		Present	**51.03**	**68.75**	**62.26**
	Leaf texture	Cariaceous	2.23	4.17	3.46
		Intermediate	26.8	41.67	36.23
		Membranous	**70.96**	**54.17**	**60.31**

4.1.2 General plant characters

4.1.2.1 Growth habit

Growth habit was classified into five characters namely: *prostrate, erect, semi-erect, climbing* and *semi-prostrate*. *Semi-erect* was the main class in both the test materials (64.78%) and controls (43.75%) [Table 3].

4.1.2.2 Growth pattern

Growth pattern was classified into two groups: *determinate* and *indeterminate* growth patterns. *Indeterminate* growth pattern was dominant in the test materials (53.95%) and controls (87.50%) [Table 3].

4.1.2.3 Twinning tendency

Twinning tendency was classified into five character states as follows: *slight*, *intermediate*, *pronounced*, *none* and *extensive*. Slightly twinned stems were dominant in test materials (58.59%) and controls (70.83%) [Table 3].

4.1.2.4 Plant hairiness

Plant hairiness was classified into: *short appressed hairs*, *pubescent to hairsute hairs* and *glabrescent hairs*. *Short appressed hairs* were the main class in the test materials (35.74%) whiles *pubescent to hairsute hairs* was dominant in the controls (66.67 %) [Table 3].

4.1.2.5 Plant vigour

Plant vigour was classified into *intermediate*, *non-vigorous*, *very-vigorous* and *vigorous*. *Vigorous* was the main character state in the test materials (26.8%), whiles *intermediate* was dominant in the controls (37.50 %) [Table 3].

4.1.3 Leaf characters

4.1.3.1 Terminal leaflet shape

Terminal leaf shape was classified into four character states namely: *globose*, *hastate*, *sub-globose* and *sub-hastate*. *Sub-globose* was predominant in the test materials (54.98%) while *globose* was predominant in the controls (50%) [Table 3].

4.1.3.2 Leaf marking

Leaf marking classified into two character states: *present* and *absent*. *Present* leaf marking was predominant in both test materials (51.03%) and controls (68.75%). [Table 3].

4.1.3.3 Leaf texture

Leaf texture was classified into three character states namely; *cariaceous*, *intermediate* and *membranous*. *Membranous* leaf texture was dominant in the test materials (70.96%) as well as the controls (54.17%) [Table 3].

4.2 Variability in morphological qualitative yield-related traits

The frequency distribution of the different classes of qualitative yield-related traits are presented in Table 4.

4.2.1 Pigmentation

4.2.1.1 Peduncle Colour

Peduncle colour was classified into six character states namely: *intermediate*, *extensive*, *solid*, *moderate*, *none* and *very slight* forms. *Very slight* forms and solid were dominant in the test materials (18.38%) whiles *none* was predominant in the controls (56.25%) [Table 4].

4.2.1.2 Flower colour

Flower colour were classified into five character states namely: *white*, *mauve*, *cream*, *yellow* and *purple*. *White* was predominant in both the test materials (45.19%) and the controls (83.33%) [Table 4].

Table 4: Percentage distribution of morphological qualitative yield and yield-related traits in 108 cowpea accessions

Characters	Traits	Charcater state	Test materials	Control	Entire population
Pigmentation	Peduncle Colour	Extensive	12.20	2.08	5.79
		Intermediate	18.21	6.25	10.63
		Moderate	17.53	6.25	10.38
		None	15.29	56.25	41.26
		Solid	18.38	4.17	9.37
		Very slight	18.38	25.00	22.58
	Flower Colour	Cream	8.59	16.67	13.71
		Mauve	6.70	0.00	2.45
		Purple	31.44	0.00	11.51
		White	45.19	83.33	69.37
		Yellow	8.08	0.00	2.96
	Immature pod pigmentation	None	55.25	75.00	67.78
		Pigmented sutures	0.69	0.00	0.25
		Pigmented tip	38.55	25.00	29.96
		Pigmented valve, green sutures	5.51	0.00	2.01
	Mature pod Colour	Black	33.05	0.00	12.08
		Brown	3.44	0.00	1.26
		Dark tan	51.81	0.00	18.94
		Straw	11.7	100.00	67.72
	Seed coat Colour	Black	19.76	0.00	7.23
		Brown	5.84	0.00	2.14
		Cream	9.97	50.00	35.35
		Cream with black patches	15.64	0.00	5.72
		Grey	14.26	0.00	5.22
		Purple	4.3	0.00	1.57
		Red	19.59	25.00	23.02
		White	10.65	25.00	19.75
	Eye colour	Eye absent	95.36	100.00	98.3
		Gray	1.03	0.00	0.38
		Red	3.61	0.00	1.32
Flower character	Raceme position	Above canopy	1.2	25.00	16.29
		Throughout canopy	77.84	72.92	74.72
		Upper canopy	20.96	2.08	8.99
Pod characters	Pod attachment to peduncle	30-90degree from erect	5.52	25.00	17.88
		Erect	0.52	0.00	0.19
		Pendant	93.97	75.00	81.93
	Pod curvature	Curved	5.17	12.50	9.82
		Slightly curved	94.31	62.50	74.12
		Straight	0.52	25.00	16.06
	Pod wall thickness	Intermediate	31.96	31.25	31.51
		Thick	34.88	25.00	28.62
		Thin	33.16	43.75	39.87
Seed characters	Seed crowding	Crowded	24.4	31.25	28.74
		Extremely crowded	24.4	18.75	20.82
		Not crowded	24.23	27.08	26.04
		Semi–crowded	26.98	22.92	24.40
	Splitting of testa	Absent	49.83	33.33	39.37
		Present	50.17	66.67	60.63

4.2.1.3 Immature pod colour

The immature pod colour was classified into four namely; *pigmented tips*, *pigmented sutures*, *pigmented valves with green sutures* and *no pigments*. The character *no pigments* were predominant in the test materials (55.25%) and the controls (75.00%) [Table 4].

4.2.1.4 Mature pod colour

Mature pod colour was classified into four character states namely: *brown*, *dark tan*, *black* and *straw*. *Dark tan* was predominant in the test materials (51.81%). *Straw* was predominant in the controls (100%) [Table 4]

4.2.1.5 Seed coat colour

Seed colour was classified into eight character states as follows: *grey*, *red*, *black*, *cream*, *brown*, *purple*, *white* and *cream with black patches*. *Black* was predominant in the test materials (19.76%) whiles the *cream* was predominant in the controls (50.00%) [Table 4].

4.2.1.6 Eye colour

The eye colour was classified into three groups including *absent*, *red* or *gray*. The seeds with *absent* eye color were predominant in the test materials (95.36%) and the controls (100%). [Table 4]

4.2.2. Flower character

4.2.2.1. Raceme position

The trait raceme position trait was classified into three; *throughout the canopy*, *at the upper part of the canopy* and *above the canopy*. The group with the raceme positioned *throughout the canopy* was dominated in test materials (77.84%) and the controls (72.92%) [Table 4].

4.2.3 Pod character

4.2.3.1 Pod attachment to peduncle

Pod attachment to peduncle was classified into three character states namely: *pendant*, *erect*, *30-900 degree down from erect*. Pendant dominated in both the test materials (93.97%) and the controls (75.00 %) [Table 4].

4.2.3.2 Pod curvature

Pods curvature was classified into three character states comprising: *straight*, *curved*, and *slightly curved*. *Slightly curved* was dominant in both the test materials (94.31%) and the controls (62.50%) [Table 4].

4.2.3.3 Pod wall thickness

The pod wall thickness was classified into three namely; *thick*, *intermediate* and *thin*. The thick pod wall dominated the test materials (34.88%), whiles the thin pod wall predominated in the controls (43.75%) [Table 4].

4.2.4 Seed character

4.2.3.1 Seed crowding

The seed crowding was into four groups namely; *crowded*, *extremely crowded*, *not crowded* and *semi-crowded*. *Semi-crowded* were predominant in the test materials (26.98%). *Crowded* seeds was predominated in the controls (31.25%) [Table 4].

4.2.3.2 Splitting of testa

The distributions were classified into two groups; *present* and *absent*. The splitting of seed was *present* in the test materials (50.17%) and controls (66.67%). The splitting of seeds was predominant in the controls compared to the test materials [Table 4].

4.2.3.3 Seed shape

Seed shape was grouped into five character states namely: *ovoid*, *rhomboid*, *kidney*, *globose* and *crowder*. *Rhomboid* was predominant in the test materials (48.28%) whiles *globose* was predominant in the controls (41.67%) [Table 4].

4.2.3.4 Seed testa texture

Seed testa texture was classified into four character states namely: *rough, smooth, smooth to rough* and *rough to wrinkle*. *Smooth* was predominant in the test materials (46.64%). Smooth and *smooth to rough* had the in same frequency the controls (50%) [Table 4].

4.2.3.5 Eye pattern

Seeds eye pattern was classified into four (*narrow, very small and Holstein eye)*. *Small eye* were predominant in the test materials (65.29%) whiles *very small eye* was monomorphic in the controls (100%) [Table 4].

Table 4 (Cont'd)

Characters	Traits	Classes	Test materials	Controls	Entire population
Seed characters	Seed crowding	Crowded	24.4	31.25	28.74
		Extremely crowded	24.4	18.75	20.82
		Not crowded	24.23	27.08	26.04
		Semi–crowded	26.98	22.92	24.40
	Splitting of testa	Absent	49.83	33.33	39.37
		Present	50.17	66.67	60.63
	Seed shape	Crowder	0.00	33.33	21.13
		Kidney	19.76	0.00	26.42
		Ovoid	31.96	0.00	7.23
		Rhomboid	48.28	25.00	11.7
		Globose	0.00	41.67	33.52
	Testa texture	Rough	36.66	0.00	13.4
		Rough to wrinkled	1.72	0.00	0.63
		Smooth	46.64	50.00	48.77
		Smooth to rough	14.97	50.00	37.19
	Eye pattern	Holstein group	4.3	0.00	1.57
		Narrow eye	2.23	0.00	0.82
		Small eye	65.29	0.00	23.9
		Very small	28.18	100.00	73.71

4.3 Chi-square test of association among morphological qualitative traits in cowpea accessions

4.3.1 Chi-square test of association among morphological qualitative traits in test materials

The total number of significant associations for the test materials was 110 as shown in Table 5. The highest number of significant associations were observed between growth habit and 15 other traits. The lowest number of significant chi-square test of association occurred (one) between eye colour and flower colour ($\chi^2 = 15.70$, $P \leq 0.05$), flower colour and splitting of testa ($\chi^2 = 14.37$, $P \leq 0.01$) and petiole colour and branch colour ($\chi^2 = 49.56$, $P \leq 0.01$) . Growth 47 habit was significantly associated with the following traits 9 yield-related traits: eye colour ($\chi^2 = 20.26$, $P \leq 0.01$), flower colour ($\chi^2 = 98.22$, $P \leq 0.001$), immature pod pigmentation ($\chi^2 = 65.29$, $P \leq 0.001$), mature pod colour ($\chi^2 = 76.10$, $P \leq 0.001$), pod attachment to peduncle ($\chi^2 = 98.82$, $P \leq 0.001$), pod curvature ($\chi^2 = 63.27$, $P \leq 0.001$), raceme position ($\chi^2 = 32.40$, $P \leq 0.001$), seed coat colour ($\chi^2 = 143.24$, $P \leq 0.001$), seed shape ($\chi^2 = 58.29$, $P \leq 0.001$), testa texture ($\chi^2 = 33.87$, $P \leq 0.001$) and 5 growth and vegetative traits as follows: twinning tendency ($\chi^2 = 251.79$, $P \leq 0.001$). leaf colour ($\chi^2 = 20.54$, $P \leq 0.01$), petiole colour ($\chi^2 = 31.93$, $P \leq 0.05$), plant hairness ($\chi^2 = 15.51$, $P \leq 0.05$), terminal leaf shape ($\chi^2 = 44.70$, $P \leq 0.001$)

Table 5: Chi-square test of association among morphological qualitative traits in 104 test materials of cowpea accessions.

Trait 1	Trait 2	χ^2 value
Eye colour	Flower colour	15.70*
Eye pattern	Eye colour	20.33**
	Flower colour	66.15***
	Plant vigour	19.14*
Flower colour	Splitting of testa	14.37**
Growth habit	Eye colour	20.26**
	Flower colour	98.22***
	Immature pod pigmentation	65.29***
	Leaf colour	20.54**
	Mature pod colour	76.10***
	Petiole colour	31.93*
	Plant hairness	15.51*
	Pod attachment to peduncle	98.82***
	Pod curvature	63.27***
	Raceme position	32.40***
	Seed coat colour	143.24***
	Seed shape	58.29***
	Terminal leaf shape	44.70***
	Testa texture	33.87***
	Twinning tendency	251.79***
Growth pattern	Branch colour	12.52*
	Twinning tendency	12.60**
Immature pod pigmentation	Eye colour	56.33***
	Eye pattern	26.72**
	Flower colour	39.33***
	Leaf texture	20.00**
	Mature pod colour	77.46***
	Pod curvature	92.04***
	Seed coat colour	125.76***
	Seed shape	104.58***
	Testa texture	28.23**
Leaf colour	Eye pattern	23.02***
	Flower colour	19.18**
	Leaf texture	11.39*
	Mature pod colour	31.43***
	Seed coat colour	62.15***
	Testa texture	27.06***
Leaf texture	Branch colour	20.94*
	Eye pattern	13.17*
	Flower colour	17.95*
	Pod wall thickness	15.34**
	Seed coat colour	36.72***
	Seed shape	10.44*
	Testa texture	35.72***

Significant level (*) = P<0.05, (**) = P<0.01 and (***) = P<0.001

Table 5 (Cont'd)

Trait 1	Trait 2	χ^2 value
Mature pod colour	Eye colour	25.69***
	Eye pattern	34.36***
	Flower colour	41.69***
	Seed coat colour	307.98***
	Seed shape	92.92***
	Testa texture	34.49***
Petiole colour	Branch colour	49.56**
Plant hairiness	Eye colour	10.04*
	Eye pattern	42.53***
	Flower colour	18.71*
	Leaf colour	10.72*
	Petiole colour	19.21*
	Seed coat colour	66.18***
	Seed shape	15.71**
	Testa texture	42.66***
Pod attachment to peduncle	Flower colour	29.95***
	Immature pod pigmentation	44.16***
	Leaf colour	22.55***
	Peduncle colour	29.57***
	Pod curvature	412.51***
	Seed coat colour	76.74***
	Seed shape	30.68***
	Testa texture	12.94*
Pod curvature	Eye pattern	14.01*
	Flower colour	24.71**
	Leaf colour	59.42***
	Leaf texture	25.30***
	Mature pod colour	14.89*
	Seed coat colour	70.44***
	Stem colour	20.88*
	Testa texture	49.80***
Raceme position	Pod attachment to peduncle	44.03***
	Seed coat colour	63.45***
Seed coat colour	Eye colour	139.57***
	Eye pattern	132.16***
	Flower colour	463.33***
	Seed shape	188.55***
	Testa texture	276.92***
Seed shape	Eye colour	39.07***
	Eye pattern	154.30***
	Flower colour	35.01***
	Testa texture	75.79***
Terminal leaf shape	Eye colour	15.20**
	Eye pattern	41.86***
	Flower colour	24.14**
	Immature pod pigmentation	37.57***
	Leaf colour	31.95***

Significant level (*) = P<0.05, (**) = P<0.01 and (***) = P<0.001

Table 5 (Cont'd)

Trait 1	Trait 2	χ^2 value
Terminal leaf shape	Mature pod colour	52.86***
	Plant hairness	71.03***
	Raceme position	24.47***
	Seed coat colour	101.17***
	Seed shape	27.70***
	Testa texture	37.02***
Testa texture	Eye colour	43.20***
	Eye pattern	419.00***
	Flower colour	71.98***
	Plant vigour	17.97*
Twinning tendency	Branch colour	32.35*
	Eye pattern	24.16*
	Flower colour	47.36***
	Immature pod pigmentation	35.25**
	Mature pod colour	30.55**
	Plant hairness	56.78***
	Pod curvature	24.52**
	Seed coat colour	105.31***
	Terminal leaf shape	44.59***

Significant level (*) = P<0.05, (**) = P<0.01 and (***) = P<0.001

4.3.2 Chi-square test of association among morphological qualitative traits in the controls

Three significant associations were observed among the controls as shown in Table 6. Growth pattern and eye pattern were significantly associated (χ^2 =18.22, P $\leq$ 0.001), Eye pattern was significantly associated with branch colour (χ^2 = 11.57, P$\leq$ 0.05) and splitting of testa (χ^2 = 6.17, P$\leq$ 0.05).

Table 6: Chi-square test of association among morphological qualitative traits in 4 controls of cowpea accessions

Trait 1	Trait 2	χ^2 value
Eye pattern	Branch colour	11.57*
	Splitting of testa	6.17*
Growth habit	Eye pattern	18.22***

Significant level (*) = P<0.05, (**) = P<0.01 and (***) = P<0.001

4.3.3 Chi-square test of association among morphological qualitative traits in entire population

There were 146 significant associations for the entire population as shown in Table 7. The lowest number of significant chi-square test of association was one, which was observed between flower colour and the following: eye colour (χ^2 =29.72, P $\leq$ 0.001) and splitting of testa (χ^2 =10.08, $P \leq 0.05$). The highest number of significant chi-square test of associations were observed between plant hairness and 14 other traits of which 11 were yield and yield-related traits, they were; eye colour (χ^2 =11.83, $P \leq 0.05$), eye pattern (χ^2 =413.72, $P \leq 0.001$), flower colour (χ^2 =318.09, $P \leq 0.001$), immature pod pigmentation (χ^2 =123.51, $P \leq 0.001$), mature pod colour (χ^2 =671.00, $P \leq 0.001$), pod attachment to peduncle (χ^2 =178.87, $P \leq 0.001$), pod curvature (χ^2 =250.05, $P \leq 0.001$), raceme position (χ^2 =251.06, $P \leq 0.001$), seed coat colour (χ^2 =734.42, $P \leq 0.001$), seed shape (χ^2 =814.71, $P \leq 0.001$), testa texture (χ^2 =421.68, $P \leq 0.001$) and 3 vegetative traits, namely; leaf colour(χ^2 =15.62, $P \leq 0.01$), leaf texture (χ^2 =18.91, $P \leq 0.001$) and leaf marking (χ^2 =27.32, $P \leq 0.001$).

Table 7: Chi-square test of association among morphological qualitative traits in entire population of 108 cowpea accessions

Trait 1	Trait 2	χ^2 value
Eye colour	Flower colour	29.72***
Eye pattern	Eye colour	65.57***
	Flower colour	177.40***
	Plant vigour	19.36*
Flower colour	Splitting of testa	10.48*
Growth habit	Eye colour	35.59***
	Eye pattern	211.88***
	Flower colour	352.66***
	Immature pod pigmentation	250.92***
	Leaf colour	51.45***
	Leaf marking	118.25***
	Mature pod colour	320.27***
	Plant hairness	541.50***
	Plant pigmentation	55.79***
	Pod attachment to peduncle	664.82***
	Pod curvature	1100.00***
	Raceme position	1000.00***
	Seed coat colour	878.47***
Growth habit	Seed shape	1200.00**
	Terminal leaf shape	1200.00***
	Testa texture	328.26***
	Twinning tendency	284.55***
	Leaf marking	7.81**
	Pod attachment to peduncle	8.20*
	Twinning tendency	15.03**
Immature pod pigmentation	Eye colour	80.28***
	Eye pattern	59.35***
	Flower colour	65.27***
	Leaf marking	40.29***
	Leaf texture	31.50***
	Mature pod colour	116.94***
	Pod curvature	229.12***
	Seed coat colour	259.78***
	Seed shape	320.57***
	Testa texture	74.63***
Leaf colour	Eye pattern	29.34***
	Flower colour	21.70**
	Leaf texture	69.06***
	Mature pod colour	32.23***
	Seed coat colour	87.25***
	Seed shape	26.89***
	Testa texture	30.42***
Leaf marking	Eye pattern	11.59**
	Flower colour	24.62***
	Mature pod colour	19.83***
	Seed coat colour	33.31***
	Seed shape	81.96***
	Testa texture	123.66***

Significant level (*) = $P<0.05$, (**) = $P<0.01$ and (***) = $P<0.001$

Table 7 (Cont'd)

Trait 1	Trait 2	χ^2 value
Leaf texture	Branch colour	20.45*
	Eye pattern	13.09*
	Flower colour	32.38***
	Seed coat colour	47.79***
	Seed shape	29.16***
	Testa texture	25.94***
Mature pod colour	Eye colour	77.28***
	Eye pattern	507.86***
	Flower colour	305.23***
	Seed coat colour	648.65***
	Seed shape	673.98***
	Testa texture	260.40***
Plant hairness	Eye colour	11.83*
	Eye pattern	413.72***
	Flower colour	318.09***
	Immature pod pigmentation	123.51***
	Leaf colour	15.62**
	Leaf marking	27.32***
	Leaf texture	18.91***
	Mature pod colour	671.00***
	Pod attachment to peduncle	178.87***
	Pod curvature	250.05***
	Raceme position	251.06***
	Seed coat colour	734.42***
	Seed shape	814.71***
	Testa texture	421.68***
Pod attachment to peduncle	Eye pattern	73.36***
	Flower colour	83.25***
	Immature pod pigmentation	85.62***
	Leaf colour	38.14***
	Leaf marking	84.53***
	Mature pod colour	105.41***
	Peduncle colour	35.41***
	Seed coat colour	342.35***
	Seed shape	605.19***
	Testa texture	113.33***
Pod curvature	Eye pattern	54.58***
	Flower colour	71.37***
	Leaf colour	56.07****
	Leaf marking	106.03***
	Leaf texture	25.18***
	Mature pod colour	123.99***
	Seed coat colour	585.25***
	Seed shape	929.67***
	Testa texture	185.87***
Raceme position	Eye colour	23.31***
	Eye pattern	82.61***
	Flower colour	78.99***
	Immature pod pigmentation	190.57***
	Leaf colour	52.18***
	Leaf marking	119.69***

Significant level (*) = P<0.05, (**) = P<0.01 and (***) = P<0.001

Table 7 (Cont'd)

Trait 1	Trait 2	χ^2 value
Raceme position	Leaf texture	10.18*
	Mature pod colour	147.50***
	Pod attachment to peduncle	635.12***
	Pod curvature	916.34***
	Seed coat colour	517.16***
	Seed shape	888.90***
	Testa texture	129.85***
Seed coat colour	Eye colour	262.43***
	Eye pattern	301.10***
	Flower colour	820.61***
	Seed shape	1300.00***
	Testa texture	811.73***
	Eye colour	58.87***
	Eye pattern	522.49***
	Flower colour	254.85***
	Testa texture	334.79***
Terminal leaf shape	Eye colour	23.05***
	Eye pattern	152.96***
	Flower colour	150.97***
	Immature pod pigmentation	216.91***
	Leaf colour	56.97***
	Leaf marking	208.76***
	Leaf texture	13.80*
Terminal leaf shape	Mature pod colour	248.53***
	Plant hairness	398.14***
	Pod attachment to peduncle	661.25***
	Pod curvature	1000.00***
	Raceme position	1000.00***
	Seed coat colour	763.22***
	Seed shape	1000.00***
	Testa texture	263.98***
Testa texture	Eye colour	38.63***
	Eye pattern	796.01***
	Flower colour	200.66***
Twinning tendency	Flower colour	37.73**
	Immature pod pigmentation	59.76**
	Leaf colour	29.65***
	Leaf marking	16.55**
	Leaf texture	29.96***
	Plant hairness	16.55*
	Pod attachment to peduncle	29.49***
	Pod curvature	71.41***
	Raceme position	48.87***
	Seed coat colour	136.07***
	Seed shape	42.26***
	Terminal leaf shape	54.97***
	Testa texture	21.02*

Significant level (*) = P<0.05, (**) = P<0.01 and (***) = P<0.001

4.4 Variability in morphological quantitative traits

4.4.1 Growth and Vegetative Characters

The means and their standard errors and test of significance for growth and vegetative traits are presented in Table 8.

4.4.2.1 Mean days to germination

The grandmean for days to germination was 4.43 ± 0.03 days. The test materials recorded the highest mean 1number of days to germination of 4.59 ± 0.05 days while the controls recorded the lowest of 4.33 ± 0.03 days. Z score and P-value for the mean number of days to germination were 4.71 and 0.001 respectively [Table 8.].

4.4.2.2 Mean number of leaflets

The grandmean for number of leaflets was 32.92±0.37. The controls recorded the highest mean value of 33.52±0.44 while the lowest of 31.88±0.67 was recorded by the test materials. The Z-score value was 2.27 with a P-value of 0.05 [Table 8.].

4.4.2.3 Mean terminal leaflet length

Terminal leaflet length recorded a grandmean of 9.76±0.04 cm. The highest mean was recorded by the controls with a value of 9.87±0.04 cm. The lowest alue was recorded by the test materials with a value of 9.57±0.07 cm. The Z-score value was 3.74, with a P-value of 0.001 [Table 8.].

4.4.2.4 Mean terminal leaflet width

Terminal leaflet width recorded a grandmean of 4.78±0.02 cm. The highest mean was recorded by the controls with a value of 4.82±0.02 cm. The lowest mean was recorded by the test materials with a value of 4.70±0.03 cm. The Z-score was 3.26 and P-value was 0.001 [Table 8.].

4.4.2.5 Mean stipule length

The grandmean value recorded was 0.88±0.00 cm. The highest mean was recorded by the test materials with a value of 0.90±0.00 cm whereas the lowest mean was recorded by the control with a value of 0.87±0.00 cm. Z-score was 5.57 and the P-value was 0.001 [Table 8.].

4.4.2.6 Mean stipule width

The grandmean for mean stipule width was 0.53±0.00 cm. Both the test materials and the control had a mean of 0.53±0.00 cm. Z-score was 1.85 and the P-value was 0.001 [Table 8.].

4.4.2.7 Mean number of nodes

The grandmean was 9.33 ± 0.14 nodes. The highest mean was recorded by the test materials with a value of 10.98 ± 0.22 nodes whiles the lowest mean was recorded by the controls with a value of 8.38 ± 0.17 nodes. Mean number of days recorded a Z-score of 9.13 and a P-value of 0.001 [Table 8.].

4.4.2.8 Mean number of branches

The grandmean was 4.32 ± 0.06 branches. The highest mean value was recorded by the Test material with a value of 4.49 ± 0.09 branches. ontrols recorded the lowest mean value of 4.23 ± 0.08 branches. Z-score recorded for the mean number of branches was 2.08 whereas the P-value was 0.05 [Table 8.].

4.4.2.9 Mean branch length

The grandmean was 7.7±0.03 cm. The highest mean was recorded by the controls with a value of 7.70±0.03 cm. The lowest mean value was recorded by the test materials with a value of 7.69±0.07 cm. Z-score recorded was 0.17 and the P-value was 0.00 [Table 8.].

4.4.2.10 Mean plant height

The grandmean recorded for this trait was 34.18 ± 0.25 cm. . The highest mean was recorded by the controls with a value of 35.1 ± 0.30 cm whiles the lowest mean was recorded by the test materials with a value of 32.6 ± 0.44 cm. Z-score was 4.75 with a P-value of 0.001 cm respectively [Table 8.].

Table 8: Means and their standard error and test of significance for 9 growth and vegetative traits in 104 test materials and 4 controls

Characters	Trait	Test	Control	Z-score	Grandmean
Phenological character	Days to germination	4.59±0.05	4.33±0.03	4.71***	4.43±0.03
Leave characters	Number of leaves	31.88±0.67	33.52±0.44	2.27*	32.92±0.37
	Terminal leaflet length [cm]	9.57±0.07	9.87±0.04	3.74***	9.76±0.04
	Terminal leaflet width [cm]	4.70±0.03	4.82±0.02	3.26***	4.78±0.02
	Stipule length [cm]	0.90±0.00	0.87±0.00	5.57***	0.88±0.00
	Stipule width [cm]	0.53±0.00	0.53±0.00	1.85	0.53±0.00
Stem characters	Number of nodes on main stem	10.98±0.22	8.38±0.17	9.13***	9.33±0.14
	Number of main branches	4.49±0.09	4.23±0.08	2.08*	4.32±0.06
	Branch length [cm]	7.69±0.07	7.70±0.03	0.17	7.7±0.03
	Plant height [cm]	32.6±0.44	35.1±0.30	4.75***	34.18±0.25

'*' =significant at 5% level, '**' = significant at 1% level, '***' = significant at 0.1%

4.4.3 Yield and yield-related components

4.4.3.1 Phenological traits

Mean days to first flower

The grandmean for mean days to first flower was 4.38±0.10 days. The highest mean was recorded by the test materials with a value of 4.77±0.26 days whereas the lowest mean of 4.15±0.05 days was recorded by the controls. The Z-score was value 6.66 and the P-value was 0.001 [Table 9].

Mean days to 50% flowering

The grandmean value for days to 50% flowering was 45.08±0.14 days. The highest mean was recorded by the controls with a value of 45.81±0.15 days whereas the lowest mean was recorded by the test materials with a value of 43.81±0.26 days. The Z-score was 6.97 and the P-value was 0.001 [Table 9].

Mean days to first mature pod

The grandmean value was 53.57±0.17days. The highest mean was recorded by the controls with a value of 54.88±0.20 days whereas the lowest mean was recorded by the test materials with a value of 51.32±0.29 days. The Z-score was 10.10 and the P-value was 0.001 [Table 9].

Mean days to 50% mature pod

The grandmean value was 61.41±0.19 days. The highest mean was recorded by the controls with a value of 62.31±0.22 days whereas the lowest mean was recorded by the test materials with a value of 59.85±0.32 days. The Z-score was 6.39 and the P-value was 0.001 [Table 9].

4.4.3.2 Yield related-traits

Mean standard petal size

The grandmean for standard petal size was 2.57±0.00 cm. Both the test materials and the controls recorded a mean value of 2.57±0.01 cm. Z-score and P-value were 0.27 and 0.02, respectively [Table 9].

Mean lobe length

The grandmean for lobe length was 1.51±0.00 cm. The highest mean value was 81.55±0.00 cm, which was recorded by the test material. The controls recorded the lowest mean value of 1.49±.00 cm. The Z-score value was 12.55 with a P-value of 0.001 [Table 9].

Mean number of racemes per plant

The grandmean was 24.07±0.3 racemes. The highest mean was recorded by the test materials with a value of 26.62±0.52 racemes whiles the lowest mean was recorded by the controls with a value of 22.6±0.36 raceme. Mean number of days recorded a Z-score of 6.41 and a P-value of 0.001 [Table 9].

Mean peduncle length

The grandmean for the peduncle length recorded was 14.42 ± 0.37 cm. The highest mean value was 8.34±0.11cm, which was recorded by the test material. The controls recorded the lowest mean value of 7.36±0.06 cm. Z-score was recorded as 8.19 whereas the P-value was 0.001 [Table 9].

Mean number of anthesis at first flowering

The grandmean was 36.81±0.16 anthesis. The highest mean value was recorded by the controls with a value of 37.63±0.15 anthesis. Test materials recorded the lowest mean value of 35.4±0.35 anthesis. Z-score recorded for the mean number of branches was 2.99 whereas the P-value was 0.001 [Table 9].

4.4.3.3 Yield traits

Mean pod length per plant

The grandmean value recorded was 18.05±0.05 cm. The highest mean was recorded by the controls with a value of 18.51±0.05 cm whereas the lowest mean was recorded by the test materials with a value of 17.25±0.09 cm. Z-score was 12.26 and the P-value was 0.001 [Table 9].

Mean pod width per plant

The grandmean value was 0.93±0.00cm. The highest mean was recorded by the controls with a value of 0.96±0.01 cm whereas the lowest mean was recorded by the test materials with a value of 0.87 ± 0.01 cm. Z-score was 9.00 and the P-value was 0.001 [Table 9].

Table 9: Mean and standard error values for yield and yield-related components in cowpea accessions

Characters	Trait	Test materials	Controls	Z-score	Grandmean
Phenological traits					
Phenological characters	Days to first flower	35.4±0.35	37.63±0.15	2.99*	36.81±0.16
	Days To 50% flowering	43.81±0.26	45.81±0.15	6.97***	45.08±0.14
	Days to first mature pod	51.32±0.29	54.88±0.20	10.10***	53.57±0.17
	Days to 50% mature pod	59.85±0.32	62.31±0.22	6.39***	61.41±0.19
Yield-related traits					
Flower Characters	Standard petal size [cm]	2.57±0.01	2.57±0.01	0.27	2.57±0.00
	Lobe length [cm]	1.55±0.00	1.49±.00	12.55***	1.51±0.00
	Number of racemes per plant	26.62±0.52	22.6±0.36	6.41***	24.07±0.3
	Peduncle length [cm]	8.34±0.11	7.36±0.06	8.19***	7.72±0.06
	Number of anthesis at first flowering	4.77±0.26	4.15±0.05	6.66***	4.38±0.10
Yield traits					
Pod characters	Pod length [cm]	17.25±0.09	18.51±0.05	12.26***	18.05±0.05
	Pod width [cm]	0.87±0.01	0.96±0.01	9.00***	0.93±0.00
	Number of pods per plant	20.1±0.44	13.92±0.24	12.85***	16.18±0.23
	Number of pods per peduncle	3.36±0.05	3.5±0.03	2.58***	3.45±0.03
	Number of locules	15.17±0.20	14.17±0.13	4.37***	14.54±0.11
	Percent seed abortion [%]	17.46±0.53	26.04±0.86	7.03***	22.9±0.59
Seed characters	Number of seeds per pod	12.46±0.2	10.4±0.15	7.95***	11.15±0.12
	Seed length [mm]	6.5±0.05	7.9±0.07	12.45***	7.39±0.05
	Seed width [mm]	4.16±0.05	5.38±0.05	14.69***	4.93±0.04
	Seed thickness [mm]	2.67±0.02	3.47±0.04	14.76***	3.18±0.03
	Seed weight ([g]	15.56±0.08	11.07±0.08	26.50***	13.65±0.08
	Seed yield [kg/h]	155.60±0.80	110.7±0.80	26.49***	136.50±0.80

'*' =significant at 5% level, '**' = significant at 1% level, '***' = significant at 0.1%

Mean number of pods per plant

The highest mean value was 20.1±0.44 pods, which was recorded by the test materials. The controls recorded the lowest mean value of 13.92±0.24 pods. Z-score was 12.85, with a P-value of 0.001 [Table 9].

Mean number of pods per peduncle

The highest mean value was 3.5±0.03 pods, which was recorded by the controls. The test materials recorded the lowest mean value of 3.36±0.05 pods. Z-score was 2.58, with a P-value of 0.001 [Table 9].

Mean number of locules per pod

The grandmean for the number of locules per pod was 14.54±0.11 locules . The highest mean value was 15.17±0.20 locules, which was recorded by the test materials. The controls recorded the lowest mean value of 14.17±0.13 locules. Z-score was 4.37, with a P-value of 0.001 [Table 9].

Seed characters

Mean percent seed abortion

The grandmean value was 22.9±0.59 %. The highest mean was recorded by the controls with a value of 26.04±0.86 % whereas the lowest mean was recorded by the test materials with a value of 17.46±0.53 %. The Z-score was 7.03and the P-value was 0.001 [Table 9].

Mean number of viable seeds per pod

The grandmean value was 11.15±0.12 seeds. The highest mean number of viable seeds was recorded by the test materials with a value of 12.46±0.2 seeds whereas the lowest mean number of viable seeds was recorded by the controls with a value of 10.4±0.15 seeds. Z-score was 7.95 and the P-value was 0.001 [Table 9].

Mean seed length

The grandmean was 7.39±0.05 mm. The highest mean value was 7.9±0.07 mm, recorded by the controls whereas the lowest mean was recorded by the test materials with a value of 6.5±0.05 mm. Z-score was 12.45 while the P-value of 0.001 [Table 9].

Mean seed width

The grandmean was 4.93±0.04 mm. The highest mean value was 5.38±0.05 mm, recorded by the controls whereas the lowest mean was recorded by the test materials with a value of 4.16±0.05 mm. Z-score was 14.69 and a P-value of 0.001 [Table 9].

Mean seed thickness

The grandmean was 3.18±0.03 mm. Controls and test materials recorded mean values of 3.47±0.04 mm and 2.67±0.02 mm respectively. Z-score was 14.76 with a P-value of 0.001 [Table 9].

Mean seed weight per plant

The grandmean was 12.71±0.08 g. The highest mean value was 15.56±0.08 g, recorded by the test materials whereas the lowest mean was recorded by the controls with a value of 11.07±0.08 g. Z-score was 26.50 while the P-value was 0.001 [Table 9]

Mean seed yield

The grandmean for seed yield was 0.013±0.000 kg/ha. The highest mean value was 0.016±0.00 kg/h yield, which was recorded by the test materials. The controls recorded the lowest mean value of 0.011±0.00 kg/h. Z-score was 26.49, with a P-value of 0.001 [Table 9]

4.5 Variability in phytochemical traits

Table 10 shows the means and their standard error values for phytochemicals (polyphenols) and amino acids in cowpea accessions.

4.5.1 Polyphenols

4.5.1.1 Mean gallic acid concentration

The grandmean for gallic acid concentration was 0.23±0.02 mg/ml. The highest mean of 0.30±0.03 mg/ml was recorded for the test materials while the lowest of 0.14±0.01 mg/ml was recorded for the controls. The Z-score was 4.41, with a P-value of 0.001 [Table 10].

4.5.1.2 Mean vanillic acid concentration

The grandmean value for vanillic acid was 0.47±0.02 mg/ml. The test materials recorded the highest mean value of 0.51±0.04 mg/ml and the lowest was recorded by the controls with a value of 0.42±0.02 mg/ml. The Z-score value was 1.90, with a P-value of 0.38 [Table 10]

4.5.1.3 Mean p-coumeric concentration

The grandmean was 0.72±0.04 mg/ml. The highest mean was 0.79±0.06 mg/ml recorded by the test materials while the lowest mean, 0.62±0.03 mg/ml was recorded by controls. Z-score was 2.30, with a P-value of 0.05 [Table 10].

4.5.1.4 Mean rutin concentration

The grandmean was 14.39±0.16 mg/ml. The controls recorded the highest mean of 15.59±0.27 mg/ml whereas the lowest mean was recorded by the test materials with a value of 13.42±0.18 mg/ml. Z-score was 6.98, with a P-value of 0.001 [Table 10].

4.5.1.5 Mean quercetin concentration

The grandmean value recorded was 2.10±0.02 mg/ml. The controls recorded the highest mean of 2.27±0.04 mg/ml whereas the lowest mean was recorded by the test materials with a value of 1.95±0.03 mg/ml. Z-score of 6.98, with a P-value of 0.001 [Table 10]

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Table 10: Means and their standard error values for phytochemical traits in cowpea accessions

Phytochemical traits	Test material	Breeder line	Z-score	Grandmean
Polyphenols (mg/ml)				
Gallic acid	0.30±0.03	0.14±0.01	4.41***	0.23±0.02
Vanillic acid	0.51±0.04	0.42±0.02	1.90	0.47±0.02
P-coumaric acid	0.79±0.06	0.62±0.03	2.30*	0.72±0.04
Rutin	13.42±0.18	15.59±0.27	6.98***	14.39±0.16
Quercetin	1.95±0.03	2.27±0.04	6.98***	2.10±0.02
Amino Acids (ppb)				
Glycine	519.60±91.25	1126.95±122.31	4.06***	792.42±75.48
L-Serine	26.44±2.18	57.82±4.87	6.19***	40.84±2.61
L-Histidine	5.68±0.65	0.01±0.00	7.83***	3.14±0.38
L-Aspartic Acid	70.47±5.37	18.88±1.08	8.52***	47.42±3.20
L-Lysine	0.28±0.16	0.01±0.00	1.56	0.15±0.09
L-Valine	6.93±0.88	4.29±0.47	2.47**	5.75±0.53
L-Methionine	102.92±3.85	49.63±1.54	11.83***	79.11±2.50
L-Asparagine	0.12±0.06	0.01±0.00	1.74	0.07±0.03
Iso Leucine	5.72±0.58	1.78±0.07	6.04***	3.96±0.33
L-Leucine	1.64±0.62	6.45±0.71	5.12***	3.79±0.48
L-Tyrosine	16.47±0.35	19.01±0.56	4.01***	17.60±0.32
D-L-B-Phenylalanine	30.78±1.32	33.80±0.95	1.77	32.13±0.85
L-Tryptophan	328.98±14.03	482.63±25.90	5.48***	397.63±14.29

4.5.2 Amino acids

4.5.2.1 Mean l-histidine concentration

The grandmean value for l-histidine concentration was 3.14±0.38 ppb. The test materials recorded the highest mean value of 5.68±0.65 ppb whereas the lowest mean was recorded by the controls with a value of 0.01±0.00 ppb. The Z-score was 7.83, with a P-value of 0.001 (Table 10).

4.5.2.2 Mean l-lysine concentration

The grandmean value was 0.15±0.09 ppb. The test materials recorded the highest mean of 0.28±0.16 ppb whereas the lowest mean was recorded by the controls with a value of 0.01±0.00 ppb. Z-score was 1.56, with a P-value ≤ 0.43 (Table 10).

4.5.2.3 Mean iso-leucine concentration

Table 10 shows the means and their standard error values for Iso-Leucine concentration. The grandmean was 3.96±0.33 ppb. The highest mean was 5.72±0.58 ppb recorded by the test materials while the lowest mean, 1.78±0.07 ppb was recorded by controls. Z-score was 6.04, with P-value ≤ 0.001(Table 10).

4.5.2.4 Mean l-leucine concentration

The grandmean value recorded was 3.79±0.48 ppb. The controls recorded the highest mean of 6.45±0.71 ppb whereas the lowest mean was recorded by the test materials with a value of 1.64±0.62 ppb. The Z-score was 5.12, with P-value ≤ 0.001 (Table 10).

4.5.2.5 Mean l-methionine concentration

The grandmean was 79.11±2.50 ppb. The highest mean was 102.92±3.85 ppb recorded by the test materials while the lowest mean, 49.63±1.54 ppb was recorded by the controls. Z-score was 11.83, with P-value ≤ 0.001 (Table 10).

4.5.2.6 Mean l-valine concentration

The grandmean value recorded was 5.75±0.53 ppb. The test materials recorded the highest mean of 6.93±0.88 ppb whereas the lowest mean was recorded by the controls with a value of 4.29±0.47 ppb. Z-score was 2.47, with a P-value ≤ 0.01(Table 10).

4.5.2.7 Mean l-tryptophan concentration

The grandmean was 397.63±14.29 ppb. The controls recorded the highest mean of 482.63±25.90 ppb whereas the lowest mean was recorded by the test materials with a value of 328.98±14.03 ppb. The Z-score was 5.48, with a P-value of ≤ 0.001(Table 10).

4.5.2.8 Mean d-l-b-phenylalanine concentration

The grandmean was recorded as 32.13±0.85 ppb. The highest mean was 33.80±0.95 ppb, recorded by the controls while the lowest mean, 30.78±1.32 ppb was recorded by the test materials. Z-score was 1.77, with a P-value of ≤ 0.03(Table 10)

4.5.2.9 Mean l-tyrosine concentration

The grandmean was 17.60±0.32 ppb. The highest mean was 19.01±0.56 ppb, recorded by the controls while the lowest mean, 16.47±0.35 ppb was recorded by test materials. Z-score was 4.01, with a P-value of ≤ 0.001 (Table 10).

4.5.2.10 Mean l-aspartic acid concentration

The grandmean value recorded was 47.42±3.20 ppb. The test materials recorded the highest mean of 70.47±5.37 ppb whereas the lowest mean was recorded by the controls with a value of 18.88±1.08 ppb. Z-score was 8.52, with a P-value of $\leq$ 0.001(Table 10).

4.5.2.11 Mean l-serine concentration

The grandmean was 40.84±2.61 ppb. The controls recorded the highest mean of 57.82±4.87 ppb whereas the lowest mean was recorded by the test materials with a value of 26.44±2.18 ppb. Z-score was 6.19, with a P-value of $\leq$ 0.001(Table 10).

4.5.2.12 Mean l- asparagine concentration

The grandmean was 0.07±0.03 ppb. The test materials recorded the highest mean of 0.12±0.06 ppb whereas the lowest mean was recorded by the controls with a value of 0.01±0.00 ppb. The Z-score was 1.74, with a P-value of $\leq$ 0.05 (Table 10).

4.5.2.13 Mean glycine concentration

The grandmean for glycine was 792.42±75.48 ppb. The controls recorded a mean value of 1126.95±122.31 ppb while the test materials recorded a mean value of 519.60±91.25 ppb. Z-score was 4.06, with a P-value of $\leq$ 0.001 (Table 10)

4.6. Association among quantitative traits

4.6.1 Association among quantitative traits in the test materials

The pairwise correlation among quantitative traits for the test materials are presented in Table 11. Seventy-seven significant associations (P≤0.05) were observed between morphological traits and eighty significant associations (P≤0.05) were observed between phytochemical traits. Association between morphological and phytochemical traits showed thirty-four significant associations (P≤0.05). Yield showed a positive and significant association (P≤0.05) with the following four vegetative traits: terminal leaf length (r=0.1788),terminal leaf width (r=0.1822), branch length (0.1442) and plant height (0.1179). Yield showed significant associations

(P≤0.05) with seven yield and yield-related traits as follows: pod length (r=0.6179), pod width (r=0.3969), number of pods per plant (r=-0.1882), seed length (r=0.6804), seed width (r=0.6671), seed thickness (r=0.7610) and seed weight (r=1.0000). A positively strong and significant association was observed between vanillic acid and p-coumaric acid (r=0.9884, P≤0.001) There was a perfect and significant correlation (r= 1.000, P≤0.05) among the flavonoids; rutin and quercetin. Among the amino acids, the highest correlation coefficient value was observed between l-serine and l-aspartic acid (r=0.7628, P≤0.01). Yield was negatively correlated with glycine (r=-0.1169, P≤0.05) and positively correlated with l-histidine (r=0.1394, P≤0.05).

Table 11:Pairwise correlation coefficient among quantitative traits in 104 test materials of cowpea accessions

	dtg	nol	tll	tlw	stl	stw	nns	nmb	bl
tlw	0.0333	0.061	0.9629*						
stw	-0.069	-0.0243	0.0483	0.0623	0.4246*				
bl	0.1004	0.0652	0.1118*	0.1295*	0.0041	0.0814	-0.0071	0.0769	
ph	0.0576	-0.0272	-0.1403*	-0.1422*	-0.0193	-0.0145	-0.0345	0.0218	-0.1195*
sps	-0.0826	0.2049*	0.0357	0.0162	0.0734	0.1076	0.1228*	-0.0585	-0.0507
lbl	-0.0474	0.0268	-0.0552	-0.0428	0.0633	0.0754	0.0524	-0.0875	-0.1357*
nrpp	0.1148*	-0.0094	0.0377	0.0416	-0.1009	-0.107	0.093	-0.0407	0.0172
naff	0.0175	0.0397	0.0433	0.0454	-0.0179	-0.0075	-0.0102	0.0392	-0.1346*
dff	0.0477	0.0476	0.0504	0.0583	-0.0533	0.0256	0.0159	-0.0096	0.1198*
d50f	0.0501	0.0086	0.0451	0.0534	-0.0612	0.0176	0.0459	-0.0047	0.1143*
apl	-0.0065	0.0148	0.0785	0.072	0.1091	-0.0042	-0.0386	0.0841	0.2169*
apw	0.0268	0.1026	0.1083	0.1162*	0.0556	0.0015	0.0039	0.1004	0.3446*
ppdn	-0.1504*	0.0219	-0.0225	-0.0263	0.0392	0.0175	0.0655	0.0105	0.001
ln	0.031	0.069	0.0373	0.0462	0.0214	0.0347	0.0812	-0.1538*	0.0204
d50mp	0.0164	0.1119*	0.0157	0.0198	0.0234	0.0823	0.0737	-0.0465	0.0617
nspp	0.0243	0.0694	0.0172	0.0233	0.0038	0.0238	0.0752	-0.1256*	0.0293
sw	0.0799	-0.0271	0.2497*	0.2490*	-0.0682	0.0492	0.0389	-0.0428	0.0116
st	0.0822	0.0374	0.1588*	0.1675*	-0.0398	0.0546	0.0046	-0.0833	-0.0084
swgt	0.062	0.0437	0.1788*	0.1822*	0.0389	0.0406	-0.0201	-0.0091	0.1442*
yld	0.062	0.0437	0.1788*	0.1822*	0.0389	0.0406	-0.0201	-0.0091	0.1442*
rut	-0.1247*	0.0776	0.0244	0.0402	-0.0326	-0.0526	-0.0683	-0.0044	-0.0664
que	-0.1247*	0.0776	0.0244	0.0402	-0.0326	-0.0526	-0.0683	-0.0044	-0.0664
gly	-0.0343	-0.1266*	-0.0175	-0.0134	-0.0359	-0.1094	-0.0356	0.0813	-0.1281*
asp	0.0565	-0.0193	-0.0036	-0.0153	0.014	0.0972	-0.0117	0.0189	0.1864*
llys	-0.021	-0.1131*	-0.0701	-0.1024	0.0457	0.0347	-0.1249*	0.0523	0.076
lval	0.0339	0.0654	0.0945	0.0968	0.054	0.0391	0.0202	-0.0848	0.1367*
lmet	0.0092	0.0065	-0.0048	0.0152	0.0731	0.1272*	-0.0258	-0.055	0.1209*
iso	-0.052	-0.1459*	-0.0261	-0.0338	-0.0267	-0.0311	-0.0698	0.0822	-0.0267

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=Lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 11 (Cont'd)

	ph	sps	lbl	nrpp	pdl	dff	d50f	apl	apw
lbl	0.0848	0.2027*							
pdl	-0.016	0.0068	0.1323*	0.0704					
naff	-0.019	-0.1225*	-0.032	-0.0254	-0.0241				
dff	-0.0623	0.1274*	-0.0774	-0.0226	-0.1628*				
d50f	-0.0646	0.1307*	-0.0615	-0.0344	-0.1407*	0.9464*			
apw	0.0203	-0.0144	-0.1096	0.0524	-0.0457	0.0811	0.099	0.6463*	
ppdn	0.0836	-0.0416	0.0037	0.0036	-0.1234*	-0.0528	-0.0331	-0.0169	-0.002
psa	-0.0326	-0.0131	0.1334*	0.0375	0.0727	-0.0935	-0.1234*	0.0285	0.0027
dfmp	-0.0385	0.1629*	-0.0711	-0.0333	-0.1310*	0.8687*	0.8270*	0.0474	0.1330*
d50mp	-0.0234	0.3529*	0.0658	-0.0027	-0.0865	0.7785*	0.7405*	-0.0084	0.1107
sl	0.1648*	0.0338	0.0538	-0.0148	0.0126	0.0016	0.0117	-0.031	-0.0561
st	0.1337*	0.0191	0.0465	-0.0116	0.0013	0.0363	0.0523	-0.0383	-0.0653
swgt	0.1179*	-0.0428	-0.0186	-0.0002	-0.0119	0.0542	0.08	0.6179*	0.3969*
yld	0.1179*	-0.0428	-0.0186	-0.0002	-0.0119	0.0542	0.08	0.6179*	0.3969*
van	-0.0578	-0.1388*	-0.0513	-0.0229	-0.1109	-0.0803	-0.0919	0.0223	0.0299
pca	-0.0699	-0.1411*	-0.0649	-0.0292	-0.1225*	-0.0663	-0.0784	0.036	0.0391
gly	0.0685	0.1158*	0.0042	-0.0549	-0.0492	0.0128	0.0406	-0.1750*	-0.0881
lhis	0.0993	-0.0384	-0.022	-0.1022	-0.1201*	0.0084	0.0233	0.0578	0.0364
lval	-0.1283*	0.0166	-0.0434	0.0297	-0.0326	-0.0625	-0.066	0.0453	0.1266*
lmet	0.0284	-0.006	0.0172	-0.1281*	-0.0091	0.0512	0.0488	0.0616	0.1324*
lasp	0.0939	-0.1366*	-0.0136	-0.0577	-0.1036	-0.0242	-0.0513	0.057	0.0213
iso	0.0026	0.0452	-0.0529	-0.0436	-0.0615	0.0367	0.0316	-0.0987	-0.1133*
ltyr	0.0843	0.0379	0.0705	-0.1142*	-0.0767	0.053	0.0732	-0.0328	-0.0399

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine,asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 11 (Cont'd)

	nplnt	ln	psa	dfmp	d50mp	nspp	sl	sw	st	swgt	yld
psa	-0.0296	-0.2067*									
d50mp	-0.0551	-0.1069	-0.0442	0.8988*							
nspp	0.0063	0.9360*	-0.5234*	-0.0502	-0.0846						
sw	-0.2052*	0.0526	0.0341	0.0885	0.052	0.0395	0.5676*				
st	-0.1563*	0.075	0.0156	0.0615	0.0233	0.0631	0.8911*	0.8793*			
swgt	-0.1882*	-0.0078	0.0295	0.0845	0.019	-0.0145	0.6804*	0.6671*	0.7610*		
yld	-0.1882*	-0.0078	0.0295	0.0845	0.019	-0.0145	0.6804*	0.6671*	0.7610*	1.0000*	
van	-0.0752	0.0709	-0.0405	-0.0553	-0.1131*	0.0827	0.0693	0.0888	0.0886	0.0853	0.0853
gly	0.035	0.0166	-0.0159	-0.0176	-0.021	0.0179	-0.0457	0.0383	-0.0052	-0.1169*	-0.1169*
lhis	-0.0031	0.1212*	-0.0713	-0.0143	-0.0405	0.1293*	0.0708	0.1605*	0.1296*	0.1394*	0.1394*
lmet	-0.1116*	0.0364	-0.0257	0.0902	0.0466	0.0409	0.0763	0.0689	0.0822	0.1095	0.1095

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine,asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 11 (Cont'd)

	gal	van	pca	rut	que	gly	lser	lhis	asp	llys	lval	lmet	iso	lleu	ltyr	dlb
van	0.3763*															
pca	0.3850*	0.9884*														
rut	0.0434	0.1166*	0.1251*													
que	0.0434	0.1166*	0.1251*	1.0000*												
gly	-0.0555	-0.1012	-0.1101	0.2932*	0.2932*											
lser	0.013	-0.0514	-0.0566	-0.1646*	-0.1646*	0.0548										
lhis	0.2887*	0.0292	0.0326	-0.0067	-0.0067	0.2508*	0.4858*									
asp	0.1339*	-0.002	0.0008	-0.2226*	-0.2226*	-0.0929	0.7628*	0.2845*								
llys	-0.0166	-0.0338	-0.0366	0.0987	0.0987	0.3945*	0.0896	0.0511	-0.0497							
lval	0.1248*	0.0841	0.0795	0.1365*	0.1365*	-0.1118*	0.2767*	0.1777*	0.1620*	-0.0439						
lmet	0.1442*	0.1107	0.1077	-0.1148*	-0.1148*	0.0112	0.5683*	0.2846*	0.5290*	0.1198*	0.1596*					
lasp	0.3716*	-0.0371	-0.04	-0.0619	-0.0619	-0.0051	0.001	0.4499*	0.1579*	-0.0108	0.0227	0.1346*				
iso	-0.0459	0.0441	0.0419	0.1340*	0.1340*	0.4896*	0.049	0.2033*	-0.0334	0.4120*	-0.0064	0.1889*				
lleu	-0.0559	0.0036	-0.0001	0.0091	0.0091	0.4136*	-0.0275	0.1025	0.0422	0.1824*	0.0606	0.0155	0.1006			
ltyr	-0.0897	-0.0674	-0.0867	-0.013	-0.013	0.5641*	0.3538*	0.5342*	0.1665*	0.2399*	0.0129	0.3351*	0.4016*	0.5617*		
dlb	0.0717	0.1637*	0.1479*	0.1503*	0.1503*	0.3626*	0.2364*	0.3342*	0.0694	0.1266*	0.1842*	0.4733*	0.5821*	0.2883*	0.5615*	
ltry	0.2288*	0.1679*	0.1513*	0.0378	0.0378	0.1096	0.2650*	0.3101*	0.0834	0.1344*	0.2006*	0.4217*	0.2763*	0.1242*	0.3333*	0.6571*

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine,lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

4.6.2 Association among quantitative traits in the controls

The pairwise correlation among quantitative traits for the controls are shown in Table 12

One hundred and seventy-six significant associations (P≤0.05) were observed between morphological traits whereas ninety-six significant associations (P≤0.05) were observed between phytochemical traits.

There were two hundred and seventy-one significant associations (P≤0.05) between quantitative traits. Yield showed a negative and significant association (P≤0.05) with the following with three growth and vegetative traits: number of leaves (r=-0.1468), number of nodes on main stem (r=-0.2451) and plant height (r= -0.2677). Yield showed significant associations (P≤0.05) with twelve yield and yield-related components as follows: days to first flower(r=0.1394), number of anthesis at first flowering (r=-0.2335), days to 50% flowering (r=-0.2163), number of locules (r=0.2463), percent seed abortion(r=0.4696), days to first mature pod (r=-0.2652), days to 50% mature pod (r=-0.2352), number of seeds per pod (r=-0.2212), seed length (r=0.6179), seed width (r=0.6179), seed thickness (r=0.6179) and seed weight (r=0.6179). A positive strong and significant association was observed between rutin and gallic acid as well as quercetin and gallic acid (r=0.9858, P≤0.001). A negatively strong and significant association was observed between vanillic acid and gallic acid (r=-0.9997), p-coumaric acid and gallic acid (r=-0.9997), rutin and vanillic acid (r=-0.9811), quercetin and vanillic acid (-0.9811), rutin and p-coumaric acid (-0.9811) and quercetin and p-coumaric acid (r=-0.9811). There was a perfect and significant correlation (r= 1.000, P≤0.05) between vanillic acid and p-coumaric acid and between rutin and quercetin. Among the amino acids, there was a perfect and significant correlation between l-leucine and glycine (r= 1.000, P≤0.05). The highest positive correlation value among the amino acid was observed between l-serine and l-tryptophan (r=0.9940, P≤0.05), l-tyrosine and glycine (r=0.9913, P≤0.05) and l-tyrosine and l-leucine (r=0.9912, P≤0.05). A strong and negative correlation was observed between isoleucine and l-aspartic acid ($r=-0.9947$, $P \leq 0.05$). Yield was significantly associated with all the phytochemical traits except l-valine (Table 12).

Table 12: Pairwise correlation coefficient among quantitative traits in 4 controls of cowpea accessions

	dtg	nol	tll	tlw	stl	stw	nns	nmb	bl
nol	0.1323*								
Tll	0.1814*	-0.0086							
tlw	0.2024*	0.0394	0.9463*						
stl	0.0893	0.1358*	0.1273*	0.1859*					
stw	0.0494	0.1339*	-0.0498	0.0164	0.5198*				
nmb	0.0687	-0.0476	-0.1016	0.0013	0.0498	0.0711	0.2287*		
Bl	0.0248	-0.0659	-0.1096	-0.0863	0.0349	-0.0262	0.1132	0.2778*	
ph	-0.0101	0.0714	-0.0152	-0.0445	-0.2814*	-0.3305*	0.2279*	-0.0668	-0.0652
sps	-0.0489	0.1289*	0.0789	0.0494	-0.0936	-0.0518	0.1927*	0.0336	-0.1455*
lbl	0.2192*	0.0145	-0.0638	-0.0299	0.0596	0.0977	-0.0816	0.0537	0.0725
nrpp	0.0962	0.1702*	0.1912*	0.1582*	-0.1037	0.0029	0.0258	0.1608*	0.0156
pdl	0.0143	0.1782*	-0.0678	-0.0755	-0.0167	0.0370	0.1889*	0.0159	0.0127
naff	0.2276*	0.0027	-0.0162	0.0054	0.0094	0.0714	-0.4281*	-0.0526	-0.1638*
dff	0.1129	0.1835*	0.0133	-0.0327	-0.0397	-0.0502	0.1123	-0.0972	-0.0898
d50f	0.1062	0.1786*	-0.0178	-0.0449	-0.0030	0.0016	0.1083	-0.0704	-0.0606
apl	-0.1233	0.0716	0.0498	0.0132	-0.0834	0.0125	-0.1729*	-0.1589*	0.1633*
apw	-0.0891	0.0056	-0.0516	-0.0694	-0.1070	0.1403*	-0.2507*	-0.1235	0.0644
nplnt	-0.0119	0.0764	-0.0592	-0.0316	-0.0437	-0.1172	0.2265*	0.0741	-0.0281
ppdn	-0.1262*	-0.0904	-0.0909	-0.1525*	0.0288	0.0818	-0.0364	-0.1540*	-0.1949*
Ln	-0.0380	-0.1140	-0.2142*	-0.2417*	-0.0560	0.0949	-0.2302*	-0.2982*	-0.1202
psa	0.0213	-0.1530*	0.0100	0.0147	0.0093	0.0703	-0.3588*	0.0078	0.1023
dfmp	0.1843*	0.2414*	0.0279	0.0192	0.0154	-0.1081	0.1671*	-0.1601*	-0.1257*
d50mp	0.2230*	0.2410*	0.0709	0.0521	0.0046	-0.1009	0.1095	-0.2112*	-0.2236*
nspp	-0.0670	0.0515	-0.1562*	-0.1740*	-0.0422	0.0064	0.1202	-0.1819*	-0.1581*
Sl	-0.1007	-0.0398	0.0703	0.1224	0.1292*	0.1389*	-0.3213*	0.0489	0.1653*
Sw	-0.0337	0.0086	0.1208	0.1721*	0.0975	0.0076	-0.1380*	-0.0416	0.0648
St	-0.0555	0.1182	-0.0006	0.0708	0.2184*	0.0958	-0.1149	-0.1299*	-0.0040
swgt	0.0355	-0.1468*	-0.0254	-0.0344	-0.0564	0.0318	-0.2451*	-0.0684	-0.0460
yld	0.0355	-0.1468*	-0.0254	-0.0344	-0.0564	0.0318	-0.2451*	-0.0684	-0.0460
gal	-0.0207	-0.1087	-0.0744	-0.0848	-0.1243*	0.0250	-0.3166*	0.0543	0.0360
van	0.0219	0.1096	0.0797	0.0911	0.1312*	-0.0212	0.3132*	-0.0540	-0.0325
pca	0.0219	0.1096	0.0797	0.0911	0.1312*	-0.0212	0.3132*	-0.0540	-0.0325
rut	-0.0127	-0.1009	-0.0394	-0.0430	-0.0779	0.0492	-0.3333*	0.0554	0.0583
que	-0.0127	-0.1009	-0.0394	-0.0430	-0.0779	0.0492	-0.3333*	0.0554	0.0583
gly	0.1153	0.1222	0.1825*	0.1932*	0.2618*	0.1580*	0.2099*	0.0944	0.1750*
lser	0.0055	-0.0602	0.0715	0.0910	0.0737	0.1012	-0.3226*	0.0335	0.0996
asp	-0.0344	-0.0449	0.0620	0.0904	0.0674	0.0256	-0.2428*	-0.0536	0.0051
lval	-0.0762	0.0105	-0.0285	-0.0136	-0.0304	-0.1335*	0.0933	-0.1505*	-0.1664*
lmet	0.0607	-0.0223	0.1298*	0.1472*	0.1563*	0.1788*	-0.2639*	0.1008	0.1914*
iso	0.0458	0.0488	-0.0435	-0.0705	-0.0433	-0.0025	0.2320*	0.0684	0.0204
lleu	0.1154	0.1221	0.1825*	0.1931*	0.2617*	0.1582*	0.2094*	0.0947	0.1753*
ltyr	0.1144	0.1260*	0.2005*	0.2161*	0.2857*	0.1634*	0.2019*	0.0852	0.1772*
dlb	0.1275*	0.0874	0.2004*	0.2133*	0.2743*	0.2161*	0.0514	0.1378*	0.2397*
ltry	0.0143	-0.0473	0.0962	0.1193	0.1084	0.1161	-0.3064*	0.0352	0.1139

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 12 (Cont'd)

	ph	sps	lbl	nrpp	pdl	naff	dff	d50f	apl
Sps	0.2026*								
Lbl	-0.0839	0.2088*							
Nrpp	0.1871*	0.2151*	-0.0078						
Pdl	-0.1249*	0.0274	0.0816	0.0659					
Dff	0.1700*	-0.0113	-0.1569*	0.1330*	0.0543	0.0034			
d50f	0.1182	0.0162	-0.1819*	0.1133	0.0434	0.0195	0.9355*		
Apl	-0.0839	-0.3085*	-0.1787*	-0.1300*	-0.0087	0.1405*	0.2466*	0.2562*	
Apw	-0.0732	-0.1967*	-0.0647	-0.1810*	-0.0305	0.2563*	0.1444*	0.1064	0.7262*
Nplnt	-0.0363	-0.0650	-0.0910	-0.0446	0.0428	-0.0580	0.1696*	0.1755*	-0.0772
Ppdn	0.1548*	-0.1626*	-0.1936*	-0.2642*	0.0258	-0.0171	0.1296*	0.0891	-0.0656
Ln	-0.0040	-0.1217	0.1273*	-0.1185	0.0131	0.0025	-0.0216	-0.0406	0.0415
Psa	-0.5492*	-0.2387*	0.0870	-0.1140	0.1412*	0.0819	-0.3035*	-0.3039*	0.0832
Dfmp	0.3780*	0.0380	-0.2135*	-0.0173	-0.0305	0.0186	0.7711*	0.7249*	0.1259*
d50mp	0.3126*	0.2325*	-0.0067	-0.0724	-0.0500	0.0334	0.6767*	0.6260*	-0.0095
Nspp	0.4311*	0.0913	0.0209	0.0349	-0.1115	-0.0666	0.1884*	0.1884*	-0.0335
Sl	-0.3725*	-0.1435*	0.0290	-0.0761	0.0835	0.0828	-0.2798*	-0.2182*	0.1195
Sw	-0.1720*	-0.1313*	-0.0637	0.0501	0.1031	0.0222	-0.1401*	-0.1529*	0.0164
St	-0.1634*	-0.0622	0.0043	-0.1763*	0.0637	0.1086	-0.0483	-0.0326	0.0317
Swgt	-0.2677*	-0.0758	-0.0522	-0.0783	0.0752	0.1394*	-0.2335*	-0.2163*	0.0589
Yld	-0.2677*	-0.0758	-0.0522	-0.0783	0.0752	0.1394*	-0.2335*	-0.2163*	0.0589
Gal	-0.3238*	-0.3600*	-0.0756	-0.0455	0.1664*	0.1139	-0.2224*	-0.2251*	0.1920*
Van	0.3168*	0.3631*	0.0779	0.0456	-0.1671*	-0.1132	0.2191*	0.2222*	-0.1942*
Pca	0.3168*	0.3631*	0.0779	0.0456	-0.1671*	-0.1132	0.2191*	0.2222*	-0.1942*
Rut	-0.3631*	-0.3340*	-0.0594	-0.0440	0.1589*	0.1161	-0.2400*	-0.2398*	0.1751*
Que	-0.3631*	-0.3340*	-0.0594	-0.0440	0.1589*	0.1161	-0.2400*	-0.2398*	0.1751*
Gly	-0.0576	0.2316*	0.1375*	0.0509	-0.0780	-0.1441*	0.1707*	0.1539*	-0.1066
Lser	-0.3922*	-0.1793*	-0.0030	-0.0327	0.0986	0.1081	-0.2538*	-0.2418*	0.0810
Asp	-0.1872*	-0.0335	-0.0088	-0.0282	0.0205	0.1127	-0.2172*	-0.1909*	-0.0095
Lval	0.3206*	0.2086*	-0.0225	0.0008	-0.1158	0.0272	0.0296	0.0555	-0.1347*
Lmet	-0.4718*	-0.1547*	0.0448	-0.0154	0.1002	0.0503	-0.1940*	-0.1949*	0.0803
Iso	0.1441*	0.0289	0.0190	0.0295	-0.0146	-0.1165	0.2108*	0.1831*	0.0131
Lleu	-0.0584	0.2309*	0.1375*	0.0508	-0.0777	-0.1440*	0.1705*	0.1535*	-0.1062
Ltyr	-0.0631	0.2568*	0.1445*	0.0512	-0.0883	-0.1391*	0.1591*	0.1457*	-0.1236
Dlb	-0.2780*	0.0929	0.1307*	0.0346	-0.0056	-0.1000	0.0570	0.0391	-0.0333
Ltry	-0.3955*	-0.1433*	0.0124	-0.0280	0.0849	0.0981	-0.2438*	-0.2313*	0.0612

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine,lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 12 (Cont'd)

	apw	nplnt	ppdn	ln	psa	dfmp	d50mp	nspp	sl
nplnt	-0.1533*								
ppdn	0.0245	-0.1318*							
ln	0.1085	0.0876	0.1698*						
psa	0.1123	0.0029	-0.2019*	0.0428					
dfmp	0.0900	0.1110	0.1855*	0.0017	-0.5072*				
d50mp	0.0300	0.0256	0.1290*	0.0030	-0.4951*	0.9081*			
nspp	-0.0367	0.0723	0.2355*	0.6015*	-0.7507*	0.3627*	0.3407*		
sl	0.0668	0.1041	-0.1890*	-0.0965	0.7399*	-0.3425*	-0.3747*	-0.6149*	
sw	-0.0514	0.2401*	-0.1880*	0.0200	0.5485*	-0.1232	-0.1972*	-0.3784*	0.7993*
st	-0.0441	0.3166*	-0.0644	0.2239*	0.2191*	0.0763	0.0426	-0.0102	0.5724*
swgt	0.0548	-0.0488	-0.1070	0.2463*	0.4696*	-0.2652*	-0.2352*	-0.2212*	0.3615*
yld	0.0548	-0.0488	-0.1070	0.2463*	0.4696*	-0.2652*	-0.2352*	-0.2212*	0.3615*
gal	0.1884*	0.0052	-0.1079	-0.0090	0.7864*	-0.4514*	-0.5046*	-0.6007*	0.6231*
van	-0.1912*	-0.0041	0.1037	0.0018	-0.7743*	0.4488*	0.5023*	0.5868*	-0.6068*
pca	-0.1912*	-0.0041	0.1037	0.0018	-0.7743*	0.4488*	0.5023*	0.5868*	-0.6068*
rut	0.1672*	0.0121	-0.1330*	-0.0551	0.8512*	-0.4610*	-0.5113*	-0.6803*	0.7177*
que	0.1672*	0.0121	-0.1330*	-0.0551	0.8512*	-0.4610*	-0.5113*	-0.6803*	0.7177*
gly	-0.1128	-0.2304*	-0.0483	-0.4678*	-0.2930*	0.1430*	0.2346*	-0.1281*	-0.3774*
lser	0.0612	0.0581	-0.1774*	-0.1465*	0.8737*	-0.3836*	-0.4204*	-0.7534*	0.8879*
asp	-0.0284	0.1884*	-0.1068	0.0626	0.5775*	-0.1682*	-0.2158*	-0.3691*	0.7817*
lval	-0.1339*	0.2400*	0.1105	0.3799*	-0.4103*	0.3198*	0.2911*	0.6018*	-0.0879
lmet	0.0597	-0.0806	-0.2107*	-0.3819*	0.8408*	-0.4029*	-0.4018*	-0.9077*	0.7408*
iso	0.0302	-0.2102*	0.0872	-0.1200	-0.5228*	0.1394*	0.1921*	0.2857*	-0.7450*
lleu	-0.1124	-0.2308*	-0.0486	-0.4685*	-0.2916*	0.1420*	0.2336*	-0.1297*	-0.3766*
ltyr	-0.1323*	-0.2092*	-0.0571	-0.4687*	-0.2718*	0.1534*	0.2439*	-0.1419*	-0.3178*
dlb	-0.0463	-0.2526*	-0.1372*	-0.5805*	0.1542*	-0.0910	-0.0129	-0.5464*	-0.0019
ltry	0.0396	0.0513	-0.1845*	-0.1833*	0.8520*	-0.3611*	-0.3907*	-0.7631*	0.8821*

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine, lleu=L-Leucine, ltyr=L-Tyrosine, dlb=D-L-B-Phenylalanine, ltry=L-Tryptophan

Table 12 (Cont'd)

	Sw	St	swgt	yld	gal	van	Pca	rut	que	gly	Lser	asp	lval	lmet	isoleu	lleu	ltyr	dlbphe
st	0.7240*																	
swgt	0.3491*	0.2252*																
yld	0.3491*	0.2252*	1.0000*															
gal	0.3807*	0.0331	0.3820*	0.3820*														
van	-0.3636*	-0.0204	-0.3778*	-0.3778*	-0.9997*													
pca	-0.3636*	-0.0204	-0.3778*	-0.3778*	-0.9997*	1.0000*												
rut	0.4840*	0.1144	0.4028*	0.4028*	0.9858*	-0.9811*	-0.9811*											
que	0.4840*	0.1144	0.4028*	0.4028*	0.9858*	-0.9811*	-0.9811*	1.0000*										
gly	-0.4394*	-0.4164*	-0.3622*	-0.3622*	-0.5509*	0.5554*	0.5554*	-0.5131*	-0.5131*									
lser	0.7552*	0.4088*	0.4044*	0.4044*	0.7284*	-0.7104*	-0.7104*	0.8322*	0.8322*	-0.3538*								
asp	0.8566*	0.7069*	0.3684*	0.3684*	0.3388*	-0.3185*	-0.3185*	0.4639*	0.4639*	-0.4855*	0.8204*							
lval	0.2525*	0.5548*	-0.0019	-0.0019	-0.5490*	0.5535*	0.5535*	-0.5113*	-0.5113*	-0.3312*	-0.2047*	0.3898*						
lmet	0.5052*	0.1056	0.2695*	0.2695*	0.6648*	-0.6478*	-0.6478*	0.7630*	0.7630*	0.0612	0.8847*	0.5149*	-0.5640*					
isoleu	-0.8468*	-0.7310*	-0.3663*	-0.3663*	-0.3058*	0.2868*	0.2868*	-0.4229*	-0.4229*	0.5442*	-0.7699*	-0.9947*	-0.4670*	-0.4288*				
lleu	-0.4394*	-0.4173*	-0.3618*	-0.3618*	-0.5490*	0.5535*	0.5535*	-0.5113*	-0.5113*	1.0000*	-0.3527*	-0.4858*	-0.3333*	0.0628	0.5447*			
ltyr	-0.3540*	-0.3278*	-0.3443*	-0.3443*	-0.5840*	0.5914*	0.5914*	-0.5266*	-0.5266*	0.9913*	-0.2955*	-0.3779*	-0.2455*	0.0898	0.4364*	0.9912*		
dlbphe	-0.1954*	-0.3784*	-0.1851*	-0.1851*	-0.0983	0.1077	0.1077	-0.0360	-0.0360	0.8744*	0.0906	-0.2499*	-0.6380*	0.5227*	0.3421*	0.8754*	0.8652*	
ltry	0.7614*	0.4229*	0.3807*	0.3807*	0.6551*	-0.6352*	-0.6352*	0.7724*	0.7724*	-0.2734*	0.9940*	0.8353*	-0.1780*	0.8961*	-0.7807*	-0.2724*	-0.2061*	0.1552*

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine,asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine,iso=IsoLeucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

4.6.3 Association among quantitative traits in the entire population

Table 13 shows the pairwise correlation among quantitative traits in the entire population. One hundred and fifty-one significant associations (P≤0.05) were observed among the morphological traits alone and ninety-six significant associations (P≤0.05) were observed among the phytochemical traits.

There were two hundred and seventy significant associations between morphological and phytochemical traits which showed one hundred and sixty-six significant (P≤0.05). Yield showed a negative and significant association (P≤0.05) with plant height (r= -0.1625). Yield was significantly associated (P≤0.05) with twelve yield and yield-related components as follows: number of anthesis at first flowering (r=-0.0906), days to 50%flowering (r=-0.0941), pod length (r=0.1098), pod width (r=0.0931), number of pod per peduncle (r=-0.1139), number of locules (r=0.1742), percent seed abortion (r=0.2448), days to first mature pod (r=-0.1670), days to 50% mature pod (r=-0.1269), seed length (r=0.1865), seed width (r=0.1238) and seed weight (r=1.0000). A positively strong and significant correlation was observed between vanillic acid and p-coumaric acid (r=0.9896, P≤0.001) There was a perfect and significant correlation (r= 1.000, P≤0.05) between rutin and quercetin. Among the amino acids, the highest correlation coefficient value was observed between l-serine and l-tryptophan (r=0.8109, P≤0.01). Yield was negatively correlated with glycine (r=--0.3213, P≤0.05) and positively correlated with l-histidine (r=0.2155, P≤0.05)

Table 13: Pairwise correlation coefficient among quantitative traits in the entire population of 108 cowpea accessions

	dtg	nol	tll	tlw	stl	stw	nns	nmb	bl
Tll	0.0858*	0.022	1						
tlw	0.1000*	0.0505	0.9564*	1					
stl	0.0193	0.0851*	0.0011	0.0362	1				
stw	-0.0228	0.0354	0.0115	0.0455	0.4627*	1			
nns	-0.0974*	0.0667	-0.0625	-0.0731	-0.0654	-0.0165	1		
Bl	0.0732	0.0201	0.0339	0.0533	0.0162	0.0442	0.0363	0.1542*	1
ph	0.0279	0.0074	-0.0846*	-0.0984*	-0.1373*	-0.1346*	0.0596	-0.0194	-0.1000*
sps	-0.0682	0.1735*	0.0532	0.0297	-0.0055	0.0421	0.1522*	-0.0151	-0.0849*
nrpp	0.1089*	0.0669	0.0944*	0.0846*	-0.1003*	-0.0644	0.076	0.0542	0.0167
naff	0.1052*	0.0208	0.0228	0.0321	-0.0057	0.0272	-0.2012*	-0.006	-0.1438*
dff	0.0761	0.1045*	0.0313	0.018	-0.046	-0.0063	0.0642	-0.0486	0.0441
apl	-0.0539	0.0321	0.0729	0.0538	0.0234	0.0043	-0.1028*	-0.0229	0.1972*
apw	-0.0253	0.0592	0.0392	0.0354	-0.0254	0.0618	-0.1133*	-0.0105	0.2309*
nplnt	0.0123	0.0604	-0.0456	-0.0214	0.0243	0.0131	0.0948*	0.0462	-0.0735
ppdn	-0.1427*	-0.0283	-0.0411	-0.07	0.0323	0.046	0.0044	-0.0663	-0.0684
Ln	0.0077	0.0063	-0.0632	-0.0666	-0.0102	0.0536	-0.0233	-0.2094*	-0.0252
psa	-0.0055	-0.1006*	0.0402	0.0409	0.0185	0.0519	-0.2285*	-0.0017	0.0341
dfmp	0.0998*	0.1430*	0.026	0.0191	-0.0251	-0.0187	0.0988*	-0.0891*	0.0139
d50mp	0.1049*	0.1655*	0.0382	0.0329	0.0145	0.0059	0.0898*	-0.1245*	-0.0446
nspp	-0.0083	0.0697	-0.0692	-0.0702	-0.0149	0.0103	0.1228*	-0.1437*	-0.0387
Sl	-0.0338	0.0029	0.0695	0.0979*	0.0683	0.0954*	-0.2190*	-0.0151	0.0608
Sw	0.0106	-0.0254	0.1917*	0.2088*	0.0158	0.0358	-0.0986*	-0.0453	0.0294
St	-0.01	0.0552	0.0799	0.1136*	0.1068*	0.0762	-0.1103*	-0.1068*	-0.0063
van	0.001	-0.0162	-0.0656	-0.0558	0.0487	0.0054	0.1335*	-0.0249	0.0092
pca	-0.0001	-0.0051	-0.0583	-0.0492	0.0484	0.0223	0.1332*	-0.0155	0.0149
rut	-0.0718	-0.0208	0.0105	0.0126	-0.0584	0.0042	-0.2275*	0.0224	-0.0108
que	-0.0718	-0.0208	0.0105	0.0126	-0.0584	0.0042	-0.2275*	0.0224	-0.0108
gly	0.0318	-0.0176	0.0864*	0.0916*	0.1170*	0.018	0.058	0.0831*	0.0003
lser	0.0093	-0.0375	0.0746	0.0819	0.0315	0.0792	-0.2219*	0.0361	0.0791
asp	0.0458	-0.0044	-0.0174	-0.0188	0.0204	0.0651	0.0128	0.0124	0.1459*
llys	-0.0145	-0.0858*	-0.0583	-0.0824	0.0327	0.0256	-0.0853*	0.0378	0.0634
lval	0.0075	0.0536	0.0536	0.0602	0.0273	-0.0069	0.0511	-0.0948*	0.0683
lmet	0.0282	0.0188	-0.008	0.014	0.0796	0.1048*	-0.0046	-0.0057	0.1164*
iso	-0.0294	-0.0972*	-0.0372	-0.0415	-0.0181	-0.0296	-0.0037	0.0647	-0.0195
lleu	0.0373	-0.0136	0.0422	0.0353	0.1333*	0.0808	0.0311	0.0605	0.0559
ltyr	0.0305	0.0184	0.1062*	0.1114*	0.1351*	0.0684	0.0836*	0.0914*	0.0629
dlb	0.0172	-0.034	0.0812	0.0908*	0.0807	0.0733	0.0175	0.0374	0.0412
ltry	0.0051	-0.048	0.0672	0.075	0.0639	0.0606	-0.1918*	0.0055	0.0417

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine,lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine,iso=IsoLeucine, lleu=L-Leucine, ltyr=L-Tyrosine, dlb=D-L-B-Phenylalanine, ltry=L-Tryptophan

Table 13 (Cont'd)

	ph	sps	lbl	nrpp	pdl	Naff	dff	d50f	apl	apw
sps	0.1033*	1								
lbl	0.0061	0.2033*	1							
nrpp	0.0608	0.1262*	0.0399	1						
pdl	-0.0616	0.0152	0.1197*	0.0729	1					
naff	-0.0139	-0.1052*	-0.057	-0.023	-0.0619	1				
dff	0.0262	0.0683	-0.0981*	0.0488	-0.0745	-0.0159	1			
d50f	0.0064	0.0829*	-0.1043*	0.0279	-0.0697	-0.0031	0.9408*	1		
apl	-0.0117	-0.1790*	-0.1294*	-0.054	-0.0188	0.0546	0.1111*	0.1298*	1	
apw	-0.0184	-0.0983*	-0.0924*	-0.0556	-0.0401	0.0855*	0.1077*	0.1014*	0.6746*	1
nplnt	-0.0831*	-0.0219	-0.0026	0.0359	0.0898*	-0.0478	0.0698	0.046	-0.1151*	-0.1099*
ppdn	0.1235*	-0.0928*	-0.0925*	-0.1202*	-0.0717	-0.0026	0.0141	0.014	-0.0222	0.013
psa	-0.2847*	-0.1408*	0.0599	-0.0718	0.0881*	0.0589	-0.2151*	-0.2123*	0.0752	0.0731
dfmp	0.1433*	0.1066*	-0.1375*	-0.0323	-0.0926*	0.0019	0.8179*	0.7793*	0.0851*	0.1141*
d50mp	0.1166*	0.2996*	0.037	-0.032	-0.0709	-0.0127	0.7331*	0.6912*	-0.0097	0.0728
nspp	0.1624*	0.0176	-0.0105	-0.0092	-0.0809	-0.0381	0.0677	0.0724	-0.0933*	-0.0438
sl	-0.0907*	-0.0645	-0.0126	-0.0759	0.0286	0.0792	-0.1639*	-0.1105*	0.076	0.0242
st	0.0024	-0.0284	-0.0406	-0.1331*	0.0107	0.0961*	-0.0377	-0.0047	0.0397	-0.0361
swgt	-0.1625*	-0.0485	0.0357	-0.0011	0.0592	0.0441	-0.0906*	-0.0941*	0.1098*	0.0931*
yld	-0.1625*	-0.0485	0.0357	-0.0011	0.0592	0.0441	-0.0906*	-0.0941*	0.1098*	0.0931*
van	0.0157	-0.0187	-0.0106	0.001	-0.1122*	-0.0525	-0.0059	-0.0196	-0.0296	-0.0254
pca	0.0058	-0.0195	-0.018	-0.0017	-0.1200*	-0.0535	0.0055	-0.0091	-0.0212	-0.0199
rut	-0.1917*	-0.1153*	-0.0857*	-0.0542	0.0457	0.0798	-0.0956*	-0.0719	0.0627	0.0943*
que	-0.1917*	-0.1153*	-0.0857*	-0.0542	0.0457	0.0798	-0.0956*	-0.0719	0.0627	0.0943*
gly	0.0238	0.1684*	0.0378	-0.0189	-0.0689	-0.044	0.0757	0.0885*	-0.1225*	-0.0941*
lser	-0.1661*	-0.1198*	-0.0375	-0.0492	0.0328	0.0717	-0.1695*	-0.1502*	0.077	0.0512
lmet	-0.1038*	-0.0296	0.0847*	-0.0428	0.033	-0.0132	0.0268	0.0057	0.0124	0.0818
lasp	0.0658	-0.1018*	0.0002	-0.0364	-0.0786	-0.0261	-0.0137	-0.0385	0.038	0.0135
iso	-0.0121	0.0359	-0.0025	-0.0065	-0.0357	-0.0241	0.0557	0.0389	-0.0980*	-0.0824
lleu	0.0116	0.0973*	0.0598	-0.0353	-0.0771	-0.0594	0.0446	0.0578	-0.046	-0.0736
ltyr	0.0244	0.1482*	0.0768	-0.0422	-0.0868*	-0.0574	0.0938*	0.1032*	-0.0579	-0.0848*
ltry	-0.1835*	-0.0435	-0.044	-0.0095	0.0216	0.0586	-0.1571*	-0.1316*	0.0464	0.0199

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine,lser=L-Serine,lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine,lval=L-Valine,lmet=L Methionine, iso=IsoLeucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 13 (Cont'd)

	Nplnt	ppdn	ln	psa	dfmp	d50mp	nspp	sl	sw	st	swgt	yld	gal	van	pca
ppdn	-0.0861*														
dfmp	-0.0296	0.06	-0.0524	-0.2994*											
d50mp	-0.021	0.0097	-0.0612	-0.3011*	0.9003*										
nspp	0.0993*	0.0793	0.7968*	-0.6487*	0.1168*	0.1061*									
sl	-0.0848*	-0.0426	-0.0502	0.5771*	-0.1538*	-0.2064*	-0.3717*								
sw	-0.1310*	0.0094	-0.0135	0.4306*	0.0071	-0.0738	-0.2538*	0.7479*							
st	-0.046	0.0428	0.0863*	0.2443*	0.0878*	0.0265	-0.0812	0.6991*	0.8003*						
swgt	0.0747	-0.1139*	0.1742*	0.2448*	-0.1670*	-0.1269*	-0.0182	0.1865*	0.1238*	0.0586					
yld	0.0747	-0.1139*	0.1742*	0.2448*	-0.1670*	-0.1269*	-0.0182	0.1865*	0.1238*	0.0586	1.0000*				
gal	-0.0088	0.0027	0.0673	0.0426	-0.0758	-0.0797	0.0299	0.0663	-0.0071	-0.0471	0.1513*	0.1513*			
van	-0.0337	0.0598	0.0629	-0.2538*	0.0557	0.0323	0.2011*	-0.1518*	-0.0671	0.0002	-0.0504	-0.0504	0.2917*		
pca	-0.0264	0.056	0.0639	-0.2556*	0.0639	0.0415	0.2036*	-0.1535*	-0.066	-0.0006	-0.0389	-0.0389	0.3015*	0.9896*	
rut	-0.1018*	-0.014	-0.024	0.6008*	-0.1900*	-0.2371*	-0.3711*	0.5065*	0.3520*	0.1705*	0.1156*	0.1156*	0.1162*	-0.1946*	-0.1958*
que	-0.1018*	-0.014	-0.024	0.6008*	-0.1900*	-0.2371*	-0.3711*	0.5065*	0.3520*	0.1705*	0.1156*	0.1156*	0.1162*	-0.1946*	-0.1958*
gly	-0.1181*	0.0228	-0.2109*	-0.1486*	0.0719	0.1018*	-0.0928*	-0.1794*	-0.1406*	-0.1754*	-0.3213*	-0.3213*	-0.1447*	0.0556	0.0481
lser	-0.0706	-0.0747	-0.0949*	0.6888*	-0.2217*	-0.2714*	-0.4723*	0.7170*	0.5827*	0.4035*	0.1943*	0.1943*	0.0799	-0.2444*	-0.2521*
lhis	0.0910*	-0.0499	0.1279*	-0.1031*	-0.0306	-0.0255	0.1635*	-0.068	-0.0382	-0.0704	0.1744*	0.1744*	0.3215*	0.0512	0.0593
asp	0.0764	-0.0624	0.0793	-0.0285	0.0062	0.0035	0.0863*	0.0274	-0.0213	-0.0175	0.2155*	0.2155*	0.1916*	0.0095	0.0175
llys	0.0156	-0.0608	-0.047	-0.0189	-0.0432	-0.039	-0.031	-0.0441	-0.013	-0.0322	0.0357	0.0357	-0.0039	-0.0265	-0.028
lval	0.0206	0.0092	0.1071*	-0.1656*	0.0307	0.047	0.1826*	-0.0858*	-0.0065	0.1049*	0.0421	0.0421	0.0868*	0.1521*	0.1500*
lmet	0.0451	-0.1347*	0.0139	0.0859*	-0.0474	-0.0401	-0.031	0.0501	-0.0499	-0.1246*	0.2881*	0.2881*	0.2356*	0.0657	0.0702
lasp	0.0611	-0.0188	0.0919*	-0.0186	-0.0294	-0.026	0.0798	-0.0203	-0.0427	-0.0331	0.0405	0.0405	0.3705*	-0.0289	-0.0304
iso	0.0612	-0.0431	-0.0109	-0.1171*	0.0034	-0.0003	0.0588	-0.1605*	-0.1368*	-0.1582*	0.0636	0.0636	-0.0033	0.0689	0.071
lleu	-0.1543*	-0.0103	-0.2416*	-0.1089*	0.062	0.0918*	-0.1386*	-0.1442*	-0.1099*	-0.1391*	-0.3069*	-0.3069*	-0.1481*	0.1056*	0.1002*
ltyr	-0.1526*	-0.037	-0.2293*	-0.1588*	0.1100*	0.1328*	-0.1010*	-0.1397*	-0.0924*	-0.1207*	-0.3011*	-0.3011*	-0.1714*	0.0992*	0.0863*
dlb	-0.1510*	-0.0523	-0.1636*	0.0797	-0.0297	-0.0403	-0.1834*	0.0443	-0.0231	-0.1039*	-0.1057*	-0.1057*	0.0364	0.1446*	0.1304*
ltry	-0.0505	-0.0593	-0.1174*	0.6269*	-0.1999*	-0.2409*	-0.4525*	0.6545*	0.5476*	0.3799*	0.1687*	0.1687*	0.1818*	-0.1013*	-0.1145*

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff =Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine,lval = L-Valine, lmet = L-Methionine, iso=IsoLeucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

Table 13 (Cont'd)

	rut	**que**	**gly**	**lser**	**lhis**	**asp**	**Llys**	**lval**	**lmet**	**iso**	**lleu**	**ltyr**	**dlb**
que	1.0000*												
gly	-0.1117*	-0.1117*											
lser	0.5697*	0.5697*	-0.1624*										
lhis	-0.0925*	-0.0925*	0.1060*	0.1266*									
asp	-0.1699*	-0.1699*	-0.1685*	0.3315*	0.3571*								
llys	0.0415	0.0415	0.2507*	0.0229	0.069	-0.0238							
lval	-0.1018*	-0.1018*	-0.1903*	0.0071	0.1867*	0.1956*	-0.0332						
lmet	-0.0301	-0.0301	-0.0585	0.3049*	0.3701*	0.5908*	0.1311*	0.1095*					
lasp	-0.0584	-0.0584	-0.0159	-0.019	0.4490*	0.1711*	-0.006	0.0283	0.1470*				
iso	-0.0213	-0.0213	0.3100*	-0.1094*	0.2636*	0.0391	0.4126*	0.0021	0.2538*				
lleu	-0.1860*	-0.1860*	0.7138*	-0.1556*	0.004	-0.0914*	0.1174*	-0.0682	-0.0734	0.0527			
ltyr	-0.2606*	-0.2606*	0.8181*	-0.0666	0.2559*	-0.0066	0.1345*	-0.0849*	0.1181*	0.2270*	0.7890*		
dlb	0.0867*	0.0867*	0.5388*	0.1501*	0.2504*	0.0116	0.1041*	0.0121	0.3864*	0.4823*	0.4841*	0.6430*	
ltry	0.5389*	0.5389*	-0.0831*	0.8109*	0.0891*	0.0676	0.058	0.0196	0.2938*	0.0276	-0.0491	0.0179	0.3872*

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff =Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine, lval = L-Valine, lmet = L-Methionine, iso=Iso Leucine, lleu=L-Leucine, ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan

4.7 Relative contribution of traits to observed variability among genotypes

4.7.1 Contribution of traits to underlying variation in yield in test materials

The results of the forward selection multiple regression analysis between yield (dependent variable) and other traits in the test material are presented in Table 14. Growth and vegetative traits accounted for 7.94% of

the regression model (P=0.005) that contributed to yield. Yield and yield-related components accounted for 100.00% of the regression model (P= 0.000) that contributed yield. Phytochemical traits contributed 12.29% to the model and, its contribution to yield was significant (P=0.003). For the vegetative traits, only branch length and plant height among the rest of the vegetative traits met the entry point criterion (P<0.05) and still left the model significant (P = 0.000).

The following yield and yield-related traits met the entry point criterion (P<0.05) and still left the model significant (P = 0.001): pod length, pod width, seed length, seed width and seed thickness.

Vanillic acid, p-coumaric acid, l-histidine, l-lysine and iso-leucine were phytochemical traits that met the entry point criterion (P<0.05) and still left the model significant (P = 0.001).

Table 14: Percentage contribution of independent variables with respect to underlying variation in yield in controls of cowpea accessions

Independent variables	P>t	%Contribution to yield
Branch length	0.018	7.94
Plant height	0.005	
Pod length	0.000	
Pod width	0.000	
Seed length	0.000	100.00***
Seed width	0.000	
Seed thickness	0.000	
Vanillic acid	0.027	
P-coumaric acid	0.012	
L-Histidine	0.017	12.29**
Iso-Leucine	0.23	
L-Lysine	0.026	

'*', '**', '***'=Significant at 5%, 1% and 0.1% level respectively

4.7.2 Contribution of traits to underlying variation in yield in control

The percentage contribution of independent variables with respect to underlying variation in yield in controls of cowpea accessions are indicated in Table 15. Vegetative traits accounted for 14.31% of the regression model (P=0.000) of the traits that contributed to yield. Yield and yield-related components accounted for 36.67% of the regression model (P= 0.000) that contributed yield.

Phytochemical traits contributed 21.89% to the model's contribution to yield and was significant (P=0.000).

For the growth and vegetative traits, only number of nodes on main stem and plant height among the rest of the vegetative traits met the entry point criterion (P<0.05) and still left the model significant (P = 0.000).

The following yield and yield-related traits met the entry point criterion (P<0.05) and still left the model significant (P<0.05): lobe length, number of locules, number of seeds per pod and seed width. Glycine, gallic acid and vanillic acid were the phytochemical traits that met the entry point criterion (P<0.05) and left the model significant (P = 0.000).

Table 15: Percentage contribution of independent variables with respect to underlying variation in yield in controls of cowpea accessions

Independent variables	P>t	%Contribution to yield
Number of nodes on main stem	0.008	14.31***
Plant height	0.000	
Lobe length	0.009	
Number of locules	0.002	36.67***
Number of seeds per pod	0.048	
Seed width	0.015	
Gallic acid	0.000	21.89***
Vanillic acid	0.000	
Glycine	0.000	

'*', '**', '***'=Significant at 5%, 1% and 0.1% level respectively

4.7.3 Contribution of other traits to underlying variation in yield in the entire population

Percentage contribution of independent variables with respect to underlying variation in yield in entire population of cowpea accessions are presented in Table 16. Growth and vegetative traits accounted for 4.01% of the regression model (P=0.01) of the traits that contributed to yield. Yield and yield-related components accounted for 16.44% of the regression model (P= 0.000) that contributed to underlying variation in yield. Phytochemical traits contributed 25.95% to the model and, its contribution to yield was significant (P=0.000).

For the vegetative traits, only plant height among the rest of the vegetative traits met the entry point criterion (P<0.05) and still left the model significant (P = 0.000). The following yield and yield-related traits met the entry point criterion (P<0.05) and still left the model significant (P = 0.001): pod length, number of pods per plant, number of locules, days to 50% flowering, days to 50% mature pod, seed length and seed thickness

Only amino acids; l-histidine, l-methionine, l-aspartic acid, l-tyrosine, d-l-b-phenylalanine and l-tryptophan were phytochemical traits that met the entry point criterion (P<0.05) and still left the model significant (P = 0.000).

Table 16: Percentage contribution of independent variables with respect to underlying variation in yield in entire population of cowpea accessions

Independent variable	P>t	%Contribution to yield
Plant height	0.000	4.01**
Pod length	0.016	
Number of pod per plant	0.026	
Number of locules	0.025	
Days to 50% flowering	0.001	16.44***
Days to 50% mature pod	0.008	
Seed length	0.050	
Seed thickness	0.023	
L-Histidine	0.000	
L-Methionine	0.000	
L-Aspartic acid	0.047	25.05**
L-Tyrosine	0.007	
D-L-B-Phenylalanine	0.008	
L-Tryptophan	0.006	

'*', '**', '***'=Significant at 5%, 1% and 0.1% level respectively

4.8 Principal Component Analysis

4.8.1 Principal component analysis of morphological quantitative traits

4.8.1.1 Principal component analysis for the morphological quantitative traits in test material

A total of 31 principal components were generated in the test material (Figure 1). The first eleven principal component axes in the PCA analysis had eigenvalues up to 1.0. (Figure 1). The first six principal components accounted for a total variability of 52.54% (Table 17). Principal component one (PC1), with an eigenvalue of 4.51, contributed 14.53% of the total variability, while PC2, with an eigenvalue of 3.62, accounted for 11.66% of total variability observed. Principal component three had an eigenvalue of 2.39 and contributed 7.72% to the total observed variability.

In PC1, the traits that accounted for most of the 14.53% observed variability among test materials included seed length (0.33), seed width (0.35), seed thickness (0.39), seed weight (0.43) and yield (0.43). Principal component 2, also identified yield-related traits such as number of anthesis at first flowering (0.46) and phenological traits which were: days to first mature pod (0.46), days to 50% mature pod (0.45) and days to 50% flowering (0.44) that accounted for the most total variability. Similarly, number of locules and number of seeds per pod were identified with high factor loadings of 0.45 and 0.49 respectively in the 3rd principal component.

Table 17**:** Principal component analysis for quantitative morphological traits of the 104 test materials of cowpea accessions

Traits	PC1	PC2	PC3	PC4	PC5	PC6
Days to germination	0.05	0.00	0.00	0.04	0.02	-0.24
Number of leaves	0.04	0.04	0.05	0.06	0.01	0.21
Terminal leaflet length	0.15	-0.02	-0.06	0.29	**0.57**	0.07
Terminal leaflet width	0.15	-0.02	-0.05	0.29	**0.56**	0.08
Stipule length	-0.01	-0.02	-0.03	-0.01	-0.16	0.52
Stipule width	0.04	0.02	0.04	-0.01	-0.01	0.51
Number of nodes on main stem	0.00	0.04	0.10	-0.01	-0.01	0.08
Number of main branches	-0.02	0.01	-0.18	0.05	-0.04	-0.24
Branch length	0.09	0.06	-0.15	0.29	-0.06	0.03
Plant height	0.05	-0.07	0.05	-0.15	-0.20	-0.06
Days to first flower	0.00	-0.03	0.04	0.01	0.07	-0.11
Days To 50% flowering	0.17	**0.44**	0.07	0.00	-0.01	-0.08
Days to first mature pod	0.17	**0.46**	0.05	-0.04	-0.03	-0.05
Days to 50% mature pod	0.14	**0.45**	0.05	-0.09	0.00	0.08
Standard petal size	0.03	0.14	0.07	-0.15	0.08	0.33
Lobe length	-0.01	-0.03	0.02	-0.26	0.06	0.26
Number of racemes per plant	0.00	-0.01	-0.08	-0.03	0.10	-0.09
Peduncle length	-0.04	-0.09	-0.07	-0.11	0.07	0.05
Number of anthesis at first flowering	0.16	**0.46**	0.06	-0.01	0.00	-0.08
Pod length	0.19	-0.03	**-0.38**	0.26	-0.27	0.08
Pod width	0.16	0.04	**-0.33**	0.32	-0.22	0.09
Number of pods per plant	-0.11	0.01	0.02	0.02	0.07	0.11
Number of pods per peduncle	0.01	-0.05	0.04	-0.02	-0.07	0.06
Number of locules	0.01	-0.08	**0.45**	0.34	-0.10	0.07
Percent seed abortion	0.00	-0.05	-0.28	-0.24	0.18	0.10
Number of seeds per pod	0.01	-0.06	**0.49**	0.38	-0.15	0.03
Seed length	**0.33**	-0.17	0.18	-0.21	-0.03	-0.02
Seed width	**0.35**	-0.13	0.15	-0.15	0.14	-0.07
Seed thickness	**0.39**	-0.17	0.19	-0.21	0.06	-0.05
Seed weight	**0.43**	-0.15	-0.10	0.01	-0.13	0.01
Yield	**0.43**	-0.15	-0.10	0.01	-0.13	0.01
Eigenvalue	**4.51**	**3.62**	**2.39**	**2.16**	**1.95**	**1.66**
Difference	**0.89**	**1.22**	**0.24**	**0.20**	**0.29**	**0.29**
Proportion (%)	**14.53**	**11.66**	**7.72**	**6.96**	**6.30**	**5.37**
Cumulative (%)	**14.53**	**26.20**	**33.92**	**40.87**	**47.17**	**52.54**

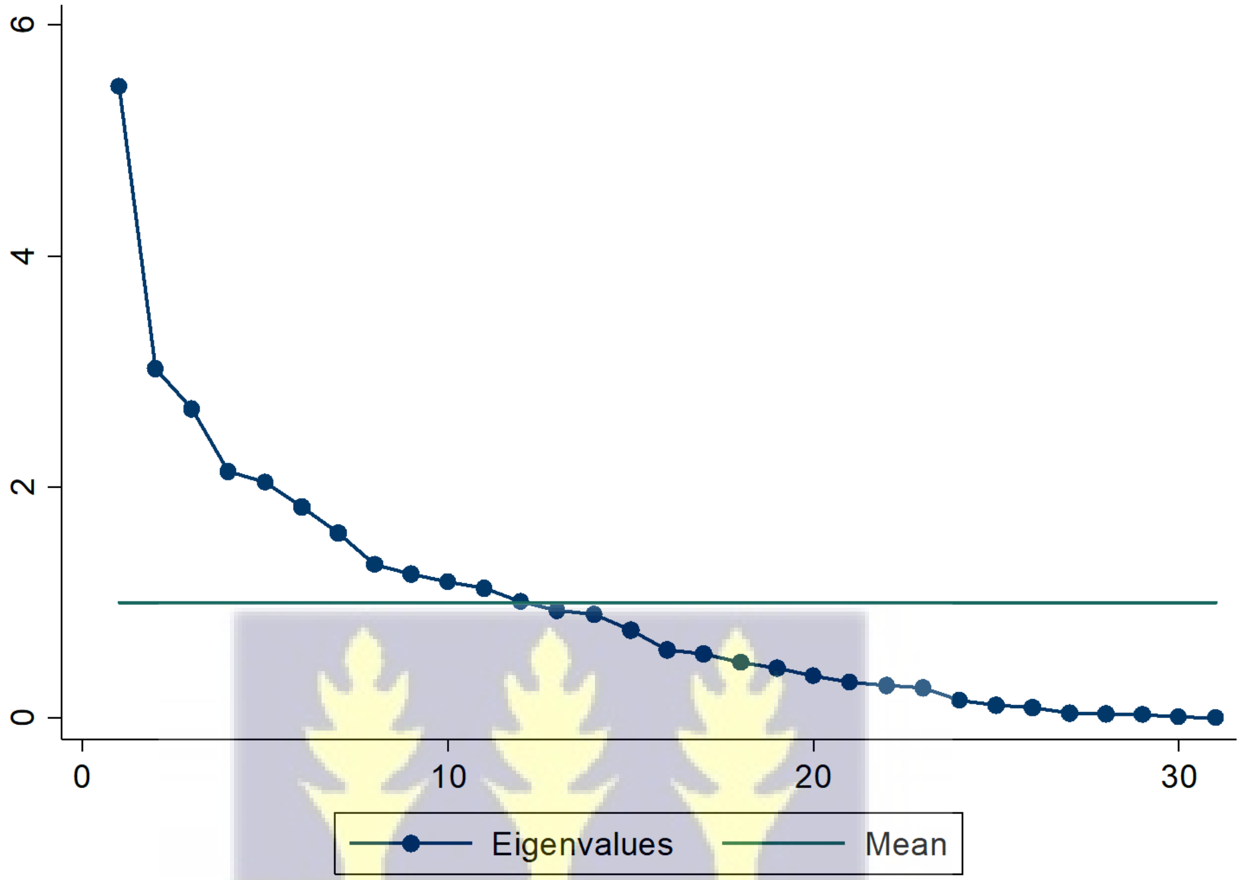

Figure 1: Scree plot of eigenvalues for morphological quantitative traits in test materials of cowpea accessions

4.8.1.2 Principal component analysis for the morphological quantitative traits in controls

The results of the principal component for the quantitative morphological traits of the controls are presented in Table 18. The first ten principal component axes in the PCA analysis had eigenvalues up to 1.0. (Figure 2). The first six principal components explained 55.40 % of the total variation. The eigenvalue for the first principal component analysis was 5.47 which represented 17.65 % of the total variation. The eigenvalue for the second principal component analysis was 3.02 which represented 9.75 % of the total variation. The third principal component analysis recorded an eigenvalue of 2.68, representing 8.63 % of the total variation. The eigenvalue for the fourth principal component was 2.13, representing 6.88 % of the total variation. The eigenvalues for the fifth and sixth principal components were 2.04 and 1.83 respectively, representing 6.58% and 5.91 % of the total variation respectively. In Principal component 1, the traits that accounted for most of the 17.65% observed variability among controls was led by yield traits as follows; percent seed abortion (-0.36) and seed length (0.33). Principal component 2, similarly identified the yield components such as number of anthesis at first flowering (0.32), days to 50% flowering (0.31), pod length (0.31) which accounted for most of the total variability. In contrast to PC1 and PC2, PC 3 was strongly correlated with the growth and vegetative traits namely, terminal leaflet length (0.40) and terminal leaflet width (0.43) respectively.

Table 18: Principal component analysis for quantitative morphological traits of the controls

Traits	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**
Days to germination	0.03	0.07	0.19	-0.08	0.17	0.10
Number of leaves	0.09	0.10	0.17	0.10	-0.05	0.17
Terminal leaflet length	-0.02	0.05	**0.40**	-0.24	0.30	-0.09
Terminal leaflet width	-0.04	0.05	**0.43**	-0.21	0.28	-0.04
Stipule length	-0.05	0.06	0.16	0.01	0.05	0.56
Stipule width	-0.06	0.06	0.01	-0.05	0.00	0.57
Number of nodes on main stem	0.15	-0.21	0.10	0.26	-0.25	-0.04
Number of main branches	-0.04	-0.22	0.15	0.01	-0.27	0.05
Branch length	-0.07	-0.09	0.04	-0.05	-0.37	0.01
Plant height	0.24	-0.08	-0.03	0.06	0.11	-0.27
Standard petal size	0.09	-0.17	0.14	0.14	0.18	-0.08
Lobe length	-0.04	-0.14	0.02	0.05	0.12	0.22
Number of racemes per plant	0.05	-0.10	0.23	0.00	0.06	-0.16
Peduncle length	-0.03	0.02	0.04	0.18	-0.14	0.04
Days to first flower	-0.05	0.19	-0.05	-0.21	0.15	0.01
Days To 50% flowering	0.26	**0.31**	0.10	0.03	-0.18	-0.02
Days to first mature pod	**0.32**	0.30	0.09	0.09	-0.02	-0.03
Days to 50% mature pod	**0.31**	0.25	0.10	0.08	0.11	0.00
Number of anthesis at first flowering	0.27	**0.32**	0.10	0.02	-0.16	-0.05
Pod length	-0.01	**0.31**	-0.11	-0.32	-0.25	-0.08
Pod width	-0.02	0.27	-0.19	**-0.36**	-0.18	0.00
Number of pods per plant	0.02	0.09	0.08	**0.37**	-0.14	-0.07
Number of pods per peduncle	0.11	0.05	-0.23	-0.02	0.08	0.14
Number of locules	-0.01	0.13	**-0.37**	0.19	0.26	0.10
Percent seed abortion	**-0.36**	0.11	0.03	-0.02	-0.10	-0.05
Number of seeds per pod	0.27	-0.01	-0.26	0.15	0.24	0.10
Seed length	**-0.33**	0.18	0.14	0.12	-0.11	-0.01
Seed width	-0.25	0.22	0.18	0.29	-0.02	-0.09
Seed thickness	-0.14	0.28	0.07	**0.38**	0.06	0.10
Seed weight	-0.26	0.16	-0.14	0.10	0.19	-0.20
Yield	-0.26	0.16	-0.14	0.10	0.19	-0.20
Eigenvalue	**5.47**	**3.02**	**2.68**	**2.13**	**2.04**	**1.83**
Difference	**2.45**	**0.35**	**0.54**	**0.09**	**0.21**	**0.23**
Proportion (%)	**17.65**	**9.75**	**8.63**	**6.88**	**6.58**	**5.91**
Cumulative (%)	**17.65**	**27.40**	**36.03**	**42.92**	**49.49**	**55.40**

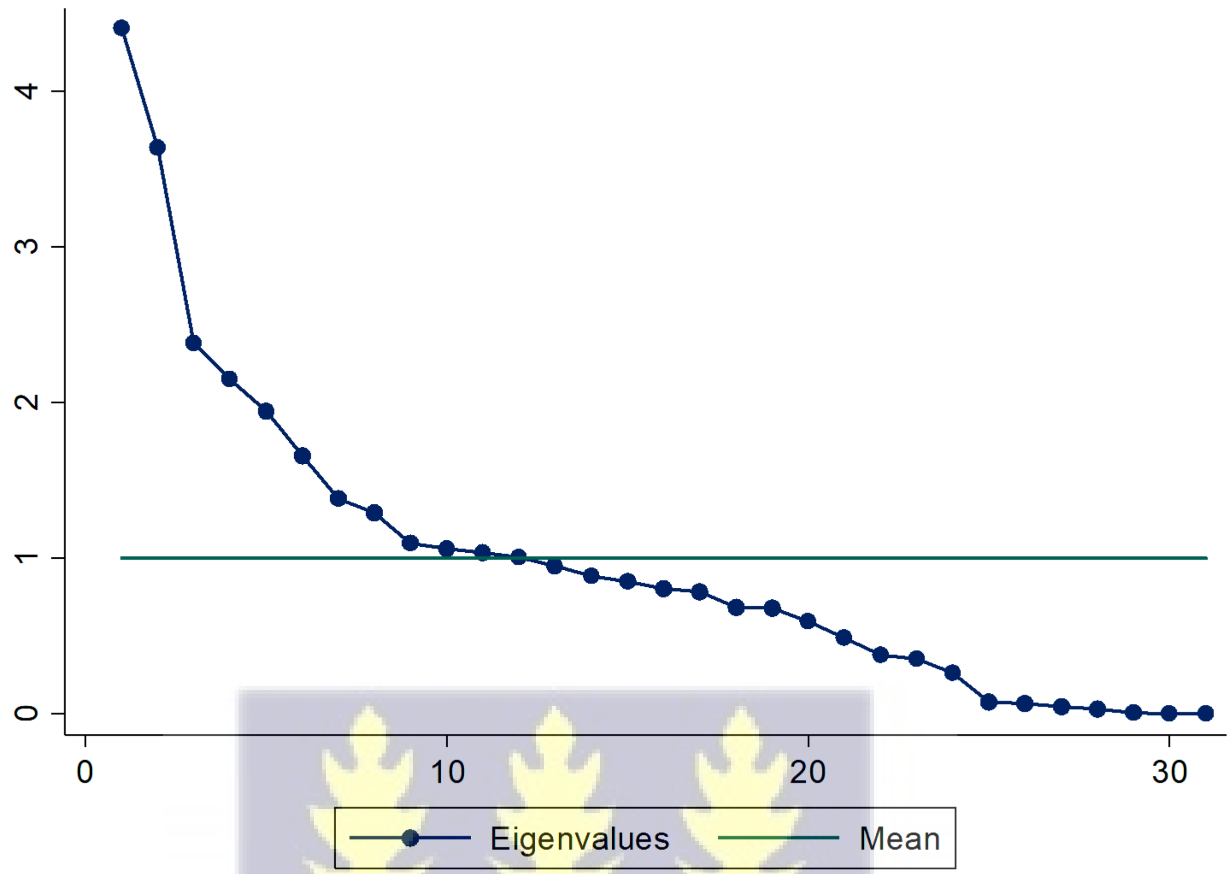

Figure 2: Scree plot of eigenvalues for morphological quantitative traits in controls of cowpea accessions

4.8.1.3 Principal component analysis for the morphological quantitative traits in entire population

The results of the principal component analysis for the quantitative morphological traits of the entire population are presented in Table 19. The first eleven principal component axes in the PCA analysis had eigenvalues up to 1.0. (Figure 3). The first seven principal components explained 53.98 % of the total variation. The eigenvalue for the first principal component analysis was 4.12 which represented 13.29 % of the total variation. The eigenvalue for the second principal component analysis was 3.09 which represented 9.96 % of the total variation. The third principal component analysis recorded an eigenvalue of 2.20, representing 7.08 % of the total variation. The eigenvalue for the fourth principal component was 2.00, representing 6.46 % of the total variation. The eigenvalue for the fifth principal component was 1.92 which represented 6.19 % of the total variation. The eigenvalue for the sixth principal component was 1.83, representing 5.89 % of the total variation and the eigenvalue for the seventh principal component was 1.85 which accounted for 5.10% of the total variation. In Principal component 1, the traits that accounted for most of the 17.65% observed variability among the entire population were number of anthesis at first flowering (0.37), days to first mature pod (0.39) and days to 50% mature pod (0.38). Principal component 2, identified yield traits and seed characters; seed length (0.33), seed width (0.37) and seed thickness (0.34) that accounted for most of the total variability. In PC 3, was strongly correlated with the yield and yield-related traits namely; number of locules (0.40), seed weight (0.50) and yield (0.50)

Table 19:Principal component analysis for quantitative morphological traits of the entire population

Traits	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Days to germination	0.03	0.06	0.02	-0.05	0.17	0.11	-0.04
Number of leaves	0.09	0.06	0.00	0.06	0.09	0.05	0.18
Terminal leaflet length	-0.03	0.21	-0.17	-0.06	0.58	-0.19	-0.04
Terminal leaflet width	-0.04	0.22	-0.17	-0.05	0.58	-0.19	-0.01
Stipule length	-0.04	0.05	-0.01	0.10	0.00	-0.06	0.62
Stipule width	-0.03	0.06	0.04	0.10	0.01	-0.06	0.61
Number of nodes on main stem	0.13	-0.12	-0.06	0.04	0.04	0.15	0.01
Number of main branches	-0.03	-0.05	-0.13	-0.23	-0.03	0.11	0.01
Branch length	-0.01	0.08	0.04	-0.25	0.00	-0.10	0.11
Plant height	0.12	-0.07	-0.08	0.13	-0.09	-0.11	-0.28
Standard petal size	0.11	-0.01	-0.12	0.13	0.14	0.27	0.09
Lobe length	-0.03	-0.09	-0.02	0.10	0.07	0.25	0.19
Number of racemes per plant	0.03	-0.04	-0.09	-0.09	0.22	0.18	-0.14
Peduncle length	-0.06	-0.03	-0.01	-0.01	0.03	0.23	0.07
Days to first flower	-0.04	0.08	0.05	0.00	-0.02	-0.11	-0.07
Days To 50% flowering	**0.36**	0.29	0.09	-0.03	-0.06	0.11	0.00
Days to first mature pod	**0.39**	0.29	0.04	0.05	-0.08	0.05	-0.03
Days to 50% mature pod	**0.38**	0.24	0.03	0.08	-0.01	0.14	0.03
Number of anthesis at first flowering	**0.37**	0.28	0.09	-0.04	-0.05	0.12	-0.01
Pod length	-0.01	0.19	0.20	-0.37	-0.10	-0.28	0.04
Pod width	0.01	0.16	0.23	-0.37	-0.09	-0.28	0.08
Number of pods per plant	0.03	-0.08	0.09	0.05	0.11	0.19	0.08
Number of pods per peduncle	0.04	-0.02	-0.02	0.13	-0.17	-0.27	-0.01
Number of locules	0.01	-0.12	**0.40**	0.34	0.13	-0.23	-0.02
Percent seed abortion	**-0.33**	0.21	-0.03	-0.08	-0.13	0.15	0.02
Number of seeds per pod	0.20	-0.22	**0.32**	0.31	0.18	-0.27	-0.02
Seed length	-0.29	**0.33**	-0.04	0.20	-0.14	0.04	-0.03
Seed width	-0.22	**0.37**	-0.08	0.29	-0.05	-0.01	-0.14
Seed thickness	-0.16	**0.34**	-0.02	0.39	-0.10	-0.07	-0.05
Seed weight	-0.19	0.07	**0.50**	-0.05	0.14	0.27	-0.08
Yield	-0.19	0.07	**0.50**	-0.05	0.14	0.27	-0.08
Eigenvalue	**4.12**	**3.09**	**2.20**	**2.00**	**1.92**	**1.83**	**1.58**
Difference	**1.03**	**0.89**	**0.19**	**0.09**	**0.09**	**0.25**	**0.24**
Proportion (%)	**13.29**	**9.96**	**7.08**	**6.46**	**6.19**	**5.89**	**5.10**
Cumulative (%)	**13.29**	**23.25**	**30.34**	**36.80**	**42.99**	**48.88**	**53.98**

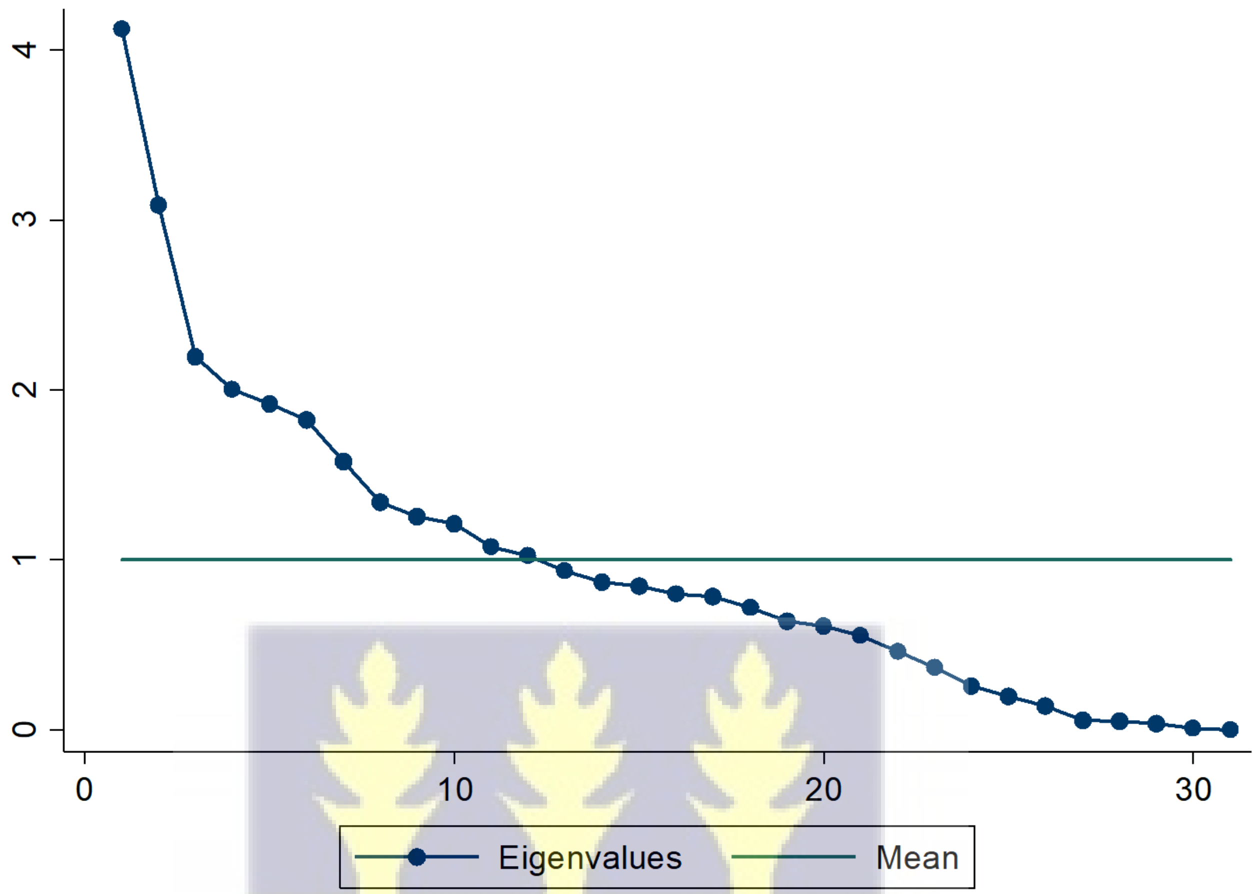

Figure 3: Scree plot of eigenvalues for morphological quantitative traits in entire population of cowpea accessions.

4.8.2 Principal component analysis of phytochemical traits

4.8.2.1 Principal component analysis for the phytochemical traits in test materials of cowpea accessions

The results of the principal component analysis in the test materials are presented in Table 20. The first seven principal component axes in the PCA analysis had eigenvalues up to 1.0 (Figure 4). The first three principal components explained 51.81 % of the total variation. The eigenvalue for the first principal component was 4.00 which represented 22.21 % of the total variation. The eigenvalue for the second principal component was 2.83 which represented 15.71 % of the total variation. The third principal component analysis recorded an eigenvalue of 2.50, representing 13.89 % of the total variation. The amino acids: d-l-b-phenylalanine and l-tyrosine were the highest correlated in PC1 with eigenvectors of 0.40 and 0.38 respectively. The flavonoids; rutin (0.43) and quercetin (0.43) were the highest correlated in the 2nd PC whereas the phenols; vanillic acid and p-coumaric acid were the highest correlated in the 3rd PC with eigenvectors of 0.55 and 0.56 respectively

Table 20: Principal component analysis for phytochemical traits of the test materials of cowpea accessions

Traits	PC1	PC2	PC3
Gallic acid	0.10	-0.11	0.37
Vanillic acid	0.08	0.03	**0.55**
P-coumaric acid	0.07	0.03	**0.56**
Rutin	0.06	**0.43**	0.18
Quercetin	0.06	**0.43**	0.18
Glycine	0.25	0.33	-0.20
L-Serine	0.28	-0.32	-0.09
L-Histidine	**0.32**	-0.13	-0.01
L-Aspartic Acid	0.19	-0.39	-0.03
L-Lysine	0.16	0.19	-0.13
L-Valine	0.18	-0.16	0.13
L-Methionine	0.31	-0.24	0.05
L-Asparagine	0.08	-0.15	0.06
Iso Leucine	0.27	0.23	-0.08
L-Leucine	0.19	0.15	-0.15
L-Tyrosine	**0.38**	0.10	-0.22
D-L-B-Phenylalanine	**0.40**	0.11	0.03
L-Tryptophan	0.32	-0.02	0.11
Eigenvalue	**4.00**	**2.83**	**2.50**
Difference	**1.17**	**0.33**	**1.02**
Proportion (%)	**22.21**	**15.71**	**13.89**
Cumulative (%)	**22.21**	**37.92**	**51.81**

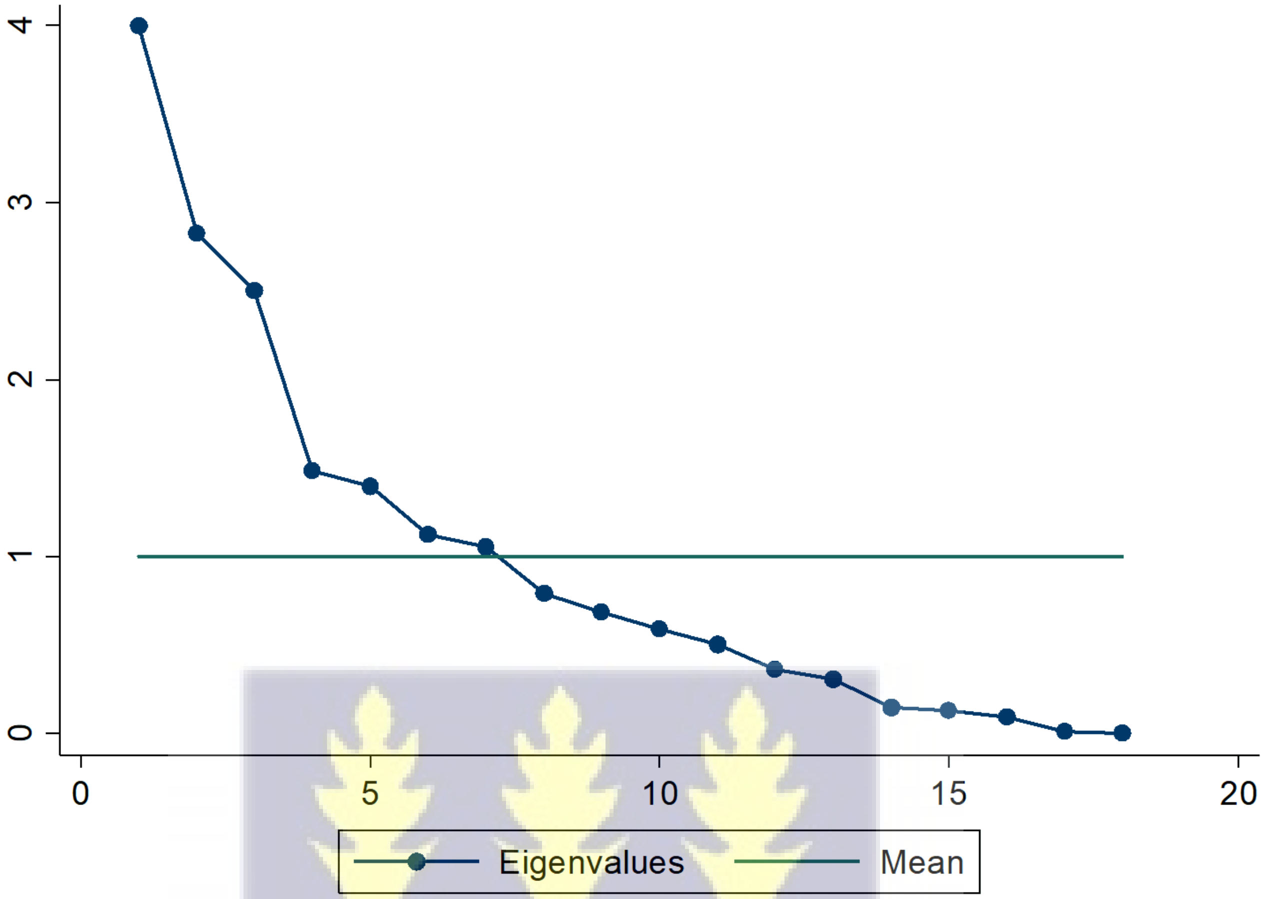

Figure 4: Scree plot of eigenvalues for phytochemical traits in test materials of cowpea accessions.

4.8.2.2 Principal component analysis for the phytochemical traits of the control

Results of the principal component analysis for the phytochemical traits of the control are presented in Table 21. The first three principal component axes in the PCA analysis had eigenvalues up to 1.0. (Figure 5) The first three principal components explained 100.00 % of the total variation. The eigenvalue for the first principal component analysis was 8.6 which represented 57.57 % of the total variation. The eigenvalue for the second principal component analysis was 4.02 which represented 26.82 % of the total variation. The third principal component analysis recorded an eigenvalue of 2.34, representing 15.6 % of the total variation. Principal component 1 was highly correlated with the polyphenolic compound with eigenvector between

±0.31 to ±0.33 whereas in the second 106 principal component amino acids almost accounted for the total variability, with d-l-b phenylalanine and l-valine contributing high eigenvectors of 0.48 and -0.41 respectively

Table 21: Principal component analysis for phytochemical traits of the controls

Variable	PC1	PC2	PC3
Gallic acid	**0.32**	0.09	-0.21
Vanillic acid	**-0.31**	-0.09	0.23
P-coumaric acid	**-0.31**	-0.09	0.23
Rutin	**0.33**	0.11	-0.11
Quercetin	**0.33**	0.11	-0.11
Glycine	-0.23	**0.36**	0.12
L-Serine	0.30	0.11	0.27
L-Aspartic Acid	0.23	-0.12	**0.46**
L-Valine	-0.09	**-0.41**	0.33
L-Methionine	0.24	0.33	0.20
Iso Leucine	-0.22	0.17	**-0.45**
L-Leucine	-0.23	**0.36**	0.12
L-Tyrosine	-0.22	0.34	0.20
D-L-B-Phenylalanine	-0.08	**0.48**	0.12
L-Tryptophan	0.28	0.13	0.32
Eigenvalue	8.63	4.02	2.34
Difference	4.61	1.68	2.34
Proportion (%)	57.57	26.82	15.62
Cumulative (%)	57.57	84.38	100.00

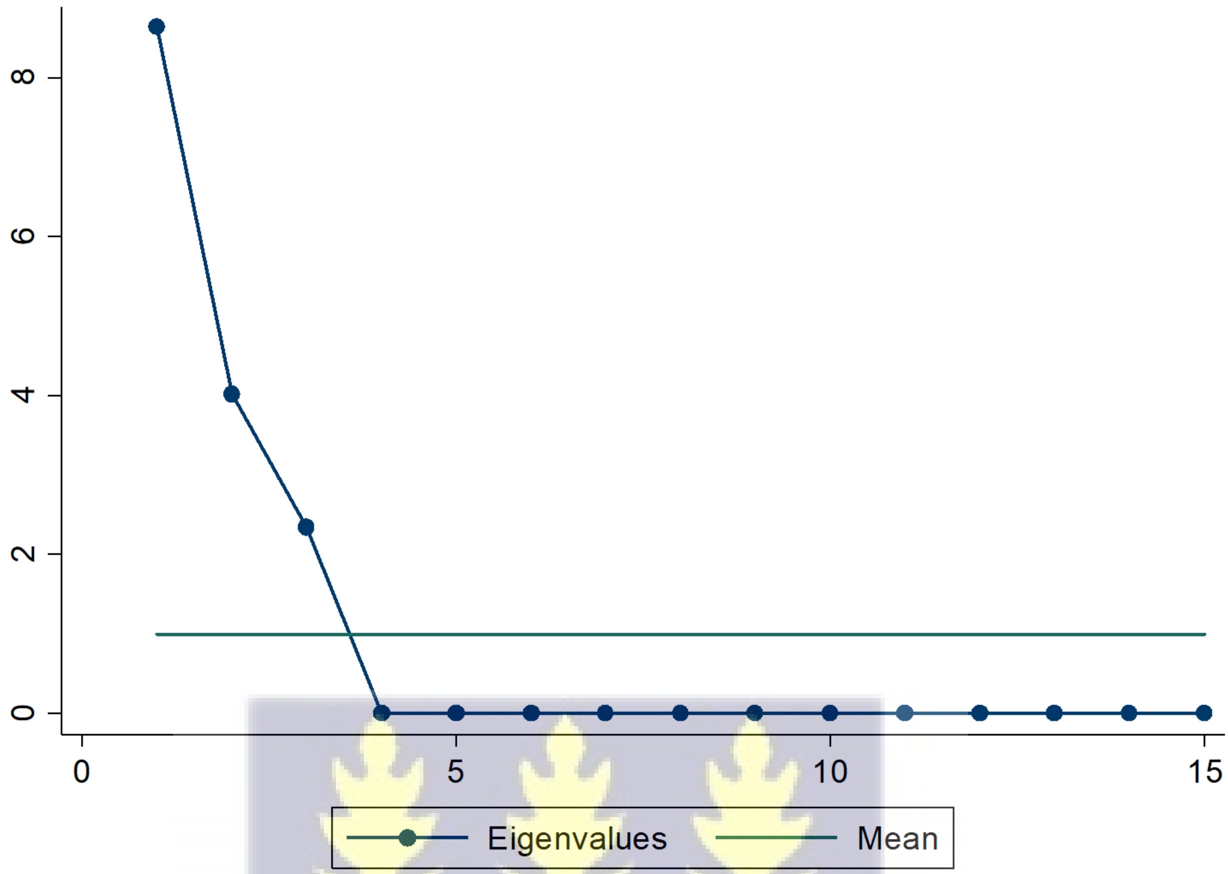

Figure 5: Scree plot of eigenvalues for phytochemical traits in test materials of cowpea accessions.

4.8.2.3 Principal component analysis for the phytochemical traits of the entire population

The results of the principal component analysis are presented in Table 22. The first six principal component axes in the PCA analysis had eigenvalues up to 1.0. (Figure 6). The first three principal components explained 53.14 % of the total variation. The eigenvalue for the first principal component analysis was 3.68 which represented 20.47 % of the total variation. The eigenvalue for the second principal component analysis was 3.19 which represented 17.72 % of the total variation. The third principal component analysis recorded an eigenvalue of 2.69, representing 14.96 % of the total variation. In PC1, total variability was mostly accounted for by the following traits: l-tyrosine (0.39), glycine (0.35), l-leucine (0.35), rutin (-0.36) and quercetin (-0.36) whereas in PC2, d-l-b-phenylalanine (0.42) l-tryptophan (0.40) and l-serine 108 (0.35), were major contributors to the total variability. L-aspartic acid, vanillic acid and isoleucine were the highest contributors in PC3, PC4 and PC5 with eigenvectors of 0.37, 0.55 and 0.46 respectively

Table 22: Principal component analysis for phytochemical traits of the entire population

Traits	PC1	PC2	PC3	PC4	PC5
Gallic acid	-0.05	0.12	0.36	0.20	0.24
Vanillic acid	0.22	-0.04	0.28	**0.55**	-0.05
P-coumaric acid	0.22	-0.04	0.28	**0.54**	-0.04
Rutin	**-0.36**	0.26	-0.16	0.26	0.11
Quercetin	**-0.36**	0.26	-0.16	0.26	0.11
Glycine	0.35	0.21	-0.29	0.01	0.05
L-Serine	-0.30	**0.35**	0.02	-0.03	-0.28
L-Histidine	0.11	0.24	0.30	-0.21	0.19
L-Aspartic Acid	-0.01	0.14	**0.37**	-0.31	-0.24
L-Lysine	0.08	0.16	-0.07	-0.04	0.47
L-Valine	0.06	0.00	0.30	-0.03	-0.26
L-Methionine	0.02	0.30	0.32	-0.17	-0.08
L-Asparagine	0.02	0.08	0.24	-0.19	0.32
Iso Leucine	0.17	0.23	0.01	-0.03	0.46
L-Leucine	0.35	0.16	-0.25	0.03	-0.21
L-Tyrosine	**0.39**	0.26	-0.18	-0.06	-0.19
D-L-B-Phenylalanine	0.22	**0.42**	-0.07	0.09	-0.08
L-Tryptophan	-0.24	**0.40**	0.00	0.12	-0.20
Eigenvalue	**3.68**	**3.19**	**2.69**	**1.87**	**1.32**
Difference	**0.50**	**0.50**	**0.82**	**0.55**	**0.04**
Proportion (%)	**20.47**	**17.72**	**14.96**	**10.39**	**7.34**
Cumulative (%)	**20.47**	**38.19**	**53.14**	**63.53**	**70.87**

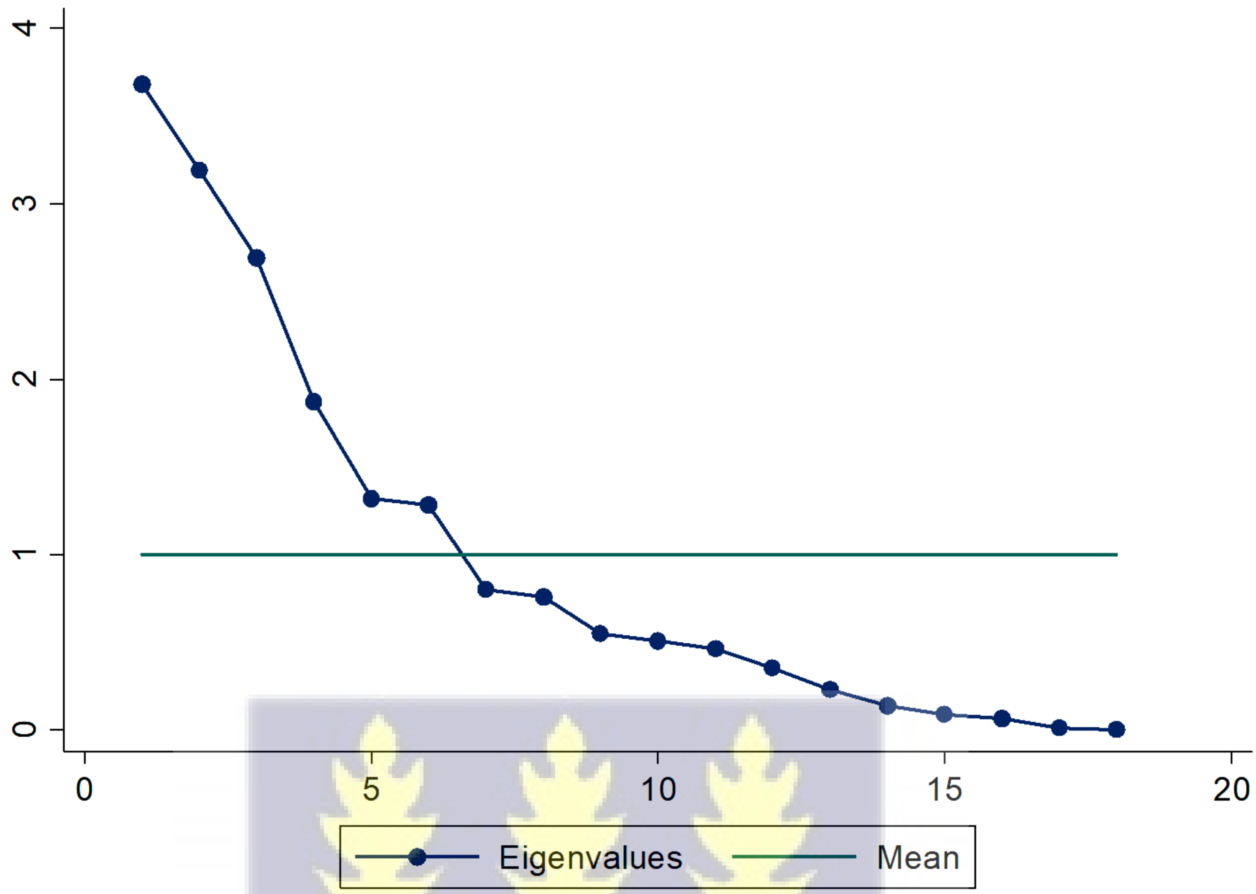

Figure 6: Scree plot of eigenvalues for phytochemical traits in entire population of cowpea accessions.

4.9 Principal Component Biplot

4.9.1 Principal component biplot among morphological quantitative traits

The biplot showing the relationships among the 108 cowpea accessions and the 31 morphological traits are presented in Figure 7. Scatter plot of the two principal components is displayed in Figure 8. The two components explained a total of 46.63% of variance. Dimension 1 of the biplot explained 26.50% whereas Dimension 2 explained 20.13% of variance. Accessions very close to the center of origin showed strong similarities with all vegetative traits except number of leaves (*nol*) which deviated from the center of origin. Similarly, majority of the accessions grouped the following yield and yield-related traits: number seeds per pod, standard petal size (*spz*), lobe length (*lbl*), peduncle length (*pdl*), number of anthesis at first flowering (*dff*), pod length (*apl*), pod width (*apw*), number of pods per peduncle (*ppdn*), number of locules (*ln*), number of seeds per pod (*nspp*), seed length (*sl*), seed width (*sw*), seed thickness (*st*), seed weight (*swgt*) and yield (*yld*). Accessions 8 (UG4), 19 (UG15),95 (UG91), and 65 (UG61) showed strong similarities for number of pods per plant and number of racemes per plant. Accessions 4 (Wang Kae) and 5 (UG1)) were outliers that showed strong similarity in percent seed abortion (Figure 7&8). There was a 45^0 angle of deviation from the centre of origin and strong correlation between days to first flower, days to 50% flowering, days to first matured pod, days to 50% matured pod with accessions 82(UG78), 30(UG26),105 (UG101), 59(UG55), 72(UG68), 41(UG37) related to the quadrant. Accessions 63 (UG59), 5(UG1), 95(UG91), 30 (UG103) were completely distinct from each other and found across all four quadrants (Figure 7&8).

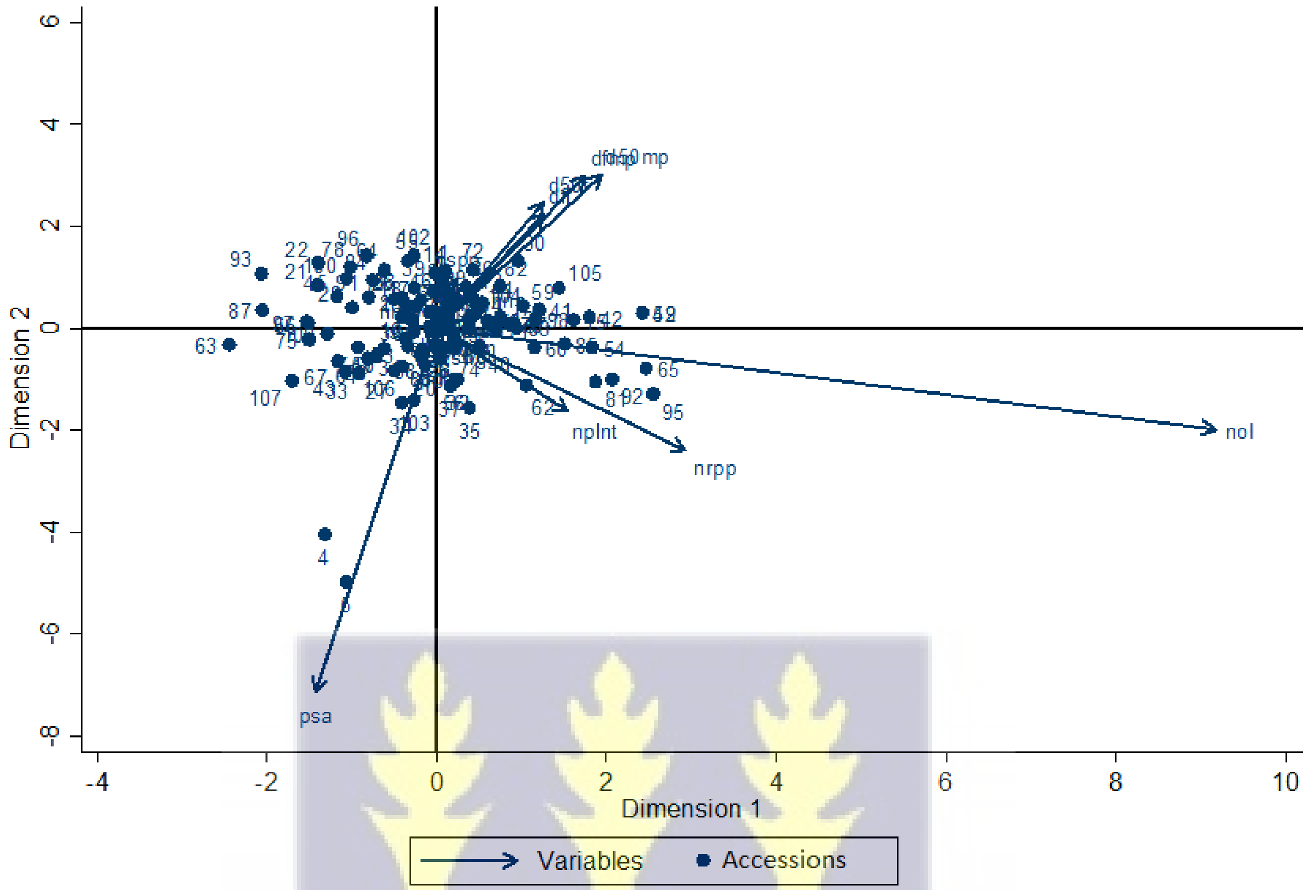

Figure 7: Biplot of PC1(dimension 1) and PC2 (dimension 2) between 108 cowpea accessions and 31 morphological quantitative traits

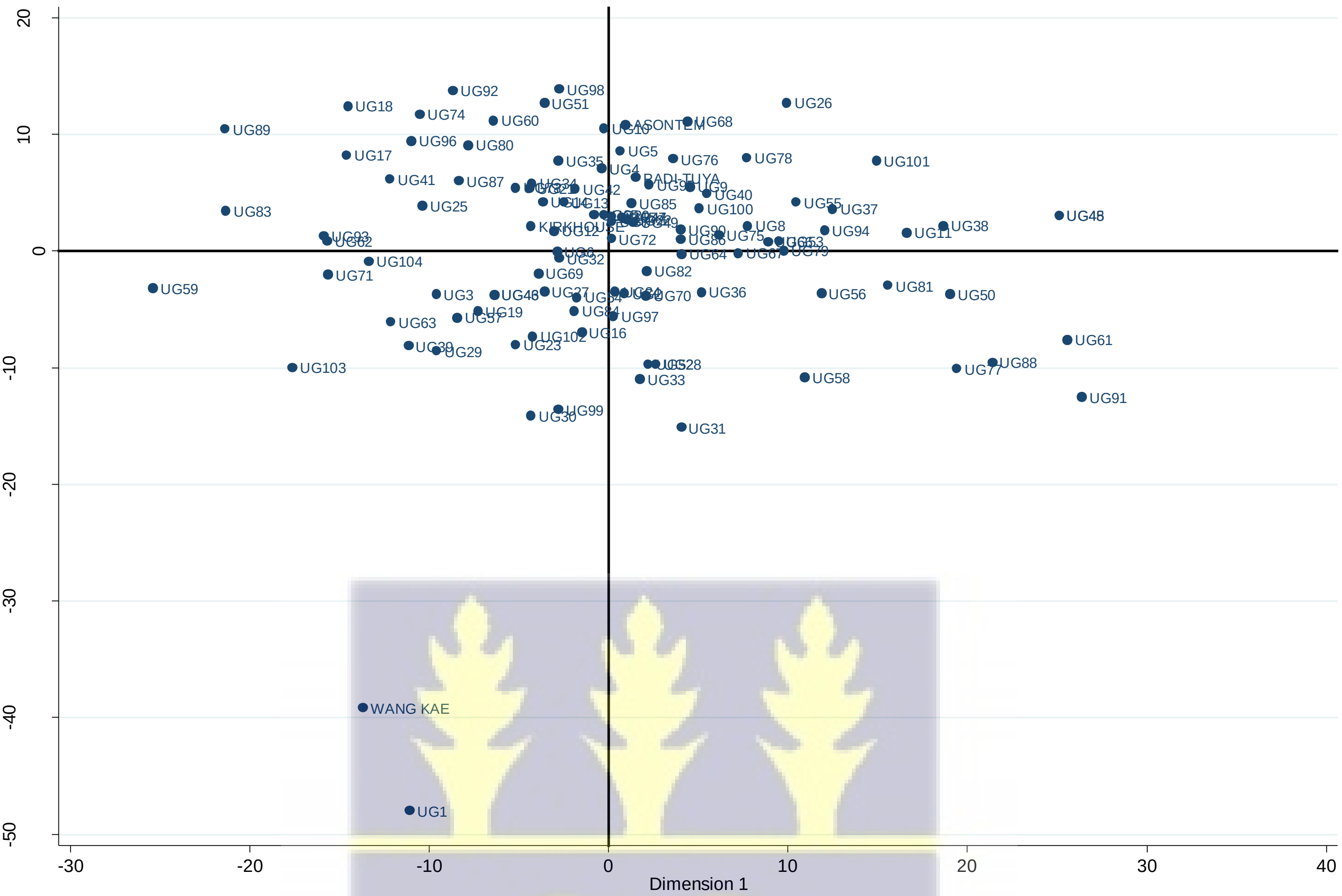

Figure 8: Scatter plot of PC1 and PC2 of 108 cowpea accessions for morphological quantitative traits

4.9.2 Principal component biplot among phytochemical traits

The biplot showing the relationships among the 103 cowpea accessions and the 18 phytochemical traits are presented in Figure 9. Scatter plot of the two principal components is displayed in Figure 10. The two components explained a total of 99.49% of variance. Component 1 of the biplot explained 97.19% whereas component 2 explained 2.3% of variance. Accessions grouped very close to the center of origin showed strong similarities with all phytochemical traits except glycine (*gly*) and l-tryptophan (*ltry*) which showed a large deviation from the center of origin. Accessions 93 (UG89), 85(UG81) and 87 (UG83) formed a group and showed strong similarity likewise 84 (UG80), 90 (UG86), Padi-tuya, 86 (UG82), 88 (UG84), 97 (UG93) and 91 (UG87) formed a major group and showed strong similarities among them (Figure 9 & 10).

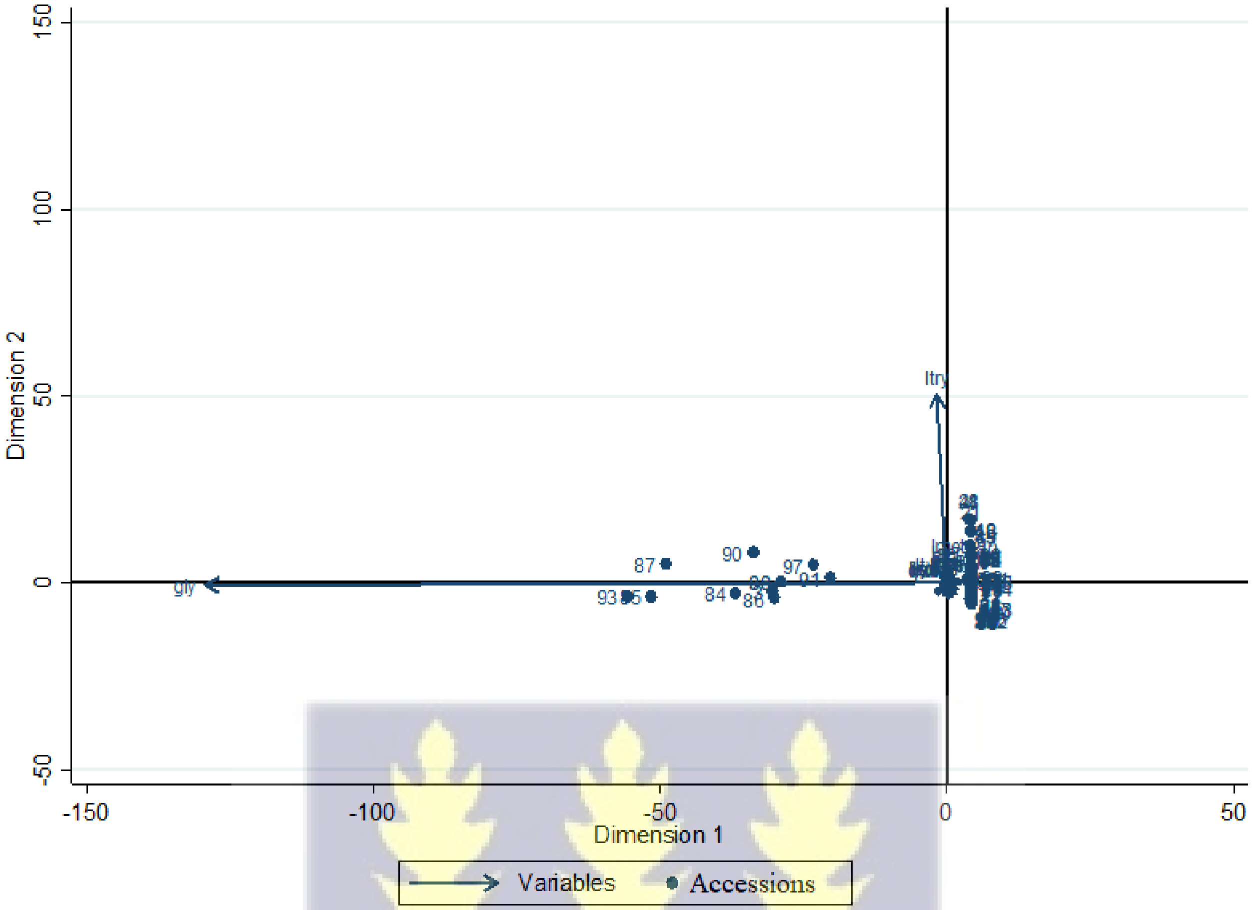

Figure 9: Biplot of PC1(dimension 1) and PC2 (dimension 2) between cowpea accessions and 18 phytochemical traits

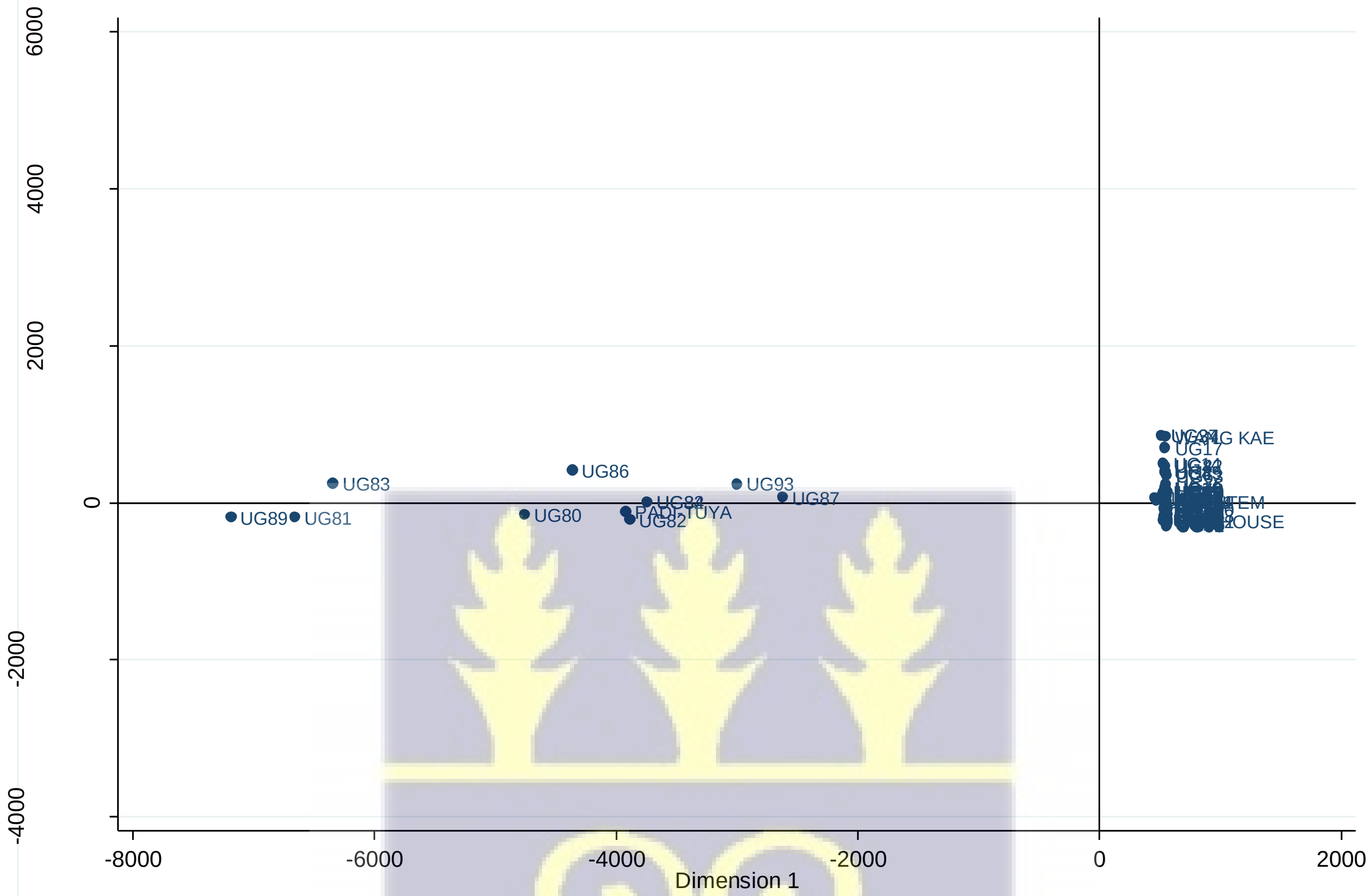

Figure 10: Scatter plot of PC1 and PC2 of 108 cowpea accessions for 18 phytochemical traits

4.9.3 Principal component biplot among all traits

The biplot showing the relationships among the cowpea accessions and 49 traits is presented in Figure 11. Scatter plot of the two principal components is displayed in Figure 12. The two components explained a total of 99.48% of variance. Component 1 of the biplot explained 97.19% whereas component 2 explained 2.3% of variance. Accessions grouped very close to the center of origin showed strong similarities in all phytochemical traits except glycine (*gly*) and l-tryptophan (*ltry*) which showed a large deviation from the center of origin. Accessions

93 (UG89), 85(UG81) and 87 (UG83) formed a group and showed strong similarity likewise 84 (UG80), 90 (UG86), 86 (UG82), 88 (UG84), Padi-tuya, 86 (UG82), 97 (UG93) and 91 (UG87) formed a major group and showed strong similarities among themselves (Figure 11&12)

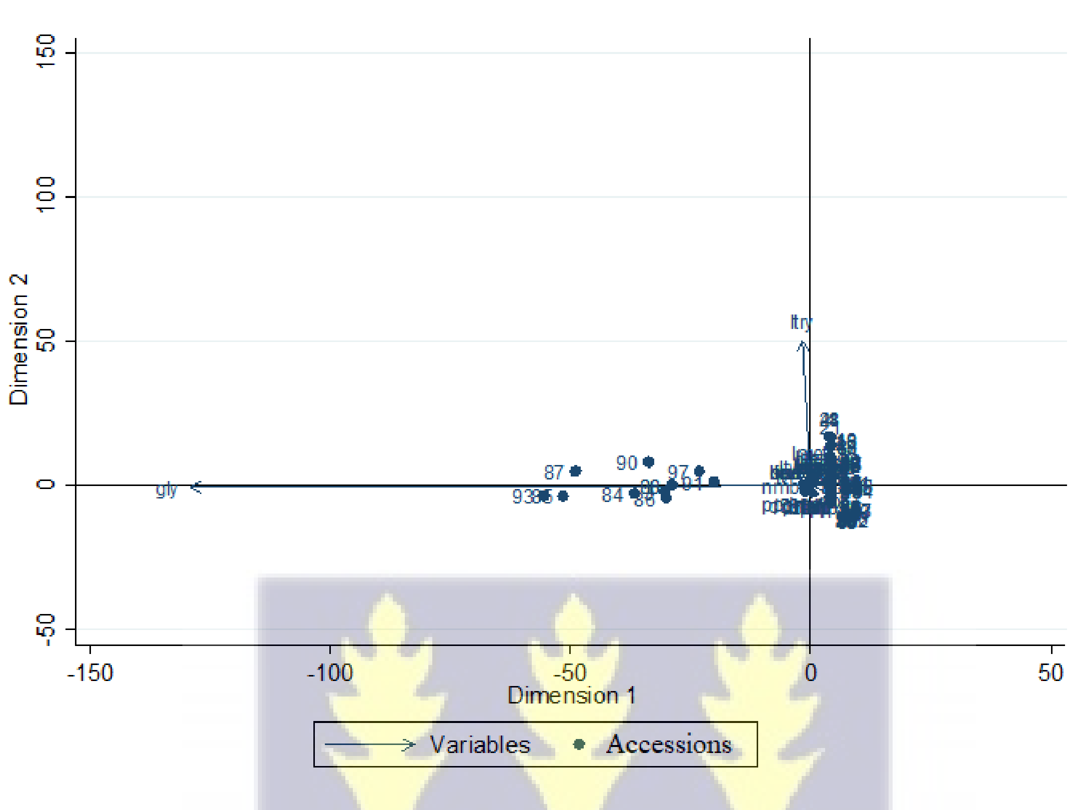

Figure 11: Biplot of PC1(dimension 1) and PC2 (dimension 2) between 108 cowpea accessions and all 49 traits

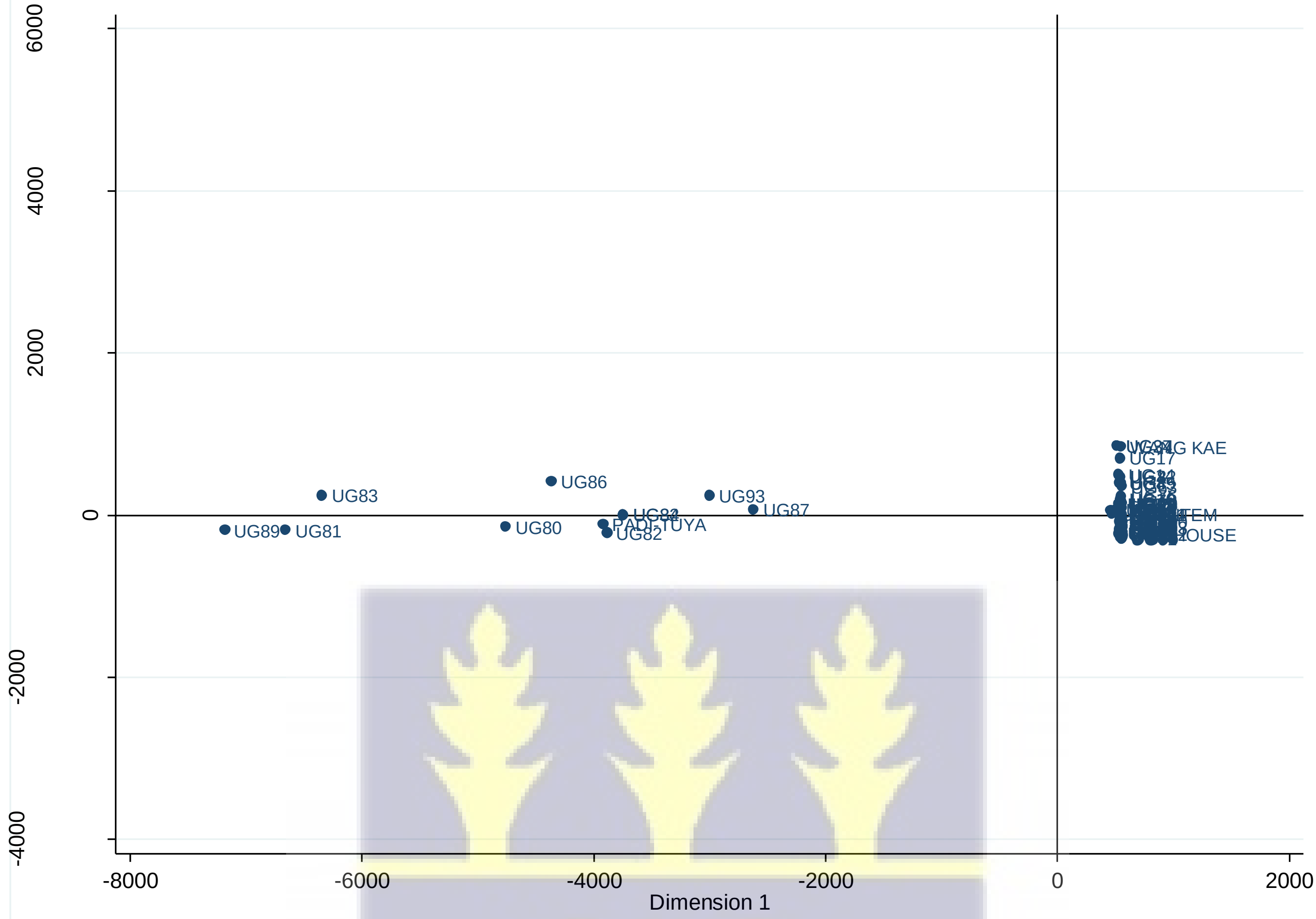

Figure 12: Scatter plot of PC1 and PC2 of 108 cowpea accessions and all 49 traits

4.10 Multiple correspondence analysis of morphological qualitative traits

Results of multiple correspondence analysis of qualitative traits showing their relative contribution to variation in the cowpea accessions are presented in Table 23. A total of 30 dimensions were generated at principal inertia of 0.168. The first two accounted for 68.80% of the total variability. The first dimension accounted for 0.086 of principal inertia which represented 51.40%. On the other hand, the 2nd dimension accounted for 0.03 of principal inertia which represented 17.40% of the total variability among qualitative traits.

The overall variation was associated with the following: seed shape (9.30%), seed coat colour (8.70), growth habit (8.40%) and terminal leaflets shape (7.50%). Terminal leaf shape, growth habit, raceme position and pod curvature were the traits contributed much to variability in dimension 1 with relative inertia contributions of 10.80, 10.70, 10.70 and 10.20%, respectively, whereas dimension 2 was highly correlated with seed shape, seed coat colour and mature pod colour which contributed 12.00,11.00 and 8.90% respectively.

Figure 13 illustrates the MCA plot. Asontem (Coordinate for dimension 1[-4.61]; Coordinate for dimension 2 [1.5]), UG8 and UG30 had a close relationship with crowder seed shape (-4.14;0.65), red seed colour (-2.51;1.36), 30^{o}-90^{o} erect pod attachment to peduncle (-2.97;0.48), above canopy raceme position (-4.54;1.27) and semi-prostrate growth habit (-4.69;1.21) smooth testa texture and crowded seeds in the first quadrant of the MCA plot. (Figure 13 & Appendix 2). The majority of the accessions were scattered in the second quadrant which showed strong similarities with traits in that quadrant. Erect growth habit (Coordinate for dimension 1 [0.10]; Coordinate for dimension 2 [-2.89]) and globose seed shape (0.03; -3.38) had a close relationship with Wang Kae (0.23;-2.86), Padituya (0.20;-3.890 and Kirkhouse (-3.22) in the fourth quadrant. Straw mature pod colour (-0.76; -1.43), very small eye pattern (-0.62; -1.08) and white flowers (-0.33; -0.33) showed a very close relationship with only UG55 (-0.37, -1.50) in quadrant 3. UG1 and UG81 were outliers and had a distant relationship with the phenotypic classes of the selected traits. However, accessions UG65 (1.33;3.83), UG63 (1.37;3.63), UG15(1.40;3.42) and UG12 (1.58;3.52) clustered with Holstein eye pattern (Figure 13; Appendix 2).

From the biplot in Figure 14 accessions that grouped very close to the centre of origin showed strong similarities in all vegetative traits. A large deviation from the centre of origin was observed for mature pod colour, seed coat colour and immature pod pigmentation. The scatter plot in Figure 15 showed that Asontem, Wang Kae and UG28 had similar testa texture and stem colour (Figure 14).

Table 23: Multiple correspondence analysis of qualitative traits showing their relative contribution to variation in cowpea accessions.

	Relative Inertia to principal inertia (%)		
Traits	**Dimension 1**	**Dimension 2**	**Overall Dimension**
Stem colour	2.60	4.60	3.80
Branch colour	2.80	4.10	3.50
Petiole colour	4.50	5.90	4.90
Plant pigmentation	3.30	5.90	3.90
Leaf colour	0.30	0.00	1.10
Growth habit	**10.70**	5.90	**8.40**
Twinning tendency	0.40	0.80	1.70
Plant hairiness	2.70	0.50	2.50
Plant vigour	0.20	0.40	0.70
Terminal leaflet shape	**10.80**	2.00	**7.50**
Leaf marking	1.40	0.00	1.20
Leaf texture	0.00	0.50	0.90
Peduncle colour	5.30	8.20	5.50
Flower colour	0.22	3.10	0.50
Immature pod pigmentation	2.80	3.90	2.70
Mature pod colour	2.40	**8.90**	4.00
Seed coat colour	6.20	**11.10**	**8.70**
Eye colour	0.10	0.50	0.80
Raceme position	**10.20**	0.80	6.30
Pod attachment to peduncle	7.20	0.20	4.20
Pod curvature	**10.70**	0.90	6.80
Pod wall thickness	0.30	0.00	0.60
Seed crowding	0.10	0.30	0.80
Splitting of testa	0.00	0.00	0.20
Seed shape	9.90	**12.00**	**9.30**
Testa texture	1.60	5.00	3.50
Eye pattern	2.10	6.60	3.70
Principal inertia	**0.086**	**0.03**	**0.17**
Proportion (%)	**51.40**	**17.40**	**100.00**
Cumulative (%)	**51.40**	**68.80**	**100.00**

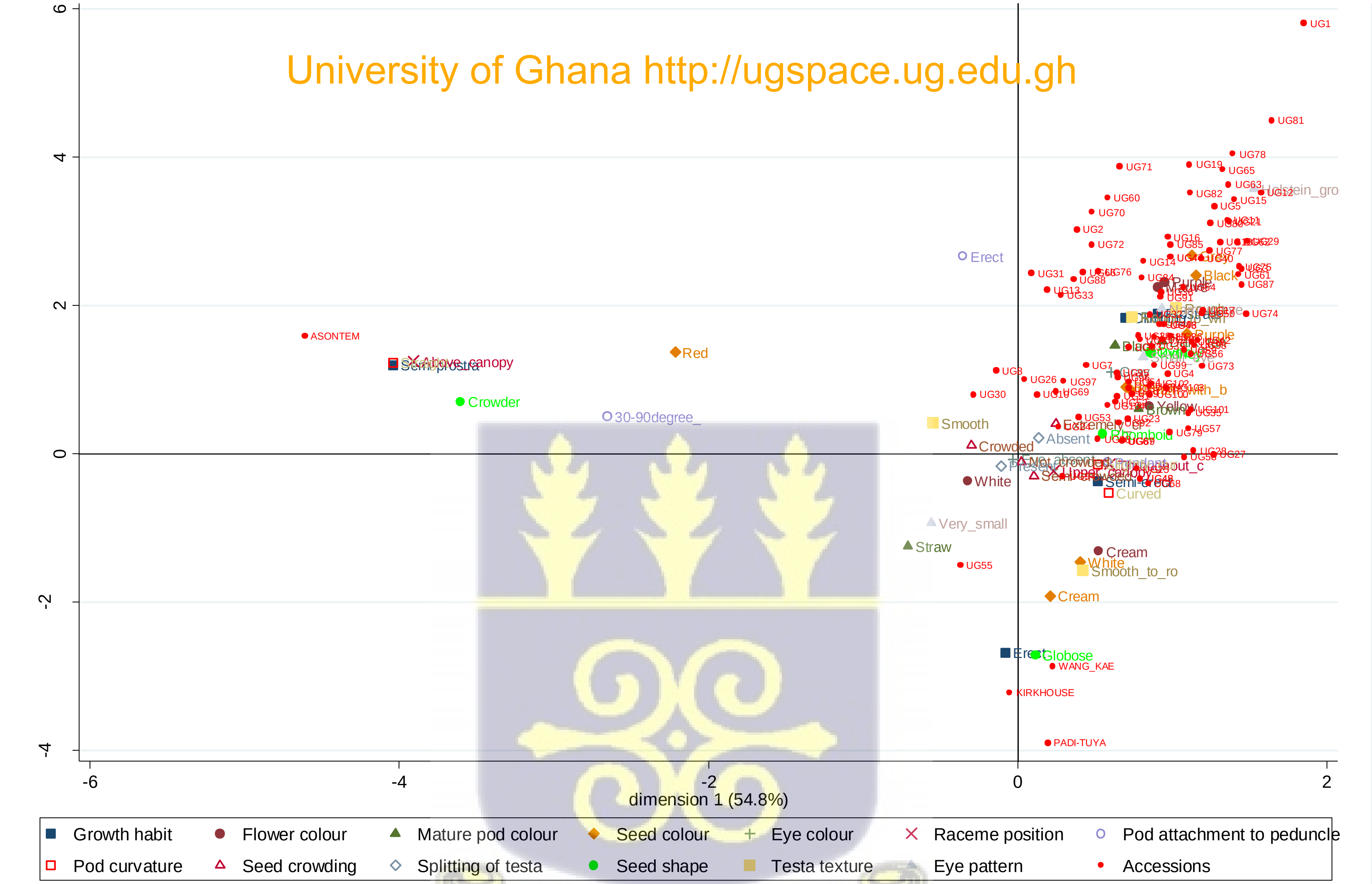

Figure 13: Multiple correspondence analysis plot of the coordinates for phenotypic classes of 14 selected morphological qualitative traits in 108 cowpea accessions

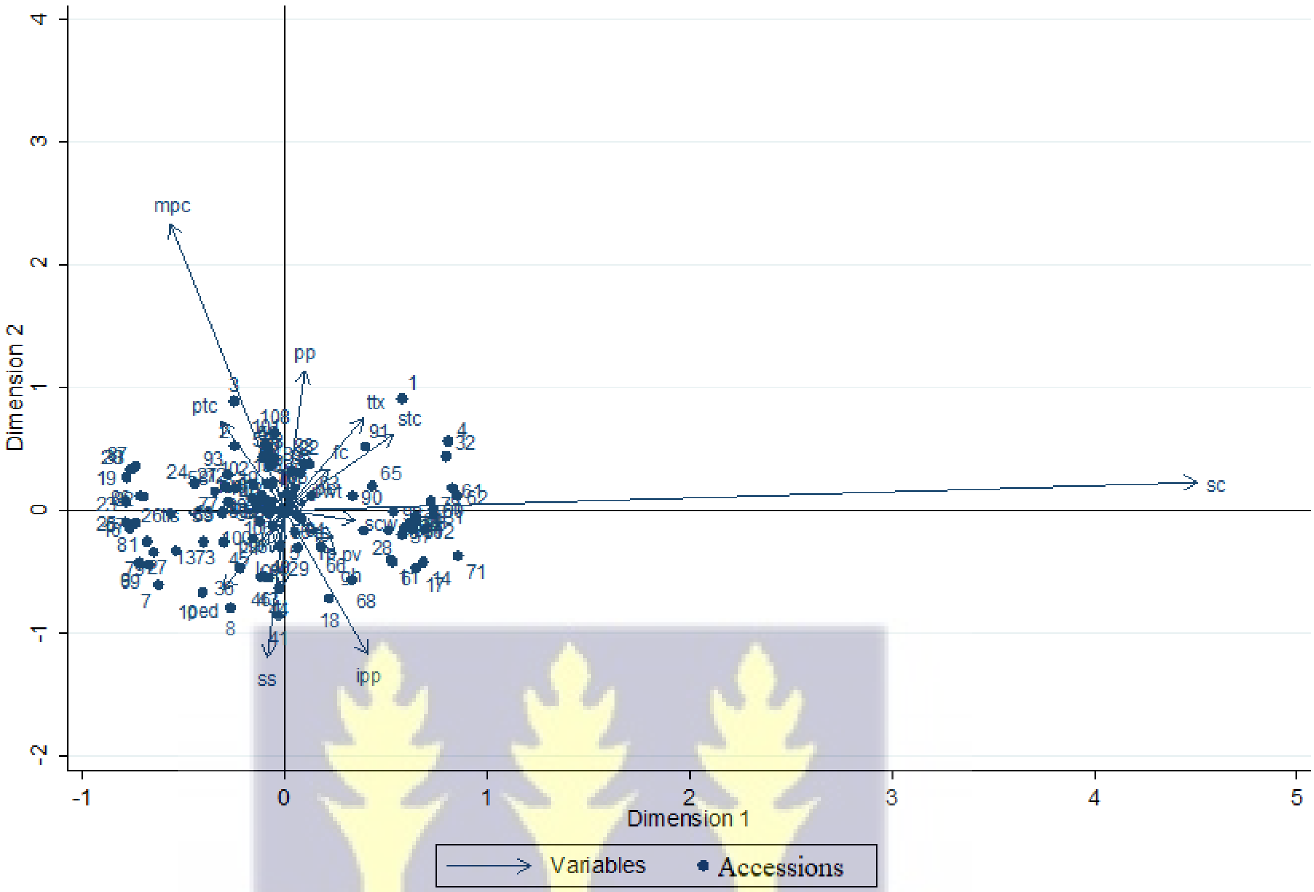

Figure 14: Biplot showing the relationships between the 108 cowpea accessions and the 27 morphological qualitative traits

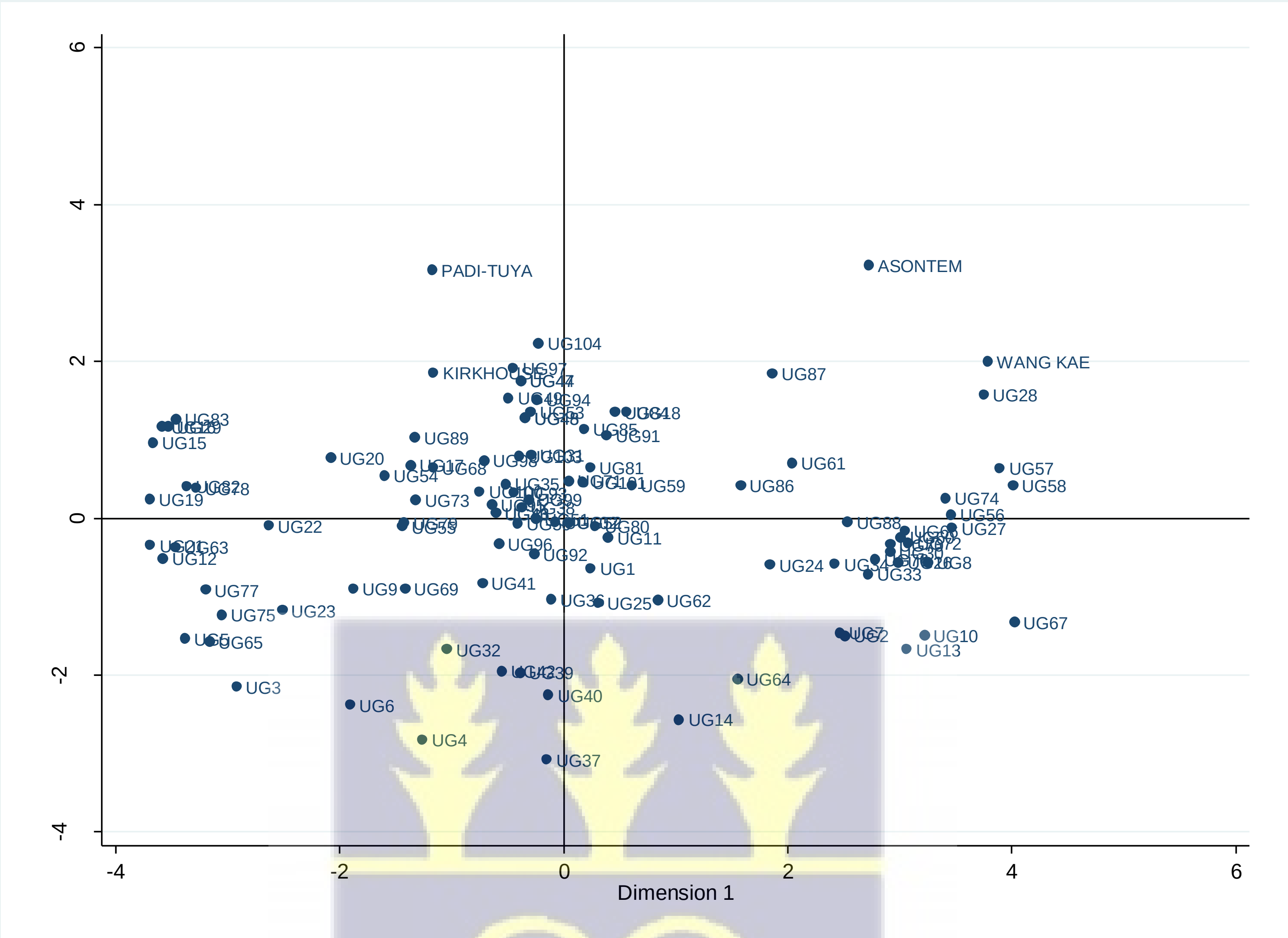

Figure 15: Scatter plot of PC1 and PC2 of 108 cowpea accessions and all 49 traits

4.11 Canonical Discriminant Analysis

4.11.1 Canonical discriminant analysis of morphological traits

Canonical discriminant coefficient showing the contribution of morphological traits to variation in yield among the 108 cowpea accessions are presented in Table 24.

Twenty-nine canonical variates (CV) axes were generated. The first (CV1) had an eigenvalue of 47.36 while CV2 and CV3 had eigenvalues 28.73 and 26.04, respectively. The canonical variate axis 1 (CV1) contributed a total of 17.19% to the total variability while CV2,3,4 and 5 contributed 10.43, 9.45, 8.38 and 6.30%. respectively.

This between-groups variability was largely influenced by terminal leaf length and leaf width, with vector loading of 1.33, and -1.60 respectively in CV1. In CV2, yield was minimally impacted by days to 50% mature pod and days to first mature pod, with vectors of 1.08 and -0.19 respectively. Vegetative traits measured did not contribute much to the expression of variability in yield with vector loadings in CV's 2-4 was less than ±1.00.

Table 24: Canonical discriminant coefficient showing the contribution of morphological traits to the expressions of the agronomic traits among the 108 cowpea accessions.

Traits	CV1	CV2	CV3	CV4	CV5	CV6	CV7	CV8	CV9	CV10
Growth and vegetative traits										
Days to germination	-0.04	0.42	0.41	0.29	-0.13	-0.13	0.07	0.15	0.05	-0.35
Number of leaves	0.01	-0.57	0.13	-0.03	-0.69	0.05	0.27	-0.11	0.47	0.33
Terminal leaflet length	**1.33**	-0.50	-0.99	-0.43	-1.19	1.88	2.56	-1.91	-0.16	-0.27
Terminal leaflet width	**-1.60**	0.89	0.90	0.31	0.90	-1.44	-2.39	2.24	-0.26	0.01
Stipule length	-0.50	0.52	-0.72	0.32	-0.13	0.51	-0.05	-0.19	-0.45	0.01
Stipule width	0.42	-0.54	0.38	0.35	-0.22	-0.77	0.01	-0.33	0.08	0.32
Number of nodes on main stem	0.17	-0.61	-0.20	0.20	-0.28	-0.17	-0.29	0.61	-0.13	0.03
Number of main branches	0.06	0.02	0.49	0.34	-0.10	-0.32	0.17	-0.36	-0.51	-0.13
Branch length	0.00	0.31	-0.24	-0.14	0.17	-0.38	0.35	0.43	-0.07	-0.34
Plant height	0.29	-0.58	0.22	-0.09	0.21	-0.13	0.13	-0.10	0.00	-0.21
Yield and yield-related component										
Days to first flower	0.43	0.34	**1.06**	0.93	0.28	0.44	1.67	2.30	-0.45	2.02
Days To 50% flowering	-0.30	**-1.00**	**-1.87**	0.08	0.83	-0.29	-1.03	-1.72	0.46	-1.23
Days to first mature pod	**-0.75**	-0.19	-1.22	0.36	-0.75	0.75	0.58	-1.22	0.30	-0.65
Days to 50% mature pod	**0.78**	**1.08**	**1.85**	-1.16	-0.47	-0.87	-1.34	-0.10	-0.35	-0.08
Standard petal size	-0.19	-0.44	-0.70	0.37	0.53	0.56	-0.24	0.30	-0.46	-0.03
Lobe length	0.14	0.34	-0.82	-0.11	0.33	-0.58	0.54	-0.16	-0.12	-0.09
Number of racemes per plant	-0.23	0.75	-0.55	-0.33	-0.22	-0.42	0.26	-0.05	-0.07	0.13
Peduncle length	-0.20	-0.52	0.58	0.02	0.69	0.12	-0.11	-0.19	-0.27	-0.14
Number of anthesis at first flowering	-0.26	0.69	0.02	0.32	0.54	0.22	-0.38	-0.15	-0.19	0.34
Pod length	-0.50	-0.41	0.57	-0.24	0.09	-0.31	-0.38	0.27	-0.09	0.19
Pod width	-0.03	0.90	-0.28	-0.17	0.49	0.39	0.05	0.14	0.50	-0.10
Number of pods per plant	0.07	0.00	0.24	0.13	0.62	0.27	0.12	-0.06	-0.01	-0.23
Number of pods per peduncle	-0.17	0.51	0.81	0.07	0.30	0.14	0.45	0.08	-0.32	0.20
Number of locules	0.21	**-2.72**	-0.40	-0.51	-1.92	-0.30	-0.66	0.11	-0.06	-0.42
Percent seed abortion	-0.57	0.96	0.38	0.42	1.25	0.11	0.69	-0.33	0.30	-0.26
Number of seeds per pod	-0.44	**2.89**	0.23	0.03	2.53	-0.02	0.75	-0.59	0.24	0.57
Seed length	-0.64	0.31	-0.29	0.75	-0.43	-0.10	-0.25	-0.04	0.18	0.16
Seed width	-0.37	-0.33	0.59	-0.52	0.25	-0.39	-0.19	-0.22	-0.48	0.53
Seed thickness	-0.29	-0.16	-0.53	-0.83	0.12	0.41	0.50	0.34	0.15	-0.54
Canonical correlations	**0.99**	**0.98**	**0.98**	**0.98**	**0.97**	**0.97**	**0.96**	**0.96**	**0.96**	**0.94**
Eigenvalue	**47.36**	**28.73**	**26.04**	**23.09**	**17.36**	**14.56**	**12.90**	**11.94**	**10.64**	**8.26**
Proportion (%)	**17.19**	**10.43**	**9.45**	**8.38**	**6.30**	**5.28**	**4.68**	**4.33**	**3.86**	**3.00**
Cumulative (%)	**17.19**	**27.61**	**37.06**	**45.44**	**51.75**	**57.03**	**61.71**	**66.04**	**69.91**	**72.90**

4.11.2 Canonical discriminant analysis of phytochemical traits

Canonical discriminant coefficient showing the contribution of phytochemical traits to the expressions of the yield among the cowpea accessions evaluated are presented in Table 25. Eighteen phytochemical traits measured were made of 5 polyphenolic and 13 amino acid traits. Of the 18 canonical variates (CV) axes generated by the 18 traits, the first (CV1) had an eigenvalue of 140.15. This identified CV1 as the axis with traits that exhibited higher between groups variability than within-groups variability, while CV2 and CV3, with their axes having eigenvalue 69.47 and 46.92 respectively, had more within-group variability as compared to CV1. The canonical variate axis 1 (CV1) contributed a total of 40.63% to the total variability observed between the groups, while CV2 and CV3 contributed 20.14 and 13.60% respectively. This between-groups variability was largely influenced by l-histidine, gallic and vanillic acids, with vector loadings of 0.91, and -0.80 respectively in CV1. Yield was marginally impacted by d-l-b-phenylalanine and l-tryptophan with vector loadings of -1.49 and -1.00 respectively in CV2. Polyphenolic compounds measured did not contribute much to the expression variability in yield in CV3 and CV5 with vector loading less than or equal to ±0.51.

Table 25: Canonical discriminant coefficient showing the contribution of phytochemical traits to the expressions of the agronomic traits among the 108 cowpea accessions.

Traits	CV1	CV2	CV3	CV4	CV5
Polyphenols					
Gallic acid	**-0.80**	0.19	0.03	0.80	0.29
Vanillic acid	**-0.80**	-0.03	0.51	0.10	0.42
P-coumaric acid	-0.65	-0.07	-0.29	-0.53	-0.62
Rutin	-0.35	0.51	0.07	-0.21	-0.01
Quercetin	-0.35	0.51	-0.07	-0.21	0.01
Amino acids					
Glycine	-0.77	-0.57	-0.53	0.07	-0.67
L-Serine	-0.47	0.22	-0.67	-0.69	0.29
L-Histidine	**0.91**	0.81	**1.82**	-0.59	0.27
L-Aspartic Acid	-0.33	-0.25	-0.18	0.38	-0.59
L-Lysine	0.37	-0.14	0.47	-0.03	0.18
L-Valine	0.39	-0.01	0.27	-0.26	-0.15
L-Methionine	0.05	0.58	0.68	-0.05	0.48
L-Asparagine	-0.60	-0.16	**-1.12**	0.60	-0.19
Iso Leucine	0.31	0.76	-0.59	0.38	-0.75
L-Leucine	0.01	0.37	-0.37	0.22	-0.66
L-Tyrosine	-0.41	-0.83	-0.27	0.00	**1.53**
D-L-B-Phenylalanine	0.71	**-1.49**	0.44	-0.29	0.10
L-Tryptophan	-0.64	**1.00**	-0.75	0.30	-0.30
Canonical correlations	**1.00**	**0.99**	**0.99**	**0.98**	**0.97**
Eigenvalue	**140.15**	**69.47**	**46.92**	**24.82**	**15.03**
Proportion (%)	**40.63**	**20.14**	**13.60**	**7.20**	**4.36**
Cumulative (%)	**40.63**	**60.77**	**74.37**	**81.57**	**85.93**

4.12 Cluster Analysis

4.12.1 Cluster Analysis of Morphological Traits

Figure 16 shows a dendrogram of 108 cowpea accessions revealed by Ward's minimum variance distance method based on morphological traits. Table 26 shows the cluster groups formed and accessions formed in each cluster from the dendrogram. Distances between clusters formed are shown in Table 27.

To discriminate against the relations in the population, the dendrograms of the 108 cowpea accessions were clustered into seven major groups based on thirty-one measurable morphological traits at a distance of 76.40. Cluster 1 represented 19 accessions (Asontem, UG73, UG10, UG80, UG92, UG96, UG17, UG74, UG41, UG93, UG104, UG43, UG46, UG18, UG83, UG89, UG59, UG103 and UG62) (Table 26) which were characterized by the least mean days to germination of 4.41 days, a mean of 36.80, 44.29, 54.95 and 60.41 days to first flower, 50% to flowering, first mature pod and 50% mature pod respectively. Among the Clusters formed, cluster 3 which contained Wang Kae and UG1 had the least mean days to first flower (23.08), days to 50% to flowering (28.51), days to first mature pod (34.46) and 50% mature pod (42.24). Cluster 6 was formed by 17 accessions (UG11, UG81, UG50, UG45, UG48, UG37, UG35, UG38, UG101, UG94, UG66, UG79, UG 61, UG77, UG91 and UG88) which were characterized by the following traits: highest mean number of leaves (47.08), mean number of nodes on stem (12.35), mean days to days to first flower, mean days to 50% to flowering, mean pod width (0.91), number of pods per peduncle, mean days to first mature pod (54.35), days to 50% mature pod (63.16), mean seed weight (16.0g) and yield (160.84 kg ha^{-1}). Cluster 6 gave the highest yield (14.79%), while Cluster 2 gave the lowest yield (13.81%). Clusters 6, 5, 7 and 4 estimated 3.17, 1.41, 0.66 and 0.1% respectively higher (+) mean yield over the average grand mean yield (155.90 kg ha^{-1}) whereas the Cluster 2 (3.70%), Cluster 3 (3.21%), and Cluster 1 (0.99%) produced lower (−) yield. The greatest distance of 52.53 was observed between Clusters 3 and 6 while the lowest distance of 13.19 was observed between clusters 2 and 4 (Table 28). There was no significant association among the clusters ($X^2$900 = 930, P>0.05).

The biplot of the first two discriminant functions showing cluster dissimilarities based on yield and yield components showed that Clusters 4 and 6 grouped towards yield whereas accessions in Cluster 3 deviated towards percentage seed abortion (Figure 17). The remaining clusters formed a single group away from the yield and yield-related components.

Table 26: Cluster groups formed and observations in each cluster from the dendrogram for 31 morphological traits in cowpea accessions

Cluster group	**Number of observations**	**Accessions**
Cluster 1	19	Asontem, UG73, UG10, UG80, UG92, UG96, UG17,UG74, UG41, UG93, UG104, UG43, UG46, UG18, UG83, UG89, UG59, UG103, UG62
Cluster 2	17	Kirkhouse, UG34, UG21, UG25, UG3, UG57, UG14, Padi-tuya, UG68, UG4, UG95, UG85, UG8, UG5, UG51, UG15, UG20
Cluster 3	2	Wang kae, UG1
Cluster 4	23	UG2, UG67, UG28, UG69, UG36, UG13, UG90, UG60, UG98, UG26, UG78, UG40, UG9, UG53, UG86, UG32, UG49, UG100, UG12, UG65, UG84, UG42, UG87,
Cluster 5	19	UG6, UG7, UG35, UG16, UG24, UG64, UG19, UG102, UG97, UG27, UG82, UG71, UG22, UG71, UG22, UG54, UG44, UG47, UG75, UG72, UG76
Cluster 6	17	UG11, UG81, UG50, UG45, UG48, UG37, UG35, UG38, UG101, UG94, UG66, UG79, UG 61, UG77, UG91, UG88
Cluster 7	11	UG23, UG63, UG29, UG39, UG30, UG31, UG33, UG99, UG52, UG58, UG70

Table 27: Distances Between Cluster Centroids for 31 cowpea morphological traits

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Cluster 5**	**Cluster 6**	**Cluster 7**
Cluster 1	0.00	14.02	49.63	15.66	18.10	29.98	19.26
Cluster 2	14.02	0.00	49.49	13.19	15.67	21.83	21.49
Cluster 3	49.63	49.49	0.00	49.91	46.41	52.53	39.08
Cluster 4	15.66	13.19	49.91	0.00	18.60	18.55	15.20
Cluster 5	18.10	15.67	46.41	18.60	0.00	21.46	21.31
Cluster 6	29.98	21.83	52.53	18.55	21.46	0.00	23.20
Cluster 7	19.26	21.49	39.08	15.20	21.31	23.20	0.00

X^2_{900}=930 At 5% probability level P= 0.237

Table 28 : Mean values of cowpea morphological traits for 7 clusters

Trait	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Grand centroid
dtg	**4.41**	4.66	4.44	4.58	4.54	4.61	***4.76***	4.57
nol	**19.05**	31.05	32.00	29.91	34.23	***47.08***	27.94	31.48
tll	9.45	**9.40**	***10.01***	9.89	9.56	9.58	9.49	9.59
tlw	4.59	**4.58**	**5.01**	4.85	4.69	4.72	4.70	4.70
stl	0.89	0.90	0.90	**0.88**	0.93	**0.88**	***0.93***	0.90
stw	0.54	0.52	**0.51**	0.53	0.55	0.53	**0.56**	0.54
nns	11.18	11.42	**6.94**	10.16	9.89	***12.35***	11.24	10.89
nmb	4.48	4.49	***5.15***	4.52	5.05	4.10	**4.03**	4.50
bl	7.80	7.50	7.54	**7.49**	7.95	***8.00***	7.60	7.72
ph	34.94	34.84	30.44	**30.03**	31.87	34.90	***35.08***	33.26
sps	2.60	2.55	**2.33**	2.59	2.54	***2.64***	2.56	2.58
lbl	***1.58***	**1.54**	**1.54**	1.55	**1.54**	**1.54**	1.55	1.55
nrpp	23.91	25.22	32.75	32.41	**16.88**	31.37	***34.06***	27.06
pdl	8.38	**7.69**	***9.60***	8.20	8.05	8.35	9.10	8.27
naff	**3.20**	3.52	4.89	3.71	3.54	**3.20**	3.85	3.52
dff	36.80	35.54	**23.08**	37.93	37.54	***38.90***	35.39	36.91
d50f	44.29	43.13	**28.51**	45.46	44.84	***46.14***	42.58	44.28
dfmp	51.95	50.22	**34.46**	52.67	52.21	***54.35***	49.85	51.72
d50mp	60.41	57.96	**42.24**	61.25	60.56	***63.16***	58.42	60.12
apl	16.96	17.61	***17.90***	17.16	17.23	17.63	**16.37**	17.22
apw	**0.83**	0.89	**0.83**	0.86	0.87	***0.91***	0.84	0.87
nplnt	17.24	**13.64**	20.37	21.45	18.12	22.96	***26.64***	19.64
ppdn	**3.33**	3.47	3.54	3.41	3.44	***3.61***	3.45	3.45
ln	14.94	14.68	14.07	15.48	15.77	15.39	***16.06***	15.33
psa	16.78	**11.89**	***49.28***	14.26	22.56	17.08	25.93	18.07
nspp	12.56	12.95	**7.29**	***13.29***	12.53	12.84	12.21	12.68
sl	6.52	6.44	***8.41***	**6.40**	6.56	6.72	6.95	6.60
sw	4.50	**4.11**	***5.02***	4.13	4.26	4.17	4.39	4.26
st	2.81	2.64	***3.05***	**2.63**	2.70	2.72	2.83	2.72
swgt	15.44	**15.01**	15.09	15.59	15.81	***16.08***	15.69	15.59
yld	154.44	**150.14**	150.90	155.91	158.10	***160.84***	156.69	155.90
RPMY (%)	**14.20**	**13.81**	**13.88**	**14.34**	**14.54**	**14.79**	**14.44**	
RPGY (%)	**(-) 0.99**	**(-) 3.70**	**(-) 3.21**	**(+) 0.01**	**(+) 1.41**	**(+) 3.17**	**(+) 0.66**	

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield, RPMY relative proportion (%) of mean yield, grand average yield=155.90 kg ha^{-1}; RPGY (%) relative proportion of grand average yield, ‘(+)’=yield higher; ‘(−)’=yield lower

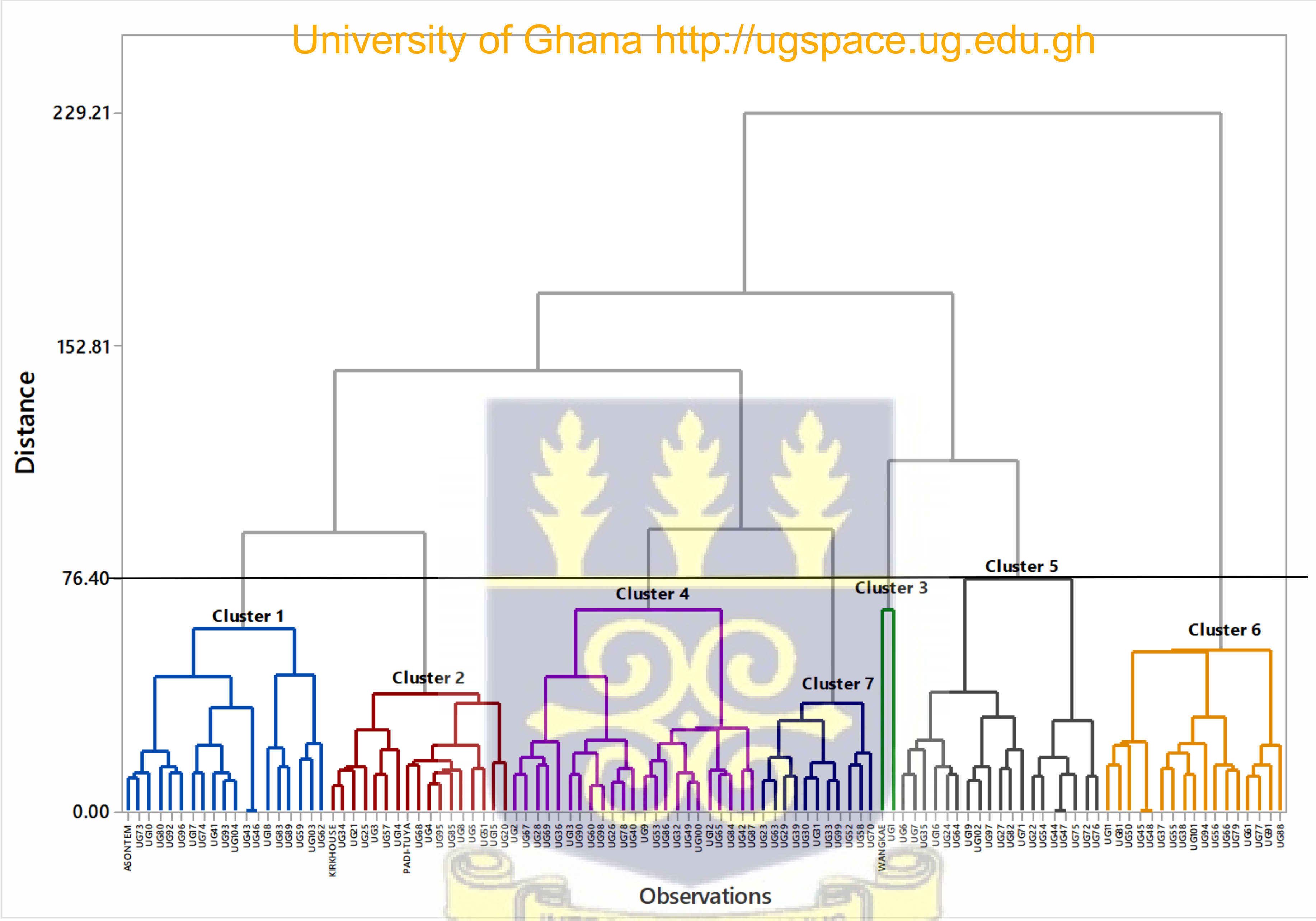

Figure 16: Dendrogram showing the relationship among the 108 cowpea accessions revealed by ward's minimum variance distance method based on morphological traits

Figure 17: Biplot of first two discriminant functions showing cluster dissimilarities based on yield and yield components

4.12.2 Cluster Analysis of Phytochemicals Traits

Figure 18 illustrates a dendrogram of 108 cowpea accessions revealed by ward's minimum variance distance method based on phytochemical traits. Table 29 shows the list of accessions grouped under each cluster. Distances between clusters formed are shown in Table 30. To discriminate against the relations in the population, the dendrograms of the 108 cowpea accessions were clustered into six major groups based on their measurable 18 phytochemical traits at 1514.30.

Table 31 showed the mean performances of the selections according to each cluster. Cluster 5 which was represented by 9 accessions (UG4, UG63, UG83, UG39, UG45, UG8, UG42, UG14, UG86) (Table 30) were characterized by the highest mean polyphenolic compound concentration compared to the other clusters (Table 31).

Among the Clusters formed, Cluster 3 which contained Wang Kae, UG25, UG52 and UG66 were the highest in all mean concentrations of all the amino acids except l-histidine and l-aspartic acid which recorded the highest mean concentration values of 3.21 ppb and 459.95 ppb for Clusters 5 and 6 respectively. The greatest distance of 1125.74 was observed between clusters 3 and 6 whereas the lowest distance of 171.90 was observed between Cluster 1 and 2 (Table 30).

The biplot of the first two discriminant functions showing cluster dissimilarities based on yield and yield components showed that Clusters 4 and 6 grouped towards yield whereas accessions in Cluster 3 deviated towards percentage seed abortion,

The biplot of the first two discriminant functions showing cluster dissimilarities based on phytochemicals which showed that Cluster 4 moved towards most of the phytochemical traits except, l-aspartic acid and l-tryptophan which angle of deviation was towards Clusters 3 and 6 respectively (Figure 19)

Table 29: Cluster groups formed and observations in each cluster from the dendrogram for 18 phytochemical traits in cowpea accessions

Cluster group	Number of observations	List of accessions
Cluster 1	33	Asontem, UG1, UG104, UG101, UG95, UG28, UG33, UG85, UG90, UG35, UG59, Padi-tuya, UG89, UG21, UG72, UG30, UG31, UG62, UG26, UG67, UG7, UG100, UG20, UG9, UG65, UG36, UG54, UG69, UG73, UG64, UG81, UG70, UG80,
Cluster 2	36	Kirkhouse, UG43, UG91, UG51, UG13, UG99, UG38, UG88, UG103, UG15, UG44, UG82, UG12, UG77, UG71, UG75, UG102, UG56, UG61, UG34, UG68, UG16, UG53, UG18, UG40, UG92, UG27, UG96, UG47, UG19, UG46, UG60, UG48, UG74
Cluster 3	4	Wang Kae, UG17, UG24, UG37
Cluster 4	23	UG2, UG23, UG29, UG10, UG94, UG5, UG58, UG11, UG79, UG22, UG50, UG97, UG32, UG84, UG87, UG3, UG41, UG55, UG76, UG78, UG93, UG6, UG49
Cluster 5	9	UG4, UG63, UG83, UG39, UG45, UG8, UG42, UG14, UG86
Cluster 6	3	UG25, UG52, UG66

Table 30: Distances Between Cluster Centroids for 18 phytochemical traits in cowpea accession

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Cluster 1	0.00	171.90	861.09	174.45	469.21	493.44
Cluster 2	171.90	0.00	1026.33	338.39	639.35	425.68
Cluster 3	861.09	1026.33	0.00	688.47	403.25	1125.74
Cluster 4	174.45	338.39	688.46	0.00	304.60	559.54
Cluster 5	469.21	639.35	403.25	304.60	0.00	816.68
Cluster 6	493.44	425.68	1125.74	559.54	816.68	0.00

Table 31: Mean values of morphological traits for 7 groups revealed by cluster analysis

Variable	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Grand centroid
Gal	0.26	0.18	0.33	0.33	***0.81***	0.17	0.30
Van	0.47	0.46	0.45	0.41	***1.12***	0.54	0.51
Pca	0.71	0.75	0.66	0.59	***1.81***	0.81	0.79
Rut	13.55	13.48	13.69	13.09	***15.13***	11.27	13.50
Que	1.97	1.96	1.99	1.90	***2.21***	1.63	1.96
Lhis	2.17	3.92	***27.80***	7.82	6.51	9.25	5.47
Asp	39.73	47.60	158.14	78.62	62.15	***459.95***	68.56
Llys	0.00	0.00	0.00	0.00	**3.21**	0.00	0.27
Lval	8.11	3.15	***24.95***	8.50	1.91	14.79	6.83
Lmet	76.30	82.96	***244.51***	125.14	118.90	157.27	100.95
Lasp	0.00	0.01	0.00	***0.51***	0.08	0.00	0.12
Iso	4.06	3.82	***15.54***	8.23	7.52	3.87	5.58
Lleu	2.06	0.00	0.00	***4.63***	2.44	0.00	1.82
Ltyr	15.21	15.70	***27.56***	17.79	17.49	14.90	16.56
Dlb	27.49	20.70	***88.85***	37.15	45.97	20.17	30.89
Ltry	294.30	122.94	***1127.46***	456.72	760.58	48.99	334.67

gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp= Asparagine, lasp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso-Leucine, lleu=L-Leucine, ltyr=L-Tyrosine, dlb=D-L-B-Phenylalanine, ltry=L-Tryptophan

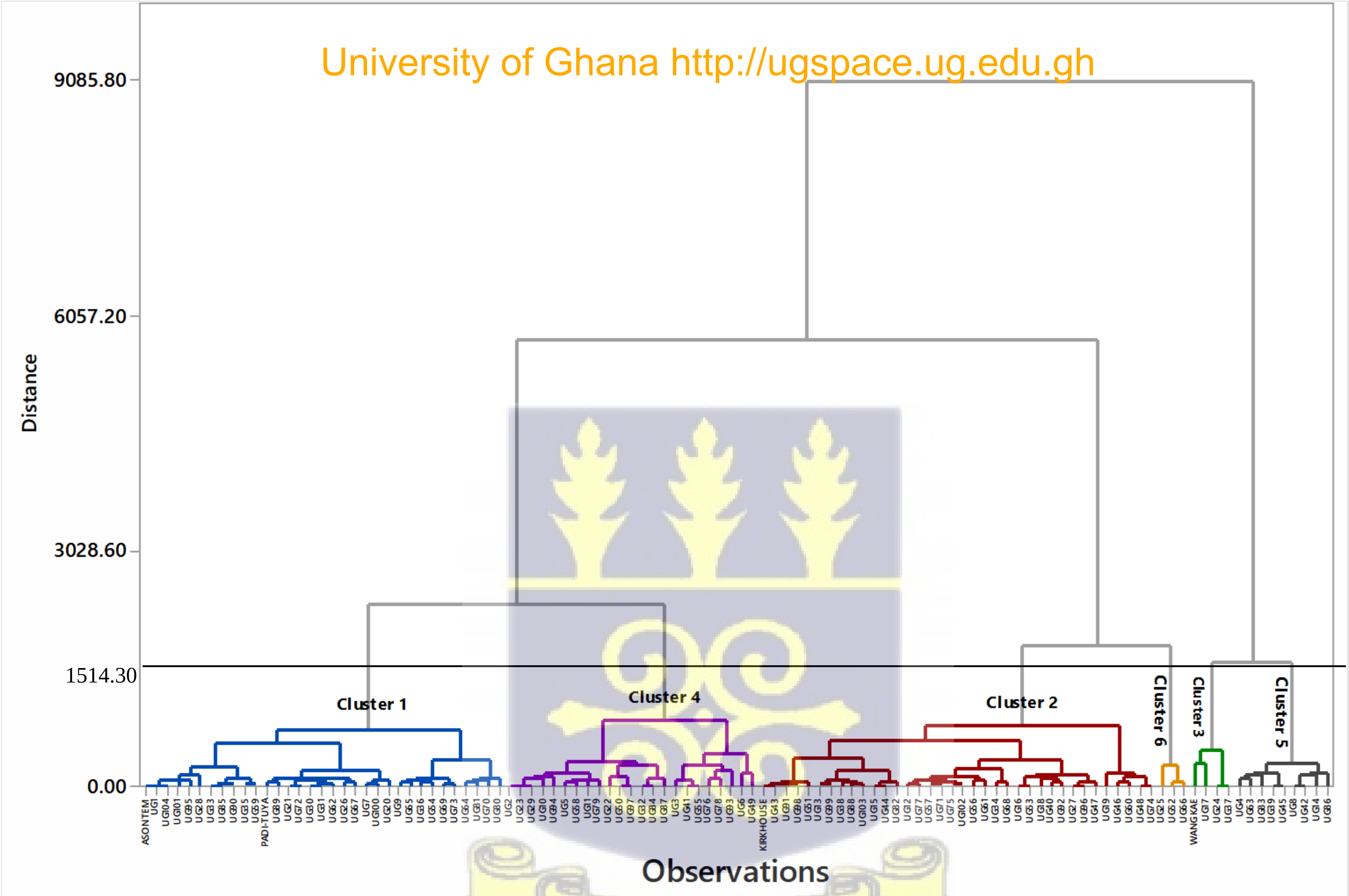

Figure 18: Dendrogram showing the relationship among the 108 cowpea accessions revealed by ward’s minimum variance distance method based on phytochemical traits

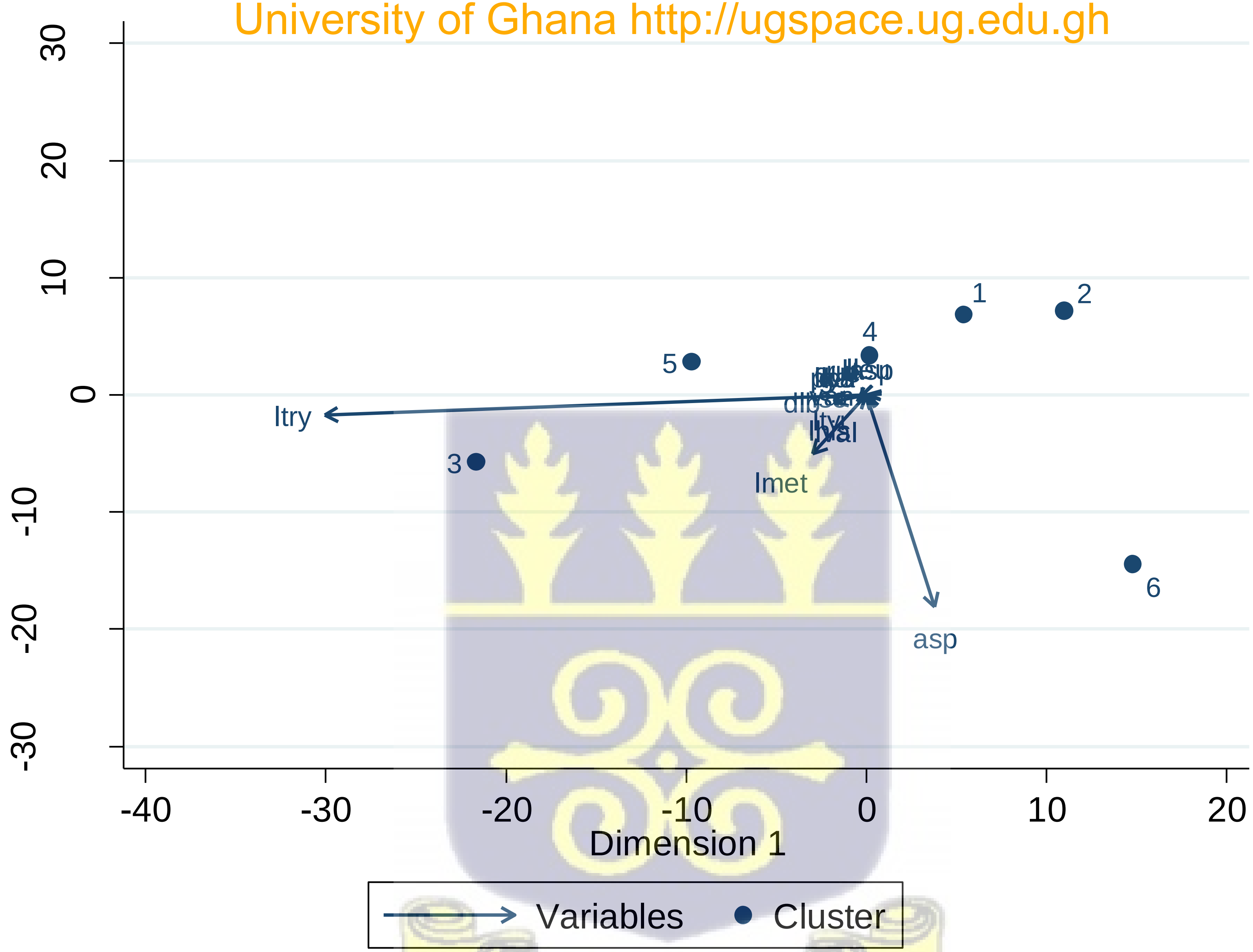

Figure 19: Biplot of first two discriminant functions showing cluster dissimilarities based on phytochemical traits

4.13 Genetic components studies

4.13.1 Genetic components study for morphological traits

Analysis of genetic components, variance and covariance, heritability in broad sense, relative differences, and genetic advances for morphological traits are presented in Table 32. The phenotypic variance (σ^2 p) was higher than the genotypic variance (σ^2 g) in all morphological traits evaluated. The yield in kg ha−1 reported the highest genotypic (63.1) and phenotypic (243.8) variances while the lowest genotypic (0.00) and phenotypic (0.00) variance was recorded by the stipule width. The following vegetative traits: terminal leaflet length (ECV 16.88%, PCV 17.53% & GCV 4.71%), terminal leaf width (ECV 16.09% PCV 16.88% & GCV 5.11%), stipule length (ECV 14.07% PCV 14.24% and GCV 5.11%), stipule width (ECV 10.93%, PCV 11.34% & GCV 3.23%) and branch length (ECV 17.51% PCV 19.54% & GCV 8.66%) showed below 20% environmental coefficient of variation (ECV), phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). The following yield and yield- related traits; SPS (ECV 6.71% PCV 6.94% & GCV 1.78%), lobe length (ECV 5.74% PCV 5.82% & GCV 0.92%), number of days to first flower (ECV 12.24% PCV 13.32% and GCV 5.27%), number of days to 50% flowering (ECV 10.14% PCV 11.33% & GCV 5.06%), pod length (ECV 9.93% PCV 10.91% & GCV 4.51%), number of days to first mature pod (ECV 10.6% PCV 11.6% & GCV 5.77%) and numbers of days to 50% mature pod (ECV 9.81% PCV 11.2% & GCV 5.4%) showed below 20% of environmental coefficient of variation (ECV), phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). The relative difference (RD) varied from 22.75%, percent seed abortion to 90.38% for days to germination.

Relatively small difference in value between GCV and PCV was recorded for yield and yield-related traits as follows: seed length (24.18%), seed width (30.99%), seed thickness (33.82%), seed weight (49.12%) and yield (49.12%). The values of heritability in broad sense observed were high for most of the traits evaluated which ranged from 0.93% for days to germination to 59.52% for percent seed abortion. Low (≤20%) heritability values were observed in the vegetative traits and ranged from 0.93% for days to germination to 19.67% for branch length. Moderate (>30 to ≤60%) heritability was measured for the following yield and yield-related traits; PSA (59.67%), SL (57.53%), SW (47.62), ST (43.8%), NSPP (37.59), SL (94.89%), SW (97.68%), ST (89.91%). However, broad-sense heritability in SWGT and YLD was low (25.9%). The trait percent seed abortion (103.3%) had topmost genetic advance (as percentage mean) value or genetic gain while the lowest had (0.30%) for LBL. Higher genetic gain was recorded for only the following yield and yield-related traits; PSA (103.3%), NSPP (30.30%), SL (28.42%), SW (29.18%), ST (24.95%), SWGT and YLD (19.30%)

Table 32: ANOVA, estimates of phenotypic and genotypic variances and coefficient of variations, broad-sense heritability, critical difference, genetic advance and genetic advance as percent of mean among morphological traits in cowpea

Trait	MS	F	CD5%	CD1%	σ^2 e	σ^2 g	σ^2 p	ECV	PCV	GCV	RD(%)	H^2%	GA	GAM
DTG	1.23	1.07	1.13 ns	1.48 ns	1.15	0.01	1.16	23.58	23.69	2.28	90.38	0.93	0.02	0.45
NOL	354.49	1.73***	15.06	19.82	205.5	21.28	226.78	46.3	48.64	14.9	69.37	9.39	2.91	9.40
TLL	4.12	1.54**	1.72	2.26	2.67	0.21	2.88	16.88	17.53	4.71	73.13	7.22	0.25	2.61
TLW	0.99	1.71***	0.8	1.05	0.58	0.06	0.64	16.09	16.88	5.11	69.73	9.16	0.15	3.18
STL	0.02	1.18	0.13	0.17	0.02	0.00	0.02	14.07	14.24	2.23	84.34	2.45	0.01	0.73
STW	0.01	1.63***	0.06	0.08	0.00	0.00	0.00	10.93	11.34	3.23	71.52	8.11	0.01	1.90
NNS	41.43	1.63***	5.3	6.98	25.46	2.28	27.74	48.99	51.14	14.66	71.33	8.22	0.89	8.66
NMB	4.96	0.92	2.44 ns	3.22 ns	5.42	0.07	5.35	52.13	51.82	5.71	88.98	1.21	0.06	1.30
BL	4.95	2.71***	1.42	1.87	1.82	0.45	2.27	17.51	19.54	8.66	55.68	19.67	0.61	7.92
PH	155.682	1.97***	9.33	12.28	78.93	10.97	89.89	26.13	27.89	9.74	65.08	12.2	2.38	7.01
SPS	0.044437	1.49**	0.18	0.24	0.03	0	0.03	6.71	6.94	1.78	74.35	6.58	0.02	0.94
LBL	0.009512	1.22	0.09 ns	0.12 ns	0.01	0	0.01	5.74	5.82	0.92	84.19	2.5	0	0.30
NRPP	186.58	1.43**	11.99	15.78	130.18	8.06	138.24	43.68	45.01	10.87	75.85	5.83	1.41	5.40
PDL	7.0598	1.30*	2.45	3.22 ns	5.42	0.23	5.65	28.51	29.12	5.93	79.64	4.15	0.2	2.49
NAFF	3.5533	1.2	1.81 ns	2.38 ns	2.97	0.08	3.06	47.46	48.12	7.93	83.52	2.72	0.1	2.69
DFF	46.17	2.30***	4.71	6.2	20.11	3.72	23.83	12.24	13.32	5.27	60.44	15.63	1.57	4.29
D50F	55.06	2.74***	4.71	6.2	20.08	5	25.08	10.14	11.33	5.06	55.34	19.93	2.06	4.65
APL	7.271	2.44***	1.81	2.39	2.98	0.61	3.59	9.93	10.91	4.51	58.66	17.07	0.67	3.84
APW	0.05242	1.85***	0.18	0.23	0.03	0	0.03	19.32	20.5	6.8	66.83	11.01	0.04	4.64
NPLNT	148.43	1.88***	9.33	12.29	78.95	9.93	88.88	51.49	54.64	18.26	66.58	11.17	2.17	12.57
PPDN	1.3146	1.14	1.13 ns	1.49 ns	1.15	0.02	1.18	30.09	30.39	4.23	86.08	1.94	0.04	1.21
LN	35.099	2.05***	4.34	5.72	17.09	2.57	19.67	27.74	29.75	10.76	63.83	13.08	1.19	8.02
PSA	1534.39	11.36***	12.21	16.07	135.11	199.9	335	53.23	83.82	64.75	22.75	59.67	22.5	103.03
DFMP	90.499	3.30***	5.5	7.24	27.43	9.01	36.44	10.06	11.6	5.77	50.26	24.73	3.08	5.91
D50MP	108.416	3.12***	6.19	8.15	34.72	10.53	45.25	9.81	11.2	5.4	51.79	23.26	3.22	5.37
NSPP	68.475	5.22***	3.81	5.01	13.13	7.91	21.03	30.9	39.12	23.99	38.68	37.59	3.55	30.30
SL	12.9195	10.48***	1.17	1.54	1.23	1.67	2.9	15.63	23.99	18.19	24.18	57.52	2.02	28.42
SW	7.8076	7.36***	1.08	1.42	1.06	0.96	2.02	21.53	29.75	20.53	30.99	47.62	1.4	29.18
ST	2.5328	6.45***	0.66	0.87	0.39	0.31	0.7	20.73	27.65	18.3	33.82	43.8	0.75	24.95
SWGT	62.254	3.45***	4.46	5.88	18.06	6.31	24.38	31.14	36.18	18.41	49.12	25.9	2.63	19.30
YLD	620.254	34.5***	44.6	58.8	180.6	63.1	243.8	31.14	36.18	18.41	49.12	25.9	2.63	19.30

dtg = Days to germination , nol = Number of leaves , tll= Terminal leaflet length, tlw = Terminal leaflet width, stl= Stipule length, stw=Stipule width, nns =Number of nodes on main stem, nmb = Number of main branches, bl = branch length, ph = Plant height, sps= Standard petal length, lbl=lobe length, nrpp = Number of racemes per plant , pdl = Peduncle length, naff = Days to first flower, dff = Number of anthesis at first flowering, d50f = Days to 50%flowering, apl = Pod length, apw = Pod width, nplnt = Number of pod per plant, ppdn = Number of pod per peduncle, ln = Number of locules, psa = Percent seed abortion, dfmp = Days to first mature pod, d50mp = Days to 50% mature pod, nspp = Number of seeds per pod, sl=Seed lenght, sw=Seed width, st=Seed thickness, swgt=Seed weight, yld=Yield,MS= Mean squares, CD5%=Critical Difference (CD) 5%, CD1%=Critical Difference (CD) 1%, σ^2 e =Environmental Variance, σ^2 g =Genotypic Variance, σ^2 p =Phenotypic Variance, ECV= Environmental Coefficient of Variance, GCV= Genotypic Coefficient of Variance, PCV=Phenotypic Coefficient of Variance, RD%= Relative difference, H^2%= Heritability (Broad Sense), GA= Genetic Advance, GAM= Genetic Advance as percentage of mean

4.13.2 Genetic components study for phytochemical traits

Analysis of genetic components, variance and covariance, heritability in broad-sense, relative differences, and genetic advances for phytochemical traits are presented in Table 33. The phenotypic variance (σ^2 p) was either higher than or equal to the genotypic variance (σ^2 g) regarding all phytochemical traits evaluated. The trait glycine reported the highest genotypic and phenotypic variance value of 2146965.78 and 2146966.30 while the lowest genotypic and phenotypic variance was 0.14 was obtained in the trait gallic acid.

High (≥20%) PCV and GCV were observed in all the phytochemicals traits except for glycine and l-serine which did not show PCV and GCV. The relative difference (RD) varied from 0.00% for l-lysine, l-aspartic acid and l-leucine to 9.12% for *dlbphe*. Broad sense heritability was very high (>80.00%) for the phytochemical traits. Broad sense heritability ranged from 82.52% % for dlbphe to 100% for glycine, l-lysine, l-aspartic acid and l-leucine. The trait l-lysine (2408.43%) had the topmost genetic advance (as percentage mean) value or genetic gain with the lowest (45.41%) in rutin.

Table 33: ANOVA, estimates of phenotypic and genotypic variances and coefficient of variations, broad-sense heritability, critical difference, genetic advance and genetic advance as percent of mean among phytochemical traits in cowpea

Trait	MS	F	CD5%	CD1%	σ^2 e	σ^2 g	σ^2 p	ECV	GCV	PCV	RD(%)	H^2%	GA	GAM
GAL	0.97	216.17***	0.07	0.09	0.00	0.14	0.14	29.34	162.67	165.30	1.59	96.85	0.75	329.78
VAN	1.46	8990.70***	0.01	0.02	0.00	0.21	0.21	0.21	96.70	96.75	0.05	99.90	0.94	199.11
PCA	4.23	1229.49***	0.06	0.08	0.00	0.60	0.61	8.20	108.61	108.92	0.28	99.44	1.60	223.12
RUT	71.12	821.60***	0.31	0.41	0.09	10.15	10.23	2.04	22.14	22.23	0.40	99.15	6.53	45.41
QUE	1.56	821.60***	0.05	0.06	0.00	0.22	0.22	2.08	22.49	22.58	0.40	99.15	0.97	46.13
GLY	15028761.00	28981759.00	0.76	1.00	0.52	2146965.78	2146966.30	.	.	.	.	100.00	3018.42	.
L-SER	19448.90	821.31***	5.11	6.73	23.68	2775.03	2798.71	.	.	.	.	99.15	108.06	.
L-HIS	413.00	374.06***	1.10	1.45	1.10	58.84	59.95	33.47	244.34	246.63	0.93	98.16	15.66	498.69
ASP	28392.80	226.02***	11.77	15.50	125.62	4038.17	4163.80	23.64	134.01	136.08	1.52	96.98	128.92	271.87
L-LYS	22.63	9.44E+29***	0.00	0.00	0.00	3.23	3.23	0.00	1169.14	1169.14	0.00	100.00	3.70	2408.43
L-VAL	796.73	453.89***	1.39	1.83	1.76	113.57	115.32	23.03	185.28	186.71	0.77	98.48	21.79	378.76
L-MET	16054.40	47.25***	19.36	25.49	339.77	2244.94	2584.71	23.30	59.89	64.26	6.80	86.85	90.96	114.98
L-ASP	3.52	1252094.00***	0.00	0.00	0.00	0.50	0.50	2.51	1061.51	1061.51	0.00	100.00	1.46	2186.75
ISO-LEU	278.04	52.67***	2.41	3.18	5.28	38.97	44.25	57.99	157.56	167.90	6.16	88.07	12.07	304.60
L-LEU	666.35	24410795.00***	0.01	0.01	0.00	95.19	95.19	0.14	257.47	257.47	0.00	100.00	20.10	530.38
L-TYR	295.82	1456.59***	0.47	0.62	0.20	42.23	42.43	2.56	36.92	37.01	0.24	99.52	13.36	75.87
D-L-B-PHE	1839.27	34.20***	7.70	10.14	53.78	255.07	308.85	22.83	49.71	54.70	9.12	82.59	29.90	93.06
L-TRY	565493.00	190.13***	57.29	75.41	2974.27	80359.76	83334.03	13.72	71.29	72.60	1.80	96.43	573.45	144.22

gal=Gallic acid, van=Vanillic acid, pca=P-coumaric acid, rut=Rutin, que=Quercetin, gly=Glycine, lser=L-Serine, lhis=L-Histidine, asp=L-Aspartic Acid, llys=L-Lysine, lval=L-Valine, lmet=L-Methionine, iso=Iso Leucine,lleu=L-Leucine,ltyr=L-Tyrosine,dlb=D-L-B-Phenylalanine,ltry=L-Tryptophan, MS= Mean squares, CD5%=Critical Difference (CD) 5%, CD1%=Critical Difference (CD) 1%, σ^2 e =Environmental Variance, σ^2 g =Genotypic Variance, σ^2 p =Phenotypic Variance, ECV= Environmental Coefficient of Variance, GCV= Genotypic Coefficient of Variance, PCV=Phenotypic Coefficient of Variance, RD%= Relative difference, H^2%= Heritability (Broad Sense), GA= Genetic Advance, GAM= Genetic Advance as percentage of mean

4.14 Selection based on rank summation index (RSI)

4.14.1 Using rank summation index (RSI) to select for high yielding potential

Table 34 shows Mean values of cowpea yield and yield-related traits their rank summation index (RSI). (Appendix 3). The values of RSI ranking of cowpea accessions with the yield and yield-related traits that were positive and significantly correlated with yield namely were pod length, pod width, number of locules, percent seed abortion, seed length, seed width and seed weight. Based on the lowest RSI scores, the 10 best performing accessions with high yield potential among the population evaluated were *UG84* (174.00 kg h^{-1}), *UG24* (186.53 kg h^{-1}), *UG44* (170.33 kg h^{-1}), *UG69* (193.50 kg h^{-1}), *UG47* (170.33 kg h^{-1}), *UG14 (*177.33 kg h^{-1}), *UG70* (171.57 kg h^{-1}), *UG66* (172.10 kg h^{-1}), *UG36* (169.90 kg h^{-1}) and UG102 (174.63 kg h^{-1}).

Table 34: Mean values of cowpea yield and yield-related traits their rank summation index (RSI)

Accession	apl	rsi	apw	rsi	ln	rsi	psa	rsi	sl	rsi	sw	rsi	swgt	rsi	RSI=∑rsi	yld	yld rank
UG84	19.27	7	0.91	33	18.00	18	22.34	32	7.10	22	4.60	33	17.40	7	152	174.00	7
UG24	18.57	17	0.90	39	15.33	53	21.31	37	8.74	3	5.53	5	18.65	2	156	186.53	2
UG44	17.94	32	0.97	22	17.67	21	22.26	33	7.10	23	5.03	16	17.03	15	162	170.33	15
UG69	19.27	8	1.01	16	13.33	77	17.57	51	9.45	2	5.28	11	19.35	1	166	193.50	1
UG47	17.94	33	0.97	23	17.67	22	22.26	34	7.10	24	5.03	17	17.03	16	169	170.33	16
UG14	18.25	23	0.94	25	18.67	13	10.68	91	7.52	13	5.51	6	17.73	3	174	177.33	3
UG70	17.66	42	0.82	67	19.00	12	23.61	26	7.60	12	5.07	14	17.16	11	184	171.57	11
UG66	17.23	60	0.91	35	17.33	27	19.42	45	7.97	5	5.06	15	17.21	8	195	172.10	8
UG36	17.55	45	0.86	56	19.00	9	22.19	35	7.69	9	4.76	25	16.99	17	196	169.90	17
UG102	19.47	5	0.99	20	12.00	94	29.96	4	6.66	51	4.92	18	17.46	5	197	174.63	5
UG97	19.00	12	1.08	7	10.33	106	31.15	3	6.79	40	4.68	26	17.20	9	203	172.00	9
UG19	17.93	34	0.96	24	10.00	108	26.67	12	7.50	14	5.29	10	17.44	6	208	174.43	6
WANG KAE	17.92	35	0.90	38	13.14	81	66.86	1	11.14	1	7.42	1	15.67	62	219	156.67	62
UG31	16.35	82	0.88	46	18.33	16	29.61	6	7.35	17	4.77	24	16.18	33	224	161.83	33
UG80	18.35	22	1.19	1	20.00	5	16.98	56	6.46	62	4.22	55	16.44	28	229	164.37	28
UG8	14.90	103	0.73	96	11.00	103	12.50	78	7.00	30	4.81	23	15.19	74	507	151.93	74
UG9	15.96	88	0.82	71	18.00	19	10.39	94	6.12	77	3.86	78	14.63	88	515	146.30	88
UG65	16.94	70	0.74	93	17.67	25	16.27	62	5.61	96	3.77	86	14.70	85	517	147.03	85
Padi-tuya	17.25	58	0.84	61	11.10	102	13.99	72	6.33	67	4.25	51	6.82	108	519	68.19	108
UG13	17.57	44	0.78	83	13.33	80	15.00	66	5.76	91	3.70	90	15.08	80	534	150.80	80
UG87	12.74	107	0.62	106	16.67	40	13.03	75	5.54	97	5.36	7	13.50	103	535	134.97	103
UG72	14.49	105	0.67	102	16.00	46	25.04	19	5.44	101	3.85	81	13.39	104	558	133.87	104
UG60	15.99	87	0.93	26	11.33	100	11.67	85	5.11	106	3.49	93	13.84	100	597	138.37	100
UG78	16.43	78	0.79	79	12.33	93	9.52	99	5.44	99	4.11	61	14.58	91	600	145.83	91
UG5	16.83	72	0.82	69	13.00	83	5.09	104	5.79	90	3.48	94	14.62	89	601	146.17	89
UG85	17.03	67	0.78	85	15.67	49	10.40	93	5.32	104	2.81	107	13.98	99	604	139.83	99
UG90	17.49	48	0.69	100	12.67	92	13.68	74	5.44	100	2.88	105	14.29	97	616	142.90	97
UG89	11.66	108	0.58	108	13.00	88	12.50	77	6.03	81	4.14	60	12.48	105	627	124.80	105
UG62	15.52	97	0.75	91	13.00	85	14.28	70	5.96	85	3.09	100	13.79	101	629	137.93	101
UG20	17.21	62	0.69	101	10.67	105	2.78	107	5.70	93	2.94	103	14.35	96	667	143.47	96

apl = pod length (mm), apw =pod width (mm), ln number of locules, sl =seed length (mm), sw =seed width (mm), psa=percent seed aborted, swgt =seed weight (kg), yld = yield (kg ha^{-1}) RSI=Rank summation index.

4.14.2 Using rank summation index (RSI) to select for high phytochemical content potential

Table 35 shows mean value of phytochemical traits with yield and their rank summation index. The values of RSI ranking of cowpea accessions with the phytochemical traits that were positive and significantly correlated with yield were gallic acid, rutin, quercetin, l-serine, l-histidine, l-aspartic acid, l-valine, l-methionine and l-tryptophan

Based on RSI, the 10 topmost accessions with high phytochemical content potential were; *UG28* (107), *UG14* (118), *Wang Kae* (139), *UG45* (152), *UG76* (188), *UG22* (196), *UG39* (214), *UG73* (216), *UG83* (218) and *UG24* (228). They were ranked with respect to yield as follws: *48th* (159.27 kg h^{-1}), *3rd* (177.33 kg h^{-1}), *62nd* (156.67 kg h^{-1}), *43rd* (160.00 kg h^{-1}), *61st* (156.90 kg h^{-1}), *86th* (146.93 kg h^{-1}), *52nd* (159.10 kg h^{-1}), *55th* (157.50 kg h^{-1}), *32nd* (162.03 kg h^{-1}), *2nd* (186.53 kg h^{-1}), *53rd* (158.33 kg h^{-1}), *92nd* (145.63 kg h^{-1}), *84th* (148.57 kg h^{-1}), *79th* (151.30 kg h^{-1}) and *70th* (153.93 kg h^{-1}) respectively.

Table 35: Mean value of positive, strongly significant correlated phytochemical traits with yield and their rank summation index (RSI).

Accession	gal	rsi	rut	rsi	que	rsi	lser	rsi	lhis	rsi	asp	rsi	lval	rsi	lmet	rsi	lasp	rsi	ltry	rsi	RSI=∑rsi	yld	yld rank
Best 15 performers																							
UG28	0.23	34	20.22	5	2.96	4	.	.	10.14	22	.	.	96.05	1	.	.	.	.	353.12	41	107	159.27	48
UG14	3.37	1	20.13	6	2.95	6	28.14	28	15.66	17	99.81	27	16.92	18	192.61	10	.	.	827.99	5	118	177.33	3
Wang Kae	0.32	19	22.10	2	3.24	2	190.16	2	.	.	40.59	53	.	.	88.41	60	.	.	1175.89	1	139	156.67	62
UG45	0.23	33	20.22	4	2.96	5	26.18	32	.	.	98.08	29	.	.	110.39	40	.	.	733.77	9	152	160.00	43
UG76	0.20	46	16.55	19	2.42	14	45.94	14	.	.	173.54	10	2.01	32	112.47	38	.	.	567.60	15	188	156.90	61
UG22	0.21	39	16.62	11	2.43	10	38.99	17	.	.	37.87	56	66.67	2	148.40	16	.	.	330.14	45	196	146.93	86
UG39	0.29	23	14.13	38	2.06	39	26.18	33	.	.	98.08	30	.	.	110.39	41	.	.	733.77	10	214	159.10	52
UG73	0.20	43	16.55	16	2.42	22	19.56	47	.	.	98.57	28	.	.	135.00	23	.	.	369.65	37	216	157.50	55
UG83	0.20	53	16.55	26	2.42	13	59.70	12	11.63	20	22.75	70	.	.	185.49	11	.	.	666.32	13	218	162.03	32
UG24	0.47	11	10.10	97	1.46	100	186.47	3	51.04	2	267.86	5	38.42	6	305.63	2	.	.	1156.57	2	228	186.53	2
UG17	0.30	22	12.46	46	1.81	47	25.00	34	9.11	23	56.24	42	22.97	13	278.38	4	.	.	1020.83	4	235	158.33	53
UG42	0.25	31	13.61	42	1.98	45	23.02	42	.	.	104.87	24	.	.	101.89	51	.	.	816.10	7	242	145.63	92
UG34	0.47	14	22.45	1	3.29	1	23.30	41	31.63	4	38.18	55	7.45	24	196.73	8	.	.	68.85	103	251	148.57	84
UG32	0.28	25	16.62	10	2.43	11	36.23	22	23.53	9	31.61	59	.	.	48.72	85	.	.	403.20	31	252	151.30	79
UG49	0.26	30	10.92	95	1.58	93	127.91	5	.	.	291.49	4	.	.	333.32	1	.	.	430.95	27	255	153.93	70
Worst 15 performers																							
UG46	0.02	68	6.30	108	0.90	109	17.43	50	5.86	25	138.06	16	.	.	130.88	27	0.17	4	104.73	90	497	160.03	42
UG33	0.00	107	14.15	37	2.06	38	2.04	89	.	.	3.41	89	.	.	36.65	90	.	.	307.90	51	501	152.13	73
UG96	0.01	98	11.85	78	1.72	75	6.05	77	.	.	60.91	37	.	.	87.65	61	.	.	147.40	82	508	149.93	81
UG18	0.21	38	9.08	105	1.31	106	30.56	24	27.33	6	53.50	43	.	.	43.01	87	.	.	75.61	101	510	162.60	30
UG68	0.01	91	11.85	71	1.72	60	21.72	45	5.10	27	15.48	76	3.47	29	178.91	12	.	.	70.51	102	513	167.63	19
UG53	0.01	76	11.85	56	1.72	83	0.63	94	.	.	58.17	41	42.62	5	81.70	71	.	.	99.66	94	520	148.67	83
UG100	0.01	102	11.85	82	1.72	67	11.08	62	.	.	49.90	46	.	.	12.02	105	.	.	262.15	59	523	157.43	56
UG103	0.01	105	11.85	85	1.72	79	3.03	85	.	.	.	.	.	.	8.96	106	.	.	194.00	71	531	159.73	46
UG99	0.01	101	11.85	81	1.72	61	18.67	48	4.11	29	48.45	48	.	.	22.17	102	.	.	191.25	72	542	144.90	94
UG95	0.01	97	11.85	77	1.72	66	11.33	61	19.25	12	2.82	90	.	.	7.29	108	.	.	373.39	36	547	174.70	4
UG21	0.10	67	11.32	86	1.64	87	0.23	96	.	.	6.60	83	.	.	78.81	74	.	.	268.60	58	551	160.13	40
UG71	0.01	94	11.85	74	1.72	71	9.61	69	.	.	23.54	69	3.40	30	102.12	50	.	.	87.62	98	555	159.93	45
UG57	0.01	80	11.85	60	1.72	76	5.68	80	.	.	27.90	65	0.69	33	83.19	66	.	.	84.70	99	559	155.50	64
UG101	0.01	103	11.85	83	1.72	80	2.64	86	5.50	26	51.29	45	12.69	21	36.36	91	.	.	349.60	43	578	154.53	69
UG102	0.01	104	11.85	84	1.72	82	1.84	90	12.16	19	0.43	91	.	.	90.32	59	.	.	107.79	88	617	174.63	5

gal=gallic acid, rut= rutin, que=quercetin, lser=l-serine,lhis=l-histidine, asp=l-aspartic acid, llval=-valine, lmet=l-methionine ltry=l-tryptophan, yld = yield (kg ha^{-1})
RSI=Rank summation index.

4.15 Selection based on contrast analysis

4.15.1 Selection based on contrast analysis of morphological traits

Table 36 shows results for the contrast analysis based on morphological traits. Two accessions, *UG10* and *UG100* with a mean value of 6.00±0.00 days for days to germination were significantly (P=0.024) higher than the grandmean value of 4.55±0.05 days whereas *UG77* and *UG98* showed a significantly (P=0.013) lower average days to germination than the grandmean with a value of 4.43±0.03 days.

Days to first flower, days to 50% flowering, days to first mature pod and days to 50% mature pod observed in accession *UG1* were significantly (P=0.000) the lowest mean values of 12.00±0.00, 15.00±0.00, 21.00±0.00 and 30.00±0.00 days as compared to the grandmean value of 36.81±0.16, 45.08±0.14, 53.57±0.17 and 61.41±0.19 days respectively.

Wang Kae, *UG69*, *UG24* and *Asontem* showed highly significant (P≤0.001) greater mean values of 11.14±0.13, 9.45±1.06, 8.74±0.40 and 7.44±0.03 mm compared to the grandmean value of 7.39±0.05 mm for seed length. Similarly, *Wang Kae* and *Asontem* recorded significantly (P=0.000) higher mean values of 7.42±0.03 and 6.19±0.05 mm for seed width and mean values of 4.47±0.04 and 4.03±0.15 mm for seed thickness compared to the grandmean of 4.93±0.04 and 3.18±0.03 respectively.

Asontem, *Kirkhouse* and *Padituya* showed significantly (P=0.000) lower mean values of 11.00±0.12, 10.60±0.12 and 6.82±0.03 g for seed weight and 110.01±1.18, 106.04±1.24 and 68.19±0.31 kg ha^{-1} for yield than the grand mean of 12.71±0.08 and 127.10±0.8 respectively

Table 36: Marginal analysis showing accessions that significantly performed below and above the grandmean for morphological traits

Trait	Treatment	Mean	semean	F	P-value
Days to germination	***UG10***	***6.00***	***0.00***	***5.15***	***0.024***
	UG100	***6.00***	***0.00***	***5.15***	***0.024***
	UG11	3.33	0.33	3.91	0.049
	UG41	3.33	0.33	3.91	0.049
	UG76	3.33	0.33	3.91	0.049
	UG91	3.33	0.33	3.91	0.049
	UG92	3.33	0.33	3.91	0.049
	UG99	3.33	0.33	3.91	0.049
	UG77	3.00	0.00	6.29	0.013
	UG98	3.00	0.00	6.29	0.013
	Grandmean	**4.43**	**0.03**	**1.11**	**0.243**
Number of leaves	***UG91***	***60.67***	***6.44***	***11.76***	***0.001***
	UG61	***57.00***	***10.15***	***8.99***	***0.003***
	UG45	***54.67***	***5.78***	***7.42***	***0.007***
	UG48	***54.67***	***5.78***	***7.42***	***0.007***
	UG50	***54.67***	***10.74***	***7.42***	***0.007***
	UG88	***51.33***	***8.97***	***5.44***	***0.020***
	UG77	***50.67***	***17.37***	***5.08***	***0.025***
	UG18	14.67	4.41	3.90	0.049
	UG83	13.00	1.00	4.71	0.031
	UG89	10.67	0.67	5.98	0.015
	UG59	10.00	1.53	6.37	0.012
	Grandmean	**32.92**	**0.37**	**1.37**	**0.015**
Terminal leaf length	***UG28***	***11.89***	***1.06***	***5.85***	***0.016***
	UG9	***11.89***	***0.49***	***5.83***	***0.016***
	UG78	***11.86***	***1.20***	***5.70***	***0.017***
	UG98	***11.53***	***0.93***	***4.15***	***0.042***
	UG24	***11.50***	***0.63***	***4.05***	***0.045***
	Padituya	***10.30***	***0.24***	***10.05***	***0.002***
	UG64	7.71	0.34	3.88	0.050
	UG23	7.68	1.15	4.03	0.045
	UG90	6.80	0.53	8.60	0.004
	Grandmean	**9.67**	**0.04**	**1.43**	**0.007**
Terminal leaf width	***UG28***	***5.83***	***0.43***	***6.48***	***0.011***
	UG65	***5.77***	***0.59***	***5.78***	***0.017***
	UG9	***5.72***	***0.33***	***5.25***	***0.022***
	UG73	***5.72***	***0.57***	***5.25***	***0.022***
	UG24	***5.70***	***0.17***	***5.04***	***0.025***
	UG78	***5.59***	***0.60***	***4.02***	***0.046***
	Padituya	***5.04***	***0.11***	***10.04***	***0.002***
	Kirkhouse	4.44	0.09	6.34	0.012
	UG83	3.82	0.25	3.98	0.047
	UG91	3.80	0.53	4.16	0.042
	UG64	3.63	0.08	5.80	0.016
	UG90	3.41	0.27	8.52	0.004
	Grandmean	**4.78**	**0.02**	**1.61**	**0.001**

Table 36 (Cont'd)

Trait	Treatment	Mean	semean	F	P-value
Stipule length	***UG95***	***1.07***	***0.01***	***5.50***	***0.020***
	UG63	***1.05***	***0.14***	***4.47***	***0.035***
	UG52	***1.05***	***0.06***	***4.28***	***0.039***
	UG68	***1.04***	***0.04***	***3.91***	***0.049***
	Padituya	***0.96***	***0.01***	***12.04***	***0.001***
	Kirkhouse	0.83	0.01	17.79	0.000
	UG34	0.75	0.03	4.10	0.044
	UG35	0.74	0.03	4.68	0.031
	Grandmean	**0.88**	**0.00**	**1.28**	**0.044**
Stipule width	***UG23***	***0.65***	***0.06***	***11.27***	***0.001***
	UG44	***0.64***	***0.02***	***8.86***	***0.003***
	UG47	***0.64***	***0.02***	***8.86***	***0.003***
	UG73	***0.63***	***0.02***	***6.75***	***0.010***
	UG41	***0.62***	***0.04***	***5.79***	***0.017***
	UG51	***0.62***	***0.11***	***5.79***	***0.017***
	UG40	***0.62***	***0.01***	***5.35***	***0.021***
	Padituya	***0.56***	***0.01***	***5.70***	***0.017***
	UG15	0.47	0.03	3.85	0.050
	UG84	0.46	0.01	4.23	0.040
	UG2	0.46	0.02	4.63	0.032
	UG104	0.46	0.02	4.63	0.032
	UG77	0.45	0.01	5.49	0.020
	UG12	0.45	0.02	5.94	0.015
	UG87	0.44	0.03	7.94	0.005
	UG91	0.43	0.01	8.48	0.004
	UG79	0.43	0.01	9.05	0.003
	Grandmean	**0.53**	**0.00**	**1.92**	**0.000**
Number of nodes on main stem	***UG91***	**18.67**	**0.33**	**6.78**	**0.010**
	UG3	**18.00**	**2.00**	**5.67**	**0.018**
	UG37	**18.00**	**1.15**	**5.67**	**0.018**
	UG101	**17.00**	**1.53**	**4.19**	**0.041**
	Wang Kae	6.54	0.52	37.64	0.000
	UG83	4.00	0.58	5.31	0.022
	UG25	3.33	1.33	6.39	0.012
	Grandmean	**9.33**	**0.14**	**1.43**	**0.007**
Number of main branches	Asontem	3.78	0.29	5.02	0.026
	UG88	1.67	0.33	4.37	0.037
	UG29	1.33	0.33	5.46	0.020
	Grandmean	**4.32**	**0.06**	**0.86**	**0.829**
Branch length	***UG97***	**10.06**	**0.26**	**8.95**	**0.003**
	UG92	**9.84**	**0.61**	**7.35**	**0.007**
	UG29	**9.80**	**1.42**	**7.05**	**0.008**
	UG28	**9.78**	**0.20**	**6.94**	**0.009**
	UG94	**9.70**	**0.28**	**6.39**	**0.012**
	UG74	**9.44**	**0.53**	**4.84**	**0.028**
	Padituya	**8.10**	**0.11**	**4.19**	**0.041**
	Asontem	7.34	0.15	4.21	0.041
	UG15	6.00	0.79	4.80	0.029
	UG104	5.93	1.09	5.20	0.023
	UG4	5.83	1.45	5.82	0.016
	UG86	5.68	1.34	6.76	0.010

Table 36(Cont'd)

Trait	Accessions	Mean	semean	F	P-value
Branch length	UG84	5.57	1.71	7.51	0.006
	UG77	5.56	2.30	7.60	0.006
	UG82	5.23	1.40	10.07	0.002
	UG89	4.19	0.17	20.26	0.000
	UG91	4.06	2.06	21.82	0.000
	UG63	3.60	2.20	27.65	0.000
	UG90	2.99	0.16	36.40	0.000
	Grandmean	**7.72**	**0.03**	**2.59**	**0.000**
Plant height	***UG77***	**44.08**	**7.86**	**4.45**	**0.035**
	UG35	**43.40**	**2.53**	**3.91**	**0.049**
	Asontem	**40.01**	**0.64**	**30.83**	**0.000**
	Kirkhouse	**37.39**	**0.59**	**11.55**	**0.001**
	Wang Kae	28.48	1.56	15.48	0.000
	UG103	20.64	8.41	6.07	0.014
	UG36	20.40	0.48	6.30	0.012
	UG62	18.35	9.25	8.46	0.004
	UG76	17.74	3.52	9.17	0.003
	UG72	15.36	7.69	12.20	0.001
	Grandmean	**34.18**	**0.25**	**1.91**	**0.000**
Standard petal size	***UG5***	**2.78**	**0.08**	**4.32**	**0.038**
	UG73	**2.78**	**0.03**	**4.32**	**0.038**
	UG78	**2.78**	**0.12**	**4.32**	**0.038**
	Padituya	**2.65**	**0.03**	**8.91**	**0.003**
	Asontem	**2.64**	**0.02**	**7.23**	**0.007**
	Wang Kae	2.51	0.02	8.58	0.004
	Kirkhouse	2.50	0.02	9.43	0.002
	UG20	2.38	0.04	4.02	0.046
	UG14	2.35	0.00	5.16	0.024
	UG87	2.34	0.16	5.47	0.020
	UG27	2.33	0.02	5.95	0.015
	UG6	2.32	0.19	6.62	0.010
	UG1	2.15	0.02	18.03	0.000
	Grandmean	**2.57**	**0.00**	**1.62**	**0.000**
Lobe length	***UG2***	***1.68***	***0.07***	***7.04***	***0.008***
	UG73	***1.67***	***0.08***	***5.41***	***0.021***
	UG61	***1.65***	***0.05***	***3.99***	***0.046***
	UG64	***1.65***	***0.05***	***3.99***	***0.046***
	UG104	***1.65***	***0.05***	***3.99***	***0.046***
	Wang Kae	1.52	0.01	5.03	0.026
	Asontem	1.52	0.01	5.89	0.016
	Kirkhouse	1.51	0.01	11.83	0.001
	UG72	1.43	0.08	5.13	0.024
	UG98	1.43	0.06	5.13	0.024
	Grandmean	**1.51**	**0.00**	**107.00**	**0.020**
Number of raceme per plant	***UG88***	***43.33***	***1.20***	***5.89***	***0.016***
	UG53	***42.00***	***7.94***	***4.96***	***0.026***
	UG58	***42.00***	***3.06***	***4.96***	***0.026***
	UG86	***42.00***	***5.29***	***4.96***	***0.026***
	UG1	***41.33***	***4.10***	***4.53***	***0.034***
	UG9	***41.33***	***3.67***	***4.53***	***0.034***

Table 36(Cont'd)

Trait	Treatment	Mean	semean	F	P-value
Number of raceme per plant	UG82	12.67	1.45	4.61	0.032
	UG35	9.00	1.00	7.25	0.007
	UG71	9.00	1.53	7.25	0.007
	Grandmean	**24.07**	**0.30**	**1.36**	**0.018**
Peduncle length	***UG77***	***13.00***	***0.45***	***12.30***	***0.001***
	UG2	***12.29***	***2.87***	***8.88***	***0.003***
	UG39	***11.68***	***0.66***	***6.38***	***0.012***
	UG43	***11.46***	***0.61***	***5.59***	***0.019***
	UG46	***11.46***	***0.61***	***5.59***	***0.019***
	UG29	***11.13***	***1.24***	***4.51***	***0.034***
	Asontem	7.59	0.28	4.39	0.037
	UG6	5.51	0.21	4.16	0.042
	UG14	4.96	1.02	6.00	0.015
	Grandmean	**7.72**	**0.06**	**1.28**	**0.046**
Number of anthesis at first flowering	***UG1***	***5.67***	***0.33***	***4.66***	***0.031***
	UG17	***5.67***	***0.33***	***4.66***	***0.031***
	Wang Kae	***4.11***	***0.20***	***6.33***	***0.012***
	UG7	1.00	0.00	6.38	0.012
	UG36	1.00	0.00	6.38	0.012
	UG94	1.00	0.00	6.38	0.012
	UG95	1.00	0.00	6.38	0.012
	Grandmean	**4.38**	**0.10**	**1.17**	**0.139**
Number of days to first flower	***UG76***	***43.00***	***1.15***	***5.16***	***0.024***
	Wang Kae	34.16	0.52	18.65	0.000
	UG20	31.33	0.67	4.31	0.038
	UG1	12.00	0.00	86.18	0.000
	Grandmean	**36.81**	**0.16**	**1.90**	**0.000**
Number of days to 50% flowering	***UG76***	**50.33**	**2.19**	**4.87**	**0.028**
	Wang Kae	42.02	0.47	12.11	0.001
	UG16	37.67	1.20	5.81	0.016
	UG1	15.00	0.00	113.99	0.000
	Grandmean	**45.08**	**0.1**	**2.11**	**0.000**
Pod length	***UG68***	***21.44***	***0.39***	***16.25***	***0.000***
	UG94	***20.90***	***0.63***	***12.34***	***0.001***
	UG92	***20.52***	***0.71***	***9.95***	***0.002***
	UG11	***19.82***	***1.26***	***6.17***	***0.013***
	UG102	***19.47***	***1.63***	***4.62***	***0.032***
	UG95	***19.47***	***0.93***	***4.61***	***0.032***
	Kirkhouse	***18.03***	***0.27***	***10.64***	***0.001***
	Wang Kae	***17.92***	***0.26***	***7.99***	***0.005***
	UG35	15.13	1.86	3.94	0.048
	UG88	15.03	1.23	4.36	0.037
	UG8	14.90	0.28	4.89	0.028
	UG99	14.72	0.90	5.68	0.018
	UG72	14.49	1.03	6.76	0.010
	UG82	13.04	1.89	15.86	0.000
	UG87	12.74	0.87	18.22	0.000
	UG89	11.66	0.36	28.07	0.000
	Grandmean	**18.05**	**0.05**	**2.27**	**0.000**
Pod width	***UG80***	***1.19***	***0.06***	***10.57***	***0.001***
	UG68	***1.18***	***0.06***	***9.72***	***0.002***

Table 36 (Cont'd)

Trait	Treatment	Mean	semean	F	P-value
Pod width	***UG95***	***1.18***	***0.01***	***9.72***	***0.002***
	UG28	***1.11***	***0.02***	***5.82***	***0.016***
	UG67	***1.10***	***0.14***	***5.50***	***0.019***
	UG94	***1.09***	***0.04***	***5.04***	***0.025***
	UG97	***1.08***	***0.06***	***4.60***	***0.033***
	UG92	***1.08***	***0.08***	***4.46***	***0.035***
	Kirkhouse	***0.93***	***0.03***	***6.92***	***0.009***
	UG76	0.67	0.08	4.06	0.045
	UG88	0.67	0.03	4.06	0.045
	UG64	0.64	0.02	5.37	0.021
	UG87	0.62	0.04	6.17	0.013
	UG82	0.58	0.06	8.14	0.005
	UG89	0.58	0.04	8.14	0.005
	Grandmean	**0.93**	**0.00**	**1.72**	**0.000**
Number of pods per plant	***UG58***	***35.33***	***1.45***	***9.46***	***0.002***
	UG70	***34.00***	***1.53***	***7.92***	***0.005***
	UG11	***32.33***	***4.10***	***6.19***	***0.013***
	UG18	***30.33***	***4.84***	***4.39***	***0.037***
	UG42	***30.00***	***2.52***	***4.12***	***0.043***
	UG27	***30.00***	***3.21***	***4.12***	***0.043***
	Asontem	***17.16***	***1.53***	***4.21***	***0.041***
	Wang Kae	14.41	0.94	18.68	0.000
	Kirkhouse	13.54	0.33	25.44	0.000
	Padituya	11.03	0.14	50.65	0.000
	UG72	9.33	5.46	4.08	0.044
	UG5	7.00	2.08	6.14	0.014
	Grandmean	**16.18**	**0.23**	**2.07**	**0.000**
Number of pods per peduncle					
	Kirkhouse	***3.95***	***0.12***	***11.82***	***0.001***
	Asontem	***3.94***	***0.11***	***11.09***	***0.001***
	UG35	***4.67***	***0.33***	***3.87***	***0.050***
	UG85	***4.67***	***0.33***	***3.87***	***0.050***
	UG95	***4.67***	***0.33***	***3.87***	***0.050***
	UG101	***4.67***	***0.33***	***3.87***	***0.050***
	Grandmean	**3.45**	**0.03**	**1.10**	**0.249**
Number of locules	***UG32***	***21.00***	***1.53***	***5.70***	***0.017***
	UG6	***20.67***	***1.45***	***5.05***	***0.025***
	UG42	***20.33***	***0.88***	***4.44***	***0.036***
	UG55	***20.33***	***2.19***	***4.44***	***0.036***
	UG80	***20.00***	***3.21***	***3.87***	***0.050***
	Asontem	***16.95***	***0.41***	***8.31***	***0.004***
	Wang Kae	13.14	0.50	15.10	0.000
	Padituya	11.10	0.31	56.60	0.000
	UG20	10.67	2.40	3.86	0.050
	UG40	10.67	2.60	3.86	0.050
	UG58	10.33	1.76	4.43	0.036
	UG97	10.33	1.45	4.43	0.036
	UG19	10.00	0.00	5.04	0.025
	Grandmean	**14.54**	**0.11**	**2.05**	**0.000**

Table 36 (Cont'd)

Trait	Treatment	Mean	semean	F	P-value
Percent seed abortion	***Wang Kae***	***66.86***	***1.84***	***941.07***	***0.000***
	UG1	***31.69***	***5.33***	***4.12***	***0.043***
	Padituya	13.99	1.41	6.58	0.011
	Asontem	8.73	1.03	34.49	0.000
	UG18	4.62	2.63	4.02	0.046
	UG26	4.55	4.55	4.06	0.044
	UG20	2.78	2.78	5.20	0.023
	UG51	2.08	2.08	5.68	0.018
	Grandmean	**22.9**	**0.59**	**11.20**	**0.000**
Days to first mature pod	***UG76***	***60.33***	***2.33***	***7.58***	***0.006***
	UG79	***59.00***	***2.08***	***5.42***	***0.020***
	UG10	***58.00***	***1.53***	***4.03***	***0.045***
	Asontem	***56.03***	***0.39***	***33.83***	***0.000***
	Padituya	***54.08***	***0.76***	***10.14***	***0.002***
	Wang Kae	47.92	0.68	26.19	0.000
	UG62	45.33	0.88	4.16	0.042
	UG3	45.00	1.15	4.61	0.032
	UG28	44.67	2.73	5.08	0.025
	UG57	44.67	1.86	5.08	0.025
	UG1	21.00	0.00	96.37	0.000
	Grandmean	**52.06**	**0.27**	**2.79**	**0.000**
Days to 50% mature pod	***UG56***	***67.67***	***3.76***	*4.59*	***0.033***
	UG76	***67.67***	***1.20***	*4.59*	***0.033***
	UG79	***67.67***	***2.60***	*4.59*	***0.033***
	UG101	***67.33***	***2.19***	*4.20*	***0.041***
	Asontem	***63.52***	***0.53***	*16.61*	***0.000***
	Padituya	***62.83***	***0.82***	*10.49*	***0.001***
	Wang Kae	54.48	0.75	45.80	0.000
	UG14	53.00	2.65	4.10	0.044
	UG3	52.33	0.88	4.90	0.027
	UG15	52.33	2.33	4.90	0.027
	UG103	52.00	4.00	5.33	0.021
	UG20	51.33	1.45	6.24	0.013
	UG57	50.67	1.67	7.22	0.008
	UG1	30.00	0.00	73.25	0.000
	Grandmean	**61.41**	**0.19**	**2.63**	**0.000**
Number of seeds per pod	***UG32***	**18.33**	**0.67**	7.39	**0.007**
	UG42	**18.33**	**1.67**	7.39	**0.007**
	UG15	**17.67**	**0.88**	**5.75**	**0.017**
	UG55	**17.33**	**1.45**	**5.01**	**0.026**
	UG96	**17.33**	**0.67**	**5.01**	**0.026**
	UG6	**17.00**	**0.58**	4.31	**0.038**
	Asontem	**15.37**	**0.34**	**29.63**	**0.000**
	Padituya	9.37	0.20	45.32	0.000
	UG58	7.67	0.88	5.82	0.016
	UG19	7.33	1.20	6.62	0.010
	UG97	7.00	0.58	7.47	0.007
	Wang Kae	3.90	0.13	317.26	0.000
	Grandmean	**11.15**	**0.12**	**5.22**	**0.000**

Table 36 (Cont'd)

Trait	Treatment	Mean	semean	F	P-value
Seed length	***Wang Kae***	***11.14***	***0.13***	***900.96***	***0.000***
	UG69	***9.45***	***1.06***	***20.03***	***0.000***
	UG24	***8.74***	***0.40***	***11.23***	***0.001***
	UG88	***8.13***	***0.72***	***5.74***	***0.017***
	UG66	***7.97***	***0.54***	***4.64***	***0.032***
	UG56	***7.94***	***1.25***	***4.44***	***0.036***
	UG51	***7.86***	***0.22***	***3.91***	***0.049***
	Asontem	***7.44***	***0.03***	***31.06***	***0.000***
	Kirkhouse	6.22	0.15	6.19	0.013
	UG85	5.32	0.24	4.05	0.045
	UG27	5.31	0.50	4.11	0.043
	UG60	5.11	0.29	5.48	0.020
	UG68	4.89	0.57	7.16	0.008
	UG11	4.40	0.45	11.86	0.001
	Grandmean	**7.39**	**0.05**	**10.76**	**0.000**
Seed width	***Wang Kae***	***7.42***	***0.03***	***505.32***	***0.000***
	Asontem	***6.19***	***0.05***	***187.94***	***0.000***
	UG56	***5.86***	***0.54***	***7.23***	***0.008***
	UG51	***5.54***	***0.23***	***4.61***	***0.032***
	UG24	***5.53***	***0.64***	***4.59***	***0.033***
	UG14	***5.51***	***0.80***	***4.42***	***0.036***
	UG91	3.09	0.25	3.92	0.048
	UG62	3.09	0.24	3.94	0.048
	UG67	3.06	0.17	4.13	0.043
	UG22	3.04	0.16	4.24	0.040
	UG20	2.94	0.41	4.96	0.026
	UG27	2.93	0.23	5.09	0.025
	UG90	2.88	0.38	5.45	0.020
	UG54	2.85	0.31	5.69	0.018
	UG85	2.81	0.33	5.99	0.015
	UG1	2.62	0.11	7.69	0.006
	Grandmean	**4.93**	**0.04**	**7.58**	**0.000**
Seed thickness	***Asontem***	***4.47***	***0.04***	***413.41***	***0.000***
	Wang Kae	***4.03***	***0.15***	***229.79***	***0.000***
	UG69	***3.68***	***0.33***	***7.02***	***0.008***
	UG24	***3.57***	***0.21***	***5.42***	***0.020***
	UG56	***3.45***	***0.42***	***4.03***	***0.045***
	Grandmean	**3.18**	**0.03**	**6.67**	**0.000**
Seed weight	Asontem	11.00	0.12	54.90	0.000
	Kirkhouse	10.60	0.12	64.80	0.000
	Padituya	6.82	0.03	200.55	0.000
	Grandmean	**13.65**	**0.22**	**2.72**	**0.000**
Yield	Asontem	110.01	1.18	54.90	0.000
	Kirkhouse	106.04	1.24	64.80	0.000
	Padituya	68.19	0.31	200.55	0.000
	Grandmean	**136.65**	**2.21**	**2.72**	**0.000**

4.15.2 Selection based on contrast analysis of phytochemical traits

Appendix 5 shows results for the contrast analysis based on phytochemical traits Regarding the polyphenolic compounds, the phenols; gallic acid had 14 test materials *(UG14, UG6, UG7, UG8, UG9, UG5, UG12, UG48, UG10, UG16, UG24, UG25, UG38* and *UG34*) which were significantly (P=0.000) higher than the grandmean value of 0.23±0.00 mg/ml, vanillic acid had 47 test materials and 2 controls (*Asontem* and *Padituya*) that had means higher than the grandmean value of 0.47±0.02 mg/ml and p-coumeric acid had 48 test materials and 2 controls (*Asontem* and *Padituya*) with higher than the grandmean value of 0.72±0.04 mg/ml. However, *UG14* had the highest significant (P=0.000) mean concentration of gallic acid, vanillic and p-coumaric acid with values of 3.37, 6.78 and 11.52 mg/ml respectively.

On the other hand, the flavonoids rutin and quercetin both recorded 33 test materials and 2 controls (*Wang Kae* and *Kirkhouse*) with mean concentrations that were higher than the grandmean values of 16.55 and 2.10±0.02 mg/ml for the respective traits. *UG34* and *Wang Kae* recorded the highest significant (P=0.000) mean concentration for rutin as follows; 22.4±50.00 and 22.10±0.00 mg/ml and mean concentration for quercetin as follows; 3.29 and 3.24 mg/ml.

Among the amino acids, l-lysine was significantly (P=0.000) higher in *UG8* than the grandmean with a mean concentration value of 28.91±0.00 ppb against 0.15±0.09 ppb whereas l-methionine showed a significantly (P=0.013) higher average concentration in 70 test materials and 1 breeder line (*Wang Kae*). *UG14* was highly significant and had the highest mean concentration of l-methionine with a value of 332.32±0.00 ppb. *UG25* (581.97 ppb), *UG66* (410.39 ppb) and *UG52* (387.5 ppb) were the highest mean performers (P=0.000) of asparagine than the grandmean of 47.42±3.20 ppb.

UG6 was identified as the accession with significant and the highest mean concentrations of l-histidine (55.81±0.00 ppb) than the grandmean value of 3.14±0.38 respectively.

UG17 was identified as the accession with the highest significant (P=0.000) and mean concentrations of iso-leucine and d-l-b-phenylalanine with values of 57.46±19.92 and 153.15±0.0 ppb against the grandmean value of 3.96±0.33 and 32.13±0.85 ppb for the respective amino acids.

For l-leucine and l-tyrosine, *UG93* was identified as the accession with the significantly highest mean concentration with values of 106.58±0.00 and 46.48±0.00 ppb, as compared to the grandmean of 37.9±0.48 and 17.60±0.32 respectively. However, *Padi-tuya* showed significant (P=0.000) higher concentration of l-leucine and l-tyrosine than the grandmean with values of 25.80 and 34.15 ppb.

Tryptophan was significantly (P=0.000) highest in *Wang Kae* with a mean concentration of 1175.89 ppb, followed by UG24, UG37, UG17 with values of 1156.57±0.00, 1156.57±0.00 and 1020.83±472.61 respectively, compared to the grandmean value of 397.63±14.29

CHAPTER FIVE

DISCUSSION

5.1. Variability in morphological qualitative traits

5.1.1 Growth and Vegetative traits

In the present research, high variability was observed in all qualitative traits. Growth habit showed 5 different forms namely climbing, erect, prostrate, semi-erect and semi-prostrate. semi-erect growth habit was the most dominant (51.45%) in the entire population. Results from this study is in contrast to Bozokalfa *et al.* (2017) who reported all possible growth habit forms in the cowpea in 32 cowpea genotypes from Turkey but prostrate growth habits as the most dominant (43.81%) growth pattern in their study. In the same study Bozokalfa *et al.* (2017), observed 2 colour forms for flower colour, white and violet with frequencies of 62.5 and 37.5%. Lazaridi *et al.* (2017) reported similar results to Bozokalfa *et al.* (2017) in their study of 23 on- farm conserved local cowpea populations from Greece. The findings of these researchers were dissimilar to the variation of flower colour forms observed in the current work, where cream, mauve, purple, white and yellow flower colour forms were found. Similar to the works of the previous authors white was the most dominant flower colour in the present study.

In this study, the results showed three classes of leaf colour: dark green, intermediate green and pale green. This was similar to what Onwubiko (2020) observed in a study of six cultivars from Nigeria but contrasted Kumar (2016) who observed two classes of leaf colour: green and dark green in 7 cowpea genotypes. The frequencies observed in this study which were 51.95, 35.85, 12.2 % for the respective classes in the entire population which was at variance with Onwubiko (2020), who observed equal frequencies of 33.33% for all the classes and Kumar (2016) who reported frequencies of 57.14 for green and 42.86% for dark green. Bozokalfa *et al.* (2017) reported 3 leaf colours: pale green (18.8%), Intermediate green ((56.3%) and dark green (25.0%).

In this study, stem colour showed six colour forms; extensive (dark red with green extensions), Intermediate (Intermediate red with green extensions), Moderate (Intermediate green), None, Solid (Dark green), Very slight (Pale green) with pale or light green being the most dominant in the entire population with a frequency of 70.63%. However, Onwubiko (2020) observed four different forms of stem colour in his study as follows; Light green, Green, Light red and Dark red. The discrepancy between the current study and that of Onwubiko might be due to the differences in environmental conditions, the cowpea genotypes used for the study and sample size.

5.1.2 Yield and yield-related components

Raceme position is a reflection of the position of pods on the cowpea plant. Raceme position can also enhance pod harvesting. Pods above canopy are easier to harvest than those below canopy level (Bennet-Lartey,1991). In the present study three (3) different forms of raceme positions; throughout the canopy, on the upper side of the canopy and above the canopy were observed which was in agreement with that of Asare *et al.* (2011) who also observed three (3) different forms of raceme position.

According to Egbadzor *et al.* (2014) observation across markets in Ghana revealed that the imported type of cowpea are different from the Ghanaian varieties.The imported ones have larger grains with cream or white coat colour (Quaye *et al.*, 2011; Egbadzor *et al.*, 2013) and were the most consumer -preferred varieties. In this study, 8 phenotypic classes of seed coat colours were observed namely black, brown, cream, cream with black patches, grey, purple, red and white in the entire population. However, Kumar (2016) in similar study of seven genotypes observed only three seed coat colours : brown, around hilum and buff without a brown spot. Onwubiko (2020) observed three seed coat colours namely; milky, white and red. Lazaridi *et al.* (2017) reported ten different seed coat colours in 23 cowpea local populations from Greece. Similarly, Bozokalfa *et al.* (2017) reported seven seed coat colours. In the current study, five seed shapes were observed as follows: crowder, kidney, ovoid, rhomboid and globose. The findings of this study is in agreement with those of Lazaridi *et al.* (2017) who observed all these shapes except crowder.

In the present work, three eye colour forms were reported as follows:; eye absent, grey and red. This finding is at variance with those of Lazaridi *et al.* (2017) and Bozokalfa *et al.* (2017) who reported five (eye absent, grey, tan brown, blue to black and speckled) and seven (eye absent, grey, tan brown, red, green blue to black and moltted) forms, respectively. The differences between the findings of the current study and those of previous studies might be due to differences in cowpea genotypes used and also sample size.

The current work identified four classes of immature pod pigmentation as follows: none, pigmented sutures, pigmented tip and pigmented valve, green sutures. This finding is similar to the results of Lazaridi *et al.* (2017) who observed all forms of immature pod pigmentation as observed in this study. In addition, the pattern of pigment distribution in full-grown immature pods varied (Cobbinah *et al.*, 2011), and many cowpea cultivars contain anthocyanin either partially or wholly purple on pods (Fery, 1985; Singh and Rachie, 1985; Bennet- Lartey and Ofori, 1999). Pigmentation is a very important trait to cowpea geneticists and breeders because it is inherited in a simple Mendelian fashion and can therefore serve as a genetic marker. For instance, Asante and Laing (1991) in a study of genetic linkage observed that flower bud tip colour is inherited in a simple Mendelian manner.

Pod characteristic is of major importance for fresh consumption or cowpea grain cultivation, and substantial strategies for consumer-oriented cowpea breeding, as well as individual selection criteria for seed multiplication by the farmers. Some desirable traits including pod colour, tender and less fibrous pods are the most prominent characters that attract the growers' interest and market quality (Ehlers *et al.*, 2002; Peksen, 2004; Pandey *et al.*, 2006). For the entire collection in this study showed that pods were mainly slightly curved (74.12%), followed by straight

(16.06%) and curved (9.82%) in this study. However, this contradicts what Bozokalfa *et al.* (2017) observed in their study of 32 cowpea genotypes from Turkey where they were mainly straight (68.8%), with few genotypes (25%) showing slightly curved pods. The present research showed that variability was identified in mature pod colour black, brown, dark tan/purple pigmentation on pods.

5.2 Variability in morphological quantitative traits

5.2.1 Growth and Vegetative traits

The cowpea genotypes studied germinated within a mean number of days of 4.43±0.03days. Iqbal (2015) who worked on cowpea seeds treated with 5 % moringa leaf extracts reported the number of days to germination as 2.89 days. The results from this current study showed the mean number of branches was 4.32±0.06. On the other hand, Lesly (2005) who also worked on cowpea reported the mean number of branches as 3.88. Similarly, in the current study, the mean number of nodes was 9.33±0.14. The value in the current study is relatively higher than the 4.78 reported by Kouam *et al.* (2018), who studied 30 genotypes of cultivated cowpea from Cameroon. A mean plant height of 34.18±0.25 cm at flowering was recorded in this study, while Musvosvi (2009) who worked on nine cowpea genotypes from Zimbabwe reported a mean plant height of 42.39 cm. The mean terminal leaflet length and width recorded were 9.76±0.04 cm and 4.78±0.02 cm respectively which was in contrast with Walle *et al.* (2019) who conducted an experiment using 324 genotypes from Ethiopia. They reported mean terminal leaf length and leaf width as 11.57±0.57 and 19.34±0.91 cm. The results from this current study showed a mean number of leaflets of 32.92±0.37. whereas Musvosvi (2009) reported a mean value of 13.10 for the mean number of leaflets.

The differences between the report of variability in this study and several works compared for various traits may be due to differences in the following; cowpea genotype, sample size, environmental conditions and soil.

5.2.2 Yield and yield-related components

For reproductive traits, the test materials had a significantly higher mean than the controls for: lobe length, number of racemes per plant, peduncle length, number of anthesis at first flowering, number of pods per plant, number of locules, seed weight and seed yield. No significant differences were observed for standard petal size. Also, the mean peduncle length for all the cowpea accessions was 7.72±0.06 while Musvosvi (2009) studied reported a mean value of 21.10 cm. The cowpea genotypes studied took an average of 45.08±0.14 days to 50% flowering. This was earlier than that reported in a study by the following authors; Walle *et al.* (2019) - 52.96±4.21 days, Musvosvi (2009) - 56.80 days and Lesly (2005)- 54.80 days.

The mean seed width in this study was lowest (4.45±0.03 mm) for test materials whereas the breeder line recorded the highest mean value of 4.14±0.08 mm. The overall mean for the entire population studied was 4.93±0.04 mm. The results are in contrast with the work of Kouam *et al.* (2018) and Milosevic (2013) who reported a grand mean of 0.65±0.02 cm and 5.84 mm for mean seed width. Mean seed length for the controls was 7.9±0.07 mm which was higher than the test material with a mean value 6.73±0.09 mm lower than the grand mean of 7.39±0.05. The results is in contrast with that of Kouam *et al.* (2018) who reported a grand mean of 0.92±0.03 cm for seed length and Milosevic (2013) who reported a mean seed length as 10.57 mm in 5 cowpea accessions. The mean number of pods per plant in the test materials (20.1±0.44) was higher than the controls (13.92±0.24) and overall mean (16.18±0.23). The findings of this is in contrast with those of Kouam *et al.* (2018) who reported a grandmean of 76.77±4.17 for mean number of pods per plant in cowpea accessions. The differences may be due to the sample size and differences in genotypes. Omoigui *et al.* (2006) reported a mean number of pods per plant of 4.81 while Walle *et al.* (2019) reported mean number of pods per plant as 27.83±1.62. In the present study, the mean pod length was 18.05±0.05. The mean value from this current study was higher than the mean value reported by Walle *et al.* (2019) [15.15±1.50 cm] and Bozokalfa *et al.* (2017) [17.01±4.54 cm]. Kouam *et al.* (2018) reported a higher mean of 20.08 cm for pod length than what was observed in this study.

The mean pod width of the controls recorded the highest mean value of 0.96±0.01 cm whereas the test materials recorded the lowest mean value of 0.87±0.01 over a grand mean of 0.93±0.00 cm. The results from this studyare at variance with the works of Kouam *et al.* (2018) and Bozokalfa *et al.* (2017) who reported a grand mean of 0.95±0.03 cm and 0.75±0.18 cm respectively. The results of the present study showed a mean value of 14.54±0.11for number of locules per pod. A study by Musvosvi (2009) on cowpea reported a mean value of 13.10 for this trait. The lowest mean of 3.36±0.05 was obtained in the test materials for the mean number of pods per peduncle and the highest mean of 3.5±0.03 in the controls with a grand mean of 3.45±0.03. This is in contrast with Walle *et al.* (2019), Kouam *et al.* (2018) and Bozokalfa *et al.* (2017) observed in their studies, where they reported 2.94±0.14, 2.88±0.58 and 2.36±0.42 respectively for mean number of pods per peduncle. The mean number of locules per pod of the controls recorded the lowest mean value (14.17±0.13) whereas the test materials recorded the highest mean value of 15.17±0.20 with a grand mean of 14.54±0.11. This finding contrast that of Kouam *et al.* (2018) who reported a grand mean of 17.78±1.36 for mean number of locules per pod in their cowpea accessions. The differences may be due to genotype differences or sample sizes studied. The mean number of seeds per pod was lowest in the controls (10.4±0.15) while the test materials recorded the highest mean value of 12.46±0.2 compared to a grand mean of 11.15±0.12. This current findings are at variance with the reports of the work carried out by Walle *et al.* (2019), Kouam *et al.* (2018) and Lazaridi *et al* (2017), who reported a grand mean of 12.74±1.14 mm, 16.60±1.63 mm, 10.23±1.59 mm respectively for mean cowpea accessions. The mean weight of 100 seeds of the controls recorded a mean value of 11.07±0.08 g lower than the test materials with a mean value of 15.56±0.08 g, and lower than the grand mean of 13.65±0.08. The results is in contrast with those of Walle *et al.* (2019), Kouam *et al.* (2018) Bozokalfa *et al.* (2017) and Musvosvi (2009) who reported a grand mean of 16.47±3.07 g, 14.29 g, 296.25 g (1000 seed weight) and 23.5 g respectively for mean seed weight. Again, Walle *et al.* (2019) and Kouam *et al.* (2018) and Musvosvi (2009) reported respective seed yields of 3013.8±75.20 g h^{-1} and 1028.51 g h^{-1} which was at variance with this study which reported a grand mean for seed yield as 136.50±0.80 kg h^{-1}. The differences in the variability identified in this study and several works compared for various traits may be due to differences in the following; cowpea genotype, sample size, environmental conditions and soil and sensitivity of statistical analysis used.

5.3 Variability in phytochemical traits

5.3.1 Flavonoids

In the present study, the mean concentration for gallic acid was 0.23±0.02 mg/ml. Similarly, Alidu *et al.* (2020), who worked on 48 cowpea recombinant inbred lines reported a mean gallic concentration value of 0.23 mg/ml. This result is at variance with the work done by Mensah (2017) who reported a grand mean of 54.69±2.34 mg/ml for mean gallic acid concentration in 42 cowpea accessions. The results from the present study showed a mean vanillic acid concentration of 0.47±0.02 mg/ml. This is in contrast with the work of Alidu *et al.* (2020) and Mensah (2017) who reported 0.14 mg/ml and 35.52±7.39 mg/ml for mean vanillic acid concentration. Alidu *et al.* (2020) and Mensah (2017) reported 22.49±10.03 mg/ml and 0.17 mg/ml respectively for mean p-coumaric acid. These varied from the findings of this study viz:

0.62±0.26 mg/ml, 1.03±0.32 mg/ml and 0.72±0.04 in controls, test materials and entire population respectively. Again, for the flavonoids, Alidu *et al.* (2020) and Mensah (2017) reported the means 0.07 mg/ml and 227.44±46.01 mg/ml for rutin and 0.57 mg/ml and114.286±5.584 mg/ml for quercetin respectively. The results from these studies contradict the results of this current study which reported a mean concentrations of 14.39±0.16 mg/ml for rutin and 2.10±0.02 mg/ml for quercetin. .

The difference in mean concentrations of polyphenolic compounds in this present study and the above mentioned authours may be mainly due to differences in cowpea genotype, sample size and laboratory procedures.

5.3.2 Amino acids

In the present study, high variability was noted among the amino acids. The results showed that the mean value for L-histidine was 3.14±0.38 ppb which was much higher than respective grand mean values of 3100 ppb and 3.1±0.03 ppb reported by Frota *et al* (2017) and Elharadallou *et al.* (2015) from the study of cowpea. Results of the current study showed a mean value of 0.15±0.09 ppb for L-lysine which is lower than the mean value of 4.28 ppb reported by Elharadallou *et al.* (2015) and 6800 ppb reported by Frota *et al* (2017) on the same trait in cowpea. Mean iso-leucine concentration of the controls was the lowest (1.78±0.07 ppb) whereas the test materials recorded the highest mean value of 5.72±0.58 ppb and a grandmean of 3.96±0.33 ppb. This is in contrast with the works of Frota *et al.* (2017) and Elharadallou *et al.* (2015) who reported a grand mean of 4.5±0.03 ppb and 4300 ppb respectively. Frota *et al* (2017) and Elharadallou *et al.* (2015) reported grand means of 4300 ppb and 1.58 ppb respectively for leucine concentration which contradicts the grand mean of 3.79±0.48 ppb obtained in the current study. The test materials recorded higher mean value of 102.92±3.85 ppb than the controls which had a mean of 49.63±1.54 ppb with grand mean of 79.11±2.50 ppb. This finding is at variance with the findings of Frota *et al.* (2017) and Elhardallou *et al.* (2014) who reported a grand mean of 800 ppb and 2.2±0.04 ppb respectively for mean l-methionine concentration in cowpea accessions. Mean L-valine concentration was 5.75±0.53 ppb in the current study. Elharadallou *et al.* (2015) reported a mean value of 0.72 ppb for the same trait. The mean l-valine concentration of the controls in the current study showed the lowest mean value of 4.29±4.29 ppb. The test materials recorded the highest mean value 6.93±0.88 ppb. The result is in contrast with the work done by Elhardallou *et al.* (2015) who reported a grand mean of 5.0±0.06 ppb for mean l-valine concentration in cowpea accessions. The differences may be due to genotype differences and sample size. Results from this current study showed mean concentration for L-tryptophan which was 397.63±14.29 ppb compared to the study by Elhardallou *et al.* (2014) who reported a grand mean of 412.52±47.24 ppb for mean tryptophan concentration. Mean d-l-b-phenylalanine concentration of the controls recorded the lowest mean value of 33.80±8.71 ppb whereas test materials recorded the highest mean value of 30.78±1.32 ppb with a grand mean of 32.13±0.85. Our findings are in contrast with the report of Elhardallou *et al.* (2014) who recorded a grand mean of 38.27±5.38 ppb for mean d-l-b- phenylalanine concentration in some cowpea accessions. The variances may be due to sample size and genotype differences. In this current study, D-L-B-phenylalanine concentration recorded a mean value which is significantly higher than the mean concentration (2.00 ppb) reported for the same trait by Elharadallou *et al.* (2015), who also worked on cowpea. The variation in results may be due to the cowpea genotypes used for the study. In this study, the mean concentration of L-tyrosine was presented as 17.60±0.32ppb in the results. Differences in this current study and a study by Frota *et al.* (2017) and Elharadallou *et al.* (2015), reported a means of 1600 ppb and 3.33 ppb respectively for the same trait. The mean l-aspartic acid concentration of the controls was 70.47±5.37 which was lower than the test materials that contained 18.88±9.86 ppb over a grand mean of 47.42±3.20. On the other hand, Elharadallou *et al.* (2015) did not detect the same trait. Cystine was not detected in the current study contrary to what Elharadallou *et al.* (2015) reported. Results from the current study showed a mean concentration value of 0.15±0.09 for L-serine which is lower than the mean concentration of 0.89 ppb presented by Elharadallou *et al.* (2015) for the same trait in cowpea genotypes. The mean glycine concentration of the controls recorded the highest mean value of 1126.95±122.31 ppb while test materials recorded the lowest mean value of 519.60±91.25 ppb and a grand mean of 792.42±75.48 ppb. This result is in contrast with the findings of Elhardallou *et al.* (2014;2015) who reported a grand mean of 0.68±0.33 ppb for mean glycine concentration in cowpea accessions.

From the result of the analysis of amino acids and phytochemical contents of the cowpea materials studied, the cowpeas have a high potential to serve as complementary food sources of amino acids and polyphenolic compounds.

However, other authors have also found values of all the essential amino acids below the recommendation in different cowpea cultivars (Dos Anjos *et al.*, 2016; Elhardallou *et al.*, 2015); this difference is probably derived from genetic and agronomic factors that may influence the amino acid profile (Pandurangan *et al.*, 2015). Furthermore, the differences in amino acid concentration recorded in this present study and other researchers may be due to cowpea genotype differences, sample size and differences in laboratory procedures.

5.4 Chi-square test of association for qualitative traits

In the present study, the chi-square test of association between qualitative traits showed 125 total number of significant associations in the test materials whereas the controls only showed 3 significant associations. The overall population exhibited 162 significant associations. Growth habit recorded the highest significant association with 15 other traits in the test material. The high number of significant associations in the test materials used in this study suggest that the accessions can be a good source of qualitative traits in breeding programmes. Significant associations observed may be linked with the expression of many important qualitative traits. The discrepancies in the number of significant associations and differences in traits associated with the controls and test material may be due to differences in genotypes and sample size. The results may also suggest pleiotropy or genetic linkages of traits. Also, significant association within traits helps to detect the extent of morphological variation

(Zoryeku, 2017).

5.5 Interrelationships among traits and accessions

5.5.1 Multiple correspondence analysis of qualitative traits

To understand the extent of variability within the phenotypic classes of qualitative traits and accessions multiple correspondences and biplot analysis were employed. Terminal leaf shape, growth habit, pod curvature and raceme position mostly led to variation in the first dimension which accounted for inertia of 51.40% whereas variation in the second dimension was led by seed shape, seed coat colour and mature pod colour which accounted for 9.30% of inertia.

Thirteen farmer and consumer-preferred traits were used in the MCA plot. The traits considered were growth habit, flower, pod and seed characteristics. Asontem had a close relationship with crowder seed shape, red seed colour, 30^{o}-90^{o} erect pod attachment to peduncle, above canopy raceme position and semi-prostrate growth habit in the first quadrant of the MCA plot. Erect growth habit, globose seed shape, cream flowers, white and cream seed coats, smooth to rough seed coat texture, globose and rhomboid seed shapes had a close relationship with Wang Kae, Padituya and Kirkhouse in the fourth quadrant. Straw mature pod colour, very small eye pattern and white flowers showed a very close relationship with only UG55 in quadrant 3. The majority of the test materials were scattered in the second quadrant which showed strong similarities with the majority of the phenotypic classes in the 2^{nd} quadrant. This implies that the distribution of phenotypic classes among qualitative traits was dominant in the test material. This further indicates that accessions within the test material may be a good source to locate preferred qualitative traits.

UG1 and UG81 were outliers and had a distant relationship with the majority of the phenotypic classes of the selected traits. This suggests that these accessions may not be a good source of qualitative traits of particular interest for both farmers and consumers. The biplot showed that accessions grouped very close to the centre of origin showed strong similarities with most of the vegetative traits. A large deviation from the centre of origin was observed in mature pod colour, seed coat colour and immature pod pigmentation. Asontem, Wang Kae and UG28 were similar for testa texture and stem colour. Genotypes allocated in particular quadrants were similar for the traits in that same quadrant. Moreover, the scattered plot showed that the genotypes were distributed in all four quadrants. Cowpea breeders may find this information useful to identify the presence of genetic variation within the tested cowpea genotypes and to select donor parents for specific traits.. Genotypes overlapping in the two principal axes have similar phenotypic expression of the traits. The loading plot indicates the similarity and differences between these 18 traits. In the biplot, the traits found near to the origin (x, y) have smaller loading and had little influence, whereas the traits far from the origin have higher loading and greater influence in this classification. Furthermore, genotypes classified using quantitative traits were explained by the first two dimensions. Genotypes close and overlapping on the loading plot showed that the genotypes had similar characteristics and were found near the origin, whereas, the genotypes far apart from each other and distant from the origin are genetically diverse for qualitative traits. This information can also be useful in selecting parents for cowpea breeding programme.

5.5.2 Correlation and forward regression analysis

Seventy-seven significant what? and 176 associations were observed between morphological traits in test and controls respectively. Eighty significant associations were observed between phytochemical traits only in the test materials whereas 90 significant associations were observed in the controls. Association between morphological and phytochemical traits recorded 34 and 271 significant associations in the test and breeder line respectively. From the results, it has been observed that controls showed higher number of inter and intra associations between traits. This may suggest that the controls used in this study are a good source of traits identification in breeding programmes. Furthermore, the study revealed that yield had a positive and significant correlation with pod length, pod width (mm) number of locules, seed length, seed width, percent seed aborted and seed weight for the entire population. This was at variance with the report of Sabale *et al*. (2019) from the correlation analysis of 12 morphological traits in 23 F_2 genotypes that for seed yield also had a positive significant correlation with number of peduncles per plant, number of pods per peduncle and number of pods per plant. Sabale *et al*. (2019) also observed positive significant association between yield and seed weight and pod length which was similar to what was observed in the present study. In the present study, the results showed significant correlations among the polyphenolic compounds in both test and controls as well as entire population. As mentioned earlier, controls had more significant associations between all the phytochemical studied as compared to the controls. This suggests that the controls used in this study are a good source for phytochemical traits identification in breeding programmes. However, associations between and within groups of phenols and flavonoids for the entire population were significant. These findings are in line with the study by Alidu *et al*. (2020) who observed strong correlations among phenolic acids and flavonoids. The present study also showed more significant correlations for amino acids in the controls than in the test materials which showed few amino acids with significant correlations. This difference may be due to the small sample size of the controls compared to the test materials. Yield was positive and significantly associated with gallic acid, rutin, quercetin, l-serine, l-histidine, l-aspartic acid, l-valine, l-methionine and l-tryptophan. Correlation analysis shows the association pattern of different yield characters to seed yield (Lesly, 2005). Genetic associations between plant characters are usually as a result of pleiotropy or linkage (Horland, 1939) or due to environmental factors (Walle *et al*., 2018). The result may also suggest pleiotropy or genetic linkages of traits. Zoryeku (2017), indicated that significant correlation within traits helps to detect the extent of morphological and phytochemical variation.

The results revealed that significant improvement in any of these characters will indirectly increase seed yield in cowpea. Therefore, these traits can be used in selection programmes for cowpea improvement. According to Grafius (1959), increasing total yield would be made easier by selecting for components because components are more often easily inherited than total yield itself. Correlation studies enable the breeder to understand the mutual component characters on which selection can be based for genetic improvement. Many economically important traits of plants, usually, are related one to another in one or several ways. Various workers studied the relationships between different traits in different crops such as soybean (Adebisi *et al.*, 2001), cassava (Varma and Rai, 1993), sweetpotato (Islam *et al.*, 2002; Stathers *et al*, 2003; Afuape and Nwachukwu, 2005, Tsegaye *et al.*, 2006).

In the present study, the forward selection multiple regression analysis revealed that the underlying determinant of yield was least influenced by growth and vegetative traits in the test materials, controls and entire population with contributions of 7.94%, 14.31% and 4.01% respectively. Although, the contribution of growth and vegetative components were low plant height influenced yield significantly in the test material, controls and entire population. Yield and yield-related components contributed significantly to the yield explaining 100% of variation with pod length, pod width, seed length, seed width and seed thickness being the major traits that influenced yield in the test materials. In contrast, yield in controls were significantly influenced by lobe length, number of locules, number of seeds per pod and seed width which contributed to 36.67%. In comparison, yield in the test materials were highly influenced by important yield components than the controls.

However, within the controls phytochemical traits had a significant influence in underlying variation to yield as compared to the test materials. A 21.89% contribution was obsevred in the breeder line compared to the test materials 12.29% contribution. Gallic acid, vanillic acid and glycine were the lead contributors of variation in yield to variation in the breeder line whiles vanillic acid, p-coumaric acid, l-histidine, l-lysine and iso leucine were discovered as contributors to yield in the controls. This may suggest that breeding programmes for high yield and important yield traits such as pod length, pod width, seed length, seed width and seed thickness should be explored within the test materials in this study. On the other hand, cowpea breeding programmes for high yield and phytochemical traits may select phytochemical traits such as gallic acid, vanillic acid and glycine since they were the lead contributors of variation in yield with respect to variation in the breeder line whiles vanillic acid, p-coumaric acid, l-histidine, l-lysine and iso leucine were the leading contributors to variation both test and controls.

5.5.3 Canonical variate analysis (CVA)

Canonical variates (CV) are linear combinations of the original measurements and are thus given as vector loadings for the original measurements. It is a tool used when it is of more interest to show differences between groups than between individuals (Labuschagne *et al.*, 2002). In this study, the 29 traits measured were comprised of ten growth and vegetative traits and 19 yield and yield-related components. The first five components of canonical variables accounted for 51.75% of total variation, Variation in the first CV was largely led by growth and vegetative traits mainly terminal leaf length (1.33) and leaf width (-1.60) which accounted for 17.19% whereas yield and yield related traits accounted for majority of variation in CV2 with number of locules and number of seeds per pod being predominant. The current findings are in contrast with Aremu *et al.* (2007) who worked on 31 cowpea accessions and evaluated

27 morphological traits sub grouped into 17 yield and yield-related traits and 10 vegetative traits. In their study, the first five CV accounted for 78.34% of total variation. Variation in the first CV accounted for 28.37% of total variation which was led by yield related traits thus seed

coat texture (0.61), seed coat colour (0.54) and number of seeds per pod (0.51) whereas the CV2 in their study contributed to 20.41% of total variance which was led by growth and vegetative traits as follows; length of branches (0.61) and number of branches (0.43). The differences observed in both studies may be attributed to differences in cowpea genotypes, sample size, environmental effects and traits measured in both studies, whereas Aremu *et al.* (2007) used both quantitative and qualitative characters this study only focused on quantitative traits. The application of canonical variate analysis in this study is to go a step beyond identifying the traits that most influenced the variability among the genotypes, but also to determine which group of the two traits were more responsible for the observed variability among the genotypes. This will help the breeder to know what group of traits to focus on more in his crop improvement plan as only few traits can be considered during breeding.

5.5.4 Principal component analysis & biplots

In the current study the first three principal components explained 30.34% of the total variation. This is in disagreement with the works of Udensi and Edu (2015), Lazaridi (2017), Aremu *et al*. (2017), Walle *et al.* (2019) who reported that the first three components accounted for 82.23%, 45.28 %, 40.48% and 49.2% of total variation respectively. The variance in the contribution of the first three principal components to total variation in this study and other authors maybe due to the differences in traits studied, sample size, cowpea genotypes and statistical analysis software used.

5.5.5 Cluster analysis

In this research work, the dendrograms of the 108 cowpea accessions were clustered into seven major groups based on morphological traits. However, in a similar study by Walle *et al*. (2019) who worked on 324 cowpea genotypes from Ethiopia six clusters were observed. The difference in the number of clusters could be due to the following: different sample size of cowpea genotypes used, differences in experimental location and differences in the type of cowpea genotypes used.

In the current research, the centroid distances between all clusters showed high divergence (P>0.05), indicating wide diversity among genotypes in the seven different clusters. The range of intra- and inter-cluster distance was 14.02 to 49.91 units to 14.20 to 52.53 units respectively. On the other hand, Walle *et al* (2019) observed a range of intra- and inter-cluster distance *et* between six clusters as 6.08 to 22.72 units and 17.37 to 41.62 units, respectively. Ahamed *al*. (2014) reported that the inter cluster distances were higher than the intra cluster distances. The differences in intra and inter cluster distances could be due to the following: different sample size of cowpea genotypes used, differences in experimental location and differences in the type of cowpea genotypes used.

The range of intra- and inter-cluster distance was 171.90 to 1026.33 units to 171.90 to 1125.75 units respectively. The cluster distances observed in the study indicates that the intra and inter cluster distances were more genetically divergent from each other. As per the inter-cluster distance, selection of parents for hybridization program among genotypes from diverse clusters (Cluster 3 and 6) would give novel recombinants for improvement of yield and yield -related components and phytochemical traits in cowpea.

5.6 Genetic components studies

In this study it was found that phenotypic variance was either greater than or equal to genotypic variance. Yield had both the highest phenotypic variance and genotypic variance. The estimated values of PCV and GCV were categorized by Robinson *et al.* (1951) and Khan *et al.* (2020), between 0 and 10% for low, 10–20% for intermediate and greater than (≥20%) for high. Broad sense heritability (h^2_b) was estimated using the formula given by Falconer (1983) and

Khan *et al.* (2020). According to Johnson *et al.*(1955) and Khan *et al.*(2020) , the heritability was categorized as between 0 and 30% for low, 30–60% for intermediate and greater than 60% for high. Genetic Advance (GA) (as a percentage of mean): was calculated with 5% selection intensity (K) following the method of Johnson *et al.* (1955). Genetic advance is categorized as between 0 and 10% for low, 10% to 20% for intermediate and more (>20%) than for high, following the formula given by Khan *et al.* (2020). K for constant also indicates the intensity of selection. According to Adewale *et al.* (2010), the rate is 2.06 at the point when the K is at 5%. Genetic Gain (%)=Estimated as genetic advance (GA)×100; it is also categorized (Johnson *et al.*, 1955; Johnson, 1998) as between (0 to 10%) for low, (10 to 20%) for intermediate and (≥20%) for high GA.

In a similar study of 42 cowpea accessions from Ethiopia, by Belay and Fischa (2020), seed yield had the highest phenotypic variance and genotypic variance among 8 traits further selection could be done considering the traits having GCV ≥ 20% (PSA, NSPP, SW and all phytochemical traits) which indicated a high degree of variability among these traits although the variation is due to the effect of additive genes. The lower GCV values (≤ 10%) in all the vegetative, yield and yield-related traits (SPS, LBL, NRPP, PDL, NAFF, DFF, D50F, APL, APW, NPLNT, PPDN, LN, DFMP, D50MP, SL, ST, SWGT and YLD) indicated the limited chance of selection based on respective traits due to the effect of environment on their phenotypic expression.

The relative difference (RD) is the ratio of GCV and PCV. In this study the estimated RD values among morphological traits varied from 22.75% (percent seed abortion) to 90.38% for days to germination, whereas for phytochemical traits RD ranged from 0.00% (l-lysine, l- aspartic acid and l-leucine) to 9.12% (dlb-phenylalanine). Relatively low difference value between GCV and PCV recorded for percent seed abortion (22.75%), seed length (24.18%), seed width (30.99%), seed thickness (33.82%) and all phytochemical traits suggests that the variation present among the traits may be due to the effect of a gene and have a better response to direct selection. On the other hand, the traits with a higher difference in between their PCV and GCV values indicated the wider genetic variability due to environmental effects and the suitability for direct selection for the improvement of traits.

The values of heritability in broad sense were observed in the current study was moderate for most of the morphological traits evaluated which ranged from 0.93% (days to germination) to 57.52% (percent seed abortion). Very high (≥ 80%) heritability was measured for all phytochemical traits this is an indication of limited environmental effect. Important yield and yield-related components such as D50F, PSA, DFMP, D50MP, NSPP, SL, SW, ST SWGT and YLD showed heritability below 60 % i.e. medium heritability. In the literature, Padi (2008) and Alidu (2013) reporeted that heritability in seed yield was low. This observation by the two authors was further confirmed in the present study which reported low heritabilty (<20%) for seed weight and yield. In contrast, Inuwa *et al* in their genetic component analysis using 20 morphological quantitative traits in 94 cowpea accessions from Nigeria reported broad sense heritability ranged from 5.2% (pod weight) to 66.4% (100 seed weight). This study also varied with what Belay and Fischa (2020) reported, who observed high heritability which ranged from 68.01% (number of seeds per pod) to 99.98% (seed yield). Re-cast for clarity!

For morphological traits, percent seed abortion (103.03%) had topmost genetic advance (as percentage mean) value (≥ 20%) or genetic gain while the lowest had (0.30%) for lobe length (LBL).With respect to phytochemical traits, genetic advance (as percentage mean) value range from 45.41% (Rutin) to 2408.43% (l-lysine) In this study, most of the yield contributing traits showed moderate heritability with genetic advance (≥ 20%). However, phytochemical traits showed very high heritability with high genetic advances. The results in this study is at variance with what Belay and Fischa (2020) reported for genetic advance (as percentage mean) which ranged from 100% (seed yield) to 13.14% (days to maturity).

Consideration of higher value of genotypic coefficient of variation along with higher heritability and genetic advance is the powerful tools of selection for crop improvement than the consideration of individual genetic matrix or measuring unit. However, these traits were governed by additive genes having a limited response to the environment and suggestively notable for the selection procedure.

5.7 Ranking and selection of superior cowpea accessions based on yield and yield components

5.7.1 Selection based on rank summation index(RSI)

The RSI method has been used by other workers to select best yielding crop genotypes. Your results should be discussed first before comparing with similar studies done elsewhere. For instance, Khan *et al* (2021) and Onwubiko *et al.* (2019) used it in the selection of Bambara groundnut accessions. Ajala *et al.*(1995) and Okoli (2021) also used in maize selection. In the current study, based on the lowest RSI scores, the best performing accessions with high yield potential among the populations evaluated clustered as follows: accessions UG84, UG69 and UG36 belonged to Cluster 4, UG24, UG44 and UG47 belonged to Cluster 5 and UG66 and UG70 belonged to Clusters 6 and 7 respectively. The worst performers with low yield values also clustered as follows: UG89 and 62 belonged to Cluster 1 and UG20 belonged to Cluster 2. Based on the RSI method the best performing accessions, with reference to phytochemical traits were: UG84, UG24, UG44, UG69, UG47, UG14, UG70, UG66, UG36, UG102, UG97, UG19, WANG KAE, UG31 and UG80.

5.7.2 Selection based on contrast analysis

In the present study, the contrast analysis of marginal linear revealed accessions that showed high and significant perfomance for the traits studied were confirmed by the cluster analysis, bipolot and rank summation index. For instance, UG77 and UG98 showed the least mean days to germination than the grand mean. Days to the first flower, days to 50% flowering, days to first mature pod and days to 50% mature pod observed in accession UG1 recorded the least mean significant values for the respective traits compared to the grand mean value. This performance of UG1 as revealed by the contrast analysis can also be confirmed in the Cluster analysis which grouped UG1 in Cluster 3 with was associated with earliness. Another example is the high mean performance of UG14 which was further confirmed by the presence of this accession belonging to Cluster 5, the highest performing cluster in terms of polyphenolic compound concentration. Tryptophan showed significantly highest level in Wang Kae, UG24, UG37, UG17 compared to the grandmean value. The cluster analysis confirmed that these accessions formed a distinct group and the mean concentration for tryptophan was the highest in the cluster formed (Cluster 3). The current research used a novel measure of the generalized linear model prediction method for contrast analysis. The post hoc? of contrast analysis helped to identify accessions in which important traits were significantly higher than the grand mean. This may be an effective tool in the selection of superior genotypes in future breeding programs and complements other multivariate analysis methods used in this study.

CHAPTER SIX

CONCLUSION & RECOMMENDATIONS

6.1 Conclusion

Different classes of qualitative traits were observed for the test materials, controls and combined materials in the frequency distribution. This study showed variation among the cowpea genotypes used based on the qualitative and quantitative traits. It also indicated the presence of phytochemicals in the cowpea seeds as they serve as good sources of protein and other nutrients. Almost all the cowpea genotypes contained the various amino acids with variations in concentrations, except for glycine, l-histidine, trans-4-hydroxy-l-proline, d-l- threonine, l-threonine, d-proline and l-l-lysine, which was found in one cowpea accession. The cowpea test materials recorded the highest amino acid concentrations for l-cysteine and d-l-b-phenylalanine, with significant differences between the test materials and the controls. It must also be highlighted that there was a significant difference between the flavonoid contents of the test materials and controls, with the controls recording the highest concentrations for both flavonoid compounds (quercetin and rutin). Hence, the extent of agro-morphological and phytochemical variability existing among cowpea accessions was evaluated.

The Chi-square test of association indicated a high number of significant associations between the qualitative traits of the cowpea genotypes which shows the dependence of one trait on the other. The study revealed strong and significant correlations between the quantitative traits of the cowpea accessions, which also shows the dependency relationships among the traits. Yield and yield components influenced the expression of yield traits in the test material more than in the controls. Phytochemical traits also contributed to the expression of yield in the entire population. The principal component and biplot showed that most of the traits and accessions co-existed in the center of origin which demonstrated inter-relationship. The seven and six clusters formed under the quantitative morphological traits and phytochemicals respectively showed the relationship among the cowpea genotypes based on the traits. This points out that the clustered traits may be expressed by particular or similar genes. The relationships existing between growth and vegetative, yield and yield-related, and phytochemical traits was established.

High heritability was more frequent in the phytochemicals compared to the morphological quantitative traits. Eleven of the phytochemical traits fell between medium to high groups (> 40) of classification. The genetic advance was low in the morphological traits as compared to phytochemical traits. Therefore, genotypic and phenotypic variances and heritability was estimated for agro- morphological and phytochemical traits.

Based on the lowest rank summation scores, the 10 best-performing accessions with high yield potential among the population evaluated were UG84, UG24, UG44, UG69, UG47, UG14, UG70, UG66, UG36, UG102 while the entries UG89, UG62 and UG20 were the worst performers. Based on phytochemical traits the best performing accession were UG84, UG24, UG44, UG69, UG47, UG14, UG70, UG66, UG36, UG102, UG97, UG19, Wang Kae, UG31 and UG80. The marginal analysis revealed that no accession was significantly higher in yield than the overall mean. Accessions were ranked and selected for high yield and yield-related traits and high phytochemical traits using rank summation index and marginal analysis.

6.2 Recommendation

1. More qualitative and quantitative traits such minerals, crude protein relating to yield should be used in further studies to check the seed yielding ability and enhanced nutritional value of the genotypes.

2. Molecular studies need to be carried out to estimate the genetic diversity among the cowpea genotypes and locate important traits.

3. Studies should be carried out to evaluate the cowpea genotypes over different locations and specific conditions to access yield stability

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APPENDIX

Appendix 1: Source populations for the 4 pure lines (control), 56 inbred lines and 43 accessions used in this study

ID	Label	Genetic Background of Source	Source
Control			
Asontem	Controls	Pure lines	SARI
Kirkhouse	Controls	Pure lines	SARI
Padi-Tuya	Controls	Pure lines	SARI
Wang Kae	Controls	Pure lines	SARI
Test materials			
UG1	F4GW LINE1#2	Inbred lines	DPEB
UG2	F2G012#6 LINE129	Inbred lines	DPEB
UG3	F2RG012#63 LINE 129	Inbred lines	DPEB
UG4	F3(GW) #R4 FAMILY 7	Inbred lines	DPEB
UG5	F3(GW) #7 FAMILY R4	Inbred lines	DPEB
UG6	F2RG012#7 LINE129	Inbred lines	DPEB
UG7	F2RG012#6C LINE 129	Inbred lines	DPEB
UG8	F2RG012#12 LINE129	Inbred lines	DPEB
UG9	F2RG012#2 LINE129	Inbred lines	DPEB
UG10	F2RG012#5A LINE129	Inbred lines	DPEB
UG11	F3(GW)R7 FAMILY 7	Inbred lines	DPEB
UG12	F3(GW)1#7 FAMILY 7	Inbred lines	DPEB
UG13	F2RG012#5B LINE129	Inbred lines	DPEB
UG14	F2RG012#10 LINE129	Inbred lines	DPEB
UG15	F3(GW)TFS	Inbred lines	DPEB
UG16	F2RG012H8 LINE129	Inbred lines	DPEB
UG17	F3(GW)R15	Inbred lines	DPEB
UG18	F3(GW)Z#7 FAMILY7	Inbred lines	DPEB
UG19	F3(GW)R5 FAMILY7	Inbred lines	DPEB
UG20	F4(GW)#4 LINE2	Inbred lines	DPEB
UG21	F4(GW)TFS	Inbred lines	DPEB
UG22	F3(GW)TFS	Inbred lines	DPEB
UG23	GWF1#3 51DAP	Inbred lines	DPEB
UG24	GRP1#3 52DAP	DPEB accessions	DPEB
UG25	F2RG012#1 LINE129	Inbred lines	DPEB
UG26	CONTROL 44	DPEB accessions	DPEB
UG27	GRP6#3 51DAP	DPEB accessions	DPEB
UG28	GRP6#1 52DAP	DPEB accessions	DPEB
UG29	BLACKSEED	DPEB accessions	DPEB
UG30	AS007#10 LINE98	DPEB accessions	DPEB
UG31	AS003#2 LINE110	DPEB accessions	DPEB
UG32	AS009#13 LINE98	DPEB accessions	DPEB
UG33	GOLDEN EYE	DPEB accessions	DPEB
UG34	BOTN01	DPEB accessions	DPEB
UG35	AS004#19 LINE95	DPEB accessions	DPEB
UG36	GRP5#8 68	DPEB accessions	DPEB
UG37	BLACKEYE1	DPEB accessions	DPEB
UG38	BLACKEYE2	DPEB accessions	DPEB
UG39	BLACKEYE3	DPEB accessions	DPEB
UG40	BLACKEYE4	DPEB accessions	DPEB
UG41	BLACKEYE5	DPEB accessions	DPEB
UG42	BLACKEYE6	DPEB accessions	DPEB
UG43	BLACKEYE7	DPEB accessions	DPEB

DPEB= Department of Plant and Environmental Biology, SARI= Savanna Agricultural Research Institute

Appendix 1 (Cont'd)

ID	Label	Genetic Background of Source	Source
UG44	BLACKEYE8	DPEB accessions	DPEB
UG45	BLACK AND WHITE MOTTLED (1)	DPEB accessions	DPEB
UG46	BLACKEYE9	DPEB accessions	DPEB
UG47	BLACK AND WHITE MOTTLED (2)	DPEB accessions	DPEB
UG48	BLACKEYE10	DPEB accessions	DPEB
UG49	BLACKEYE11	DPEB accessions	DPEB
UG50	BLACKEYE12	DPEB accessions	DPEB
UG51	BLACKEYE13	DPEB accessions	DPEB
UG52	BLACKEYE14	DPEB accessions	DPEB
UG53	BLACKEYE15	DPEB accessions	DPEB
UG54	F2RG007#12 LINE127	Inbred lines	DPEB
UG55	FG2RG009#4 LINE132	Inbred lines	DPEB
UG56	FG2RG009#6 LINE132	Inbred lines	DPEB
UG57	FG2RG007#6 LINE127	Inbred lines	DPEB
UG58	FG2RG009#3 LINE132	Inbred lines	DPEB
UG59	F2RG009 Line132 seed coat flesh, seed size Golinga	Inbred lines	DPEB
UG60	F2RG007#9 LINE 127	Inbred lines	DPEB
UG61	F2RG005#8 LINE 21	Inbred lines	DPEB
UG62	F2RG004#6 LINE125	Inbred lines	DPEB
UG63	AS009#12 LINE98	Inbred lines	DPEB
UG64	F2 (RXG) LINE 13	Inbred lines	DPEB
UG65	F2RG005#8 LINE 9	Inbred lines	DPEB
UG67	F2RG0074#2	Inbred lines	DPEB
UG68	F2RG007 LINE127	Inbred lines	DPEB
UG69	F2RG006 LINE11	Inbred lines	DPEB
UG70	F2RG005#21 LINE21	Inbred lines	DPEB
UG71	F2 (RXG) LINE 13B	Inbred lines	DPEB
UG72	F2RG004#13 LINE125	Inbred lines	DPEB
UG73	F2RG011#6 LINE124	Inbred lines	DPEB
UG74	F2RG004#1 LINE125	Inbred lines	DPEB
UG75	F2RG007#14B LINE127	Inbred lines	DPEB
UG76	F2RG004#4 LINE124	Inbred lines	DPEB
UG77	F2RG005#9 Line21 seed mottled seed size red	Inbred lines	DPEB
UG78	F2RG005#11 LINE21 seed coat flesh seed size Golinga	Inbred lines	DPEB
UG79	F2(RXG) LINE 12	Inbred lines	DPEB
UG80	F2RGW5#2 LINE21 SC dark motteled seed size red	Inbred lines	DPEB
UG81	F2RG011#3 Line124 seed coat colour flesh seed size Golinga	Inbred lines	DPEB
UG82	COLMUT40-01#10 line6 seed coat brown molles	Inbred lines	DPEB
UG83	F2RG013 LINE15 seed coat brown mottled seed size red	Inbred lines	DPEB
UG84	F2RG009#132 line 10 seed coat color red seed size Golinga	Inbred lines	DPEB
UG85	F2RG005#10 line21 seedcoat red motteled seed size red	Inbred lines	DPEB
UG86	BOTN111 RED	DPEB accessions	DPEB
UG87	F2RG005#12 line21 seed coat flesh seed size Golinga	Inbred lines	DPEB
UG88	F2RG010 line6 seed coat mottled seed size Golinga	Inbred lines	DPEB
UG89	F2RG004#9 line 125 seed coat mottled seed size golinga	Inbred lines	DPEB
UG90	F2(RXG) seed coat mottled seed size red	Inbred lines	DPEB
UG91	Parents red seed coat blackeyed	DPEB accessions	DPEB
UG92	KK blackeyed	DPEB accessions	DPEB
UG93	Unnumbered	DPEB accessions	DPEB
UG94	KK blackeyed	DPEB accessions	DPEB
UG95	Blackeyed	DPEB accessions	DPEB
UG96	Unnumbered	DPEB accessions	DPEB
UG97	Black eyed	DPEB accessions	DPEB
UG98	KK black eyed	DPEB accessions	DPEB

DPEB= Department of Plant and Environmental Biology, SARI= Savanna Agricultural Research Institute

Appendix 1 (Cont'd)

ID	Label	Genetic Background of Source	Source
UG99	L22 F4	DPEB accessions	DPEB
UG100	Unnumbered	DPEB accessions	DPEB
UG101	KK blackeyed	DPEB accessions	DPEB
UG102	JJ blackeyed	DPEB accessions	DPEB
UG103	JJ blackeyed	DPEB accessions	DPEB
UG104	Unnumbered	DPEB accessions	DPEB

DPEB= Department of Plant and Environmental Biology, SARI= Savanna Agricultural Research Institute

Appendix 2: Multiple correspondence analysis of morphological qualitative traits and 108 cowpea accessions showing mass , quality and %inertia of overall dimensions and coordinates, square correlations and %inertia for dimensions 1 and 2

Traits	Classes	Overall dimensions			Dimension 1			Dimension 2		
		Mass	Quality	%Inertia	Coordinates	Square correlations	%Inertia	Coordinates	Square correlations	%Inertia
Stem colour	Extensive	0.00	0.60	0.50	0.98	0.30	0.30	1.68	0.30	0.80
	Intermediate	0.00	0.65	0.40	0.88	0.31	0.30	1.58	0.34	0.80
	Moderate	0.00	0.63	0.40	0.90	0.29	0.20	1.71	0.35	0.90
	None	0.00	0.74	0.60	0.91	0.33	0.40	1.74	0.41	1.30
	Solid	0.00	0.55	0.50	0.81	0.24	0.20	1.60	0.31	0.80
	Very slight	0.02	0.90	1.40	-0.76	0.41	1.20	-1.41	0.49	0.00
Branch colour	Extensive	0.00	0.69	0.40	0.90	0.42	0.30	1.23	0.27	0.60
	Intermediate	0.01	0.87	1.00	-1.39	0.73	1.40	1.04	0.14	0.80
	Moderate	0.00	0.40	0.40	0.84	0.36	0.30	0.51	0.04	0.10
	None	0.01	0.57	0.60	0.49	0.18	0.20	-1.25	0.39	1.30
	Solid	0.00	0.70	0.60	1.06	0.32	0.40	1.98	0.38	1.30
	Very slight	0.01	0.58	0.50	-0.45	0.19	0.20	-1.11	0.39	0.00
Petiole colour	Extensive	0.00	0.74	0.50	0.90	0.31	0.30	1.83	0.43	1.20
	Intermediate	0.00	0.70	0.40	0.94	0.40	0.30	1.41	0.30	0.80
	Moderate	0.01	0.27	0.70	0.52	0.12	0.20	-0.96	0.14	0.60
	None	0.01	0.52	1.00	0.49	0.12	0.20	-1.51	0.39	2.30
	Solid	0.00	0.71	0.50	1.01	0.32	0.30	1.94	0.39	1.00
	Very slight	0.01	0.94	1.80	-1.78	0.93	3.20	0.37	0.01	0.00
Plant pigmentation	Extensive	0.00	0.39	0.40	0.84	0.34	0.30	1.83	0.43	1.20
	Intermediate	0.01	0.50	0.80	0.36	0.07	0.10	1.41	0.30	0.80
	Moderate	0.00	0.71	0.50	1.04	0.34	0.30	-0.96	0.14	0.60
	None	0.00	0.74	0.40	0.85	0.29	0.20	-1.51	0.39	2.30
	Solid	0.01	0.43	0.40	0.75	0.37	0.30	1.94	0.39	1.00
	Very slight	0.01	0.75	1.40	-1.29	0.75	2.10	0.37	0.01	0.00
Leaf colour	Dark green	0.03	0.12	0.20	-0.12	0.12	0.00	0.02	0.00	0.00
	Intermediate green	0.01	0.02	0.40	-0.01	0.00	0.00	-0.22	0.02	0.00
	Pale green	0.00	0.29	0.50	0.84	0.28	0.30	0.32	0.01	0.00
Growth habit	Climbing	0.00	0.31	0.80	1.02	0.13	0.20	2.04	0.18	0.80
	Erect	0.00	0.59	0.90	0.10	0.00	0.00	-2.89	0.59	3.00
	Prostrate	0.01	0.69	0.80	0.90	0.27	0.40	1.95	0.42	1.80
	Semi-erect	0.02	0.74	0.60	0.59	0.65	0.80	-0.37	0.09	0.30
	Semi–prostrate	0.00	0.92	5.30	-4.69	0.90	9.30	1.21	0.02	0.00

Appendix 2 (Cont'd)

Traits	Classes	Overall dimensions			Dimension 1			Dimension 2		
		Mass	Quality	%Inertia	Coordinates	Square corrleations	%Inertia	Coordinates	Square corrleations	%Inertia
Twinning tendency	Extensive	0.00	0.12	0.30	1.43	0.05	0.00	3.10	0.08	0.10
	Intermediate	0.01	0.03	0.30	-0.03	0.00	0.00	0.37	0.03	0.10
	None	0.01	0.39	0.40	0.73	0.35	0.30	-0.42	0.04	0.10
	Pronounced	0.00	0.13	0.50	-0.09	0.00	0.00	1.04	0.13	0.40
	Slight	0.02	0.26	0.20	-0.17	0.21	0.10	-0.13	0.05	0.10
Plant hairiness	Glabrescent	0.01	0.56	0.70	0.67	0.48	0.60	-0.46	0.08	0.30
	Pubescent	0.02	0.81	1.00	-0.96	0.77	1.50	-0.38	0.04	0.20
	Short appressed hairs	0.01	0.86	0.80	0.92	0.36	0.60	1.84	0.50	0.00
Plant vigour	Intermediate	0.01	0.20	0.10	0.02	0.00	0.00	-0.36	0.20	0.10
	Non-vigorous	0.01	0.33	0.20	-0.30	0.22	0.10	0.36	0.11	0.10
	Very vigorous	0.01	0.43	0.20	0.34	0.32	0.10	-0.35	0.11	0.10
	Vigorous	0.01	0.16	0.20	-0.07	0.02	0.00	0.38	0.14	0.10
Terminal leaflet shape	Globose	0.02	0.41	0.90	0.48	0.21	0.40	-0.81	0.20	1.00
	Hastate	0.00	0.92	5.40	-4.77	0.90	9.50	1.21	0.02	0.60
	Sub-globose	0.02	0.50	1.00	0.72	0.45	0.90	0.43	0.05	0.30
	Sub-hastate	0.00	0.14	0.20	1.09	0.05	0.00	2.48	0.09	0.10
Leaf marking	Absent	0.02	0.65	0.70	0.72	0.65	0.80	0.03	0.00	0.00
	Present	0.02	0.65	0.50	-0.56	0.65	0.60	-0.02	0.00	0.00
Leaf texture	Cariaceous	0.00	0.16	0.40	-0.39	0.02	0.00	-1.74	0.14	0.30
	Intermediate	0.01	0.03	0.40	0.01	0.00	0.00	-0.26	0.03	0.10
	Membranous	0.03	0.09	0.10	0.01	0.00	0.00	0.16	0.09	0.10
Peduncle colour	Extensive	0.00	0.46	0.40	0.93	0.33	0.30	1.02	0.13	0.30
	Intermediate	0.01	0.50	0.40	0.78	0.38	0.30	0.77	0.13	0.30
	Moderate	0.00	0.54	0.50	0.92	0.39	0.30	0.98	0.15	0.40
	None	0.01	0.74	1.30	0.25	0.03	0.10	-2.07	0.70	5.30
	Solid	0.01	0.59	0.40	0.89	0.50	0.40	0.64	0.09	0.20
	Very slight	0.01	0.94	2.50	-2.22	0.82	3.90	1.48	0.12	1.70
Flower colour	Cream	0.00	0.20	0.60	0.49	0.06	0.10	-1.23	0.14	0.50
	Mauve	0.00	0.26	0.40	0.92	0.11	0.10	1.92	0.16	0.40
	Purple	0.01	0.67	0.80	1.00	0.29	0.50	2.00	0.39	1.80
	White	0.03	0.52	0.40	-0.33	0.38	0.30	-0.33	0.13	0.30
	Yellow	0.00	0.29	0.30	0.80	0.20	0.10	0.91	0.09	0.10

Appendix 2 (Cont'd)

Traits	Classes	Overall dimensions			Dimension 1			Dimension 2		
		Mass	Quality	%Inertia	Coordinates	Square correlations	%Inertia	Coordinates	Square correlations	%Inertia
Immature pod pigmentation	None	0.03	0.88	0.70	0.58	0.58	0.80	-0.72	0.30	1.30
	Pigmented sutures	0.00	0.09	0.10	1.24	0.04	0.00	2.47	0.05	0.00
	Pigmented tip	0.01	0.89	1.60	-1.32	0.63	2.00	1.44	0.26	2.40
	Pigmented valve, green sutures	0.00	0.20	0.30	0.86	0.09	0.00	1.74	0.12	0.20
Mature pod colour	Black	0.01	0.56	0.90	0.74	0.20	0.30	1.67	0.35	1.80
	Brown	0.00	0.23	0.40	0.96	0.15	0.10	1.19	0.08	0.20
	Dark tan	0.01	0.79	1.20	0.94	0.38	0.90	1.69	0.41	2.80
	Straw	0.02	0.89	1.50	-0.76	0.40	1.10	-1.43	0.49	4.10
Seed coat colour	Black	0.00	0.56	0.80	1.08	0.25	0.40	2.11	0.32	1.40
	Brown	0.00	0.17	0.40	0.72	0.07	0.10	1.46	0.10	0.20
	Cream	0.01	0.70	1.40	0.20	0.02	0.00	-2.27	0.69	5.70
	Cream with black patches	0.01	0.48	1.00	0.89	0.25	0.50	1.46	0.23	1.30
	Grey	0.00	0.38	0.70	1.14	0.16	0.20	2.31	0.22	0.90
	Purple	0.00	0.26	0.30	1.09	0.15	0.10	1.58	0.11	0.20
	Red	0.01	0.91	2.90	-2.51	0.83	4.60	1.36	0.08	1.40
	White	0.01	0.23	1.20	0.67	0.11	0.30	-1.22	0.12	0.90
Eye colour	Eye absent	0.04	0.29	0.00	-0.04	0.14	0.00	-0.07	0.15	0.00
	Gray	0.00	0.04	0.30	0.43	0.01	0.00	2.13	0.04	0.10
	Red	0.00	0.27	0.50	0.99	0.14	0.10	1.61	0.13	0.40
Raceme position	Above canopy	0.00	0.92	5.20	-4.54	0.90	9.00	1.27	0.02	0.70
	Throughout canopy	0.03	0.82	0.70	0.65	0.81	1.10	-0.15	0.01	0.10
	Upper canopy	0.01	0.15	0.40	0.43	0.14	0.10	-0.26	0.02	0.00
Pod attachment to peduncle	30-90degree from erect	0.01	0.92	3.30	-2.97	0.91	5.90	0.48	0.01	0.20
	Erect	0.00	0.06	0.20	-0.19	0.00	0.00	2.71	0.06	0.00
	Pendant	0.03	0.92	0.70	0.65	0.91	1.30	-0.11	0.01	0.00
Pod curvature	Curved	0.00	0.06	0.70	0.68	0.04	0.10	-0.69	0.02	0.10
	Slightly curved	0.03	0.87	0.70	0.61	0.86	1.20	-0.14	0.02	0.10
	Straight	0.00	0.92	5.40	-4.70	0.90	9.40	1.24	0.02	0.70
Pod wall thickness	Intermediate	0.01	0.09	0.20	-0.17	0.09	0.00	-0.02	0.00	0.00
	Thick	0.01	0.52	0.20	0.44	0.52	0.20	0.02	0.00	0.00
	Thin	0.01	0.20	0.20	-0.24	0.20	0.10	0.00	0.00	0.00
Seed crowding	Crowded	0.01	0.29	0.20	-0.34	0.28	0.10	0.13	0.01	0.00
	Extremely crowded	0.01	0.19	0.20	0.22	0.11	0.00	0.32	0.08	0.10
	Not crowded	0.01	0.05	0.20	0.12	0.04	0.00	0.10	0.01	0.00
	Semi–crowded	0.01	0.21	0.20	0.07	0.01	0.00	-0.48	0.20	0.20

Appendix 2 (Cont'd)

Categories	Classes	Overall dimensions			Dimension 1			Dimension 2		
		Mass	Quality	%Inertia	Coordinates	Square correlations	%Inertia	Coordinates	Square correlations	%Inertia
Splitting of testa	Absent	0.02	0.20	0.10	0.15	0.14	0.00	0.17	0.06	0.00
	Present	0.02	0.20	0.10	-0.12	0.14	0.00	-0.14	0.06	0.00
Seed shape	Crowder	0.01	0.92	4.70	-4.14	0.91	8.30	0.65	0.01	0.20
	Globose	0.01	0.72	2.10	0.03	0.00	0.00	-3.38	0.72	8.80
	Kidney	0.00	0.40	0.70	0.81	0.16	0.20	1.68	0.24	1.00
	Ovoid	0.01	0.66	0.90	0.97	0.33	0.60	1.63	0.32	1.70
	Rhomboid	0.02	0.50	0.90	0.74	0.45	0.80	0.44	0.05	0.30
Testa texture	Rough	0.01	0.62	1.00	0.97	0.27	0.50	1.93	0.35	1.90
	Rough to wrinkled	0.00	0.05	0.80	0.80	0.02	0.00	1.87	0.03	0.10
	Smooth	0.02	0.60	0.70	-0.61	0.53	0.70	0.37	0.07	0.30
	Smooth to rough	0.01	0.64	1.00	0.55	0.18	0.40	-1.50	0.46	2.70
Eye pattern	Holstein group	0.00	0.23	0.40	1.17	0.08	0.10	2.76	0.15	0.40
	Narrow eye	0.00	0.08	0.90	0.94	0.03	0.10	1.95	0.05	0.20
	Small eye	0.01	0.84	1.40	0.91	0.42	1.10	1.58	0.42	3.40
	Very small	0.02	0.89	1.00	-0.62	0.44	0.80	-1.08	0.46	2.60
Asontem		0.11	5.08	26.80	-4.61	4.92		1.59	0.15	
Kirkhouse		0.11	0.68	24.70	-0.05	0.00		-3.22	0.68	
Padi-Tuya		0.11	1.06	23.60	0.20	0.01		-3.89	1.05	
Wang Kae		0.11	0.58	23.60	0.23	0.01		-2.86	0.56	
UG1		0.01	0.14	25.90	1.85	0.04		5.80	0.10	
UG2		0.01	0.04	21.40	0.39	0.00		3.03	0.03	
UG3		0.01	0.04	27.40	1.45	0.02		2.50	0.02	
UG4		0.01	0.02	23.40	0.97	0.01		1.08	0.00	
UG5		0.01	0.05	26.90	1.27	0.02		3.34	0.03	
UG6		0.01	0.02	22.40	0.79	0.01		1.54	0.01	
UG7		0.01	0.01	23.90	0.44	0.00		1.19	0.01	
UG8		0.01	0.00	24.90	-0.14	0.00		1.12	0.00	
UG9		0.01	0.01	24.40	0.74	0.01		0.81	0.00	
UG10		0.01	0.00	25.40	0.12	0.00		0.80	0.00	
UG11		0.01	0.05	24.40	1.36	0.02		3.15	0.03	
UG12		0.01	0.06	26.40	1.58	0.03		3.52	0.04	
UG13		0.01	0.02	24.40	0.19	0.00		2.21	0.02	
UG14		0.01	0.03	23.90	0.82	0.01		2.59	0.02	

Appendix 2 (Cont'd)

Category	Mass	Quality	%inert	Coordinates	Square Correlation	Coordinates	Square Correlation
UG15	0.01	0.06	25.90	1.40	0.02	3.42	0.04
UG16	0.01	0.03	27.40	0.97	0.01	2.92	0.02
UG17	0.01	0.03	22.40	1.20	0.02	1.93	0.01
UG18	0.01	0.04	26.90	1.31	0.02	2.85	0.02
UG19	0.01	0.06	24.90	1.11	0.02	3.90	0.05
UG20	0.01	0.02	28.40	0.93	0.01	1.54	0.01
UG21	0.01	0.05	27.40	1.37	0.02	3.13	0.03
UG22	0.01	0.01	27.40	0.78	0.01	1.59	0.01
UG23	0.01	0.01	26.90	0.71	0.01	0.47	0.00
UG24	0.01	0.00	24.90	0.27	0.00	0.36	0.00
UG25	0.01	0.01	24.40	0.77	0.01	-0.21	0.00
UG26	0.01	0.00	25.90	0.04	0.00	1.00	0.00
UG27	0.01	0.02	26.40	1.27	0.02	-0.01	0.00
UG28	0.01	0.02	25.90	1.14	0.02	0.05	0.00
UG29	0.01	0.05	27.40	1.49	0.02	2.87	0.02
UG30	0.01	0.00	27.40	-0.29	0.00	0.80	0.00
UG31	0.01	0.02	26.40	0.09	0.00	2.43	0.02
UG32	0.01	0.02	27.40	0.86	0.01	1.88	0.01
UG33	0.01	0.01	27.90	0.28	0.00	2.14	0.01
UG34	0.01	0.01	26.40	0.85	0.01	0.91	0.00
UG35	0.01	0.01	29.40	1.11	0.01	0.55	0.00
UG36	0.01	0.02	27.40	0.93	0.01	2.18	0.01
UG37	0.01	0.01	27.40	0.72	0.01	0.88	0.00
UG38	0.01	0.02	26.40	1.15	0.02	1.46	0.01
UG39	0.01	0.02	26.40	0.87	0.01	1.45	0.01
UG40	0.01	0.03	27.90	1.19	0.02	2.63	0.02
UG41	0.01	0.02	26.40	1.13	0.01	1.51	0.01
UG42	0.01	0.02	26.40	1.17	0.02	1.53	0.01
UG43	0.01	0.02	26.40	0.95	0.01	1.74	0.01
UG44	0.01	0.03	26.90	0.99	0.01	2.65	0.02
UG45	0.01	0.01	28.40	0.80	0.01	-0.33	0.00
UG46	0.01	0.02	26.40	0.95	0.01	1.74	0.01
UG47	0.01	0.03	26.90	0.99	0.01	2.65	0.02
UG48	0.01	0.01	28.40	0.80	0.01	-0.33	0.00
UG49	0.01	0.02	27.40	0.92	0.01	1.74	0.01
UG50	0.01	0.03	26.90	1.20	0.02	1.90	0.01
UG51	0.01	0.01	27.90	0.65	0.00	0.78	0.00
UG52	0.01	0.01	27.90	0.63	0.00	0.69	0.00
UG53	0.01	0.00	29.40	0.39	0.00	0.49	0.00
UG54	0.00	0.01	28.30	0.72	0.00	0.97	0.00
UG55	0.01	0.01	26.90	-0.37	0.00	-1.50	0.01
UG56	0.01	0.02	27.40	1.12	0.01	1.35	0.01
UG57	0.01	0.02	25.40	1.11	0.01	0.34	0.00
UG58	0.01	0.01	26.90	1.08	0.01	-0.04	0.00
UG59	0.01	0.02	27.40	1.08	0.01	1.40	0.01
UG60	0.01	0.04	27.40	0.58	0.00	3.45	0.03
UG61	0.01	0.04	25.40	1.43	0.02	2.41	0.02
UG62	0.01	0.05	26.90	1.43	0.02	2.86	0.02
UG63	0.01	0.06	26.90	1.37	0.02	3.63	0.04
UG64	0.01	0.03	27.40	1.07	0.01	2.25	0.01
UG65	0.01	0.06	28.40	1.33	0.02	3.83	0.04
UG66	0.01	0.02	28.40	0.42	0.00	2.44	0.02
UG67	0.01	0.01	26.90	0.67	0.01	0.17	0.00
UG68	0.01	0.01	24.40	0.85	0.01	-0.40	0.00
UG69	0.01	0.00	23.90	0.25	0.00	0.84	0.00
UG70	0.01	0.03	27.90	0.48	0.00	3.26	0.03

Appendix 2 (Cont'd)

Category	Mass	Quality	%inert	Coordinates	Square Correlation	Coordinates	Square Correlation
UG71	0.01	0.05	25.90	0.66	0.01	3.87	0.05
UG72	0.01	0.03	26.40	0.48	0.00	2.82	0.02
UG73	0.01	0.02	25.40	1.19	0.02	1.18	0.00
UG74	0.00	0.02	27.10	1.48	0.02	1.89	0.01
UG75	0.01	0.04	25.90	1.44	0.02	2.52	0.02
UG76	0.01	0.02	26.90	0.53	0.00	2.46	0.02
UG77	0.01	0.04	27.40	1.24	0.02	2.74	0.02
UG78	0.01	0.07	26.90	1.39	0.02	4.04	0.05
UG79	0.01	0.01	26.90	0.99	0.01	0.29	0.00
UG80	0.01	0.05	23.40	1.25	0.02	3.11	0.03
UG81	0.01	0.09	27.40	1.65	0.03	4.49	0.06
UG82	0.01	0.05	27.40	1.12	0.01	3.51	0.04
UG83	0.01	0.02	25.90	0.89	0.01	1.57	0.01
UG84	0.00	0.02	24.90	0.80	0.01	2.37	0.01
UG85	0.01	0.04	23.40	0.99	0.01	2.82	0.03
UG86	0.01	0.02	26.90	0.99	0.01	1.58	0.01
UG87	0.01	0.04	27.40	1.45	0.02	2.28	0.02
UG88	0.01	0.02	24.90	0.36	0.00	2.34	0.02
UG89	0.01	0.01	26.40	0.68	0.01	0.18	0.00
UG91	0.01	0.02	24.90	0.93	0.01	2.11	0.01
UG92	0.01	0.01	26.90	0.66	0.01	0.42	0.00
UG93	0.01	0.01	27.40	0.72	0.01	1.44	0.01
UG94	0.01	0.00	26.90	0.30	0.00	-0.30	0.00
UG95	0.01	0.01	27.90	0.64	0.00	1.09	0.00
UG96	0.01	0.01	26.90	0.65	0.01	1.03	0.00
UG97	0.01	0.00	25.90	0.30	0.00	0.98	0.00
UG98	0.01	0.00	27.40	0.52	0.00	0.20	0.00
UG99	0.01	0.01	28.40	0.89	0.01	1.19	0.00
UG100	0.01	0.01	26.90	0.86	0.01	0.80	0.00
UG101	0.01	0.02	26.90	1.13	0.01	0.60	0.00
UG102	0.01	0.01	26.90	0.87	0.01	0.95	0.00
UG103	0.01	0.01	23.90	0.96	0.01	0.89	0.00
UG104	0.01	0.01	27.40	0.58	0.00	0.65	0.00

Appendix 3: Mean value of positive, strongly significant correlated yield and yield-related traits with yield and their rank summation index (RSI).

Accession	apl	rsi	apw	rsi	ln	rsi	psa	rsi	sl	rsi	sw	rsi	swgt	rsi	RSI=∑rsi	yld	yld rank
UG84	19.27	7	0.91	33	18.00	18	22.34	32	7.10	22	4.60	33	17.40	7	152	174.00	7
UG24	18.57	17	0.90	39	15.33	53	21.31	37	8.74	3	5.53	5	18.65	2	156	186.53	2
UG44	17.94	32	0.97	22	17.67	21	22.26	33	7.10	23	5.03	16	17.03	15	162	170.33	15
UG69	19.27	8	1.01	16	13.33	77	17.57	51	9.45	2	5.28	11	19.35	1	166	193.50	1
UG47	17.94	33	0.97	23	17.67	22	22.26	34	7.10	24	5.03	17	17.03	16	169	170.33	16
UG14	18.25	23	0.94	25	18.67	13	10.68	91	7.52	13	5.51	6	17.73	3	174	177.33	3
UG70	17.66	42	0.82	67	19.00	12	23.61	26	7.60	12	5.07	14	17.16	11	184	171.57	11
UG66	17.23	60	0.91	35	17.33	27	19.42	45	7.97	5	5.06	15	17.21	8	195	172.10	8
UG36	17.55	45	0.86	56	19.00	9	22.19	35	7.69	9	4.76	25	16.99	17	196	169.90	17
UG102	19.47	5	0.99	20	12.00	94	29.96	4	6.66	51	4.92	18	17.46	5	197	174.63	5
UG97	19.00	12	1.08	7	10.33	106	31.15	3	6.79	40	4.68	26	17.20	9	203	172.00	9
UG19	17.93	34	0.96	24	10.00	108	26.67	12	7.50	14	5.29	10	17.44	6	208	174.43	6
WANG KAE	17.92	35	0.90	38	13.14	81	66.86	1	11.14	1	7.42	1	15.67	62	219	156.67	62
UG31	16.35	82	0.88	46	18.33	16	29.61	6	7.35	17	4.77	24	16.18	33	224	161.83	33
UG80	18.35	22	1.19	1	20.00	5	16.98	56	6.46	62	4.22	55	16.44	28	229	164.37	28
UG95	19.47	6	1.18	3	13.00	82	11.79	83	6.96	32	4.49	40	17.47	4	250	174.70	4
UG56	15.60	95	0.89	45	14.00	71	26.47	13	7.94	6	5.86	3	16.87	18	251	168.67	18
UG75	19.05	10	0.87	51	17.33	29	20.67	42	6.46	60	4.42	46	16.76	20	258	167.60	20
UG30	15.76	91	0.91	37	19.33	7	29.13	7	7.03	26	4.66	28	15.64	63	259	156.43	63
UG4	17.84	37	1.00	17	14.67	64	11.72	84	7.69	10	4.52	37	17.05	13	262	170.50	13
UG6	18.61	15	0.92	30	20.67	2	17.30	54	6.63	52	3.82	83	16.30	29	265	163.00	29
UG25	18.92	14	0.88	47	17.67	24	15.64	63	6.77	41	4.07	63	16.68	22	274	166.83	22
UG77	18.98	13	0.91	34	14.00	70	24.99	20	6.91	33	3.82	84	16.65	23	277	166.53	23
UG71	17.54	46	0.90	40	17.33	28	24.55	21	6.83	37	4.01	69	15.99	45	286	159.93	45
UG79	16.62	76	1.02	15	15.33	51	24.37	22	6.89	34	4.49	41	15.93	49	288	159.27	48
UG2	19.22	9	0.99	19	16.00	44	18.68	48	6.60	54	3.62	92	16.49	27	293	164.90	27
UG38	18.44	18	1.03	13	13.67	73	12.96	76	7.64	11	3.42	95	16.65	24	310	166.47	24
UG92	20.52	3	1.08	8	16.67	37	9.72	97	6.28	69	3.72	89	17.05	14	317	170.50	14
UG37	17.68	40	0.92	31	17.33	26	10.32	95	6.19	73	4.85	21	16.21	31	317	162.07	31
UG63	17.34	53	0.83	62	19.00	10	23.61	25	6.68	48	4.02	68	15.78	54	320	157.80	54
UG103	17.32	54	0.81	75	16.67	39	28.79	8	5.91	88	5.15	13	15.97	46	323	159.73	46
UG61	17.82	38	0.92	32	15.00	60	21.66	36	6.44	63	4.21	57	16.02	39	325	160.20	39
UG74	18.36	21	1.03	14	11.67	99	14.95	67	6.46	61	4.50	39	16.54	26	327	165.43	26
UG29	16.69	75	0.84	60	14.33	67	25.56	17	6.42	65	5.33	8	16.10	35	327	161.03	35

apl = pod length (mm), apw =pod width (mm), ln number of locules, sl =seed length (mm), sw =seed width (mm), psa=percent seed aborted, swgt =seed weight (kg), yld = yield (kg ha^{-1}) RSI=Rank summation index.

Appendix 3 (Cont'd)

Accession	apl	rsi	apw	rsi	ln	rsi	psa	rsi	sl	rsi	sw	rsi	swgt	rsi	RSI=∑rsi	yld	yld rank
UG28	18.08	24	1.11	4	15.33	50	19.34	46	6.32	68	3.82	85	15.93	50	327	159.27	49
UG55	17.01	68	0.83	63	20.33	4	14.01	71	7.02	27	4.21	56	15.95	47	336	159.47	47
UG86	17.04	66	0.78	84	13.67	75	16.35	60	7.29	19	5.25	12	16.75	21	337	167.47	21
UG68	21.44	1	1.18	2	16.33	41	11.43	88	4.89	107	3.83	82	16.76	19	340	167.63	19
UG94	20.90	2	1.09	6	15.00	58	10.58	92	6.04	80	3.65	91	17.05	12	341	170.53	12
UG39	17.31	56	0.85	58	14.33	66	25.35	18	6.79	39	4.14	59	15.91	52	348	159.10	52
UG11	19.82	4	1.05	10	11.67	98	16.36	58	4.40	108	4.56	35	16.04	38	351	160.43	38
UG50	17.96	28	0.92	29	15.33	52	11.61	86	6.56	57	4.04	67	16.07	37	356	160.67	37
UG10	17.23	59	0.86	54	16.67	38	11.11	90	6.75	45	4.53	36	16.10	36	358	160.97	36
UG43	17.41	50	0.81	73	12.67	90	26.28	15	6.17	74	4.86	19	16.00	41	362	160.03	41
UG27	19.01	11	0.97	21	17.00	34	27.36	11	5.31	105	2.93	104	15.14	78	364	151.37	78
UG18	17.17	64	0.80	76	17.33	32	4.62	105	6.83	36	4.81	22	16.26	30	365	162.60	30
UG83	18.42	20	0.89	43	12.00	95	16.67	57	5.97	83	4.51	38	16.20	32	368	162.03	32
UG46	17.41	51	0.81	74	12.67	91	26.28	16	6.17	75	4.86	20	16.00	42	369	160.03	42
UG12	17.45	49	0.79	80	11.33	101	17.46	52	7.83	8	4.18	58	16.62	25	373	166.23	25
UG45	17.95	29	0.87	48	15.33	55	11.91	80	6.66	49	3.88	76	16.00	43	380	160.00	43
UG3	18.00	27	1.05	11	14.00	69	19.88	43	5.70	92	3.89	75	15.52	65	382	155.20	65
UG88	15.03	102	0.67	104	17.33	33	20.69	41	8.13	4	4.48	42	15.72	57	383	157.23	57
UG49	15.56	96	0.87	52	19.00	8	11.53	87	7.01	29	4.47	43	15.39	70	385	153.93	70
UG48	17.95	30	0.87	49	15.33	56	11.91	81	6.66	50	3.88	77	16.00	44	387	160.00	44
UG51	16.82	73	0.76	89	12.00	97	2.08	108	7.86	7	5.54	4	17.16	10	388	171.63	10
UG73	15.21	100	0.71	99	17.00	35	14.55	69	7.15	21	5.30	9	15.75	55	388	157.50	55
KIRKHOUSE	18.03	26	0.93	27	16.13	43	18.09	49	6.22	71	4.07	65	10.60	107	388	106.04	107
UG23	15.68	93	0.81	72	17.33	31	22.98	27	7.41	16	3.85	79	15.28	71	389	152.83	71
ASONTEM	17.16	65	0.83	64	16.95	36	8.73	101	7.44	15	6.19	2	11.00	106	389	110.01	106
UG41	16.35	80	0.80	78	13.67	74	17.07	55	7.10	25	4.66	27	15.92	51	390	159.23	51
UG33	15.63	94	0.80	77	15.67	48	28.73	9	6.60	55	4.60	34	15.21	73	390	152.13	73
UG58	17.28	57	1.00	18	10.33	107	24.11	23	6.50	59	3.99	70	15.70	60	394	157.00	60
UG91	17.94	31	0.89	42	15.33	54	24.11	24	6.19	72	3.09	99	15.22	72	394	152.20	72
UG21	18.04	25	0.77	86	14.67	65	15.60	64	5.96	84	4.61	31	16.01	40	395	160.13	40
UG100	16.94	69	0.74	92	18.67	15	11.80	82	6.79	38	4.25	52	15.74	56	404	157.43	56
UG59	17.34	52	0.73	97	14.00	72	27.78	10	6.76	43	3.94	73	15.72	58	405	157.20	58
UG53	17.32	55	1.05	12	18.00	17	16.35	59	5.81	89	3.29	96	14.87	83	411	148.67	83
UG26	17.49	47	0.86	53	15.00	61	4.55	106	6.15	76	4.65	30	15.93	48	421	159.27	50
UG34	16.40	79	0.93	28	18.67	14	16.27	61	5.99	82	3.92	74	14.86	84	422	148.57	84
UG57	17.65	43	0.85	57	13.33	78	17.44	53	6.97	31	3.11	98	15.55	64	424	155.50	64

apl = pod length (mm), apw =pod width (mm), ln number of locules, sl =seed length (mm), sw =seed width (mm), psa=percent seed aborted, swgt =seed weight (kg), yld = yield (kg ha^{-1})
RSI=Rank summation index

Appendix 3 (Cont'd)

Accession	apl	rsi	Apw	rsi	ln	rsi	psa	rsi	sl	rsi	sw	rsi	swgt	rsi	RSI=∑rsi	yld	yld rank
UG16	16.26	85	0.78	82	15.00	62	20.83	40	6.52	58	4.60	32	15.47	68	427	154.73	68
UG22	17.78	39	1.06	9	15.00	59	22.72	29	5.40	103	3.04	102	14.69	86	427	146.93	86
UG93	16.90	71	0.79	81	13.00	84	21.10	39	6.34	66	4.66	29	15.71	59	429	157.10	59
UG98	17.66	41	0.82	68	12.00	96	8.33	102	6.77	42	4.26	50	16.13	34	433	161.30	34
UG7	16.29	83	0.86	55	16.33	42	17.72	50	6.71	47	3.85	80	15.18	76	433	151.80	76
UG32	16.26	84	0.82	70	21.00	1	11.94	79	6.09	78	4.46	44	15.13	79	435	151.30	79
UG104	16.77	74	0.76	90	14.33	68	22.46	31	6.44	64	4.36	47	15.51	66	440	155.10	66
UG67	18.42	19	1.10	5	12.67	89	14.65	68	5.62	95	3.06	101	15.19	75	452	151.87	75
UG82	13.04	106	0.58	107	16.00	47	22.54	30	7.28	20	4.43	45	14.14	98	453	141.37	98
UG99	14.72	104	0.77	87	15.33	57	29.63	5	6.75	44	4.04	66	14.49	94	457	144.90	94
UG76	17.20	63	0.67	103	13.00	87	21.28	38	6.56	56	4.25	53	15.69	61	461	156.90	61
UG17	17.21	61	0.73	95	13.00	86	13.69	73	7.02	28	3.96	71	15.83	53	467	158.33	53
UG15	15.37	99	0.83	66	19.00	11	6.72	103	6.87	35	3.96	72	14.87	82	468	148.70	82
UG52	15.69	92	0.74	94	13.67	76	22.92	28	7.33	18	3.77	87	15.16	77	472	151.57	77
UG42	15.41	98	0.87	50	20.33	3	10.05	96	6.05	79	4.22	54	14.56	92	472	145.63	92
UG35	15.13	101	0.89	44	17.67	23	9.69	98	6.27	70	4.28	48	14.60	90	474	146.03	90
UG96	15.89	89	0.71	98	19.67	6	11.27	89	6.63	53	4.08	62	14.99	81	478	149.93	81
UG40	18.57	16	0.90	41	10.67	104	15.25	65	5.51	98	3.72	88	15.51	67	479	155.10	67
UG81	16.48	77	0.91	36	16.00	45	19.50	44	5.94	86	3.17	97	14.39	95	480	143.93	95
UG1	17.88	36	0.76	88	15.00	63	31.69	2	5.68	94	2.62	108	14.51	93	484	145.13	93
UG101	16.35	81	0.83	65	13.33	79	9.49	100	6.72	46	4.26	49	15.45	69	489	154.53	69
UG64	16.24	86	0.64	105	18.00	20	19.01	47	5.93	87	4.07	64	14.69	87	496	146.87	87
UG54	15.89	90	0.84	59	17.33	30	26.36	14	5.41	102	2.85	106	13.52	102	503	135.23	102
UG8	14.90	103	0.73	96	11.00	103	12.50	78	7.00	30	4.81	23	15.19	74	507	151.93	74
UG9	15.96	88	0.82	71	18.00	19	10.39	94	6.12	77	3.86	78	14.63	88	515	146.30	88
UG65	16.94	70	0.74	93	17.67	25	16.27	62	5.61	96	3.77	86	14.70	85	517	147.03	85
PADI-TUYA	17.25	58	0.84	61	11.10	102	13.99	72	6.33	67	4.25	51	6.82	108	519	68.19	108
UG13	17.57	44	0.78	83	13.33	80	15.00	66	5.76	91	3.70	90	15.08	80	534	150.80	80
UG87	12.74	107	0.62	106	16.67	40	13.03	75	5.54	97	5.36	7	13.50	103	535	134.97	103
UG72	14.49	105	0.67	102	16.00	46	25.04	19	5.44	101	3.85	81	13.39	104	558	133.87	104
UG60	15.99	87	0.93	26	11.33	100	11.67	85	5.11	106	3.49	93	13.84	100	597	138.37	100
UG78	16.43	78	0.79	79	12.33	93	9.52	99	5.44	99	4.11	61	14.58	91	600	145.83	91
UG5	16.83	72	0.82	69	13.00	83	5.09	104	5.79	90	3.48	94	14.62	89	601	146.17	89
UG85	17.03	67	0.78	85	15.67	49	10.40	93	5.32	104	2.81	107	13.98	99	604	139.83	99
UG90	17.49	48	0.69	100	12.67	92	13.68	74	5.44	100	2.88	105	14.29	97	616	142.90	97

apl = pod length (mm), apw =pod width (mm), ln number of locules, sl =seed length (mm), sw =seed width (mm), psa=percent seed aborted, swgt =seed weight (kg), yld = yield (kg ha^{-1}) RSI=Rank summation index

Appendix 3 (Cont'd)

Accession	apl	rsi	Apw	rsi	ln	rsi	psa	rsi	sl	rsi	sw	rsi	swgt	rsi	RSI=∑rsi	yld	yld rank
UG89	11.66	108	0.58	108	13.00	88	12.50	77	6.03	81	4.14	60	12.48	105	627	124.80	105
UG62	15.52	97	0.75	91	13.00	85	14.28	70	5.96	85	3.09	100	13.79	101	629	137.93	101
UG20	17.21	62	0.69	101	10.67	105	2.78	107	5.70	93	2.94	103	14.35	96	667	143.47	96

apl = pod length (mm), apw =pod width (mm), ln number of locules, sl =seed length (mm), sw =seed width (mm), psa=percent seed aborted, swgt =seed weight (kg), yld = yield (kg ha^{-1}) RSI=Rank summation indec

Appendix 4: Mean value of positive, strongly significant correlated phytochemical traits with yield and their rank summation index (RSI).

Accession	gal	rsi	rut	Rsi	que	rsi	lser	rsi	lhis	rsi	asp	rsi	lval	rsi	lmet	rsi	lasp	rsi	ltry	rsi	RSI=∑rsi	yld	yld rank
UG28	0.23	34	20.22	5	2.96	4	.	.	10.14	22	.	.	96.05	1	.	.	.	.	353.12	41	107	159.27	48
UG14	3.37	1	20.13	6	2.95	6	28.14	28	15.66	17	99.81	27	16.92	18	192.61	10	.	.	827.99	5	118	177.33	3
WANG KAE	0.32	19	22.10	2	3.24	2	190.16	2	.	.	40.59	53	.	.	88.41	60	.	.	1175.89	1	139	156.67	62
UG45	0.23	33	20.22	4	2.96	5	26.18	32	.	.	98.08	29	.	.	110.39	40	.	.	733.77	9	152	160.00	43
UG76	0.20	46	16.55	19	2.42	14	45.94	14	.	.	173.54	10	2.01	32	112.47	38	.	.	567.60	15	188	156.90	61
UG22	0.21	39	16.62	11	2.43	10	38.99	17	.	.	37.87	56	66.67	2	148.40	16	.	.	330.14	45	196	146.93	86
UG39	0.29	23	14.13	38	2.06	39	26.18	33	.	.	98.08	30	.	.	110.39	41	.	.	733.77	10	214	159.10	52
UG73	0.20	43	16.55	16	2.42	22	19.56	47	.	.	98.57	28	.	.	135.00	23	.	.	369.65	37	216	157.50	55
UG83	0.20	53	16.55	26	2.42	13	59.70	12	11.63	20	22.75	70	.	.	185.49	11	.	.	666.32	13	218	162.03	32
UG24	0.47	11	10.10	97	1.46	100	186.47	3	51.04	2	267.86	5	38.42	6	305.63	2	.	.	1156.57	2	228	186.53	2
UG17	0.30	22	12.46	46	1.81	47	25.00	34	9.11	23	56.24	42	22.97	13	278.38	4	.	.	1020.83	4	235	158.33	53
UG42	0.25	31	13.61	42	1.98	45	23.02	42	.	.	104.87	24	.	.	101.89	51	.	.	816.10	7	242	145.63	92
UG34	0.47	14	22.45	1	3.29	1	23.30	41	31.63	4	38.18	55	7.45	24	196.73	8	.	.	68.85	103	251	148.57	84
UG32	0.28	25	16.62	10	2.43	11	36.23	22	23.53	9	31.61	59	.	.	48.72	85	.	.	403.20	31	252	151.30	79
UG49	0.26	30	10.92	95	1.58	93	127.91	5	.	.	291.49	4	.	.	333.32	1	.	.	430.95	27	255	153.93	70
UG26	0.35	17	16.55	12	2.42	20	22.58	44	.	.	38.28	54	25.81	12	114.23	37	.	.	248.52	62	258	159.27	49
UG74	0.20	44	16.55	17	2.42	16	36.32	20	3.43	30	164.28	11	.	.	104.54	47	.	.	162.80	78	263	165.43	26
UG37	0.21	37	10.10	99	1.46	101	186.47	4	51.04	3	267.86	6	38.42	7	305.63	3	.	.	1156.57	3	263	162.07	31
UG47	0.35	18	20.01	7	2.93	7	10.82	63	17.67	16	59.09	39	.	.	118.33	35	.	.	158.74	80	265	170.33	15
UG78	0.20	48	16.55	21	2.42	28	4.13	83	.	.	110.39	19	33.74	8	108.73	42	.	.	521.87	17	266	145.83	91
KIRKHOUSE	0.20	40	16.55	13	2.42	34	.	.	.	.	.	.	.	.	32.07	93	.	.	109.44	86	266	106.04	107
UG87	0.20	57	16.55	30	2.42	15	42.59	15	24.48	8	77.03	34	.	.	56.92	83	0.38	3	443.78	26	271	134.97	103
UG86	0.20	56	16.55	29	2.42	12	68.65	10	31.31	5	6.92	81	.	.	58.78	81	0.76	2	822.60	6	282	167.47	21
UG30	0.17	64	20.01	8	2.93	8	7.26	74	.	.	.	.	.	.	85.81	63	.	.	235.43	67	284	156.43	63
UG38	0.47	13	20.22	3	2.96	3	.	.	.	.	13.54	78	9.59	23	32.54	92	.	.	184.44	73	285	166.47	24
UG41	0.01	106	14.15	36	2.06	37	14.16	56	.	.	138.32	14	.	.	159.84	13	.	.	466.90	23	285	159.23	51
UG82	0.20	52	16.55	25	2.42	23	18.35	49	18.79	13	.	.	.	.	103.98	49	.	.	177.91	76	287	141.37	98
UG6	2.52	3	11.25	87	1.63	88	23.59	39	55.81	1	225.62	7	11.33	22	200.10	7	11.22	1	385.89	35	290	163.00	29
UG2	0.21	35	13.61	43	1.98	43	23.81	36	.	.	19.48	71	.	.	105.70	44	.	.	477.25	20	292	164.90	27
UG81	0.20	51	16.55	24	2.42	27	8.90	71	.	.	82.20	33	.	.	133.19	25	.	.	236.81	65	296	143.93	95
UG79	0.20	49	16.55	22	2.42	32	.	.	2.52	34	12.75	79	.	.	101.82	53	.	.	422.88	30	299	159.27	50
UG23	0.21	36	13.61	44	1.98	44	23.81	37	.	.	19.48	72	.	.	105.70	45	.	.	477.25	21	299	152.83	71
UG5	1.52	6	11.25	91	1.63	92	.	.	.	.	37.34	57	47.73	3	135.25	22	.	.	430.95	28	299	146.17	89
UG80	0.20	50	16.55	23	2.42	18	27.51	30	3.20	32	49.33	47	0.25	36	194.07	9	.	.	244.87	63	308	164.37	28
UG84	0.20	54	16.55	27	2.42	17	36.23	23	23.53	10	31.61	60	.	.	48.72	86	.	.	403.20	32	309	174.00	7
UG55	0.01	78	11.85	58	1.72	64	14.16	57	.	.	138.32	15	.	.	159.84	14	.	.	466.90	24	310	159.47	47
UG8	2.52	5	11.25	89	1.63	89	23.02	43	.	.	104.87	25	.	.	101.89	52	.	.	816.10	8	311	151.93	74
UG50	0.23	32	12.82	45	1.86	46	9.74	65	.	.	16.51	74	.	.	144.77	17	.	.	389.30	33	312	160.67	37
UG54	0.01	77	11.85	57	1.72	52	80.82	9	.	.	118.39	18	26.01	11	116.78	36	.	.	290.38	53	313	135.23	102
UG15	0.01	72	11.85	52	1.72	49	.	.	.	.	.	.	.	.	82.87	67	.	.	179.43	74	314	148.70	82

gal=gallic acid, rut= rutin, que=quercetin, lser=l-serine,lhis=l-histidine, asp=l-aspartic acid, llval=-valine, lmet=l-methionine ltry=l-tryptophan, yld = yield (kg ha-1) RSI=Rank summation index.

Appendix 4 (Cont'd)

Accession	gal	rsi	rut	Rsi	que	rsi	lser	rsi	lhis	rsi	asp	rsi	lval	rsi	lmet	rsi	lasp	rsi	ltry	rsi	RSI=∑rsi	yld	yld rank
UG77	0.20	47	16.55	20	2.42	19	23.54	40	.	.	9.01	80	.	.	122.38	33	.	.	127.24	84	323	166.53	23
UG90	0.20	60	16.55	33	2.42	25	14.86	54	.	.	.	.	.	.	25.70	100	.	.	302.71	52	324	142.90	97
UG63	0.01	86	11.85	66	1.72	84	.	.	.	.	.	.	.	.	65.22	79	.	.	695.11	12	327	157.80	54
UG16	0.47	10	17.34	9	2.53	9	0.63	93	.	.	58.17	40	42.62	4	81.70	70	.	.	99.66	93	328	154.73	68
UG91	0.20	61	16.55	34	2.42	35	.	.	.	.	.	.	.	.	16.53	104	.	.	92.54	96	330	152.20	72
UG3	0.32	21	8.79	106	1.27	107	23.85	35	.	.	154.85	13	.	.	142.49	20	.	.	430.16	29	331	155.20	65
UG58	0.01	81	11.85	61	1.72	54	37.99	18	.	.	67.88	35	5.65	27	122.76	32	.	.	456.68	25	333	157.00	60
UG19	0.28	26	10.78	96	1.56	97	86.28	8	.	.	194.33	8	.	.	225.20	5	0.01	5	104.32	91	336	174.43	6
UG104	0.32	20	13.99	40	2.04	41	30.46	25	.	.	30.41	61	17.17	15	25.76	97	.	.	356.13	38	337	155.10	66
UG75	0.20	45	16.55	18	2.42	30	1.64	91	.	.	.	.	.	.	81.72	69	.	.	105.64	89	342	167.60	20
UG25	0.47	12	10.10	98	1.46	99	200.39	1	26.90	7	581.97	1	16.71	19	216.67	6	.	.	62.88	104	347	166.83	22
UG40	0.38	15	13.71	41	2.00	42	26.81	31	.	.	108.32	23	0.32	34	57.45	82	.	.	149.29	81	349	155.10	67
UG66	0.01	89	11.85	69	1.72	50	98.73	6	.	.	410.39	2	27.65	10	134.97	24	.	.	43.05	107	357	172.10	8
UG36	0.17	65	11.91	47	1.73	48	4.13	84	.	.	110.39	20	33.74	9	108.73	43	.	.	311.99	47	363	169.90	17
UG9	2.52	4	11.25	90	1.63	91	11.85	60	.	.	109.22	22	.	.	95.13	54	.	.	350.63	42	363	146.30	88
UG29	0.01	73	11.85	53	1.72	59	23.81	38	.	.	19.48	73	.	.	105.70	46	.	.	477.25	22	364	161.03	35
UG52	0.01	75	11.85	55	1.72	51	87.38	7	0.86	35	387.50	3	.	.	120.17	34	.	.	41.03	108	368	151.57	77
UG35	0.00	108	14.13	39	2.06	40	13.63	58	.	.	.	.	.	.	69.45	76	.	.	311.99	48	369	146.03	90
UG13	0.20	41	16.55	14	2.42	26	9.42	70	.	.	46.44	51	.	.	20.85	103	.	.	206.32	70	375	150.80	80
UG62	0.01	85	11.85	65	1.72	85	.	.	.	.	.	.	.	.	73.73	75	.	.	235.63	66	376	137.93	101
UG88	0.20	58	16.55	31	2.42	33	.	.	.	.	4.91	85	.	.	26.06	96	.	.	166.61	77	380	157.23	57
UG89	0.20	59	16.55	32	2.42	21	20.09	46	11.02	21	25.92	66	.	.	68.84	77	.	.	252.56	60	382	124.80	105
UG60	0.01	83	11.85	63	1.72	55	37.16	19	.	.	174.78	9	.	.	95.02	55	.	.	79.94	100	384	138.37	100
UG4	0.20	63	11.85	48	1.72	74	6.89	76	.	.	23.98	68	0.29	35	143.42	19	.	.	733.42	11	394	170.50	13
UG72	0.20	42	16.55	15	2.42	31	0.23	95	.	.	6.60	82	.	.	78.81	73	.	.	268.60	57	395	133.87	104
UG92	0.20	62	16.55	35	2.42	24	17.15	51	4.73	28	110.26	21	.	.	63.91	80	.	.	93.46	95	396	170.50	14
UG64	0.01	87	11.85	67	1.72	65	12.57	59	.	.	100.95	26	.	.	130.30	28	.	.	239.01	64	396	146.87	87
UG44	0.28	24	9.61	104	1.39	105	.	.	6.87	24	.	.	.	.	82.59	68	.	.	179.36	75	400	170.33	16
UG59	0.01	82	11.85	62	1.72	73	7.86	73	.	.	.	.	.	.	83.96	65	.	.	329.10	46	401	157.20	58
UG48	0.61	8	9.83	102	1.42	103	36.32	21	3.43	31	164.28	12	.	.	104.54	48	.	.	162.80	79	404	160.00	44
UG93	0.01	95	11.85	75	1.72	63	14.28	55	17.87	15	125.90	17	21.19	14	93.65	56	0.01	6	623.09	14	410	157.10	59
UG20	0.26	29	10.92	94	1.58	94	59.98	11	.	.	52.54	44	.	.	66.21	78	.	.	250.82	61	411	143.47	96
ASONTEM	0.01	69	11.85	49	1.72	56	30.46	26	.	.	30.41	62	17.17	16	25.76	98	.	.	356.13	39	415	110.01	106
UG11	0.26	27	10.92	93	1.58	95	9.63	68	13.73	18	33.39	58	7.14	25	158.02	15	.	.	486.68	19	418	160.43	38
UG1	0.01	71	11.85	51	1.72	57	30.46	27	.	.	30.41	63	17.17	17	25.76	99	.	.	356.13	40	425	145.13	93
UG85	0.20	55	16.55	28	2.42	29	2.04	88	.	.	3.41	88	.	.	36.65	89	.	.	307.90	50	427	139.83	99
UG31	0.38	16	9.83	103	1.42	104	7.26	75	.	.	.	.	.	.	85.81	64	.	.	235.43	68	430	161.83	33
UG10	0.56	9	6.64	107	0.95	108	5.83	79	18.40	14	28.81	64	.	.	111.68	39	.	.	534.83	16	436	160.97	36
UG65	0.01	88	11.85	68	1.72	62	16.82	53	.	.	88.49	32	5.61	28	90.82	57	.	.	307.97	49	437	147.03	85
UG97	0.01	99	11.85	79	1.72	69	9.74	66	.	.	16.51	75	.	.	144.77	18	.	.	389.30	34	440	172.00	9
UG43	0.17	66	10.10	100	1.46	98	.	.	.	.	.	.	.	.	32.07	94	.	.	109.44	85	443	160.03	41
UG69	0.01	92	11.85	72	1.72	72	8.04	72	0.81	36	91.64	31	.	.	132.03	26	.	.	340.74	44	445	193.50	1

Appendix 4 (Cont'd)

Accession	gal	rsi	rut	Rsi	que	rsi	lser	rsi	lhis	rsi	asp	rsi	lval	rsi	lmet	rsi	lasp	rsi	Ltry	rsi	RSI=∑rsi	yld	yld rank
UG98	0.01	100	11.85	80	1.72	86	.	.	.	.	.	.	.	.	39.12	88	.	.	90.21	97	451	161.30	34
UG94	0.01	96	11.85	76	1.72	81	2.48	87	.	.	.	.	.	.	28.88	95	.	.	488.53	18	453	170.53	12
UG7	2.52	2	11.25	88	1.63	90	17.00	52	21.75	11	62.24	36	15.97	20	25.54	101	.	.	272.22	56	456	151.80	76
UG70	0.01	93	11.85	73	1.72	78	4.22	82	.	.	47.97	49	.	.	140.76	21	.	.	218.61	69	465	171.57	11
UG61	0.01	84	11.85	64	1.72	53	54.21	13	.	.	3.89	87	.	.	90.36	58	.	.	48.03	106	465	160.20	39
PADI-TUYA	0.01	70	11.85	50	1.72	68	10.67	64	.	.	4.50	86	.	.	52.29	84	.	.	289.06	54	476	68.19	108
UG67	0.01	90	11.85	70	1.72	77	4.59	81	.	.	15.27	77	.	.	125.56	30	.	.	278.19	55	480	151.87	75
UG51	0.01	74	11.85	54	1.72	58	27.95	29	.	.	24.80	67	.	.	8.22	107	.	.	101.66	92	481	171.63	10
UG12	0.65	7	10.92	92	1.58	96	1.19	92	.	.	5.58	84	.	.	125.75	29	.	.	108.85	87	487	166.23	25
UG27	0.26	28	10.00	101	1.45	102	6.05	78	.	.	60.91	38	.	.	87.65	62	.	.	147.40	83	492	151.37	78
UG56	0.01	79	11.85	59	1.72	70	9.66	67	.	.	46.21	52	3.28	31	125.54	31	.	.	48.31	105	494	168.67	18
UG46	0.02	68	6.30	108	0.90	109	17.43	50	5.86	25	138.06	16	.	.	130.88	27	0.17	4	104.73	90	497	160.03	42
UG33	0.00	107	14.15	37	2.06	38	2.04	89	.	.	3.41	89	.	.	36.65	90	.	.	307.90	51	501	152.13	73
UG96	0.01	98	11.85	78	1.72	75	6.05	77	.	.	60.91	37	.	.	87.65	61	.	.	147.40	82	508	149.93	81
UG18	0.21	38	9.08	105	1.31	106	30.56	24	27.33	6	53.50	43	.	.	43.01	87	.	.	75.61	101	510	162.60	30
UG68	0.01	91	11.85	71	1.72	60	21.72	45	5.10	27	15.48	76	3.47	29	178.91	12	.	.	70.51	102	513	167.63	19
UG53	0.01	76	11.85	56	1.72	83	0.63	94	.	.	58.17	41	42.62	5	81.70	71	.	.	99.66	94	520	148.67	83
UG100	0.01	102	11.85	82	1.72	67	11.08	62	.	.	49.90	46	.	.	12.02	105	.	.	262.15	59	523	157.43	56
UG103	0.01	105	11.85	85	1.72	79	3.03	85	.	.	.	.	.	.	8.96	106	.	.	194.00	71	531	159.73	46
UG99	0.01	101	11.85	81	1.72	61	18.67	48	4.11	29	48.45	48	.	.	22.17	102	.	.	191.25	72	542	144.90	94
UG95	0.01	97	11.85	77	1.72	66	11.33	61	19.25	12	2.82	90	.	.	7.29	108	.	.	373.39	36	547	174.70	4
UG21	0.10	67	11.32	86	1.64	87	0.23	96	.	.	6.60	83	.	.	78.81	74	.	.	268.60	58	551	160.13	40
UG71	0.01	94	11.85	74	1.72	71	9.61	69	.	.	23.54	69	3.40	30	102.12	50	.	.	87.62	98	555	159.93	45
UG57	0.01	80	11.85	60	1.72	76	5.68	80	.	.	27.90	65	0.69	33	83.19	66	.	.	84.70	99	559	155.50	64
UG101	0.01	103	11.85	83	1.72	80	2.64	86	5.50	26	51.29	45	12.69	21	36.36	91	.	.	349.60	43	578	154.53	69
UG102	0.01	104	11.85	84	1.72	82	1.84	90	12.16	19	0.43	91	.	.	90.32	59	.	.	107.79	88	617	174.63	5

gal=gallic acid, rut= rutin, que=quercetin, lser=l-serine,lhis=l-histidine, asp=l-aspartic acid, llval=-valine, lmet=l-methionine ltry=l-tryptophan, yld = yield (kg ha-1) RSI=Rank summation index.

Appendix 5: Marginal analysis showing accessions that significantly (P<0.05) performed below and above the grandmean for morphological traits

Accession	DTG						NOL						TLL						TLW					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
Asontem	4.38	0.12	-0.19	0.15	1.70	0.193	30.52	1.29	-0.96	2.02	0.22	0.636	9.71	0.18	0.12	0.23	0.30	0.583	4.76	0.09	0.06	0.11	0.31	0.581
Kirkhouse	4.43	0.14	-0.15	0.15	0.97	0.326	28.60	1.23	-2.88	2.02	2.03	0.155	9.19	0.23	-0.40	0.23	3.15	0.077	4.44	0.09	-0.26	0.11	6.34	0.012
Padituya	4.73	0.14	0.16	0.15	1.09	0.297	33.27	2.59	1.79	2.02	0.79	0.375	10.30	0.24	0.72	0.23	10.05	0.002	5.04	0.11	0.33	0.11	10.04	0.002
Wang Kae	4.54	0.12	-0.04	0.15	0.06	0.814	28.67	1.71	-2.81	2.02	1.94	0.164	9.96	0.14	0.38	0.23	2.77	0.097	4.88	0.07	0.18	0.11	2.87	0.091
UG1	4.33	0.88	-0.24	0.63	0.15	0.701	35.33	12.25	3.85	8.51	0.21	0.651	10.06	0.78	0.47	0.95	0.24	0.623	5.14	0.31	0.44	0.44	0.97	0.325
UG2	5.00	1.00	0.43	0.63	0.46	0.499	32.00	9.85	0.52	8.51	0.00	0.951	10.17	1.07	0.58	0.95	0.37	0.544	4.97	0.64	0.27	0.44	0.37	0.543
UG3	4.00	0.58	-0.57	0.63	0.84	0.360	28.00	7.64	-3.48	8.51	0.17	0.683	9.81	0.57	0.22	0.95	0.05	0.816	4.79	0.18	0.09	0.44	0.04	0.839
UG4	3.67	0.67	-0.91	0.63	2.09	0.149	31.33	1.67	-0.15	8.51	0.00	0.986	9.44	0.27	-0.15	0.95	0.03	0.874	4.61	0.24	-0.10	0.44	0.05	0.829
UG5	4.00	0.58	-0.57	0.63	0.84	0.360	31.67	5.36	0.19	8.51	0.00	0.982	8.76	0.58	-0.82	0.95	0.75	0.387	4.27	0.21	-0.43	0.44	0.95	0.330
UG6	4.67	0.67	0.09	0.63	0.02	0.884	31.00	11.59	-0.48	8.51	0.00	0.955	8.18	0.36	-1.41	0.95	2.20	0.139	3.98	0.08	-0.73	0.44	2.67	0.103
UG7	4.33	0.67	-0.24	0.63	0.15	0.701	34.00	15.72	2.52	8.51	0.09	0.767	8.84	0.60	-0.75	0.95	0.62	0.432	4.09	0.30	-0.62	0.44	1.92	0.166
UG8	5.33	0.67	0.76	0.63	1.46	0.228	40.33	15.34	8.85	8.51	1.08	0.299	9.54	0.87	-0.04	0.95	0.00	0.963	4.55	0.52	-0.15	0.44	0.12	0.731
UG9	5.00	1.00	0.43	0.63	0.46	0.499	29.67	10.27	-1.81	8.51	0.05	0.832	11.89	0.49	2.30	0.95	5.83	0.016	5.72	0.33	1.02	0.44	5.25	0.022
UG10	6.00	0.00	1.43	0.63	5.15	0.024	25.33	5.21	-6.15	8.51	0.52	0.471	8.23	0.24	-1.36	0.95	2.05	0.153	4.00	0.05	-0.70	0.44	2.50	0.114
UG11	3.33	0.33	-1.24	0.63	3.91	0.049	44.67	3.18	13.19	8.51	2.40	0.122	9.23	1.36	-0.36	0.95	0.14	0.707	4.39	0.58	-0.31	0.44	0.50	0.482
UG12	5.67	0.33	1.09	0.63	3.02	0.083	26.67	9.28	-4.81	8.51	0.32	0.572	10.42	0.59	0.83	0.95	0.76	0.383	4.99	0.22	0.28	0.44	0.41	0.523
UG13	5.00	0.00	0.43	0.63	0.46	0.499	28.67	11.89	-2.81	8.51	0.11	0.741	8.57	0.93	-1.01	0.95	1.14	0.287	4.28	0.47	-0.42	0.44	0.89	0.345
UG14	4.00	1.00	-0.57	0.63	0.84	0.360	31.33	6.36	-0.15	8.51	0.00	0.986	7.83	0.31	-1.76	0.95	3.43	0.065	3.91	0.16	-0.79	0.44	3.16	0.076
UG15	5.33	0.67	0.76	0.63	1.46	0.228	33.00	2.65	1.52	8.51	0.03	0.858	9.96	0.12	0.37	0.95	0.15	0.699	4.64	0.06	-0.06	0.44	0.02	0.894
UG16	5.33	0.67	0.76	0.63	1.46	0.228	37.00	14.18	5.52	8.51	0.42	0.517	8.81	0.29	-0.78	0.95	0.67	0.412	4.29	0.25	-0.41	0.44	0.86	0.353
UG17	4.33	0.67	-0.24	0.63	0.15	0.701	18.67	2.60	-12.81	8.51	2.27	0.133	10.30	0.63	0.71	0.95	0.56	0.455	5.04	0.20	0.33	0.44	0.57	0.453
UG18	5.33	0.33	0.76	0.63	1.46	0.228	14.67	4.41	-16.81	8.51	3.90	0.049	9.22	0.74	-0.37	0.95	0.15	0.697	4.61	0.37	-0.09	0.44	0.04	0.835
UG19	4.00	0.58	-0.57	0.63	0.84	0.360	29.00	8.72	-2.48	8.51	0.08	0.771	10.44	1.27	0.85	0.95	0.80	0.373	5.11	0.57	0.40	0.44	0.83	0.364
UG20	4.67	0.88	0.09	0.63	0.02	0.884	31.67	8.21	0.19	8.51	0.00	0.982	8.29	0.13	-1.30	0.95	1.87	0.172	4.03	0.09	-0.67	0.44	2.27	0.132
UG21	5.00	0.58	0.43	0.63	0.46	0.499	30.33	10.17	-1.15	8.51	0.02	0.893	9.46	2.20	-0.12	0.95	0.02	0.896	4.84	0.76	0.14	0.44	0.10	0.752
UG22	5.00	0.58	0.43	0.63	0.46	0.499	34.00	8.50	2.52	8.51	0.09	0.767	9.74	1.55	0.15	0.95	0.03	0.873	4.76	0.86	0.06	0.44	0.02	0.898
UG23	4.33	0.33	-0.24	0.63	0.15	0.701	25.00	10.26	-6.48	8.51	0.58	0.447	7.68	1.15	-1.91	0.95	4.03	0.045	3.95	0.49	-0.75	0.44	2.87	0.091
UG24	5.67	0.33	1.09	0.63	3.02	0.083	37.33	2.60	5.85	8.51	0.47	0.492	11.50	0.63	1.92	0.95	4.05	0.045	5.70	0.17	1.00	0.44	5.04	0.025
UG25	5.33	0.33	0.76	0.63	1.46	0.228	23.33	4.26	-8.15	8.51	0.92	0.339	9.29	1.32	-0.30	0.95	0.10	0.752	4.42	0.55	-0.28	0.44	0.41	0.525
UG26	5.00	0.00	0.43	0.63	0.46	0.499	36.67	5.36	5.19	8.51	0.37	0.543	10.46	0.63	0.87	0.95	0.83	0.362	5.12	0.37	0.42	0.44	0.88	0.348
UG27	4.67	0.88	0.09	0.63	0.02	0.884	29.67	10.71	-1.81	8.51	0.05	0.832	9.82	0.87	0.23	0.95	0.06	0.808	4.80	0.51	0.10	0.44	0.05	0.827
UG28	4.67	0.88	0.09	0.63	0.02	0.884	35.33	1.86	3.85	8.51	0.21	0.651	11.89	1.06	2.30	0.95	5.85	0.016	5.83	0.43	1.13	0.44	6.48	0.011
UG29	5.00	0.00	0.43	0.63	0.46	0.499	21.33	3.84	-10.15	8.51	1.42	0.234	11.23	0.42	1.64	0.95	2.96	0.086	5.56	0.13	0.86	0.44	3.73	0.054
UG30	4.00	1.00	-0.57	0.63	0.84	0.360	30.00	3.46	-1.48	8.51	0.03	0.862	10.58	1.29	0.99	0.95	1.09	0.298	5.29	0.69	0.59	0.44	1.75	0.187
Grandmean	**4.55**	**0.05**			**1.11**	**0.243**	**30.96**	**0.65**			**1.37**	**0.015**	**9.67**	**0.07**			**1.43**	**0.007**	**4.74**	**0.03**			**1.61**	**0.001**

Appendix 5 (Cont'd)

Accession	DTG						NOL						TLL						TLW					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG31	5.67	0.33	1.09	0.63	3.02	0.083	36.00	15.31	4.52	8.51	0.28	0.596	10.23	1.21	0.64	0.95	0.45	0.503	5.00	0.65	0.30	0.44	0.46	0.499
UG32	5.00	0.58	0.43	0.63	0.46	0.499	26.67	9.82	-4.81	8.51	0.32	0.572	10.26	1.13	0.67	0.95	0.50	0.481	4.91	0.55	0.21	0.44	0.22	0.641
UG33	5.00	0.58	0.43	0.63	0.46	0.499	32.33	13.02	0.85	8.51	0.01	0.920	8.89	0.51	-0.70	0.95	0.54	0.462	4.44	0.40	-0.26	0.44	0.34	0.559
UG34	4.33	0.67	-0.24	0.63	0.15	0.701	28.00	9.87	-3.48	8.51	0.17	0.683	9.62	1.53	0.03	0.95	0.00	0.976	4.92	0.55	0.22	0.44	0.24	0.625
UG35	5.00	0.58	0.43	0.63	0.46	0.499	35.33	10.37	3.85	8.51	0.21	0.651	8.97	0.93	-0.62	0.95	0.43	0.514	4.26	0.37	-0.44	0.44	0.98	0.323
UG36	4.33	0.33	-0.24	0.63	0.15	0.701	36.00	7.57	4.52	8.51	0.28	0.596	9.23	1.17	-0.36	0.95	0.14	0.704	4.61	0.53	-0.09	0.44	0.04	0.841
UG37	4.67	0.33	0.09	0.63	0.02	0.884	43.33	13.53	11.85	8.51	1.94	0.164	10.66	1.74	1.08	0.95	1.28	0.259	5.22	0.89	0.52	0.44	1.36	0.245
UG38	4.33	0.67	-0.24	0.63	0.15	0.701	46.00	6.66	14.52	8.51	2.91	0.089	10.52	1.38	0.94	0.95	0.97	0.326	5.15	0.62	0.45	0.44	1.01	0.314
UG39	5.33	0.67	0.76	0.63	1.46	0.228	21.00	5.03	-10.48	8.51	1.52	0.219	10.10	0.59	0.51	0.95	0.29	0.593	4.83	0.18	0.12	0.44	0.08	0.780
UG40	4.33	0.88	-0.24	0.63	0.15	0.701	35.33	3.93	3.85	8.51	0.21	0.651	10.10	0.27	0.51	0.95	0.29	0.591	4.94	0.06	0.24	0.44	0.29	0.594
UG41	3.33	0.33	-1.24	0.63	3.91	0.049	15.00	2.31	-16.48	8.51	3.75	0.054	8.35	0.87	-1.24	0.95	1.70	0.193	3.95	0.34	-0.75	0.44	2.87	0.091
UG42	5.33	0.33	0.76	0.63	1.46	0.228	23.00	3.06	-8.48	8.51	0.99	0.320	8.83	0.70	-0.76	0.95	0.64	0.424	4.30	0.24	-0.40	0.44	0.82	0.365
UG43	4.00	1.00	-0.57	0.63	0.84	0.360	23.00	4.16	-8.48	8.51	0.99	0.320	9.72	0.95	0.14	0.95	0.02	0.887	4.86	0.48	0.16	0.44	0.13	0.718
UG44	4.00	1.00	-0.57	0.63	0.84	0.360	35.33	7.51	3.85	8.51	0.21	0.651	8.87	0.35	-0.71	0.95	0.56	0.453	4.33	0.20	-0.38	0.44	0.72	0.398
UG45	5.00	0.58	0.43	0.63	0.46	0.499	54.67	5.78	23.19	8.51	7.42	0.007	10.99	0.74	1.40	0.95	2.16	0.142	5.38	0.46	0.68	0.44	2.33	0.128
UG46	4.00	1.00	-0.57	0.63	0.84	0.360	23.00	4.16	-8.48	8.51	0.99	0.320	9.72	0.95	0.14	0.95	0.02	0.887	4.86	0.48	0.16	0.44	0.13	0.718
UG47	4.00	1.00	-0.57	0.63	0.84	0.360	35.33	7.51	3.85	8.51	0.21	0.651	8.87	0.35	-0.71	0.95	0.56	0.453	4.33	0.20	-0.38	0.44	0.72	0.398
UG48	5.00	0.58	0.43	0.63	0.46	0.499	54.67	5.78	23.19	8.51	7.42	0.007	10.99	0.74	1.40	0.95	2.16	0.142	5.38	0.46	0.68	0.44	2.33	0.128
UG49	4.00	0.00	-0.57	0.63	0.84	0.360	30.67	10.73	-0.81	8.51	0.01	0.924	8.22	0.94	-1.37	0.95	2.08	0.150	4.22	0.25	-0.48	0.44	1.18	0.278
UG50	5.33	0.67	0.76	0.63	1.46	0.228	54.67	10.74	23.19	8.51	7.42	0.007	8.61	0.49	-0.97	0.95	1.05	0.306	4.53	0.04	-0.17	0.44	0.15	0.697
UG51	5.67	0.33	1.09	0.63	3.02	0.083	27.67	3.84	-3.81	8.51	0.20	0.655	10.32	0.67	0.73	0.95	0.59	0.444	4.94	0.41	0.23	0.44	0.28	0.599
UG52	5.00	0.58	0.43	0.63	0.46	0.499	30.67	9.70	-0.81	8.51	0.01	0.924	8.34	1.26	-1.25	0.95	1.73	0.189	4.06	0.55	-0.64	0.44	2.10	0.149
UG53	5.00	0.58	0.43	0.63	0.46	0.499	34.33	7.69	2.85	8.51	0.11	0.738	8.55	0.60	-1.04	0.95	1.19	0.276	4.39	0.02	-0.32	0.44	0.51	0.477
UG54	4.33	0.88	-0.24	0.63	0.15	0.701	35.00	12.74	3.52	8.51	0.17	0.679	10.20	0.39	0.62	0.95	0.42	0.518	5.10	0.20	0.40	0.44	0.80	0.372
UG55	5.33	0.67	0.76	0.63	1.46	0.228	38.33	9.35	6.85	8.51	0.65	0.421	9.70	1.87	0.12	0.95	0.01	0.904	4.74	0.84	0.04	0.44	0.01	0.927
UG56	5.33	0.33	0.76	0.63	1.46	0.228	40.67	15.30	9.19	8.51	1.17	0.281	10.17	1.26	0.58	0.95	0.37	0.544	4.97	0.65	0.27	0.44	0.36	0.548
UG57	4.67	0.67	0.09	0.63	0.02	0.884	27.67	4.48	-3.81	8.51	0.20	0.655	7.81	0.06	-1.78	0.95	3.49	0.062	3.91	0.03	-0.80	0.44	3.21	0.074
UG58	4.33	0.88	-0.24	0.63	0.15	0.701	36.67	10.17	5.19	8.51	0.37	0.543	10.64	0.45	1.05	0.95	1.21	0.271	5.32	0.23	0.62	0.44	1.93	0.165
UG59	5.00	1.00	0.43	0.63	0.46	0.499	10.00	1.53	-21.48	8.51	6.37	0.012	9.61	1.60	0.02	0.95	0.00	0.984	4.58	0.69	-0.12	0.44	0.08	0.782
UG60	4.67	0.88	0.09	0.63	0.02	0.884	21.67	8.41	-9.81	8.51	1.33	0.250	10.16	0.59	0.58	0.95	0.37	0.546	4.97	0.26	0.27	0.44	0.36	0.548
UG61	4.67	0.33	0.09	0.63	0.02	0.884	57.00	10.15	25.52	8.51	8.99	0.003	8.99	1.45	-0.60	0.95	0.39	0.530	4.38	0.62	-0.32	0.44	0.53	0.468
UG62	4.00	0.58	-0.57	0.63	0.84	0.360	20.00	5.57	-11.48	8.51	1.82	0.178	8.00	1.23	-1.58	0.95	2.77	0.097	3.89	0.63	-0.81	0.44	3.32	0.069
UG63	5.00	1.00	0.43	0.63	0.46	0.499	18.33	6.36	-13.15	8.51	2.39	0.123	9.68	0.93	0.09	0.95	0.01	0.923	4.62	0.38	-0.08	0.44	0.03	0.852
UG64	5.33	0.33	0.76	0.63	1.46	0.228	38.67	12.78	7.19	8.51	0.71	0.399	7.71	0.34	-1.87	0.95	3.88	0.050	3.63	0.08	-1.07	0.44	5.80	0.016
UG65	4.00	0.58	-0.57	0.63	0.84	0.360	26.67	5.61	-4.81	8.51	0.32	0.572	11.38	0.67	1.79	0.95	3.53	0.061	5.77	0.59	1.07	0.44	5.78	0.017
UG66	5.00	0.58	0.43	0.63	0.46	0.499	38.33	17.89	6.85	8.51	0.65	0.421	9.87	0.99	0.28	0.95	0.09	0.767	4.82	0.44	0.12	0.44	0.07	0.792
UG67	4.67	0.33	0.09	0.63	0.02	0.884	37.67	6.17	6.19	8.51	0.53	0.468	8.60	0.92	-0.98	0.95	1.07	0.301	4.36	0.24	-0.34	0.44	0.60	0.441
UG68	5.00	0.58	0.43	0.63	0.46	0.499	36.00	18.36	4.52	8.51	0.28	0.596	11.02	0.72	1.43	0.95	2.26	0.133	5.40	0.45	0.70	0.44	2.47	0.117
Grandmean	**4.55**	**0.05**			**1.11**	**0.243**	**30.96**	**0.65**			**1.37**	**0.015**	**9.67**	**0.07**			**1.43**	**0.007**	**4.74**	**0.03**			**1.61**	**0.001**

Appendix 5 (Cont'd)

Accession	DTG						NOL						TLL						TLW					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG69	4.67	0.88	0.09	0.63	0.02	0.884	25.67	9.33	-5.81	8.51	0.47	0.495	10.35	0.93	0.77	0.95	0.65	0.422	4.95	0.56	0.25	0.44	0.32	0.573
UG70	5.33	0.33	0.76	0.63	1.46	0.228	27.33	7.54	-4.15	8.51	0.24	0.627	8.10	0.59	-1.49	0.95	2.46	0.118	4.27	0.28	-0.43	0.44	0.94	0.334
UG71	4.67	0.67	0.09	0.63	0.02	0.884	22.00	8.72	-9.48	8.51	1.24	0.266	10.78	0.39	1.19	0.95	1.57	0.211	5.39	0.19	0.69	0.44	2.42	0.121
UG72	4.67	0.67	0.09	0.63	0.02	0.884	34.33	1.67	2.85	8.51	0.11	0.738	9.69	1.26	0.10	0.95	0.01	0.918	4.90	0.67	0.20	0.44	0.20	0.657
UG73	5.00	0.58	0.43	0.63	0.46	0.499	25.00	5.29	-6.48	8.51	0.58	0.447	11.44	1.14	1.86	0.95	3.80	0.052	5.72	0.57	1.02	0.44	5.25	0.022
UG74	4.67	0.88	0.09	0.63	0.02	0.884	19.33	6.36	-12.15	8.51	2.04	0.154	10.52	0.54	0.93	0.95	0.95	0.330	5.04	0.16	0.33	0.44	0.57	0.453
UG75	4.33	0.88	-0.24	0.63	0.15	0.701	40.67	2.73	9.19	8.51	1.17	0.281	10.90	1.20	1.31	0.95	1.89	0.170	5.45	0.60	0.74	0.44	2.81	0.095
UG76	3.33	0.33	-1.24	0.63	3.91	0.049	36.33	16.59	4.85	8.51	0.33	0.569	8.65	1.11	-0.93	0.95	0.96	0.327	4.21	0.65	-0.49	0.44	1.21	0.271
UG77	3.00	0.00	-1.57	0.63	6.29	0.013	50.67	17.37	19.19	8.51	5.08	0.025	8.08	1.07	-1.51	0.95	2.51	0.114	3.93	0.52	-0.77	0.44	3.03	0.083
UG78	4.67	0.88	0.09	0.63	0.02	0.884	36.00	3.00	4.52	8.51	0.28	0.596	11.86	1.20	2.27	0.95	5.70	0.017	5.59	0.60	0.89	0.44	4.02	0.046
UG79	4.33	0.88	-0.24	0.63	0.15	0.701	38.33	12.25	6.85	8.51	0.65	0.421	10.50	1.35	0.91	0.95	0.91	0.340	5.25	0.49	0.55	0.44	1.52	0.219
UG80	4.33	0.33	-0.24	0.63	0.15	0.701	22.33	3.67	-9.15	8.51	1.15	0.283	10.78	0.64	1.19	0.95	1.57	0.211	5.28	0.43	0.58	0.44	1.69	0.194
UG81	5.00	1.00	0.43	0.63	0.46	0.499	47.67	8.21	16.19	8.51	3.62	0.058	8.67	1.09	-0.92	0.95	0.94	0.334	4.45	0.26	-0.26	0.44	0.33	0.564
UG82	4.00	0.58	-0.57	0.63	0.84	0.360	37.67	8.25	6.19	8.51	0.53	0.468	10.98	0.63	1.39	0.95	2.14	0.144	5.49	0.31	0.79	0.44	3.17	0.076
UG83	4.33	0.88	-0.24	0.63	0.15	0.701	13.00	1.00	-18.48	8.51	4.71	0.031	8.30	0.51	-1.28	0.95	1.82	0.178	3.82	0.25	-0.89	0.44	3.98	0.047
UG84	4.33	0.88	-0.24	0.63	0.15	0.701	28.33	8.25	-3.15	8.51	0.14	0.712	10.52	0.87	0.93	0.95	0.95	0.330	5.04	0.39	0.33	0.44	0.57	0.453
UG85	4.33	0.33	-0.24	0.63	0.15	0.701	32.00	8.50	0.52	8.51	0.00	0.951	8.37	0.32	-1.22	0.95	1.64	0.201	4.07	0.27	-0.63	0.44	2.01	0.157
UG86	3.67	0.33	-0.91	0.63	2.09	0.149	28.00	8.89	-3.48	8.51	0.17	0.683	9.66	1.23	0.08	0.95	0.01	0.937	4.89	0.79	0.18	0.44	0.17	0.679
UG87	3.67	0.67	-0.91	0.63	2.09	0.149	17.33	7.54	-14.15	8.51	2.76	0.097	9.14	0.62	-0.45	0.95	0.22	0.636	4.46	0.20	-0.25	0.44	0.31	0.580
UG88	5.33	0.67	0.76	0.63	1.46	0.228	51.33	8.97	19.85	8.51	5.44	0.020	10.37	2.45	0.78	0.95	0.67	0.414	5.13	1.02	0.42	0.44	0.91	0.340
UG89	5.00	0.58	0.43	0.63	0.46	0.499	10.67	0.67	-20.81	8.51	5.98	0.015	8.81	1.56	-0.77	0.95	0.66	0.416	4.52	0.56	-0.18	0.44	0.17	0.681
UG90	3.67	0.67	-0.91	0.63	2.09	0.149	33.00	9.45	1.52	8.51	0.03	0.858	6.80	0.53	-2.79	0.95	8.60	0.004	3.41	0.27	-1.30	0.44	8.52	0.004
UG91	3.33	0.33	-1.24	0.63	3.91	0.049	60.67	6.44	29.19	8.51	11.76	0.001	8.04	0.88	-1.55	0.95	2.65	0.105	3.80	0.53	-0.91	0.44	4.16	0.042
UG92	3.33	0.33	-1.24	0.63	3.91	0.049	22.33	6.44	-9.15	8.51	1.15	0.283	9.54	0.67	-0.05	0.95	0.00	0.957	4.66	0.45	-0.05	0.44	0.01	0.917
UG93	4.33	0.88	-0.24	0.63	0.15	0.701	17.00	5.20	-14.48	8.51	2.89	0.090	8.59	0.61	-1.00	0.95	1.10	0.295	4.07	0.31	-0.63	0.44	2.01	0.157
UG94	4.67	0.88	0.09	0.63	0.02	0.884	40.67	16.86	9.19	8.51	1.17	0.281	8.63	1.33	-0.96	0.95	1.01	0.315	4.48	0.60	-0.22	0.44	0.24	0.621
UG95	4.67	0.67	0.09	0.63	0.02	0.884	33.67	1.20	2.19	8.51	0.07	0.797	10.75	1.29	1.16	0.95	1.48	0.224	5.15	0.63	0.45	0.44	1.01	0.314
UG96	3.67	0.67	-0.91	0.63	2.09	0.149	18.33	1.45	-13.15	8.51	2.39	0.123	9.44	0.35	-0.15	0.95	0.03	0.874	4.39	0.17	-0.32	0.44	0.51	0.477
UG97	5.00	1.00	0.43	0.63	0.46	0.499	36.67	15.19	5.19	8.51	0.37	0.543	8.69	1.92	-0.89	0.95	0.88	0.348	4.35	0.80	-0.36	0.44	0.64	0.423
UG98	3.00	0.00	-1.57	0.63	6.29	0.013	26.00	2.08	-5.48	8.51	0.41	0.520	11.53	0.93	1.94	0.95	4.15	0.042	5.43	0.47	0.72	0.44	2.66	0.104
UG99	3.33	0.33	-1.24	0.63	3.91	0.049	28.67	7.06	-2.81	8.51	0.11	0.741	8.92	0.36	-0.67	0.95	0.49	0.483	4.35	0.11	-0.35	0.44	0.63	0.427
UG100	6.00	0.00	1.43	0.63	5.15	0.024	32.67	12.25	1.19	8.51	0.02	0.889	8.81	1.40	-0.78	0.95	0.67	0.412	4.51	0.48	-0.19	0.44	0.18	0.670
UG101	4.67	0.88	0.09	0.63	0.02	0.884	38.67	4.84	7.19	8.51	0.71	0.399	8.88	1.10	-0.71	0.95	0.55	0.457	4.23	0.45	-0.47	0.44	1.13	0.288
UG102	4.00	0.58	-0.57	0.63	0.84	0.360	31.00	14.84	-0.48	8.51	0.00	0.955	9.91	2.06	0.32	0.95	0.11	0.738	4.95	0.74	0.25	0.44	0.32	0.573
UG103	5.00	0.58	0.43	0.63	0.46	0.499	16.33	1.67	-15.15	8.51	3.17	0.076	10.82	1.16	1.24	0.95	1.68	0.195	5.19	0.69	0.49	0.44	1.20	0.273
UG104	3.67	0.67	-0.91	0.63	2.09	0.149	17.33	4.33	-14.15	8.51	2.76	0.097	8.46	0.45	-1.13	0.95	1.41	0.237	4.01	0.12	-0.70	0.44	2.46	0.118
Grandmean	**4.55**	**0.05**			**1.11**	**0.243**	**30.96**	**0.65**			**1.37**	**0.015**	**9.67**	**0.07**			**1.43**	**0.007**	**4.74**	**0.03**			**1.61**	**0.001**

Appendix 5 (Cont'd)

Accessions	STL						STV						NNS						NMB					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
Asontem	0.89	0.02	-0.01	0.02	0.35	0.552	0.52	0.01	-0.01	0.01	1.78	0.183	10.35	0.72	-0.54	0.71	0.57	0.449	3.78	0.29	-0.72	0.32	5.02	0.026
Kirkhouse	0.83	0.01	-0.07	0.02	17.79	0.000	0.52	0.01	-0.01	0.01	1.73	0.190	9.75	0.71	-1.14	0.71	2.59	0.108	4.44	0.35	-0.05	0.32	0.03	0.870
Padituya	0.96	0.01	0.06	0.02	12.04	0.001	0.56	0.01	0.02	0.01	5.70	0.017	11.40	0.50	0.51	0.71	0.52	0.471	4.83	0.28	0.33	0.32	1.05	0.307
Wang Kae	0.91	0.02	0.01	0.02	0.42	0.515	0.55	0.01	0.01	0.01	3.02	0.083	6.54	0.52	-4.35	0.71	37.64	0.000	4.63	0.31	0.14	0.32	0.18	0.668
UG1	0.88	0.04	-0.02	0.07	0.05	0.817	0.47	0.01	-0.07	0.04	3.49	0.062	7.33	3.18	-3.55	2.99	1.41	0.235	5.67	0.33	1.17	1.35	0.75	0.388
UG2	0.89	0.06	-0.01	0.07	0.03	0.853	0.46	0.02	-0.08	0.04	4.63	0.032	7.67	2.03	-3.22	2.99	1.16	0.282	5.33	0.67	0.84	1.35	0.38	0.537
UG3	0.84	0.04	-0.06	0.07	0.69	0.408	0.48	0.04	-0.05	0.04	2.21	0.138	18.00	2.00	7.11	2.99	5.67	0.018	4.33	0.88	-0.16	1.35	0.01	0.904
UG4	0.90	0.02	0.00	0.07	0.00	0.964	0.52	0.02	-0.01	0.04	0.12	0.728	11.67	3.93	0.78	2.99	0.07	0.794	3.00	1.53	-1.50	1.35	1.22	0.270
UG5	0.93	0.07	0.03	0.07	0.13	0.714	0.52	0.02	-0.02	0.04	0.20	0.658	9.67	1.86	-1.22	2.99	0.17	0.683	4.33	1.67	-0.16	1.35	0.01	0.904
UG6	1.00	0.09	0.10	0.07	1.78	0.183	0.57	0.08	0.03	0.04	0.79	0.375	14.67	2.73	3.78	2.99	1.60	0.207	3.67	1.76	-0.83	1.35	0.38	0.540
UG7	0.90	0.00	0.00	0.07	0.00	0.963	0.51	0.03	-0.02	0.04	0.40	0.527	9.33	2.33	-1.55	2.99	0.27	0.604	2.33	0.67	-2.16	1.35	2.55	0.111
UG8	0.96	0.07	0.06	0.07	0.61	0.435	0.51	0.03	-0.03	0.04	0.53	0.467	11.00	1.53	0.11	2.99	0.00	0.970	5.00	0.00	0.50	1.35	0.14	0.711
UG9	0.90	0.04	0.00	0.07	0.00	0.963	0.53	0.05	-0.01	0.04	0.02	0.875	15.00	3.61	4.11	2.99	1.90	0.169	5.33	1.76	0.84	1.35	0.38	0.537
UG10	0.91	0.06	0.01	0.07	0.03	0.855	0.48	0.03	-0.06	0.04	2.51	0.114	13.00	1.00	2.11	2.99	0.50	0.480	2.00	0.58	-2.50	1.35	3.40	0.066
UG11	1.01	0.12	0.11	0.07	2.44	0.119	0.57	0.06	0.04	0.04	1.16	0.282	9.67	4.70	-1.22	2.99	0.17	0.683	6.33	0.88	1.84	1.35	1.84	0.176
UG12	0.82	0.02	-0.08	0.07	1.22	0.270	0.45	0.02	-0.09	0.04	5.94	0.015	6.67	2.03	-4.22	2.99	1.99	0.159	4.33	1.45	-0.16	1.35	0.01	0.904
UG13	0.90	0.09	0.00	0.07	0.00	0.999	0.60	0.08	0.06	0.04	3.04	0.082	12.33	2.33	1.45	2.99	0.23	0.628	5.67	2.33	1.17	1.35	0.75	0.388
UG14	0.91	0.09	0.01	0.07	0.03	0.855	0.53	0.02	0.00	0.04	0.00	0.950	14.67	1.86	3.78	2.99	1.60	0.207	4.00	1.15	-0.50	1.35	0.13	0.714
UG15	0.79	0.09	-0.11	0.07	2.31	0.130	0.47	0.03	-0.07	0.04	3.85	0.050	9.67	3.71	-1.22	2.99	0.17	0.683	3.00	1.15	-1.50	1.35	1.22	0.270
UG16	0.99	0.07	0.09	0.07	1.54	0.215	0.58	0.01	0.04	0.04	1.37	0.242	8.67	1.45	-2.22	2.99	0.55	0.458	5.67	2.33	1.17	1.35	0.75	0.388
UG17	0.89	0.01	-0.01	0.07	0.01	0.926	0.57	0.01	0.04	0.04	1.16	0.282	8.67	2.60	-2.22	2.99	0.55	0.458	4.33	1.76	-0.16	1.35	0.01	0.904
UG18	0.86	0.03	-0.04	0.07	0.31	0.581	0.58	0.01	0.05	0.04	1.86	0.174	12.00	3.06	1.11	2.99	0.14	0.710	5.67	1.20	1.17	1.35	0.75	0.388
UG19	1.00	0.11	0.10	0.07	2.03	0.155	0.60	0.01	0.06	0.04	3.04	0.082	6.00	3.51	-4.89	2.99	2.67	0.103	5.00	1.53	0.50	1.35	0.14	0.711
UG20	0.81	0.04	-0.09	0.07	1.43	0.232	0.50	0.04	-0.04	0.04	1.03	0.312	10.67	2.40	-0.22	2.99	0.01	0.942	6.33	0.88	1.84	1.35	1.84	0.176
UG21	0.93	0.07	0.03	0.07	0.17	0.680	0.55	0.04	0.01	0.04	0.10	0.751	11.00	4.51	0.11	2.99	0.00	0.970	2.67	0.88	-1.83	1.35	1.83	0.177
UG22	1.03	0.11	0.13	0.07	3.38	0.067	0.57	0.00	0.03	0.04	0.79	0.375	16.00	3.06	5.11	2.99	2.93	0.088	4.33	1.33	-0.16	1.35	0.01	0.904
UG23	0.97	0.09	0.07	0.07	0.84	0.359	0.65	0.06	0.12	0.04	11.27	0.001	8.00	3.21	-2.89	2.99	0.93	0.335	4.00	1.73	-0.50	1.35	0.13	0.714
UG24	0.96	0.06	0.06	0.07	0.76	0.383	0.56	0.02	0.03	0.04	0.63	0.429	10.67	2.33	-0.22	2.99	0.01	0.942	7.00	0.00	2.50	1.35	3.42	0.065
UG25	0.87	0.10	-0.03	0.07	0.21	0.645	0.47	0.01	-0.06	0.04	3.14	0.077	3.33	1.33	-7.55	2.99	6.39	0.012	5.33	1.76	0.84	1.35	0.38	0.537
UG26	0.96	0.03	0.06	0.07	0.61	0.435	0.54	0.01	0.00	0.04	0.00	0.974	11.67	2.91	0.78	2.99	0.07	0.794	5.00	1.53	0.50	1.35	0.14	0.711
UG27	0.84	0.03	-0.06	0.07	0.61	0.434	0.56	0.01	0.03	0.04	0.63	0.429	11.33	1.76	0.45	2.99	0.02	0.881	5.67	1.45	1.17	1.35	0.75	0.388
UG28	0.88	0.03	-0.02	0.07	0.08	0.782	0.52	0.03	-0.01	0.04	0.12	0.728	8.00	3.21	-2.89	2.99	0.93	0.335	2.00	0.58	-2.50	1.35	3.40	0.066
UG29	1.04	0.15	0.14	0.07	3.55	0.060	0.56	0.01	0.03	0.04	0.63	0.429	11.67	0.67	0.78	2.99	0.07	0.794	1.33	0.33	-3.16	1.35	5.46	0.020
UG30	0.90	0.10	0.00	0.07	0.00	0.999	0.57	0.05	0.04	0.04	1.16	0.282	10.00	4.36	-0.89	2.99	0.09	0.767	5.00	1.53	0.50	1.35	0.14	0.711
Grandmean	**0.90**	**0.01**			**1.28**	**0.044**	**0.54**	**0.00**			**1.92**	**0.000**	**10.30**	**0.23**			**1.43**	**0.007**	**4.46**	**0.10**			**0.86**	**0.829**

Appendix 5 (Cont'd)

Accessions	STL						STW						NNS						NMB					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG31	0.81	0.03	-0.09	0.07	1.66	0.198	0.52	0.01	-0.02	0.04	0.29	0.591	12.33	4.81	1.45	2.99	0.23	0.628	4.00	1.73	-0.50	1.35	0.13	0.714
UG32	0.88	0.07	-0.02	0.07	0.10	0.747	0.54	0.03	0.01	0.04	0.05	0.824	10.67	4.37	-0.22	2.99	0.01	0.942	4.33	0.88	-0.16	1.35	0.01	0.904
UG33	0.77	0.05	-0.13	0.07	3.22	0.073	0.54	0.03	0.00	0.04	0.00	0.974	15.00	4.51	4.11	2.99	1.90	0.169	4.33	1.45	-0.16	1.35	0.01	0.904
UG34	0.75	0.03	-0.15	0.07	4.10	0.044	0.53	0.03	-0.01	0.04	0.06	0.801	11.00	3.46	0.11	2.99	0.00	0.970	3.67	0.33	-0.83	1.35	0.38	0.540
UG35	0.74	0.03	-0.16	0.07	4.68	0.031	0.51	0.02	-0.03	0.04	0.53	0.467	7.67	2.40	-3.22	2.99	1.16	0.282	6.33	0.88	1.84	1.35	1.84	0.176
UG36	0.96	0.09	0.06	0.07	0.68	0.409	0.55	0.03	0.01	0.04	0.10	0.751	9.67	4.33	-1.22	2.99	0.17	0.683	2.33	0.88	-2.16	1.35	2.55	0.111
UG37	0.81	0.08	-0.09	0.07	1.66	0.198	0.53	0.03	-0.01	0.04	0.02	0.875	18.00	1.15	7.11	2.99	5.67	0.018	3.33	1.86	-1.16	1.35	0.74	0.391
UG38	0.93	0.05	0.03	0.07	0.17	0.680	0.53	0.01	-0.01	0.04	0.02	0.875	11.67	2.33	0.78	2.99	0.07	0.794	5.67	0.88	1.17	1.35	0.75	0.388
UG39	0.85	0.07	-0.05	0.07	0.48	0.490	0.55	0.03	0.01	0.04	0.17	0.680	10.33	2.33	-0.55	2.99	0.03	0.853	3.67	1.45	-0.83	1.35	0.38	0.540
UG40	0.88	0.03	-0.02	0.07	0.05	0.817	0.62	0.01	0.08	0.04	5.35	0.021	10.00	4.16	-0.89	2.99	0.09	0.767	4.00	1.53	-0.50	1.35	0.13	0.714
UG41	0.88	0.07	-0.02	0.07	0.08	0.782	0.62	0.04	0.08	0.04	5.79	0.017	11.67	2.96	0.78	2.99	0.07	0.794	4.00	1.00	-0.50	1.35	0.13	0.714
UG42	0.77	0.03	-0.13	0.07	3.06	0.081	0.50	0.02	-0.03	0.04	0.84	0.359	10.00	4.93	-0.89	2.99	0.09	0.767	5.00	0.58	0.50	1.35	0.14	0.711
UG43	0.82	0.04	-0.08	0.07	1.12	0.290	0.56	0.03	0.02	0.04	0.36	0.547	15.00	2.00	4.11	2.99	1.90	0.169	5.00	1.15	0.50	1.35	0.14	0.711
UG44	0.95	0.01	0.05	0.07	0.47	0.491	0.64	0.02	0.10	0.04	8.86	0.003	9.00	5.03	-1.89	2.99	0.40	0.528	5.67	0.88	1.17	1.35	0.75	0.388
UG45	0.84	0.08	-0.06	0.07	0.61	0.434	0.58	0.04	0.05	0.04	1.86	0.174	8.67	3.67	-2.22	2.99	0.55	0.458	5.33	0.33	0.84	1.35	0.38	0.537
UG46	0.82	0.04	-0.08	0.07	1.12	0.290	0.56	0.03	0.02	0.04	0.36	0.547	15.00	2.00	4.11	2.99	1.90	0.169	5.00	1.15	0.50	1.35	0.14	0.711
UG47	0.95	0.01	0.05	0.07	0.47	0.491	0.64	0.02	0.10	0.04	8.86	0.003	9.00	5.03	-1.89	2.99	0.40	0.528	5.67	0.88	1.17	1.35	0.75	0.388
UG48	0.84	0.08	-0.06	0.07	0.61	0.434	0.58	0.04	0.05	0.04	1.86	0.174	8.67	3.67	-2.22	2.99	0.55	0.458	5.33	0.33	0.84	1.35	0.38	0.537
UG49	0.87	0.04	-0.03	0.07	0.21	0.645	0.60	0.02	0.07	0.04	3.73	0.054	13.00	1.15	2.11	2.99	0.50	0.480	2.33	1.33	-2.16	1.35	2.55	0.111
UG50	0.84	0.01	-0.06	0.07	0.61	0.434	0.57	0.03	0.03	0.04	0.96	0.327	10.00	4.36	-0.89	2.99	0.09	0.767	4.67	0.88	0.17	1.35	0.02	0.900
UG51	0.88	0.12	-0.02	0.07	0.08	0.782	0.62	0.11	0.08	0.04	5.79	0.017	12.67	5.46	1.78	2.99	0.36	0.552	4.00	2.00	-0.50	1.35	0.13	0.714
UG52	1.05	0.06	0.15	0.07	4.28	0.039	0.55	0.02	0.01	0.04	0.17	0.680	9.33	3.93	-1.55	2.99	0.27	0.604	6.33	1.20	1.84	1.35	1.84	0.176
UG53	0.81	0.01	-0.09	0.07	1.43	0.232	0.54	0.01	0.00	0.04	0.00	0.974	13.00	4.36	2.11	2.99	0.50	0.480	4.00	1.53	-0.50	1.35	0.13	0.714
UG54	0.84	0.06	-0.06	0.07	0.61	0.434	0.56	0.01	0.03	0.04	0.63	0.429	13.67	4.48	2.78	2.99	0.87	0.353	5.67	2.33	1.17	1.35	0.75	0.388
UG55	0.87	0.04	-0.03	0.07	0.14	0.712	0.60	0.03	0.06	0.04	3.04	0.082	13.00	4.16	2.11	2.99	0.50	0.480	5.67	0.33	1.17	1.35	0.75	0.388
UG56	0.88	0.03	-0.02	0.07	0.10	0.747	0.55	0.02	0.01	0.04	0.17	0.680	11.33	4.37	0.45	2.99	0.02	0.881	3.00	1.00	-1.50	1.35	1.22	0.270
UG57	0.96	0.11	0.06	0.07	0.61	0.435	0.54	0.03	0.00	0.04	0.02	0.899	10.33	4.37	-0.55	2.99	0.03	0.853	4.33	2.03	-0.16	1.35	0.01	0.904
UG58	0.94	0.06	0.04	0.07	0.30	0.582	0.59	0.03	0.05	0.04	2.41	0.121	8.33	0.88	-2.55	2.99	0.73	0.393	5.33	1.33	0.84	1.35	0.38	0.537
UG59	0.90	0.02	0.00	0.07	0.00	0.999	0.57	0.04	0.03	0.04	0.96	0.327	9.00	4.04	-1.89	2.99	0.40	0.528	3.00	1.15	-1.50	1.35	1.22	0.270
UG60	0.85	0.06	-0.05	0.07	0.42	0.519	0.59	0.04	0.06	0.04	2.71	0.100	12.33	5.17	1.45	2.99	0.23	0.628	4.67	1.45	0.17	1.35	0.02	0.900
UG61	0.93	0.03	0.03	0.07	0.21	0.647	0.54	0.03	0.01	0.04	0.05	0.824	13.67	4.10	2.78	2.99	0.87	0.353	4.67	0.67	0.17	1.35	0.02	0.900
UG62	0.97	0.04	0.07	0.07	0.84	0.359	0.51	0.02	-0.03	0.04	0.53	0.467	8.67	2.60	-2.22	2.99	0.55	0.458	4.33	0.88	-0.16	1.35	0.01	0.904
UG63	1.05	0.14	0.15	0.07	4.47	0.035	0.56	0.02	0.02	0.04	0.49	0.486	11.00	2.52	0.11	2.99	0.00	0.970	3.33	1.86	-1.16	1.35	0.74	0.391
UG64	1.01	0.02	0.11	0.07	2.16	0.142	0.50	0.02	-0.04	0.04	1.03	0.312	14.67	2.60	3.78	2.99	1.60	0.207	5.33	0.88	0.84	1.35	0.38	0.537
UG65	0.88	0.07	-0.02	0.07	0.05	0.817	0.47	0.02	-0.06	0.04	3.14	0.077	8.00	3.21	-2.89	2.99	0.93	0.335	3.33	1.86	-1.16	1.35	0.74	0.391
UG66	0.83	0.04	-0.07	0.07	0.85	0.358	0.58	0.04	0.04	0.04	1.37	0.242	16.00	3.06	5.11	2.99	2.93	0.088	3.67	2.19	-0.83	1.35	0.38	0.540
UG67	0.97	0.10	0.07	0.07	0.84	0.359	0.58	0.03	0.04	0.04	1.61	0.206	10.00	1.00	-0.89	2.99	0.09	0.767	5.33	1.45	0.84	1.35	0.38	0.537
UG68	1.04	0.04	0.14	0.07	3.91	0.049	0.52	0.04	-0.01	0.04	0.12	0.728	11.33	4.33	0.45	2.99	0.02	0.881	5.00	1.15	0.50	1.35	0.14	0.711
Grandmean	**0.90**	**0.01**			**1.28**	**0.044**	**0.54**	**0.00**			**1.92**	**0.000**	**10.30**	**0.23**			**1.43**	**0.007**	**4.46**	**0.10**			**0.86**	**0.829**

Appendix 5 (Cont'd)

Accessions	STL						STW						NNS						NMB					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG69	1.01	0.09	0.11	0.07	2.44	0.119	0.51	0.03	-0.03	0.04	0.53	0.467	7.00	1.15	-3.89	2.99	1.69	0.194	3.67	1.76	-0.83	1.35	0.38	0.540
UG70	0.94	0.04	0.04	0.07	0.25	0.614	0.50	0.01	-0.04	0.04	1.23	0.269	12.67	4.06	1.78	2.99	0.36	0.552	3.00	1.15	-1.50	1.35	1.22	0.270
UG71	1.00	0.08	0.10	0.07	1.90	0.169	0.58	0.13	0.04	0.04	1.37	0.242	10.33	2.91	-0.55	2.99	0.03	0.853	2.67	0.33	-1.83	1.35	1.83	0.177
UG72	0.96	0.08	0.06	0.07	0.61	0.435	0.49	0.02	-0.05	0.04	1.68	0.195	6.33	2.19	-4.55	2.99	2.32	0.128	5.00	1.15	0.50	1.35	0.14	0.711
UG73	0.91	0.04	0.01	0.07	0.03	0.855	0.63	0.02	0.09	0.04	6.75	0.010	10.33	5.24	-0.55	2.99	0.03	0.853	3.33	1.86	-1.16	1.35	0.74	0.391
UG74	0.89	0.08	-0.01	0.07	0.02	0.890	0.52	0.05	-0.02	0.04	0.29	0.591	6.33	3.38	-4.55	2.99	2.32	0.128	4.33	1.33	-0.16	1.35	0.01	0.904
UG75	0.91	0.11	0.01	0.07	0.02	0.891	0.53	0.05	-0.01	0.04	0.02	0.875	8.67	2.60	-2.22	2.99	0.55	0.458	5.33	0.88	0.84	1.35	0.38	0.537
UG76	0.95	0.12	0.05	0.07	0.54	0.463	0.49	0.03	-0.04	0.04	1.45	0.230	7.00	1.73	-3.89	2.99	1.69	0.194	3.00	1.53	-1.50	1.35	1.22	0.270
UG77	0.89	0.03	-0.01	0.07	0.03	0.853	0.45	0.01	-0.08	0.04	5.49	0.020	11.67	1.33	0.78	2.99	0.07	0.794	2.33	0.33	-2.16	1.35	2.55	0.111
UG78	1.00	0.13	0.10	0.07	1.78	0.183	0.57	0.05	0.04	0.04	1.16	0.282	7.33	3.33	-3.55	2.99	1.41	0.235	3.67	0.33	-0.83	1.35	0.38	0.540
UG79	0.80	0.04	-0.10	0.07	1.78	0.183	0.43	0.01	-0.11	0.04	9.05	0.003	16.00	2.08	5.11	2.99	2.93	0.088	4.00	0.00	-0.50	1.35	0.13	0.714
UG80	0.87	0.04	-0.03	0.07	0.14	0.712	0.52	0.04	-0.01	0.04	0.12	0.728	14.33	2.96	3.45	2.99	1.33	0.249	5.00	1.00	0.50	1.35	0.14	0.711
UG81	0.90	0.11	0.00	0.07	0.00	0.963	0.49	0.04	-0.04	0.04	1.45	0.230	15.33	4.18	4.45	2.99	2.21	0.137	3.33	0.88	-1.16	1.35	0.74	0.391
UG82	0.99	0.08	0.09	0.07	1.54	0.215	0.55	0.02	0.01	0.04	0.17	0.680	9.33	2.33	-1.55	2.99	0.27	0.604	5.67	1.20	1.17	1.35	0.75	0.388
UG83	0.96	0.16	0.06	0.07	0.61	0.435	0.56	0.03	0.02	0.04	0.49	0.486	4.00	0.58	-6.89	2.99	5.31	0.022	5.67	1.86	1.17	1.35	0.75	0.388
UG84	0.84	0.07	-0.06	0.07	0.69	0.408	0.46	0.01	-0.07	0.04	4.23	0.040	7.67	2.60	-3.22	2.99	1.16	0.282	5.67	0.67	1.17	1.35	0.75	0.388
UG85	0.89	0.02	-0.01	0.07	0.01	0.926	0.50	0.03	-0.04	0.04	1.23	0.269	13.67	2.40	2.78	2.99	0.87	0.353	5.67	0.33	1.17	1.35	0.75	0.388
UG86	0.82	0.04	-0.08	0.07	1.12	0.290	0.49	0.03	-0.04	0.04	1.45	0.230	11.33	3.48	0.45	2.99	0.02	0.881	4.67	1.86	0.17	1.35	0.02	0.900
UG87	0.77	0.04	-0.13	0.07	3.39	0.066	0.44	0.03	-0.10	0.04	7.94	0.005	11.00	3.61	0.11	2.99	0.00	0.970	6.33	1.20	1.84	1.35	1.84	0.176
UG88	0.88	0.12	-0.02	0.07	0.10	0.747	0.48	0.01	-0.05	0.04	2.21	0.138	5.33	0.88	-5.55	2.99	3.45	0.064	1.67	0.33	-2.83	1.35	4.37	0.037
UG89	0.87	0.02	-0.03	0.07	0.21	0.645	0.48	0.03	-0.06	0.04	2.51	0.114	10.67	2.03	-0.22	2.99	0.01	0.942	5.67	0.67	1.17	1.35	0.75	0.388
UG90	0.95	0.08	0.05	0.07	0.54	0.463	0.52	0.03	-0.02	0.04	0.20	0.658	11.67	4.06	0.78	2.99	0.07	0.794	5.33	0.67	0.84	1.35	0.38	0.537
UG91	0.82	0.09	-0.08	0.07	1.12	0.290	0.43	0.01	-0.10	0.04	8.48	0.004	18.67	0.33	7.78	2.99	6.78	0.010	2.33	0.88	-2.16	1.35	2.55	0.111
UG92	0.85	0.06	-0.05	0.07	0.42	0.519	0.51	0.03	-0.03	0.04	0.68	0.411	12.67	2.03	1.78	2.99	0.36	0.552	4.67	2.03	0.17	1.35	0.02	0.900
UG93	0.93	0.04	0.03	0.07	0.13	0.714	0.56	0.03	0.03	0.04	0.63	0.429	8.00	4.04	-2.89	2.99	0.93	0.335	5.33	0.33	0.84	1.35	0.38	0.537
UG94	0.91	0.08	0.01	0.07	0.02	0.891	0.49	0.04	-0.05	0.04	1.94	0.164	5.33	0.88	-5.55	2.99	3.45	0.064	4.33	1.67	-0.16	1.35	0.01	0.904
UG95	1.07	0.01	0.17	0.07	5.50	0.020	0.55	0.02	0.02	0.04	0.26	0.612	14.33	2.33	3.45	2.99	1.33	0.249	6.33	0.88	1.84	1.35	1.84	0.176
UG96	0.90	0.07	0.00	0.07	0.00	0.999	0.55	0.05	0.01	0.04	0.10	0.751	12.67	1.45	1.78	2.99	0.36	0.552	5.00	1.00	0.50	1.35	0.14	0.711
UG97	0.85	0.08	-0.05	0.07	0.54	0.462	0.47	0.02	-0.06	0.04	3.14	0.077	8.67	4.70	-2.22	2.99	0.55	0.458	7.00	1.00	2.50	1.35	3.42	0.065
UG98	0.86	0.07	-0.04	0.07	0.36	0.549	0.53	0.04	0.00	0.04	0.00	0.950	9.67	1.20	-1.22	2.99	0.17	0.683	5.00	1.00	0.50	1.35	0.14	0.711
UG99	0.93	0.07	0.03	0.07	0.13	0.714	0.55	0.10	0.01	0.04	0.10	0.751	15.00	2.89	4.11	2.99	1.90	0.169	4.00	1.53	-0.50	1.35	0.13	0.714
UG100	0.84	0.06	-0.06	0.07	0.61	0.434	0.50	0.03	-0.04	0.04	1.23	0.269	10.00	3.51	-0.89	2.99	0.09	0.767	6.67	0.88	2.17	1.35	2.57	0.110
UG101	0.93	0.02	0.03	0.07	0.17	0.680	0.54	0.03	0.00	0.04	0.00	0.974	17.00	1.53	6.11	2.99	4.19	0.041	4.00	2.08	-0.50	1.35	0.13	0.714
UG102	0.85	0.05	-0.05	0.07	0.54	0.462	0.50	0.04	-0.04	0.04	1.23	0.269	7.00	4.00	-3.89	2.99	1.69	0.194	5.00	2.00	0.50	1.35	0.14	0.711
UG103	0.98	0.07	0.08	0.07	1.22	0.271	0.54	0.00	0.01	0.04	0.05	0.824	15.67	2.19	4.78	2.99	2.56	0.110	4.67	1.76	0.17	1.35	0.02	0.900
UG104	0.79	0.02	-0.11	0.07	2.45	0.118	0.46	0.02	-0.08	0.04	4.63	0.032	14.33	1.76	3.45	2.99	1.33	0.249	4.33	0.88	-0.16	1.35	0.01	0.904
Grandmean	**0.90**	**0.01**			**1.28**	**0.044**	**0.54**	**0.00**			**1.92**	**0.000**	**10.30**	**0.23**			**1.43**	**0.007**	**4.46**	**0.10**			**0.86**	**0.829**

Appendix 5 (Cont'd)

Accessions	BL						PH						SPS						LBL					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
Asontem	7.34	0.15	-0.38	0.19	4.21	0.041	40.01	0.64	6.75	1.22	30.83	0.000	2.64	0.02	0.06	0.02	7.23	0.007	1.52	0.01	-0.03	0.01	5.89	0.016
Kirkhouse	7.44	0.22	-0.28	0.19	2.21	0.138	37.39	0.59	4.13	1.22	11.55	0.001	2.50	0.02	-0.07	0.02	9.43	0.002	1.51	0.01	-0.04	0.01	11.83	0.001
Padituya	8.10	0.11	0.38	0.19	4.19	0.041	34.08	0.94	0.81	1.22	0.45	0.504	2.65	0.03	0.07	0.02	8.91	0.003	1.54	0.01	-0.01	0.01	0.28	0.596
Wang Kae	7.95	0.13	0.23	0.19	1.60	0.207	28.48	1.56	-4.78	1.22	15.48	0.000	2.51	0.02	-0.07	0.02	8.58	0.004	1.52	0.01	-0.03	0.01	5.03	0.026
UG1	7.12	0.14	-0.60	0.78	0.59	0.444	32.40	1.66	-0.86	5.13	0.03	0.866	2.15	0.02	-0.42	0.10	18.03	0.000	1.55	0.00	0.00	0.05	0.00	0.976
UG2	7.44	0.08	-0.28	0.78	0.13	0.721	26.16	7.80	-7.10	5.13	1.92	0.166	2.63	0.07	0.06	0.10	0.33	0.568	1.68	0.07	0.13	0.05	7.04	0.008
UG3	7.63	0.84	-0.09	0.78	0.01	0.905	33.20	3.07	-0.06	5.13	0.00	0.990	2.54	0.11	-0.03	0.10	0.11	0.741	1.60	0.06	0.05	0.05	1.03	0.311
UG4	5.83	1.45	-1.89	0.78	5.82	0.016	35.82	6.07	2.56	5.13	0.25	0.618	2.50	0.23	-0.08	0.10	0.59	0.444	1.57	0.02	0.02	0.05	0.13	0.720
UG5	7.70	0.45	-0.02	0.78	0.00	0.976	32.24	16.32	-1.02	5.13	0.04	0.842	2.78	0.08	0.21	0.10	4.32	0.038	1.58	0.06	0.03	0.05	0.47	0.493
UG6	7.32	0.36	-0.40	0.78	0.26	0.607	42.40	9.13	9.14	5.13	3.18	0.075	2.32	0.19	-0.26	0.10	6.62	0.010	1.53	0.10	-0.02	0.05	0.09	0.766
UG7	8.48	0.55	0.76	0.78	0.94	0.332	41.13	7.96	7.87	5.13	2.36	0.126	2.70	0.06	0.12	0.10	1.54	0.215	1.48	0.04	-0.07	0.05	1.64	0.201
UG8	8.04	0.24	0.32	0.78	0.17	0.680	37.28	3.84	4.02	5.13	0.61	0.434	2.57	0.19	-0.01	0.10	0.01	0.923	1.48	0.04	-0.07	0.05	1.64	0.201
UG9	7.63	0.87	-0.09	0.78	0.01	0.912	27.60	3.86	-5.66	5.13	1.22	0.270	2.70	0.14	0.12	0.10	1.54	0.215	1.55	0.03	0.00	0.05	0.00	0.976
UG10	8.27	0.56	0.55	0.78	0.50	0.480	41.52	4.10	8.26	5.13	2.60	0.108	2.56	0.06	-0.02	0.10	0.03	0.870	1.50	0.06	-0.05	0.05	0.91	0.341
UG11	8.69	0.91	0.97	0.78	1.54	0.215	34.48	7.37	1.22	5.13	0.06	0.813	2.67	0.09	0.09	0.10	0.82	0.365	1.48	0.04	-0.07	0.05	1.64	0.201
UG12	7.52	0.34	-0.20	0.78	0.06	0.802	37.04	7.24	3.78	5.13	0.54	0.462	2.43	0.12	-0.15	0.10	2.26	0.134	1.55	0.00	0.00	0.05	0.00	0.976
UG13	7.68	0.30	-0.04	0.78	0.00	0.960	27.52	5.75	-5.74	5.13	1.26	0.263	2.57	0.07	-0.01	0.10	0.01	0.923	1.53	0.02	-0.02	0.05	0.09	0.766
UG14	7.80	0.52	0.08	0.78	0.01	0.922	25.20	2.53	-8.06	5.13	2.48	0.116	2.35	0.00	-0.23	0.10	5.16	0.024	1.48	0.07	-0.07	0.05	1.64	0.201
UG15	6.00	0.79	-1.72	0.78	4.80	0.029	35.68	5.34	2.42	5.13	0.22	0.638	2.49	0.15	-0.08	0.10	0.69	0.405	1.48	0.04	-0.07	0.05	1.64	0.201
UG16	6.79	0.21	-0.93	0.78	1.42	0.234	30.96	3.55	-2.30	5.13	0.20	0.653	2.63	0.15	0.05	0.10	0.26	0.614	1.50	0.05	-0.05	0.05	0.91	0.341
UG17	7.36	0.04	-0.36	0.78	0.21	0.643	28.48	5.19	-4.78	5.13	0.87	0.351	2.65	0.15	0.07	0.10	0.55	0.460	1.57	0.02	0.02	0.05	0.13	0.720
UG18	7.77	0.26	0.05	0.78	0.00	0.946	36.13	11.87	2.86	5.13	0.31	0.577	2.48	0.08	-0.10	0.10	1.00	0.318	1.55	0.03	0.00	0.05	0.00	0.976
UG19	8.11	0.55	0.39	0.78	0.24	0.622	38.48	4.51	5.22	5.13	1.04	0.309	2.53	0.03	-0.04	0.10	0.19	0.666	1.50	0.08	-0.05	0.05	0.91	0.341
UG20	7.63	0.27	-0.09	0.78	0.01	0.905	40.24	5.77	6.98	5.13	1.85	0.174	2.38	0.04	-0.20	0.10	4.02	0.046	1.47	0.03	-0.08	0.05	2.59	0.108
UG21	7.25	0.59	-0.47	0.78	0.36	0.546	31.84	4.11	-1.42	5.13	0.08	0.781	2.60	0.18	0.02	0.10	0.06	0.812	1.60	0.00	0.05	0.05	1.03	0.311
UG22	8.12	0.31	0.40	0.78	0.27	0.607	27.84	2.70	-5.42	5.13	1.12	0.291	2.49	0.16	-0.09	0.10	0.81	0.369	1.52	0.06	-0.03	0.05	0.39	0.532
UG23	7.13	0.46	-0.59	0.78	0.57	0.452	38.40	8.45	5.14	5.13	1.00	0.317	2.50	0.00	-0.08	0.10	0.59	0.444	1.57	0.02	0.02	0.05	0.13	0.720
UG24	7.34	0.54	-0.38	0.78	0.24	0.625	36.96	4.04	3.70	5.13	0.52	0.471	2.53	0.08	-0.04	0.10	0.19	0.666	1.58	0.02	0.03	0.05	0.47	0.493
UG25	8.67	0.26	0.95	0.78	1.48	0.224	32.96	3.07	-0.30	5.13	0.00	0.953	2.49	0.23	-0.08	0.10	0.69	0.405	1.52	0.04	-0.03	0.05	0.39	0.532
UG26	7.57	0.51	-0.15	0.78	0.03	0.852	25.60	3.51	-7.66	5.13	2.24	0.136	2.61	0.14	0.03	0.10	0.11	0.736	1.50	0.05	-0.05	0.05	0.91	0.341
UG27	8.65	0.58	0.93	0.78	1.40	0.237	30.68	5.26	-2.58	5.13	0.25	0.615	2.33	0.02	-0.24	0.10	5.95	0.015	1.45	0.05	-0.10	0.05	3.75	0.054
UG28	9.78	0.20	2.06	0.78	6.94	0.009	23.82	2.58	-9.44	5.13	3.39	0.066	2.59	0.08	0.02	0.10	0.03	0.865	1.55	0.03	0.00	0.05	0.00	0.976
UG29	9.80	1.42	2.08	0.78	7.05	0.008	29.04	7.54	-4.22	5.13	0.68	0.410	2.58	0.07	0.01	0.10	0.00	0.944	1.52	0.06	-0.03	0.05	0.39	0.532
UG30	7.05	0.72	-0.67	0.78	0.74	0.391	29.28	5.20	-3.98	5.13	0.60	0.438	2.55	0.05	-0.03	0.10	0.07	0.792	1.47	0.06	-0.08	0.05	2.59	0.108
Grandmean	**7.72**	**0.07**			**2.59**	**0.000**	**34.00**	**0.41**			**1.91**	**0.000**	**2.58**	**0.01**			**1.62**	**0.000**	**1.54**	**0.00**			**107.00**	**1.350**

Appendix 5 (Cont'd)

Accessions	BL						PH						SPS						LBL					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG31	6.88	0.69	-0.84	0.78	1.16	0.282	28.62	1.17	-4.65	5.13	0.82	0.365	2.56	0.15	-0.02	0.10	0.03	0.870	1.53	0.03	-0.02	0.05	0.09	0.766
UG32	7.82	0.37	0.10	0.78	0.02	0.902	32.48	6.11	-0.78	5.13	0.02	0.879	2.62	0.08	0.04	0.10	0.16	0.686	1.57	0.03	0.02	0.05	0.13	0.720
UG33	7.35	0.63	-0.37	0.78	0.22	0.637	38.24	3.12	4.98	5.13	0.94	0.332	2.57	0.15	-0.01	0.10	0.01	0.923	1.57	0.03	0.02	0.05	0.13	0.720
UG34	8.29	0.76	0.57	0.78	0.52	0.470	34.72	3.32	1.46	5.13	0.08	0.776	2.54	0.06	-0.03	0.10	0.11	0.741	1.58	0.04	0.03	0.05	0.47	0.493
UG35	7.70	1.27	-0.02	0.78	0.00	0.983	43.40	2.53	10.14	5.13	3.91	0.049	2.48	0.15	-0.09	0.10	0.87	0.351	1.55	0.03	0.00	0.05	0.00	0.976
UG36	8.46	0.27	0.74	0.78	0.88	0.347	20.40	0.48	-12.86	5.13	6.30	0.012	2.55	0.06	-0.03	0.10	0.07	0.792	1.55	0.03	0.00	0.05	0.00	0.976
UG37	9.16	0.18	1.44	0.78	3.36	0.067	31.44	4.13	-1.82	5.13	0.13	0.722	2.67	0.12	0.09	0.10	0.82	0.365	1.52	0.02	-0.03	0.05	0.39	0.532
UG38	8.74	1.12	1.02	0.78	1.70	0.194	33.52	7.39	0.26	5.13	0.00	0.960	2.55	0.08	-0.03	0.10	0.07	0.792	1.52	0.08	-0.03	0.05	0.39	0.532
UG39	8.11	1.51	0.39	0.78	0.25	0.619	35.36	2.56	2.10	5.13	0.17	0.683	2.60	0.03	0.02	0.10	0.06	0.812	1.53	0.03	-0.02	0.05	0.09	0.766
UG40	6.88	0.78	-0.84	0.78	1.14	0.286	24.00	4.58	-9.26	5.13	3.27	0.071	2.52	0.04	-0.06	0.10	0.36	0.550	1.55	0.08	0.00	0.05	0.00	0.976
UG41	8.28	0.09	0.56	0.78	0.51	0.478	33.68	4.30	0.42	5.13	0.01	0.935	2.63	0.03	0.06	0.10	0.33	0.568	1.52	0.06	-0.03	0.05	0.39	0.532
UG42	6.42	0.73	-1.30	0.78	2.74	0.099	37.20	4.67	3.94	5.13	0.59	0.443	2.72	0.07	0.14	0.10	1.98	0.160	1.48	0.02	-0.07	0.05	1.64	0.201
UG43	7.70	0.21	-0.02	0.78	0.00	0.976	39.98	7.91	6.72	5.13	1.72	0.191	2.53	0.02	-0.04	0.10	0.19	0.666	1.63	0.02	0.08	0.05	2.79	0.096
UG44	7.76	0.56	0.04	0.78	0.00	0.959	28.19	4.43	-5.07	5.13	0.98	0.323	2.63	0.06	0.06	0.10	0.33	0.568	1.63	0.02	0.08	0.05	2.79	0.096
UG45	8.36	0.16	0.64	0.78	0.67	0.412	29.92	2.64	-3.34	5.13	0.43	0.515	2.47	0.07	-0.11	0.10	1.21	0.272	1.45	0.05	-0.10	0.05	3.75	0.054
UG46	7.70	0.21	-0.02	0.78	0.00	0.976	39.98	7.91	6.72	5.13	1.72	0.191	2.53	0.02	-0.04	0.10	0.19	0.666	1.63	0.02	0.08	0.05	2.79	0.096
UG47	7.76	0.56	0.04	0.78	0.00	0.959	28.19	4.43	-5.07	5.13	0.98	0.323	2.63	0.06	0.06	0.10	0.33	0.568	1.63	0.02	0.08	0.05	2.79	0.096
UG48	8.36	0.16	0.64	0.78	0.67	0.412	29.92	2.64	-3.34	5.13	0.43	0.515	2.47	0.07	-0.11	0.10	1.21	0.272	1.45	0.05	-0.10	0.05	3.75	0.054
UG49	7.88	0.63	0.16	0.78	0.04	0.841	32.88	4.59	-0.38	5.13	0.01	0.940	2.65	0.10	0.07	0.10	0.55	0.460	1.60	0.05	0.05	0.05	1.03	0.311
UG50	7.58	0.36	-0.14	0.78	0.03	0.858	30.48	4.56	-2.78	5.13	0.29	0.587	2.75	0.10	0.17	0.10	3.04	0.082	1.55	0.05	0.00	0.05	0.00	0.976
UG51	7.71	0.70	-0.01	0.78	0.00	0.987	37.33	3.42	4.07	5.13	0.63	0.428	2.48	0.09	-0.09	0.10	0.87	0.351	1.55	0.08	0.00	0.05	0.00	0.976
UG52	8.37	0.35	0.65	0.78	0.70	0.405	42.48	2.93	9.22	5.13	3.23	0.073	2.58	0.03	0.01	0.10	0.00	0.944	1.58	0.04	0.03	0.05	0.47	0.493
UG53	8.69	0.31	0.97	0.78	1.52	0.218	32.08	4.20	-1.18	5.13	0.05	0.818	2.53	0.04	-0.04	0.10	0.19	0.666	1.52	0.06	-0.03	0.05	0.39	0.532
UG54	8.10	0.16	0.38	0.78	0.24	0.628	26.88	1.27	-6.38	5.13	1.55	0.214	2.70	0.09	0.12	0.10	1.54	0.215	1.57	0.03	0.02	0.05	0.13	0.720
UG55	8.60	0.10	0.88	0.78	1.25	0.264	29.28	0.96	-3.98	5.13	0.60	0.438	2.72	0.13	0.14	0.10	1.98	0.160	1.47	0.03	-0.08	0.05	2.59	0.108
UG56	7.45	0.65	-0.27	0.78	0.12	0.731	41.32	1.46	8.06	5.13	2.47	0.117	2.70	0.05	0.12	0.10	1.54	0.215	1.63	0.04	0.08	0.05	2.79	0.096
UG57	7.58	0.76	-0.14	0.78	0.03	0.858	35.60	8.87	2.34	5.13	0.21	0.649	2.47	0.06	-0.11	0.10	1.21	0.272	1.57	0.06	0.02	0.05	0.13	0.720
UG58	8.47	0.18	0.75	0.78	0.92	0.339	35.87	2.14	2.61	5.13	0.26	0.611	2.70	0.09	0.12	0.10	1.54	0.215	1.60	0.05	0.05	0.05	1.03	0.311
UG59	8.05	0.03	0.33	0.78	0.18	0.671	26.56	1.25	-6.70	5.13	1.71	0.192	2.62	0.07	0.04	0.10	0.16	0.686	1.63	0.02	0.08	0.05	2.79	0.096
UG60	8.52	0.53	0.80	0.78	1.05	0.306	26.64	1.81	-6.62	5.13	1.67	0.197	2.50	0.08	-0.08	0.10	0.59	0.444	1.52	0.06	-0.03	0.05	0.39	0.532
UG61	7.30	2.46	-0.42	0.78	0.29	0.592	37.68	10.34	4.42	5.13	0.74	0.389	2.58	0.12	0.01	0.10	0.00	0.944	1.65	0.05	0.10	0.05	3.99	0.046
UG62	7.62	0.54	-0.10	0.78	0.02	0.895	18.35	9.25	-14.91	5.13	8.46	0.004	2.45	0.10	-0.13	0.10	1.61	0.205	1.60	0.00	0.05	0.05	1.03	0.311
UG63	3.60	2.20	-4.12	0.78	27.65	0.000	40.56	4.12	7.30	5.13	2.03	0.155	2.50	0.16	-0.08	0.10	0.59	0.444	1.55	0.13	0.00	0.05	0.00	0.976
UG64	7.46	1.12	-0.26	0.78	0.11	0.740	35.04	4.67	1.78	5.13	0.12	0.729	2.48	0.13	-0.09	0.10	0.87	0.351	1.65	0.05	0.10	0.05	3.99	0.046
UG65	8.71	0.43	0.99	0.78	1.60	0.207	36.56	2.97	3.30	5.13	0.41	0.520	2.45	0.10	-0.13	0.10	1.61	0.205	1.48	0.07	-0.07	0.05	1.64	0.201
UG66	9.10	0.35	1.38	0.78	3.12	0.078	38.64	0.77	5.38	5.13	1.10	0.295	2.45	0.10	-0.13	0.10	1.61	0.205	1.48	0.07	-0.07	0.05	1.99	0.159
UG67	8.86	1.24	1.14	0.78	2.11	0.147	29.36	4.78	-3.90	5.13	0.58	0.447	2.57	0.06	-0.01	0.10	0.01	0.923	1.53	0.07	-0.02	0.05	0.09	0.766
UG68	6.96	0.43	-0.76	0.78	0.95	0.331	34.54	7.09	1.27	5.13	0.06	0.804	2.45	0.10	-0.13	0.10	1.61	0.205	1.52	0.08	-0.03	0.05	0.39	0.532
Grandmean	**7.72**	**0.07**			**2.59**	**0.000**	**34.00**	**0.41**			**1.91**	**0.000**	**2.58**	**0.01**			**1.62**	**0.000**	**1.54**	**0.00**			**107.00**	**1.350**

Appendix 5 (Cont'd)

Accessions	BL						PH						SPS						LBL					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG69	6.77	2.46	-0.95	0.78	1.48	0.224	25.44	5.64	-7.82	5.13	2.33	0.128	2.47	0.06	-0.11	0.10	1.21	0.272	1.63	0.02	0.08	0.05	2.79	0.096
UG70	8.58	1.10	0.86	0.78	1.21	0.273	36.24	2.31	2.98	5.13	0.34	0.562	2.48	0.09	-0.09	0.10	0.87	0.351	1.55	0.05	0.00	0.05	0.00	0.976
UG71	7.99	0.37	0.27	0.78	0.12	0.730	27.87	2.10	-5.39	5.13	1.11	0.293	2.51	0.08	-0.07	0.10	0.44	0.506	1.50	0.08	-0.05	0.05	0.91	0.341
UG72	8.51	0.77	0.79	0.78	1.02	0.314	15.36	7.69	-17.90	5.13	12.20	0.001	2.45	0.10	-0.13	0.10	1.61	0.205	1.43	0.08	-0.12	0.05	5.13	0.024
UG73	8.21	0.38	0.49	0.78	0.39	0.532	38.64	10.60	5.38	5.13	1.10	0.295	2.78	0.03	0.21	0.10	4.32	0.038	1.67	0.08	0.12	0.05	5.41	0.021
UG74	9.44	0.53	1.72	0.78	4.84	0.028	32.47	4.36	-0.79	5.13	0.02	0.878	2.55	0.12	-0.03	0.10	0.07	0.792	1.58	0.12	0.03	0.05	0.47	0.493
UG75	9.08	0.24	1.36	0.78	3.01	0.083	26.28	4.17	-6.98	5.13	1.86	0.174	2.65	0.12	0.07	0.10	0.55	0.460	1.52	0.04	-0.03	0.05	0.39	0.532
UG76	8.97	0.25	1.25	0.78	2.55	0.111	17.74	3.52	-15.52	5.13	9.17	0.003	2.62	0.21	0.04	0.10	0.16	0.686	1.52	0.04	-0.03	0.05	0.39	0.532
UG77	5.56	2.30	-2.16	0.78	7.60	0.006	44.08	7.86	10.82	5.13	4.45	0.035	2.65	0.06	0.07	0.10	0.55	0.460	1.63	0.02	0.08	0.05	2.79	0.096
UG78	8.98	0.13	1.26	0.78	2.59	0.108	25.20	7.09	-8.06	5.13	2.48	0.116	2.78	0.12	0.21	0.10	4.32	0.038	1.53	0.02	-0.02	0.05	0.09	0.766
UG79	8.26	0.55	0.54	0.78	0.48	0.491	31.54	6.70	-1.72	5.13	0.11	0.737	2.72	0.03	0.14	0.10	1.98	0.160	1.52	0.08	-0.03	0.05	0.39	0.532
UG80	8.32	0.80	0.60	0.78	0.59	0.444	36.89	4.22	3.63	5.13	0.50	0.479	2.67	0.16	0.09	0.10	0.82	0.365	1.55	0.03	0.00	0.05	0.00	0.976
UG81	9.10	0.45	1.38	0.78	3.09	0.080	28.80	3.97	-4.46	5.13	0.76	0.384	2.68	0.03	0.11	0.10	1.15	0.283	1.58	0.04	0.03	0.05	0.47	0.493
UG82	5.23	1.40	-2.49	0.78	10.07	0.002	33.60	4.92	0.34	5.13	0.00	0.948	2.72	0.09	0.14	0.10	1.98	0.160	1.53	0.03	-0.02	0.05	0.09	0.766
UG83	9.06	0.30	1.34	0.78	2.94	0.087	36.56	6.47	3.30	5.13	0.41	0.520	2.63	0.14	0.06	0.10	0.33	0.568	1.50	0.03	-0.05	0.05	0.91	0.341
UG84	5.57	1.71	-2.15	0.78	7.51	0.006	39.12	3.47	5.86	5.13	1.31	0.254	2.75	0.15	0.17	0.10	3.04	0.082	1.52	0.03	-0.03	0.05	0.39	0.532
UG85	6.39	0.99	-1.33	0.78	2.88	0.090	40.08	10.26	6.82	5.13	1.77	0.184	2.73	0.10	0.16	0.10	2.48	0.116	1.58	0.04	0.03	0.05	0.47	0.493
UG86	5.68	1.34	-2.04	0.78	6.76	0.010	37.68	3.54	4.42	5.13	0.74	0.389	2.70	0.10	0.12	0.10	1.54	0.215	1.62	0.03	0.07	0.05	1.80	0.180
UG87	7.13	0.69	-0.59	0.78	0.57	0.449	32.89	2.76	-0.37	5.13	0.01	0.943	2.34	0.16	-0.23	0.10	5.47	0.020	1.47	0.09	-0.08	0.05	2.59	0.108
UG88	7.29	0.69	-0.43	0.78	0.31	0.581	36.16	5.75	2.90	5.13	0.32	0.572	2.68	0.03	0.11	0.10	1.15	0.283	1.55	0.10	0.00	0.05	0.00	0.976
UG89	4.19	0.17	-3.53	0.78	20.26	0.000	39.84	5.61	6.58	5.13	1.65	0.200	2.67	0.13	0.09	0.10	0.82	0.365	1.55	0.06	0.00	0.05	0.00	0.976
UG90	2.99	0.16	-4.73	0.78	36.40	0.000	29.76	7.23	-3.50	5.13	0.47	0.495	2.62	0.13	0.04	0.10	0.16	0.686	1.63	0.09	0.08	0.05	2.79	0.096
UG91	4.06	2.06	-3.66	0.78	21.82	0.000	41.12	5.77	7.86	5.13	2.35	0.126	2.72	0.03	0.14	0.10	1.98	0.160	1.48	0.08	-0.07	0.05	1.64	0.201
UG92	9.84	0.61	2.12	0.78	7.35	0.007	41.68	7.18	8.42	5.13	2.70	0.101	2.62	0.03	0.04	0.10	0.16	0.686	1.63	0.04	0.08	0.05	2.79	0.096
UG93	7.31	0.99	-0.41	0.78	0.27	0.601	35.92	4.12	2.66	5.13	0.27	0.605	2.52	0.09	-0.06	0.10	0.36	0.550	1.62	0.03	0.07	0.05	1.80	0.180
UG94	9.70	0.28	1.98	0.78	6.39	0.012	42.00	2.23	8.74	5.13	2.91	0.089	2.68	0.03	0.11	0.10	1.15	0.283	1.57	0.08	0.02	0.05	0.13	0.720
UG95	8.53	1.24	0.81	0.78	1.08	0.300	34.00	8.11	0.74	5.13	0.02	0.886	2.73	0.10	0.16	0.10	2.48	0.116	1.50	0.05	-0.05	0.05	0.91	0.341
UG96	8.69	0.20	0.97	0.78	1.53	0.216	40.32	9.83	7.06	5.13	1.90	0.169	2.68	0.03	0.11	0.10	1.15	0.283	1.58	0.09	0.03	0.05	0.47	0.493
UG97	10.06	0.26	2.34	0.78	8.95	0.003	37.68	3.72	4.42	5.13	0.74	0.389	2.41	0.12	-0.17	0.10	2.79	0.096	1.53	0.07	-0.02	0.05	0.09	0.766
UG98	6.84	1.99	-0.88	0.78	1.25	0.264	28.64	0.16	-4.62	5.13	0.81	0.368	2.68	0.07	0.11	0.10	1.15	0.283	1.43	0.06	-0.12	0.05	5.13	0.024
UG99	8.30	0.31	0.58	0.78	0.55	0.459	31.84	10.22	-1.42	5.13	0.08	0.781	2.53	0.09	-0.05	0.10	0.25	0.618	1.58	0.03	0.03	0.05	0.47	0.493
UG100	8.44	0.31	0.72	0.78	0.85	0.356	32.67	2.19	-0.59	5.13	0.01	0.908	2.56	0.06	-0.02	0.10	0.03	0.870	1.60	0.05	0.05	0.05	1.03	0.311
UG101	8.62	0.53	0.90	0.78	1.33	0.249	33.00	4.88	-0.26	5.13	0.00	0.959	2.68	0.03	0.11	0.10	1.15	0.283	1.58	0.09	0.03	0.05	0.47	0.493
UG102	7.61	1.52	-0.11	0.78	0.02	0.889	36.80	5.72	3.54	5.13	0.48	0.491	2.52	0.09	-0.06	0.10	0.36	0.550	1.58	0.06	0.03	0.05	0.47	0.493
UG103	7.15	0.46	-0.57	0.78	0.52	0.470	20.64	8.41	-12.62	5.13	6.07	0.014	2.63	0.16	0.06	0.10	0.33	0.568	1.57	0.04	0.02	0.05	0.13	0.720
UG104	5.93	1.09	-1.79	0.78	5.20	0.023	36.16	1.29	2.90	5.13	0.32	0.572	2.62	0.03	0.04	0.10	0.16	0.686	1.65	0.05	0.10	0.05	3.99	0.046
Grandmean	**7.72**	**0.07**			**2.59**	**0.000**	**34.00**	**0.41**			**1.91**	**0.000**	**2.58**	**0.01**			**1.62**	**0.000**	**1.54**	**0.00**			**107.00**	**1.350**

Appendix 5 (Cont'd)

Accession	NRPP						PDL						NAFF						DFF					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
Asontem	24.87	1.52	-2.186508	1.58976	1.89	0.170	7.59	0.28	-0.67	0.32	4.39	0.037	3.87	0.22	0.36	0.24	2.27	0.132	36.54	0.48	-0.37	0.64	0.33	0.565
Kirkhouse	24.49	1.36	-2.56746	1.58976	2.61	0.107	8.32	0.26	0.06	0.32	0.03	0.857	3.83	0.20	0.31	0.24	1.71	0.192	36.73	0.70	-0.18	0.64	0.08	0.783
Padituya	25.89	1.72	-1.170635	1.58976	0.54	0.462	7.74	0.23	-0.53	0.32	2.72	0.100	3.35	0.25	-0.17	0.24	0.50	0.478	37.73	0.66	0.82	0.64	1.68	0.196
Wang Kae	24.17	1.31	-2.884921	1.58976	3.29	0.070	8.46	0.31	0.20	0.32	0.38	0.538	4.11	0.20	0.59	0.24	6.33	0.012	34.16	0.52	-2.75	0.64	18.65	0.000
UG1	41.33	4.10	14.27381	6.705481	4.53	0.034	10.74	0.81	2.48	1.35	3.37	0.067	5.67	0.33	2.15	1.00	4.66	0.031	12.00	0.00	-24.91	2.68	86.18	0.000
UG2	34.00	4.04	6.940476	6.705481	1.07	0.301	12.29	2.87	4.02	1.35	8.88	0.003	3.00	1.53	-0.52	1.00	0.27	0.604	36.00	2.65	-0.91	2.68	0.11	0.736
UG3	19.33	3.33	-7.72619	6.705481	1.33	0.250	7.91	0.77	-0.36	1.35	0.07	0.793	3.33	0.88	-0.18	1.00	0.03	0.854	33.33	1.33	-3.57	2.68	1.77	0.184
UG4	26.33	2.85	-0.726191	6.705481	0.01	0.914	8.65	2.67	0.38	1.35	0.08	0.778	3.00	1.00	-0.52	1.00	0.27	0.604	37.00	2.65	0.09	2.68	0.00	0.972
UG5	32.67	1.76	5.607143	6.705481	0.70	0.404	6.11	0.51	-2.16	1.35	2.55	0.111	4.00	1.53	0.48	1.00	0.24	0.628	34.00	1.73	-2.91	2.68	1.17	0.279
UG6	18.67	6.01	-8.392857	6.705481	1.57	0.211	5.51	0.21	-2.76	1.35	4.16	0.042	3.00	1.15	-0.52	1.00	0.27	0.604	35.33	3.53	-1.57	2.68	0.34	0.558
UG7	16.00	4.73	-11.05952	6.705481	2.72	0.100	8.15	2.24	-0.12	1.35	0.01	0.930	1.00	0.00	-2.52	1.00	6.38	0.012	36.00	4.00	-0.91	2.68	0.11	0.736
UG8	27.67	6.89	0.607143	6.705481	0.01	0.928	9.52	2.18	1.26	1.35	0.87	0.352	2.33	0.67	-1.18	1.00	1.41	0.235	35.67	2.85	-1.24	2.68	0.21	0.644
UG9	41.33	3.67	14.27381	6.705481	4.53	0.034	8.64	1.44	0.38	1.35	0.08	0.780	5.00	0.58	1.48	1.00	2.22	0.137	38.33	1.20	1.43	2.68	0.28	0.595
UG10	30.00	11.50	2.940476	6.705481	0.19	0.661	9.43	2.41	1.16	1.35	0.74	0.389	3.67	0.88	0.15	1.00	0.02	0.881	39.67	0.67	2.76	2.68	1.06	0.304
UG11	27.00	3.21	-0.059524	6.705481	0.00	0.993	8.73	1.03	0.47	1.35	0.12	0.729	3.67	1.33	0.15	1.00	0.02	0.881	41.00	2.52	4.09	2.68	2.33	0.128
UG12	31.00	10.00	3.940476	6.705481	0.35	0.557	8.17	1.43	-0.10	1.35	0.01	0.942	3.67	0.88	0.15	1.00	0.02	0.881	37.33	3.53	0.43	2.68	0.03	0.874
UG13	21.00	10.54	-6.059524	6.705481	0.82	0.367	7.06	1.76	-1.21	1.35	0.80	0.371	4.00	1.15	0.48	1.00	0.24	0.628	37.67	3.93	0.76	2.68	0.08	0.777
UG14	23.33	10.35	-3.72619	6.705481	0.31	0.579	4.96	1.02	-3.31	1.35	6.00	0.015	2.33	1.33	-1.18	1.00	1.41	0.235	34.00	1.53	-2.91	2.68	1.17	0.279
UG15	27.33	9.02	0.27381	6.705481	0.00	0.967	6.68	1.20	-1.59	1.35	1.38	0.240	2.67	0.88	-0.85	1.00	0.73	0.394	34.67	2.73	-2.24	2.68	0.70	0.404
UG16	19.33	4.63	-7.72619	6.705481	1.33	0.250	9.84	3.14	1.58	1.35	1.37	0.243	3.00	1.15	-0.52	1.00	0.27	0.604	32.00	1.53	-4.91	2.68	3.34	0.068
UG17	19.00	7.21	-8.059524	6.705481	1.44	0.230	8.99	1.53	0.72	1.35	0.29	0.592	5.67	0.33	2.15	1.00	4.66	0.031	37.00	2.31	0.09	2.68	0.00	0.972
UG18	18.67	5.70	-8.392857	6.705481	1.57	0.211	6.06	1.22	-2.21	1.35	2.68	0.103	3.67	1.45	0.15	1.00	0.02	0.881	35.00	1.53	-1.91	2.68	0.50	0.478
UG19	15.00	7.02	-12.05952	6.705481	3.23	0.073	7.05	0.43	-1.22	1.35	0.81	0.367	3.33	0.88	-0.18	1.00	0.03	0.854	37.00	3.06	0.09	2.68	0.00	0.972
UG20	28.00	7.00	0.940476	6.705481	0.02	0.889	7.19	0.12	-1.08	1.35	0.63	0.426	5.33	0.67	1.82	1.00	3.33	0.069	31.33	0.67	-5.57	2.68	4.31	0.038
UG21	18.33	3.93	-8.72619	6.705481	1.69	0.194	6.36	2.07	-1.91	1.35	2.00	0.158	4.00	1.00	0.48	1.00	0.24	0.628	34.33	1.86	-2.57	2.68	0.92	0.338
UG22	21.00	8.19	-6.059524	6.705481	0.82	0.367	9.83	0.65	1.56	1.35	1.34	0.247	2.67	0.33	-0.85	1.00	0.73	0.394	38.33	3.28	1.43	2.68	0.28	0.595
UG23	32.67	5.24	5.607143	6.705481	0.70	0.404	9.21	0.95	0.94	1.35	0.49	0.485	4.67	0.88	1.15	1.00	1.33	0.249	35.00	3.51	-1.91	2.68	0.50	0.478
UG24	17.00	5.03	-10.05952	6.705481	2.25	0.134	7.97	0.31	-0.30	1.35	0.05	0.825	4.67	0.67	1.15	1.00	1.33	0.249	37.00	2.52	0.09	2.68	0.00	0.972
UG25	24.33	4.26	-2.72619	6.705481	0.17	0.685	8.60	0.13	0.33	1.35	0.06	0.804	3.33	1.20	-0.18	1.00	0.03	0.854	36.33	1.33	-0.57	2.68	0.05	0.831
UG26	28.00	11.53	0.940476	6.705481	0.02	0.889	9.08	0.72	0.81	1.35	0.36	0.548	4.33	1.67	0.82	1.00	0.67	0.413	41.00	1.53	4.09	2.68	2.33	0.128
UG27	15.67	5.70	-11.39286	6.705481	2.89	0.090	8.02	0.62	-0.24	1.35	0.03	0.858	3.67	0.33	0.15	1.00	0.02	0.881	38.33	1.33	1.43	2.68	0.28	0.595
UG28	32.33	12.25	5.27381	6.705481	0.62	0.432	8.02	0.71	-0.25	1.35	0.03	0.856	3.33	1.33	-0.18	1.00	0.03	0.854	33.67	2.73	-3.24	2.68	1.46	0.228
UG29	31.00	7.64	3.940476	6.705481	0.35	0.557	11.13	1.24	2.87	1.35	4.51	0.034	4.00	0.00	0.48	1.00	0.24	0.628	34.67	1.33	-2.24	2.68	0.70	0.404
UG30	29.00	4.58	1.940476	6.705481	0.08	0.772	10.12	2.11	1.85	1.35	1.89	0.170	3.67	1.45	0.15	1.00	0.02	0.881	31.67	1.67	-5.24	2.68	3.81	0.052
Grandmean	**26.12**	**0.51**			**1.36**	**0.018**	**8.16**	**0.10**			**1.28**	**0.046**	**3.63**	**0.07**			**1.17**	**0.139**	**36.64**	**0.21**			**1.90**	**0.000**

Appendix 5 (Cont'd)

Accession	NRPP						PDL						NAFF						DFF					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG31	35.33	3.53	8.27381	6.705481	1.52	0.218	8.25	0.53	-0.01	1.35	0.00	0.993	3.00	1.15	-0.52	1.00	0.27	0.604	33.67	1.76	-3.24	2.68	1.46	0.228
UG32	37.00	4.36	9.940476	6.705481	2.20	0.139	6.41	0.34	-1.86	1.35	1.89	0.170	3.00	1.00	-0.52	1.00	0.27	0.604	34.67	0.88	-2.24	2.68	0.70	0.404
UG33	34.67	5.21	7.607143	6.705481	1.29	0.257	8.68	0.79	0.41	1.35	0.09	0.761	4.67	0.88	1.15	1.00	1.33	0.249	37.33	1.45	0.43	2.68	0.03	0.874
UG34	23.00	7.55	-4.059524	6.705481	0.37	0.545	8.42	2.36	0.16	1.35	0.01	0.907	3.33	0.67	-0.18	1.00	0.03	0.854	38.67	3.53	1.76	2.68	0.43	0.512
UG35	9.00	1.00	-18.05952	6.705481	7.25	0.007	8.86	0.47	0.59	1.35	0.19	0.662	4.33	1.20	0.82	1.00	0.67	0.413	35.33	3.84	-1.57	2.68	0.34	0.558
UG36	36.33	12.84	9.27381	6.705481	1.91	0.167	7.80	1.18	-0.47	1.35	0.12	0.731	1.00	0.00	-2.52	1.00	6.38	0.012	37.67	2.96	0.76	2.68	0.08	0.777
UG37	30.33	5.81	3.27381	6.705481	0.24	0.626	7.64	0.84	-0.62	1.35	0.21	0.645	2.33	1.33	-1.18	1.00	1.41	0.235	36.33	2.85	-0.57	2.68	0.05	0.831
UG38	37.67	4.26	10.60714	6.705481	2.50	0.114	9.16	0.83	0.89	1.35	0.44	0.510	3.67	0.33	0.15	1.00	0.02	0.881	41.00	2.31	4.09	2.68	2.33	0.128
UG39	32.00	4.93	4.940476	6.705481	0.54	0.462	11.68	0.66	3.41	1.35	6.38	0.012	3.33	0.88	-0.18	1.00	0.03	0.854	33.33	2.03	-3.57	2.68	1.77	0.184
UG40	27.00	7.51	-0.059524	6.705481	0.00	0.993	7.79	1.37	-0.48	1.35	0.13	0.723	2.00	0.58	-1.52	1.00	2.32	0.129	40.67	2.60	3.76	2.68	1.97	0.162
UG41	31.33	5.78	4.27381	6.705481	0.41	0.524	10.18	1.50	1.91	1.35	2.01	0.157	2.33	0.88	-1.18	1.00	1.41	0.235	39.00	3.61	2.09	2.68	0.61	0.436
UG42	35.33	5.17	8.27381	6.705481	1.52	0.218	7.05	1.45	-1.22	1.35	0.81	0.367	3.00	1.00	-0.52	1.00	0.27	0.604	36.67	3.71	-0.24	2.68	0.01	0.929
UG43	31.67	4.81	4.607143	6.705481	0.47	0.492	11.46	0.61	3.19	1.35	5.59	0.019	2.00	0.58	-1.52	1.00	2.32	0.129	37.00	1.53	0.09	2.68	0.00	0.972
UG44	17.00	4.04	-10.05952	6.705481	2.25	0.134	6.27	1.35	-2.00	1.35	2.19	0.140	3.67	0.67	0.15	1.00	0.02	0.881	38.33	2.19	1.43	2.68	0.28	0.595
UG45	27.33	10.93	0.27381	6.705481	0.00	0.967	7.67	1.86	-0.60	1.35	0.19	0.660	2.33	1.33	-1.18	1.00	1.41	0.235	41.33	2.67	4.43	2.68	2.72	0.100
UG46	31.67	4.81	4.607143	6.705481	0.47	0.492	11.46	0.61	3.19	1.35	5.59	0.019	2.00	0.58	-1.52	1.00	2.32	0.129	37.00	1.53	0.09	2.68	0.00	0.972
UG47	17.00	4.04	-10.05952	6.705481	2.25	0.134	6.27	1.35	-2.00	1.35	2.19	0.140	3.67	0.67	0.15	1.00	0.02	0.881	38.33	2.19	1.43	2.68	0.28	0.595
UG48	27.33	10.93	0.27381	6.705481	0.00	0.967	7.67	1.86	-0.60	1.35	0.19	0.660	2.33	1.33	-1.18	1.00	1.41	0.235	41.33	2.67	4.43	2.68	2.72	0.100
UG49	35.67	10.93	8.607143	6.705481	1.65	0.200	8.67	2.10	0.40	1.35	0.09	0.766	3.67	1.45	0.15	1.00	0.02	0.881	34.33	2.33	-2.57	2.68	0.92	0.338
UG50	22.67	1.45	-4.392857	6.705481	0.43	0.513	7.40	0.41	-0.86	1.35	0.41	0.524	2.00	0.58	-1.52	1.00	2.32	0.129	34.00	2.08	-2.91	2.68	1.17	0.279
UG51	25.00	2.08	-2.059524	6.705481	0.09	0.759	8.36	2.89	0.09	1.35	0.00	0.946	4.33	0.88	0.82	1.00	0.67	0.413	36.67	2.19	-0.24	2.68	0.01	0.929
UG52	38.67	3.28	11.60714	6.705481	3.00	0.084	8.68	0.33	0.41	1.35	0.09	0.761	3.00	1.53	-0.52	1.00	0.27	0.604	35.00	3.00	-1.91	2.68	0.50	0.478
UG53	42.00	7.94	14.94048	6.705481	4.96	0.026	7.87	0.73	-0.40	1.35	0.09	0.768	5.33	0.67	1.82	1.00	3.33	0.069	38.67	2.33	1.76	2.68	0.43	0.512
UG54	18.67	5.90	-8.392857	6.705481	1.57	0.211	7.70	0.42	-0.57	1.35	0.18	0.676	4.33	0.88	0.82	1.00	0.67	0.413	36.00	4.51	-0.91	2.68	0.11	0.736
UG55	31.00	5.13	3.940476	6.705481	0.35	0.557	6.15	2.30	-2.12	1.35	2.46	0.117	4.33	1.20	0.82	1.00	0.67	0.413	39.67	1.45	2.76	2.68	1.06	0.304
UG56	34.00	4.73	6.940476	6.705481	1.07	0.301	10.15	2.43	1.88	1.35	1.94	0.164	2.67	1.20	-0.85	1.00	0.73	0.394	42.00	1.73	5.09	2.68	3.61	0.058
UG57	25.33	7.31	-1.72619	6.705481	0.07	0.797	10.20	2.98	1.93	1.35	2.05	0.153	5.00	1.00	1.48	1.00	2.22	0.137	31.67	0.88	-5.24	2.68	3.81	0.052
UG58	42.00	3.06	14.94048	6.705481	4.96	0.026	7.52	0.87	-0.74	1.35	0.30	0.583	4.33	1.67	0.82	1.00	0.67	0.413	38.00	2.65	1.09	2.68	0.17	0.684
UG59	19.00	4.04	-8.059524	6.705481	1.44	0.230	6.98	1.33	-1.29	1.35	0.91	0.340	3.00	0.00	-0.52	1.00	0.27	0.604	35.00	2.65	-1.91	2.68	0.50	0.478
UG60	23.00	3.46	-4.059524	6.705481	0.37	0.545	7.43	0.28	-0.83	1.35	0.38	0.538	4.00	1.15	0.48	1.00	0.24	0.628	40.33	2.19	3.43	2.68	1.63	0.202
UG61	34.00	9.07	6.940476	6.705481	1.07	0.301	8.96	1.31	0.69	1.35	0.26	0.609	3.33	0.88	-0.18	1.00	0.03	0.854	37.33	3.18	0.43	2.68	0.03	0.874
UG62	19.33	10.40	-7.72619	6.705481	1.33	0.250	8.40	0.13	0.13	1.35	0.01	0.921	4.67	0.33	1.15	1.00	1.33	0.249	33.00	2.00	-3.91	2.68	2.12	0.146
UG63	29.33	7.22	2.27381	6.705481	0.11	0.735	8.82	0.79	0.56	1.35	0.17	0.680	3.67	1.45	0.15	1.00	0.02	0.881	34.33	3.38	-2.57	2.68	0.92	0.338
UG64	19.33	3.84	-7.72619	6.705481	1.33	0.250	10.23	0.88	1.97	1.35	2.12	0.146	3.33	1.45	-0.18	1.00	0.03	0.854	38.00	3.06	1.09	2.68	0.17	0.684
UG65	33.67	7.75	6.607143	6.705481	0.97	0.325	6.79	1.11	-1.48	1.35	1.19	0.275	3.00	1.15	-0.52	1.00	0.27	0.604	40.67	2.03	3.76	2.68	1.97	0.162
UG66	29.67	4.41	2.607143	6.705481	0.15	0.698	6.97	1.15	-1.30	1.35	0.92	0.337	3.33	1.20	-0.18	1.00	0.03	0.854	39.67	1.86	2.76	2.68	1.06	0.304
UG67	31.67	9.26	4.607143	6.705481	0.47	0.492	7.97	1.92	-0.30	1.35	0.05	0.825	2.67	0.33	-0.85	1.00	0.73	0.394	35.00	2.65	-1.91	2.68	0.50	0.478
UG68	21.33	4.98	-5.72619	6.705481	0.73	0.394	6.94	1.51	-1.32	1.35	0.96	0.328	5.33	0.33	1.82	1.00	3.33	0.069	40.33	4.67	3.43	2.68	1.63	0.202
Grandmean	**26.12**	**0.51**			**1.36**	**0.018**	**8.16**	**0.10**			**1.28**	**0.046**	**3.63**	**0.07**			**1.17**	**0.139**	**36.64**	**0.21**			**1.90**	**0.000**

Appendix 5 (Cont'd)

Accession	NRPP						PDL						NAFF						DFF					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG69	30.33	2.03	3.27381	6.705481	0.24	0.626	10.91	3.20	2.64	1.35	3.84	0.051	4.67	0.88	1.15	1.00	1.33	0.249	35.67	3.71	-1.24	2.68	0.21	0.644
UG70	35.00	12.50	7.940476	6.705481	1.40	0.237	8.94	1.14	0.68	1.35	0.25	0.616	5.00	0.58	1.48	1.00	2.22	0.137	40.33	0.88	3.43	2.68	1.63	0.202
UG71	9.00	1.53	-18.05952	6.705481	7.25	0.007	10.26	2.21	1.99	1.35	2.18	0.141	2.33	1.33	-1.18	1.00	1.41	0.235	35.67	3.18	-1.24	2.68	0.21	0.644
UG72	22.00	10.00	-5.059524	6.705481	0.57	0.451	7.57	2.67	-0.70	1.35	0.27	0.605	4.00	1.53	0.48	1.00	0.24	0.628	41.00	2.08	4.09	2.68	2.33	0.128
UG73	26.00	6.03	-1.059524	6.705481	0.02	0.875	10.29	1.85	2.02	1.35	2.25	0.134	4.00	1.00	0.48	1.00	0.24	0.628	35.67	4.26	-1.24	2.68	0.21	0.644
UG74	22.33	9.49	-4.72619	6.705481	0.50	0.481	7.04	1.36	-1.22	1.35	0.82	0.366	2.00	0.58	-1.52	1.00	2.32	0.129	39.67	1.86	2.76	2.68	1.06	0.304
UG75	18.33	5.21	-8.72619	6.705481	1.69	0.194	7.24	0.78	-1.02	1.35	0.57	0.450	3.67	1.20	0.15	1.00	0.02	0.881	40.00	2.08	3.09	2.68	1.33	0.249
UG76	18.00	1.53	-9.059524	6.705481	1.83	0.177	7.98	1.99	-0.29	1.35	0.05	0.831	3.00	1.53	-0.52	1.00	0.27	0.604	43.00	1.15	6.09	2.68	5.16	0.024
UG77	35.00	9.61	7.940476	6.705481	1.40	0.237	13.00	0.45	4.73	1.35	12.30	0.001	4.33	0.88	0.82	1.00	0.67	0.413	36.67	3.53	-0.24	2.68	0.01	0.929
UG78	28.00	2.08	0.940476	6.705481	0.02	0.889	7.83	0.61	-0.43	1.35	0.10	0.749	4.33	1.67	0.82	1.00	0.67	0.413	41.67	2.40	4.76	2.68	3.15	0.077
UG79	26.67	8.95	-0.392857	6.705481	0.00	0.953	9.37	2.00	1.10	1.35	0.67	0.415	3.00	1.15	-0.52	1.00	0.27	0.604	41.33	2.19	4.43	2.68	2.72	0.100
UG80	24.33	3.53	-2.72619	6.705481	0.17	0.685	8.53	1.74	0.27	1.35	0.04	0.843	4.33	0.67	0.82	1.00	0.67	0.413	38.33	3.18	1.43	2.68	0.28	0.595
UG81	24.33	6.23	-2.72619	6.705481	0.17	0.685	7.07	0.69	-1.20	1.35	0.79	0.375	5.00	0.58	1.48	1.00	2.22	0.137	37.67	3.93	0.76	2.68	0.08	0.777
UG82	12.67	1.45	-14.39286	6.705481	4.61	0.032	6.82	1.16	-1.45	1.35	1.15	0.285	4.00	0.58	0.48	1.00	0.24	0.628	37.67	2.33	0.76	2.68	0.08	0.777
UG83	17.00	4.58	-10.05952	6.705481	2.25	0.134	8.38	0.31	0.11	1.35	0.01	0.934	2.00	0.00	-1.52	1.00	2.32	0.129	34.67	0.88	-2.24	2.68	0.70	0.404
UG84	35.00	1.73	7.940476	6.705481	1.40	0.237	9.88	1.52	1.61	1.35	1.43	0.232	4.33	0.88	0.82	1.00	0.67	0.413	36.67	0.67	-0.24	2.68	0.01	0.929
UG85	30.33	10.49	3.27381	6.705481	0.24	0.626	7.72	1.57	-0.55	1.35	0.16	0.687	3.33	0.88	-0.18	1.00	0.03	0.854	35.00	2.52	-1.91	2.68	0.50	0.478
UG86	42.00	5.29	14.94048	6.705481	4.96	0.026	8.88	1.09	0.61	1.35	0.21	0.651	4.00	1.15	0.48	1.00	0.24	0.628	41.00	1.00	4.09	2.68	2.33	0.128
UG87	34.33	8.01	7.27381	6.705481	1.18	0.279	7.10	0.90	-1.17	1.35	0.74	0.389	3.67	0.33	0.15	1.00	0.02	0.881	38.33	3.84	1.43	2.68	0.28	0.595
UG88	43.33	1.20	16.27381	6.705481	5.89	0.016	9.56	1.64	1.29	1.35	0.91	0.339	2.33	0.88	-1.18	1.00	1.41	0.235	36.67	1.86	-0.24	2.68	0.01	0.929
UG89	14.67	3.71	-12.39286	6.705481	3.42	0.065	8.22	1.20	-0.05	1.35	0.00	0.973	3.33	1.45	-0.18	1.00	0.03	0.854	37.33	3.84	0.43	2.68	0.03	0.874
UG90	29.67	3.48	2.607143	6.705481	0.15	0.698	6.53	0.27	-1.73	1.35	1.65	0.200	5.33	0.33	1.82	1.00	3.33	0.069	39.00	4.51	2.09	2.68	0.61	0.436
UG91	30.33	11.46	3.27381	6.705481	0.24	0.626	6.97	0.81	-1.30	1.35	0.92	0.337	4.67	0.88	1.15	1.00	1.33	0.249	37.00	0.58	0.09	2.68	0.00	0.972
UG92	18.33	5.81	-8.72619	6.705481	1.69	0.194	7.20	1.32	-1.07	1.35	0.62	0.431	1.67	0.67	-1.85	1.00	3.45	0.064	38.33	2.03	1.43	2.68	0.28	0.595
UG93	22.67	3.28	-4.392857	6.705481	0.43	0.513	6.87	0.40	-1.40	1.35	1.07	0.301	3.00	1.53	-0.52	1.00	0.27	0.604	35.67	2.73	-1.24	2.68	0.21	0.644
UG94	33.00	8.74	5.940476	6.705481	0.78	0.376	7.52	0.95	-0.75	1.35	0.30	0.581	1.00	0.00	-2.52	1.00	6.38	0.012	36.67	1.67	-0.24	2.68	0.01	0.929
UG95	26.00	5.51	-1.059524	6.705481	0.02	0.875	7.01	0.41	-1.26	1.35	0.86	0.353	1.00	0.00	-2.52	1.00	6.38	0.012	36.67	2.85	-0.24	2.68	0.01	0.929
UG96	24.33	8.76	-2.72619	6.705481	0.17	0.685	6.21	1.70	-2.05	1.35	2.31	0.129	3.67	1.33	0.15	1.00	0.02	0.881	38.67	4.33	1.76	2.68	0.43	0.512
UG97	16.67	4.06	-10.39286	6.705481	2.40	0.122	7.65	0.84	-0.61	1.35	0.21	0.651	5.33	0.67	1.82	1.00	3.33	0.069	40.00	3.21	3.09	2.68	1.33	0.249
UG98	21.00	7.37	-6.059524	6.705481	0.82	0.367	7.49	1.34	-0.78	1.35	0.33	0.566	4.67	0.33	1.15	1.00	1.33	0.249	40.00	3.06	3.09	2.68	1.33	0.249
UG99	35.00	4.73	7.940476	6.705481	1.40	0.237	7.05	0.31	-1.21	1.35	0.81	0.370	3.00	1.15	-0.52	1.00	0.27	0.604	36.00	4.58	-0.91	2.68	0.11	0.736
UG100	35.67	6.12	8.607143	6.705481	1.65	0.200	9.02	0.66	0.75	1.35	0.31	0.576	3.33	0.33	-0.18	1.00	0.03	0.854	37.33	2.40	0.43	2.68	0.03	0.874
UG101	39.67	5.21	12.60714	6.705481	3.53	0.061	7.90	2.37	-0.37	1.35	0.07	0.787	4.00	1.00	0.48	1.00	0.24	0.628	41.67	0.33	4.76	2.68	3.15	0.077
UG102	20.33	6.06	-6.72619	6.705481	1.01	0.316	9.68	2.39	1.41	1.35	1.09	0.296	4.33	0.88	0.82	1.00	0.67	0.413	36.00	2.89	-0.91	2.68	0.11	0.736
UG103	30.00	6.51	2.940476	6.705481	0.19	0.661	6.51	2.24	-1.76	1.35	1.69	0.194	3.33	0.33	-0.18	1.00	0.03	0.854	35.00	3.51	-1.91	2.68	0.50	0.478
UG104	29.00	4.58	1.940476	6.705481	0.08	0.772	9.46	1.55	1.19	1.35	0.78	0.378	2.67	0.33	-0.85	1.00	0.73	0.394	36.67	3.18	-0.24	2.68	0.01	0.929
Grandmean	**26.12**	**0.51**			**1.36**	**0.018**	**8.16**	**0.10**			**1.28**	**0.046**	**3.63**	**0.07**			**1.17**	**0.139**	**36.64**	**0.21**			**1.90**	**0.000**

Appendix 5 (Cont'd)

Accessions	D50F						AFL						AFW						NPLNT					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
Asontem	44.59	0.54	0.31	0.65	0.23	0.635	17.16	0.19	-0.05	0.25	0.05	0.826	0.83	0.02	-0.04	0.02	2.33	0.128	17.16	1.53	-2.48	1.21	4.21	0.041
Kirkhouse	44.41	0.73	0.13	0.65	0.04	0.837	18.03	0.27	0.81	0.25	10.64	0.001	0.93	0.03	0.06	0.02	6.92	0.009	13.54	0.33	-6.10	1.21	25.44	0.000
Padituya	45.43	0.66	1.15	0.65	3.13	0.078	17.25	0.18	0.04	0.25	0.02	0.885	0.84	0.02	-0.03	0.02	1.49	0.222	11.03	0.14	-8.61	1.21	50.65	0.000
Wang Kae	42.02	0.47	-2.26	0.65	12.11	0.001	17.92	0.26	0.70	0.25	7.99	0.005	0.90	0.02	0.04	0.02	2.43	0.119	14.41	0.94	-5.23	1.21	18.68	0.000
UG1	15.00	0.00	-29.28	2.74	113.99	0.000	17.88	0.68	0.67	1.05	0.40	0.525	0.76	0.08	-0.10	0.10	1.09	0.298	26.33	5.24	6.69	5.10	1.72	0.190
UG2	43.33	2.40	-0.95	2.74	0.12	0.730	19.22	0.78	2.00	1.05	3.64	0.057	0.99	0.11	0.12	0.10	1.53	0.216	17.00	8.54	-2.64	5.10	0.27	0.605
UG3	40.67	2.33	-3.61	2.74	1.73	0.188	18.00	0.77	0.78	1.05	0.56	0.455	1.05	0.05	0.18	0.10	3.27	0.071	13.00	7.77	-6.64	5.10	1.69	0.194
UG4	45.33	3.84	1.05	2.74	0.15	0.701	17.84	1.82	0.62	1.05	0.35	0.552	1.00	0.12	0.13	0.10	1.71	0.192	10.33	2.85	-9.31	5.10	3.33	0.069
UG5	42.00	1.53	-2.28	2.74	0.69	0.406	16.83	1.00	-0.39	1.05	0.14	0.713	0.82	0.08	-0.05	0.10	0.26	0.614	7.00	2.08	-12.64	5.10	6.14	0.014
UG6	41.00	3.79	-3.28	2.74	1.43	0.233	18.61	0.17	1.39	1.05	1.77	0.184	0.92	0.10	0.05	0.10	0.29	0.593	24.67	5.36	5.03	5.10	0.97	0.325
UG7	42.67	3.71	-1.61	2.74	0.35	0.557	16.29	0.65	-0.92	1.05	0.77	0.379	0.86	0.08	0.00	0.10	0.00	0.971	23.33	8.69	3.69	5.10	0.52	0.470
UG8	44.00	2.31	-0.28	2.74	0.01	0.919	14.90	0.28	-2.32	1.05	4.89	0.028	0.73	0.04	-0.13	0.10	1.81	0.180	15.00	6.51	-4.64	5.10	0.83	0.364
UG9	45.67	2.19	1.39	2.74	0.26	0.613	15.96	2.10	-1.26	1.05	1.43	0.232	0.82	0.07	-0.05	0.10	0.26	0.614	17.33	4.10	-2.31	5.10	0.20	0.651
UG10	47.33	1.67	3.05	2.74	1.24	0.266	17.23	1.29	0.01	1.05	0.00	0.989	0.86	0.08	0.00	0.10	0.00	0.971	22.00	1.15	2.36	5.10	0.21	0.644
UG11	48.00	3.46	3.72	2.74	1.84	0.176	19.82	1.26	2.60	1.05	6.17	0.013	1.05	0.09	0.18	0.10	3.40	0.066	32.33	4.10	12.69	5.10	6.19	0.013
UG12	44.00	2.89	-0.28	2.74	0.01	0.919	17.45	0.10	0.23	1.05	0.05	0.824	0.79	0.07	-0.08	0.10	0.65	0.420	16.67	9.74	-2.97	5.10	0.34	0.560
UG13	46.33	4.81	2.05	2.74	0.56	0.454	17.57	0.57	0.35	1.05	0.11	0.738	0.78	0.02	-0.09	0.10	0.76	0.382	25.67	8.09	6.03	5.10	1.40	0.238
UG14	41.33	2.03	-2.95	2.74	1.15	0.283	18.25	1.09	1.03	1.05	0.97	0.325	0.94	0.14	0.07	0.10	0.49	0.483	10.67	4.33	-8.97	5.10	3.09	0.079
UG15	41.67	3.67	-2.61	2.74	0.91	0.341	15.37	0.36	-1.85	1.05	3.11	0.079	0.83	0.05	-0.04	0.10	0.14	0.711	20.67	5.67	1.03	5.10	0.04	0.841
UG16	37.67	1.20	-6.61	2.74	5.81	0.016	16.26	0.59	-0.96	1.05	0.83	0.362	0.78	0.02	-0.08	0.10	0.71	0.401	17.00	4.62	-2.64	5.10	0.27	0.605
UG17	43.00	2.31	-1.28	2.74	0.22	0.641	17.21	0.71	-0.01	1.05	0.00	0.995	0.73	0.03	-0.13	0.10	1.81	0.180	12.33	2.67	-7.31	5.10	2.05	0.153
UG18	41.67	2.03	-2.61	2.74	0.91	0.341	17.17	0.31	-0.05	1.05	0.00	0.963	0.80	0.14	-0.06	0.10	0.41	0.523	30.33	4.84	10.69	5.10	4.39	0.037
UG19	43.67	2.33	-0.61	2.74	0.05	0.824	17.93	1.39	0.71	1.05	0.46	0.498	0.96	0.03	0.10	0.10	0.94	0.332	22.67	5.36	3.03	5.10	0.35	0.553
UG20	39.00	0.58	-5.28	2.74	3.71	0.055	17.21	1.36	-0.01	1.05	0.00	0.993	0.69	0.07	-0.18	0.10	3.17	0.076	26.00	4.58	6.36	5.10	1.55	0.213
UG21	42.00	3.06	-2.28	2.74	0.69	0.406	18.04	0.29	0.82	1.05	0.62	0.432	0.77	0.01	-0.10	0.10	0.95	0.330	11.33	1.20	-8.31	5.10	2.65	0.104
UG22	45.33	3.48	1.05	2.74	0.15	0.701	17.78	0.81	0.56	1.05	0.29	0.593	1.06	0.02	0.19	0.10	3.78	0.053	11.67	0.88	-7.97	5.10	2.44	0.119
UG23	42.67	3.18	-1.61	2.74	0.35	0.557	15.68	1.07	-1.54	1.05	2.15	0.144	0.81	0.01	-0.05	0.10	0.29	0.590	28.33	11.17	8.69	5.10	2.90	0.089
UG24	45.00	1.73	0.72	2.74	0.07	0.793	18.57	0.69	1.36	1.05	1.68	0.196	0.90	0.18	0.04	0.10	0.13	0.714	18.67	5.78	-0.97	5.10	0.04	0.849
UG25	42.67	0.67	-1.61	2.74	0.35	0.557	18.92	0.35	1.71	1.05	2.65	0.104	0.88	0.07	0.01	0.10	0.01	0.922	10.00	5.57	-9.64	5.10	3.57	0.059
UG26	48.00	2.08	3.72	2.74	1.84	0.176	17.49	0.45	0.27	1.05	0.07	0.794	0.86	0.09	0.00	0.10	0.00	0.971	24.33	4.91	4.69	5.10	0.85	0.358
UG27	46.33	2.60	2.05	2.74	0.56	0.454	19.01	1.84	1.80	1.05	2.94	0.087	0.97	0.10	0.11	0.10	1.15	0.285	30.00	3.21	10.36	5.10	4.12	0.043
UG28	42.00	2.08	-2.28	2.74	0.69	0.406	18.08	1.60	0.86	1.05	0.67	0.412	1.11	0.02	0.24	0.10	5.82	0.016	27.00	6.24	7.36	5.10	2.08	0.150
UG29	43.33	0.67	-0.95	2.74	0.12	0.730	16.69	1.89	-0.53	1.05	0.25	0.614	0.84	0.12	-0.03	0.10	0.07	0.787	26.00	3.61	6.36	5.10	1.55	0.213
UG30	40.33	1.45	-3.95	2.74	2.07	0.151	15.76	0.63	-1.46	1.05	1.93	0.166	0.91	0.06	0.04	0.10	0.19	0.665	24.67	7.45	5.03	5.10	0.97	0.325
Grandmean	**44.21**	**0.22**			**2.11**	**0.000**	**17.38**	**0.09**			**2.27**	**0.000**	**0.87**	**0.01**			**1.72**	**0.000**	**17.26**	**0.41**			**2.07**	**0.000**

Appendix 5 (Cont'd)

Accessions	**D50F**						**APL**						**APW**						**NPLNT**					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG31	41.00	0.58	-3.28	2.74	1.43	0.233	16.35	0.13	-0.87	1.05	0.69	0.408	0.88	0.09	0.01	0.10	0.02	0.895	25.00	4.04	5.36	5.10	1.10	0.294
UG32	42.33	1.76	-1.95	2.74	0.50	0.478	16.26	1.06	-0.96	1.05	0.83	0.362	0.82	0.01	-0.05	0.10	0.26	0.614	20.33	8.37	0.69	5.10	0.02	0.892
UG33	42.67	1.20	-1.61	2.74	0.35	0.557	15.63	0.91	-1.59	1.05	2.30	0.130	0.80	0.05	-0.06	0.10	0.41	0.523	22.33	7.31	2.69	5.10	0.28	0.598
UG34	47.00	4.58	2.72	2.74	0.98	0.322	16.40	0.82	-0.82	1.05	0.61	0.437	0.93	0.11	0.06	0.10	0.36	0.548	12.67	2.91	-6.97	5.10	1.87	0.172
UG35	43.67	4.18	-0.61	2.74	0.05	0.824	15.13	1.86	-2.08	1.05	3.94	0.048	0.89	0.10	0.02	0.10	0.05	0.816	15.67	5.04	-3.97	5.10	0.61	0.437
UG36	44.67	1.86	0.39	2.74	0.02	0.888	17.55	1.31	0.34	1.05	0.10	0.748	0.86	0.08	-0.01	0.10	0.00	0.945	10.67	2.19	-8.97	5.10	3.09	0.079
UG37	44.00	4.04	-0.28	2.74	0.01	0.919	17.68	0.61	0.47	1.05	0.20	0.656	0.92	0.05	0.05	0.10	0.29	0.593	16.33	6.57	-3.31	5.10	0.42	0.517
UG38	48.00	2.31	3.72	2.74	1.84	0.176	18.44	0.80	1.23	1.05	1.37	0.242	1.03	0.10	0.17	0.10	2.81	0.095	19.00	9.87	-0.64	5.10	0.02	0.900
UG39	42.33	2.60	-1.95	2.74	0.50	0.478	17.31	0.34	0.09	1.05	0.01	0.929	0.85	0.09	-0.02	0.10	0.04	0.839	18.00	1.73	-1.64	5.10	0.10	0.748
UG40	47.33	2.67	3.05	2.74	1.24	0.266	18.57	0.67	1.36	1.05	1.68	0.196	0.90	0.10	0.03	0.10	0.09	0.765	19.00	8.00	-0.64	5.10	0.02	0.900
UG41	47.00	4.00	2.72	2.74	0.98	0.322	16.35	0.56	-0.86	1.05	0.68	0.411	0.80	0.01	-0.07	0.10	0.50	0.480	16.67	6.89	-2.97	5.10	0.34	0.560
UG42	42.00	4.04	-2.28	2.74	0.69	0.406	15.41	0.86	-1.81	1.05	2.97	0.086	0.87	0.01	0.00	0.10	0.00	0.975	30.00	2.52	10.36	5.10	4.12	0.043
UG43	45.33	1.45	1.05	2.74	0.15	0.701	17.41	1.13	0.20	1.05	0.04	0.851	0.81	0.03	-0.06	0.10	0.33	0.567	18.00	7.55	-1.64	5.10	0.10	0.748
UG44	47.00	2.08	2.72	2.74	0.98	0.322	17.94	0.51	0.72	1.05	0.48	0.490	0.97	0.07	0.10	0.10	1.08	0.300	13.67	4.98	-5.97	5.10	1.37	0.242
UG45	48.00	1.00	3.72	2.74	1.84	0.176	17.95	0.80	0.73	1.05	0.49	0.484	0.87	0.03	0.00	0.10	0.00	0.975	28.33	6.06	8.69	5.10	2.90	0.089
UG46	45.33	1.45	1.05	2.74	0.15	0.701	17.41	1.13	0.20	1.05	0.04	0.851	0.81	0.03	-0.06	0.10	0.33	0.567	18.00	7.55	-1.64	5.10	0.10	0.748
UG47	47.00	2.08	2.72	2.74	0.98	0.322	17.94	0.51	0.72	1.05	0.48	0.490	0.97	0.07	0.10	0.10	1.08	0.300	13.67	4.98	-5.97	5.10	1.37	0.242
UG48	48.00	1.00	3.72	2.74	1.84	0.176	17.95	0.80	0.73	1.05	0.49	0.484	0.87	0.03	0.00	0.10	0.00	0.975	28.33	6.06	8.69	5.10	2.90	0.089
UG49	41.67	3.76	-2.61	2.74	0.91	0.341	15.56	1.52	-1.65	1.05	2.48	0.116	0.87	0.06	0.00	0.10	0.00	0.998	15.33	4.98	-4.31	5.10	0.71	0.399
UG50	41.67	1.20	-2.61	2.74	0.91	0.341	17.96	0.74	0.75	1.05	0.51	0.476	0.92	0.05	0.06	0.10	0.32	0.570	26.33	9.39	6.69	5.10	1.72	0.190
UG51	44.00	2.08	-0.28	2.74	0.01	0.919	16.82	0.05	-0.39	1.05	0.14	0.708	0.76	0.02	-0.11	0.10	1.16	0.283	12.33	7.88	-7.31	5.10	2.05	0.153
UG52	40.33	2.85	-3.95	2.74	2.07	0.151	15.69	0.83	-1.52	1.05	2.11	0.147	0.74	0.06	-0.13	0.10	1.63	0.202	28.33	8.17	8.69	5.10	2.90	0.089
UG53	47.00	2.08	2.72	2.74	0.98	0.322	17.32	1.05	0.10	1.05	0.01	0.921	1.05	0.12	0.18	0.10	3.27	0.071	21.33	3.28	1.69	5.10	0.11	0.740
UG54	44.33	5.36	0.05	2.74	0.00	0.984	15.89	0.40	-1.33	1.05	1.61	0.206	0.84	0.07	-0.02	0.10	0.06	0.813	12.67	6.23	-6.97	5.10	1.87	0.172
UG55	47.33	2.19	3.05	2.74	1.24	0.266	17.01	1.78	-0.20	1.05	0.04	0.847	0.83	0.06	-0.03	0.10	0.11	0.736	23.67	4.33	4.03	5.10	0.62	0.430
UG56	47.67	1.20	3.39	2.74	1.53	0.217	15.60	0.46	-1.62	1.05	2.38	0.123	0.89	0.12	0.02	0.10	0.04	0.842	16.67	2.19	-2.97	5.10	0.34	0.560
UG57	39.33	0.33	-4.95	2.74	3.25	0.072	17.65	1.57	0.44	1.05	0.17	0.677	0.85	0.15	-0.01	0.10	0.02	0.892	16.67	9.82	-2.97	5.10	0.34	0.560
UG58	44.00	2.65	-0.28	2.74	0.01	0.919	17.28	1.79	0.07	1.05	0.00	0.949	1.00	0.14	0.13	0.10	1.71	0.192	35.33	1.45	15.69	5.10	9.46	0.002
UG59	42.00	3.00	-2.28	2.74	0.69	0.406	17.34	0.88	0.13	1.05	0.01	0.903	0.73	0.06	-0.14	0.10	1.99	0.159	14.00	8.74	-5.64	5.10	1.22	0.270
UG60	46.33	1.20	2.05	2.74	0.56	0.454	15.99	1.00	-1.23	1.05	1.37	0.242	0.93	0.09	0.06	0.10	0.40	0.526	22.67	6.98	3.03	5.10	0.35	0.553
UG61	45.33	2.03	1.05	2.74	0.15	0.701	17.82	1.31	0.60	1.05	0.33	0.565	0.92	0.15	0.05	0.10	0.25	0.617	20.67	8.69	1.03	5.10	0.04	0.841
UG62	41.00	2.65	-3.28	2.74	1.43	0.233	15.52	1.64	-1.70	1.05	2.62	0.107	0.75	0.02	-0.11	0.10	1.31	0.254	19.00	5.57	-0.64	5.10	0.02	0.900
UG63	41.00	2.52	-3.28	2.74	1.43	0.233	17.34	0.23	0.13	1.05	0.01	0.903	0.83	0.06	-0.03	0.10	0.11	0.736	27.00	9.71	7.36	5.10	2.08	0.150
UG64	44.00	2.89	-0.28	2.74	0.01	0.919	16.24	0.52	-0.98	1.05	0.87	0.352	0.64	0.02	-0.23	0.10	5.37	0.021	19.33	8.17	-0.31	5.10	0.00	0.952
UG65	48.33	3.18	4.05	2.74	2.19	0.140	16.94	1.70	-0.27	1.05	0.07	0.795	0.74	0.09	-0.13	0.10	1.63	0.202	20.67	2.60	1.03	5.10	0.04	0.841
UG66	46.33	1.20	2.05	2.74	0.56	0.454	17.23	0.77	0.01	1.05	0.00	0.989	0.91	0.09	0.04	0.10	0.19	0.665	19.33	7.36	-0.31	5.10	0.00	0.952
UG67	43.00	2.08	-1.28	2.74	0.22	0.641	18.42	1.66	1.20	1.05	1.32	0.252	1.10	0.14	0.23	0.10	5.50	0.019	20.33	7.22	0.69	5.10	0.02	0.892
UG68	48.33	3.84	4.05	2.74	2.19	0.140	21.44	0.39	4.23	1.05	16.25	0.000	1.18	0.06	0.31	0.10	9.72	0.002	11.00	3.21	-8.64	5.10	2.87	0.091
Grandmean	**44.21**	**0.22**			**2.11**	**0.000**	**17.38**	**0.09**			**2.27**	**0.000**	**0.87**	**0.01**			**1.72**	**0.000**	**17.26**	**0.41**			**2.07**	**0.000**

Appendix 5 (Cont'd)

Accessions	D50F						APL						APW						NPLNT					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG69	45.00	3.51	0.72	2.74	0.07	0.793	19.27	0.91	2.05	1.05	3.82	0.051	1.01	0.04	0.14	0.10	2.07	0.151	26.67	8.11	7.03	5.10	1.90	0.169
UG70	48.00	1.00	3.72	2.74	1.84	0.176	17.66	0.51	0.44	1.05	0.18	0.675	0.82	0.03	-0.04	0.10	0.19	0.661	34.00	1.53	14.36	5.10	7.92	0.005
UG71	42.67	3.18	-1.61	2.74	0.35	0.557	17.54	1.35	0.32	1.05	0.10	0.758	0.90	0.15	0.03	0.10	0.11	0.739	23.00	8.66	3.36	5.10	0.43	0.511
UG72	47.33	1.67	3.05	2.74	1.24	0.266	14.49	1.03	-2.73	1.05	6.76	0.010	0.67	0.08	-0.19	0.10	3.79	0.052	9.33	5.46	-10.31	5.10	4.08	0.044
UG73	42.67	3.67	-1.61	2.74	0.35	0.557	15.21	0.45	-2.00	1.05	3.65	0.057	0.71	0.05	-0.15	0.10	2.39	0.123	18.00	5.77	-1.64	5.10	0.10	0.748
UG74	48.00	1.53	3.72	2.74	1.84	0.176	18.36	1.09	1.14	1.05	1.19	0.276	1.03	0.15	0.16	0.10	2.59	0.109	11.67	2.85	-7.97	5.10	2.44	0.119
UG75	48.33	2.60	4.05	2.74	2.19	0.140	19.05	1.34	1.83	1.05	3.06	0.081	0.87	0.17	0.00	0.10	0.00	0.998	17.33	1.45	-2.31	5.10	0.20	0.651
UG76	50.33	2.19	6.05	2.74	4.87	0.028	17.20	0.31	-0.01	1.05	0.00	0.990	0.67	0.08	-0.20	0.10	4.06	0.045	10.00	2.08	-9.64	5.10	3.57	0.059
UG77	44.67	3.38	0.39	2.74	0.02	0.888	18.98	0.67	1.76	1.05	2.82	0.094	0.91	0.16	0.04	0.10	0.19	0.665	20.67	7.26	1.03	5.10	0.04	0.841
UG78	49.00	1.00	4.72	2.74	2.96	0.086	16.43	1.23	-0.79	1.05	0.56	0.454	0.79	0.15	-0.08	0.10	0.60	0.439	24.00	4.16	4.36	5.10	0.73	0.393
UG79	49.00	3.61	4.72	2.74	2.96	0.086	16.62	2.25	-0.60	1.05	0.33	0.568	1.02	0.23	0.15	0.10	2.27	0.133	24.67	4.06	5.03	5.10	0.97	0.325
UG80	46.67	3.28	2.39	2.74	0.76	0.384	18.35	1.26	1.13	1.05	1.16	0.282	1.19	0.06	0.32	0.10	10.57	0.001	9.67	3.93	-9.97	5.10	3.82	0.051
UG81	45.00	3.51	0.72	2.74	0.07	0.793	16.48	1.66	-0.73	1.05	0.49	0.485	0.91	0.09	0.04	0.10	0.19	0.665	27.00	12.01	7.36	5.10	2.08	0.150
UG82	45.00	2.89	0.72	2.74	0.07	0.793	13.04	1.89	-4.18	1.05	15.86	0.000	0.58	0.06	-0.28	0.10	8.14	0.005	27.67	4.48	8.03	5.10	2.48	0.116
UG83	41.33	1.20	-2.95	2.74	1.15	0.283	18.42	0.41	1.20	1.05	1.31	0.253	0.89	0.15	0.03	0.10	0.07	0.790	19.33	2.91	-0.31	5.10	0.00	0.952
UG84	46.33	0.88	2.05	2.74	0.56	0.454	19.27	1.20	2.05	1.05	3.84	0.051	0.91	0.17	0.04	0.10	0.19	0.665	18.00	6.81	-1.64	5.10	0.10	0.748
UG85	41.33	1.86	-2.95	2.74	1.15	0.283	17.03	0.76	-0.19	1.05	0.03	0.857	0.78	0.07	-0.09	0.10	0.82	0.364	15.67	7.06	-3.97	5.10	0.61	0.437
UG86	49.33	1.33	5.05	2.74	3.40	0.066	17.04	0.97	-0.18	1.05	0.03	0.864	0.78	0.10	-0.09	0.10	0.76	0.382	24.33	3.84	4.69	5.10	0.85	0.358
UG87	46.33	3.18	2.05	2.74	0.56	0.454	12.74	0.87	-4.48	1.05	18.22	0.000	0.62	0.04	-0.25	0.10	6.17	0.013	24.33	3.18	4.69	5.10	0.85	0.358
UG88	43.00	1.53	-1.28	2.74	0.22	0.641	15.03	1.23	-2.19	1.05	4.36	0.037	0.67	0.03	-0.20	0.10	4.06	0.045	17.33	4.10	-2.31	5.10	0.20	0.651
UG89	45.00	3.06	0.72	2.74	0.07	0.793	11.66	0.36	-5.56	1.05	28.07	0.000	0.58	0.04	-0.28	0.10	8.14	0.005	21.67	4.98	2.03	5.10	0.16	0.691
UG90	45.33	5.36	1.05	2.74	0.15	0.701	17.49	0.88	0.27	1.05	0.07	0.794	0.69	0.02	-0.18	0.10	3.17	0.076	26.67	6.69	7.03	5.10	1.90	0.169
UG91	45.33	1.45	1.05	2.74	0.15	0.701	17.94	1.73	0.73	1.05	0.48	0.488	0.89	0.12	0.03	0.10	0.07	0.790	23.00	9.87	3.36	5.10	0.43	0.511
UG92	45.33	2.19	1.05	2.74	0.15	0.701	20.52	0.71	3.31	1.05	9.95	0.002	1.08	0.08	0.21	0.10	4.46	0.035	13.67	4.70	-5.97	5.10	1.37	0.242
UG93	44.33	2.33	0.05	2.74	0.00	0.984	16.90	0.02	-0.32	1.05	0.09	0.761	0.79	0.01	-0.08	0.10	0.65	0.420	15.33	8.45	-4.31	5.10	0.71	0.399
UG94	45.00	2.89	0.72	2.74	0.07	0.793	20.90	0.63	3.68	1.05	12.34	0.001	1.09	0.04	0.22	0.10	5.04	0.025	25.67	3.28	6.03	5.10	1.40	0.238
UG95	44.67	3.38	0.39	2.74	0.02	0.888	19.47	0.93	2.25	1.05	4.61	0.032	1.18	0.01	0.31	0.10	9.72	0.002	15.00	4.58	-4.64	5.10	0.83	0.364
UG96	45.67	3.38	1.39	2.74	0.26	0.613	15.89	0.47	-1.33	1.05	1.61	0.206	0.71	0.03	-0.15	0.10	2.39	0.123	19.67	6.64	0.03	5.10	0.00	0.996
UG97	47.00	4.36	2.72	2.74	0.98	0.322	19.00	0.68	1.78	1.05	2.88	0.090	1.08	0.06	0.21	0.10	4.60	0.033	15.33	6.23	-4.31	5.10	0.71	0.399
UG98	47.33	2.03	3.05	2.74	1.24	0.266	17.66	0.78	0.44	1.05	0.18	0.672	0.82	0.05	-0.05	0.10	0.26	0.614	21.00	4.62	1.36	5.10	0.07	0.790
UG99	42.67	4.81	-1.61	2.74	0.35	0.557	14.72	0.90	-2.50	1.05	5.68	0.018	0.77	0.03	-0.10	0.10	1.02	0.314	24.00	11.24	4.36	5.10	0.73	0.393
UG100	45.00	3.21	0.72	2.74	0.07	0.793	16.94	1.70	-0.27	1.05	0.07	0.795	0.74	0.09	-0.13	0.10	1.63	0.202	20.00	1.53	0.36	5.10	0.00	0.944
UG101	48.00	0.58	3.72	2.74	1.84	0.176	16.35	1.12	-0.87	1.05	0.68	0.409	0.83	0.05	-0.04	0.10	0.14	0.711	21.00	5.51	1.36	5.10	0.07	0.790
UG102	43.67	3.53	-0.61	2.74	0.05	0.824	19.47	1.63	2.25	1.05	4.62	0.032	0.99	0.14	0.12	0.10	1.45	0.229	18.67	2.03	-0.97	5.10	0.04	0.849
UG103	41.67	2.73	-2.61	2.74	0.91	0.341	17.32	0.74	0.11	1.05	0.01	0.919	0.81	0.08	-0.06	0.10	0.33	0.567	15.33	3.67	-4.31	5.10	0.71	0.399
UG104	43.67	2.91	-0.61	2.74	0.05	0.824	16.77	0.64	-0.45	1.05	0.18	0.669	0.76	0.03	-0.11	0.10	1.16	0.283	15.67	2.85	-3.97	5.10	0.61	0.437
Grandmean	**44.21**	**0.22**			**2.11**	**0.000**	**17.38**	**0.09**			**2.27**	**0.000**	**0.87**	**0.01**			**1.72**	**0.000**	**17.26**	**0.41**			**2.07**	**0.000**

Appendix 5 (Cont'd)

Accessions	PPDN						LN						PSA						DFMP					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
Asontem	3.94	0.11	0.49	0.15	11.09	0.001	16.95	0.41	1.62	0.56	8.31	0.004	8.73	1.03	-9.34	1.59	34.49	0.000	56.03	0.39	4.31	0.74	33.83	0.000
Kirkhouse	3.95	0.12	0.51	0.15	11.82	0.001	16.13	0.38	0.80	0.56	2.00	0.158	18.09	0.90	0.02	1.59	0.00	0.992	52.05	0.91	0.33	0.74	0.20	0.656
Padituya	3.65	0.14	0.20	0.15	1.92	0.166	11.10	0.31	-4.23	0.56	56.60	0.000	13.99	1.41	-4.08	1.59	6.58	0.011	54.08	0.76	2.36	0.74	10.14	0.002
Wang Kae	3.41	0.14	-0.03	0.15	0.05	0.815	13.14	0.50	-2.19	0.56	15.10	0.000	66.86	1.84	48.79	1.59	941.07	0.000	47.92	0.68	-3.80	0.74	26.19	0.000
UG1	3.67	0.88	0.22	0.62	0.13	0.723	15.00	4.04	-0.33	2.37	0.02	0.890	31.69	5.33	13.62	6.71	4.12	0.043	21.00	0.00	-30.72	3.13	96.37	0.000
UG2	2.67	0.67	-0.78	0.62	1.58	0.209	16.00	3.21	0.67	2.37	0.08	0.778	18.68	5.71	0.61	6.71	0.01	0.927	49.67	2.96	-2.05	3.13	0.43	0.513
UG3	3.00	0.58	-0.45	0.62	0.52	0.471	14.00	4.58	-1.33	2.37	0.31	0.576	19.88	8.89	1.81	6.71	0.07	0.788	45.00	1.15	-6.72	3.13	4.61	0.032
UG4	3.00	1.00	-0.45	0.62	0.52	0.471	14.67	3.93	-0.66	2.37	0.08	0.780	11.72	2.93	-6.35	6.71	0.90	0.345	52.67	3.53	0.95	3.13	0.09	0.762
UG5	3.33	0.88	-0.11	0.62	0.03	0.855	13.00	3.00	-2.33	2.37	0.96	0.327	5.09	2.89	-12.98	6.71	3.75	0.054	50.00	2.52	-1.72	3.13	0.30	0.584
UG6	3.33	0.88	-0.11	0.62	0.03	0.855	20.67	1.45	5.34	2.37	5.05	0.025	17.30	3.19	-0.77	6.71	0.01	0.909	49.33	4.98	-2.38	3.13	0.58	0.447
UG7	4.00	0.58	0.55	0.62	0.80	0.373	16.33	3.53	1.00	2.37	0.18	0.673	17.72	5.08	-0.35	6.71	0.00	0.958	52.00	4.36	0.28	3.13	0.01	0.928
UG8	4.00	1.00	0.55	0.62	0.80	0.373	11.00	4.58	-4.33	2.37	3.33	0.069	12.50	12.50	-5.57	6.71	0.69	0.407	50.33	4.41	-1.38	3.13	0.20	0.659
UG9	4.00	1.00	0.55	0.62	0.80	0.373	18.00	1.53	2.67	2.37	1.26	0.261	10.39	4.33	-7.68	6.71	1.31	0.253	54.33	0.88	2.62	3.13	0.70	0.404
UG10	3.00	0.00	-0.45	0.62	0.52	0.471	16.67	1.67	1.34	2.37	0.32	0.574	11.11	11.11	-6.96	6.71	1.08	0.300	58.00	1.53	6.28	3.13	4.03	0.045
UG11	3.67	0.88	0.22	0.62	0.13	0.723	11.67	1.20	-3.66	2.37	2.38	0.124	16.36	12.11	-1.71	6.71	0.06	0.799	56.33	2.19	4.62	3.13	2.18	0.141
UG12	3.33	0.67	-0.11	0.62	0.03	0.855	11.33	2.85	-4.00	2.37	2.83	0.093	17.46	2.81	-0.61	6.71	0.01	0.927	53.00	3.06	1.28	3.13	0.17	0.682
UG13	3.00	0.58	-0.45	0.62	0.52	0.471	13.33	3.33	-2.00	2.37	0.71	0.401	15.00	5.00	-3.07	6.71	0.21	0.647	51.33	5.55	-0.38	3.13	0.02	0.903
UG14	4.33	0.33	0.89	0.62	2.04	0.154	18.67	1.45	3.34	2.37	1.98	0.161	10.68	2.76	-7.39	6.71	1.21	0.271	50.00	2.31	-1.72	3.13	0.30	0.584
UG15	2.33	0.33	-1.11	0.62	3.23	0.073	19.00	1.15	3.67	2.37	2.39	0.123	6.72	4.15	-11.35	6.71	2.86	0.091	45.67	2.91	-6.05	3.13	3.74	0.054
UG16	2.33	0.33	-1.11	0.62	3.23	0.073	15.00	2.65	-0.33	2.37	0.02	0.890	20.83	15.02	2.76	6.71	0.17	0.681	46.33	3.18	-5.38	3.13	2.96	0.086
UG17	2.67	0.67	-0.78	0.62	1.58	0.209	13.00	2.65	-2.33	2.37	0.96	0.327	13.69	8.27	-4.38	6.71	0.43	0.514	51.33	0.88	-0.38	3.13	0.02	0.903
UG18	2.67	0.67	-0.78	0.62	1.58	0.209	17.33	4.18	2.00	2.37	0.71	0.399	4.62	2.63	-13.45	6.71	4.02	0.046	50.33	0.33	-1.38	3.13	0.20	0.659
UG19	4.33	0.33	0.89	0.62	2.04	0.154	10.00	0.00	-5.33	2.37	5.04	0.025	26.67	12.02	8.60	6.71	1.64	0.201	49.00	3.79	-2.72	3.13	0.75	0.386
UG20	3.33	0.88	-0.11	0.62	0.03	0.855	10.67	2.40	-4.66	2.37	3.86	0.050	2.78	2.78	-15.29	6.71	5.20	0.023	47.00	1.53	-4.72	3.13	2.27	0.132
UG21	3.33	0.88	-0.11	0.62	0.03	0.855	14.67	2.40	-0.66	2.37	0.08	0.780	15.60	7.93	-2.47	6.71	0.14	0.713	52.33	1.33	0.62	3.13	0.04	0.844
UG22	3.33	0.67	-0.11	0.62	0.03	0.855	15.00	1.15	-0.33	2.37	0.02	0.890	22.72	6.23	4.65	6.71	0.48	0.488	56.33	3.84	4.62	3.13	2.18	0.141
UG23	3.33	0.88	-0.11	0.62	0.03	0.855	17.33	0.33	2.00	2.37	0.71	0.399	22.98	5.63	4.91	6.71	0.54	0.464	48.33	2.40	-3.38	3.13	1.17	0.280
UG24	2.67	0.33	-0.78	0.62	1.58	0.209	15.33	2.19	0.00	2.37	0.00	0.999	21.31	1.61	3.24	6.71	0.23	0.630	48.67	1.45	-3.05	3.13	0.95	0.330
UG25	3.33	0.88	-0.11	0.62	0.03	0.855	17.67	2.33	2.34	2.37	0.97	0.326	15.64	4.22	-2.43	6.71	0.13	0.717	50.67	2.03	-1.05	3.13	0.11	0.737
UG26	2.67	0.33	-0.78	0.62	1.58	0.209	15.00	3.61	-0.33	2.37	0.02	0.890	4.55	4.55	-13.52	6.71	4.06	0.044	55.67	4.18	3.95	3.13	1.59	0.208
UG27	3.00	0.58	-0.45	0.62	0.52	0.471	17.00	4.62	1.67	2.37	0.49	0.482	27.36	8.57	9.29	6.71	1.92	0.167	55.00	0.58	3.28	3.13	1.10	0.295
UG28	4.00	0.58	0.55	0.62	0.80	0.373	15.33	1.20	0.00	2.37	0.00	0.999	19.34	2.90	1.27	6.71	0.04	0.850	44.67	2.73	-7.05	3.13	5.08	0.025
UG29	3.33	0.67	-0.11	0.62	0.03	0.855	14.33	2.33	-1.00	2.37	0.18	0.675	25.56	14.44	7.49	6.71	1.25	0.265	48.67	2.67	-3.05	3.13	0.95	0.330
UG30	4.33	0.67	0.89	0.62	2.04	0.154	19.33	4.70	4.00	2.37	2.84	0.092	29.13	10.46	11.06	6.71	2.72	0.100	47.33	2.60	-4.38	3.13	1.96	0.162
Grandmean	**3.57**	**0.05**			**1.10**	**0.249**	**14.90**	**0.19**			**2.05**	**0.000**	**21.84**	**0.84**			**11.20**	**0.00**	**52.06**	**0.27**			**2.790**	**0.00**

Appendix 5 (Cont'd)

Accessions	PPDN						LN						PSA						DFMP					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG31	3.00	0.58	-0.45	0.62	0.52	0.471	18.33	3.48	3.00	2.37	1.60	0.207	29.61	6.24	11.54	6.71	2.96	0.086	50.33	2.19	-1.38	3.13	0.20	0.659
UG32	3.67	0.67	0.22	0.62	0.13	0.723	21.00	1.53	5.67	2.37	5.70	0.017	11.94	6.20	-6.13	6.71	0.83	0.362	46.33	0.67	-5.38	3.13	2.96	0.086
UG33	3.00	1.00	-0.45	0.62	0.52	0.471	15.67	1.76	0.34	2.37	0.02	0.887	28.73	5.13	10.66	6.71	2.52	0.113	50.33	1.45	-1.38	3.13	0.20	0.659
UG34	2.67	0.67	-0.78	0.62	1.58	0.209	18.67	1.86	3.34	2.37	1.98	0.161	16.27	5.74	-1.80	6.71	0.07	0.788	52.33	5.04	0.62	3.13	0.04	0.844
UG35	4.67	0.33	1.22	0.62	3.87	0.050	17.67	1.76	2.34	2.37	0.97	0.326	9.69	4.02	-8.38	6.71	1.56	0.212	47.33	4.37	-4.38	3.13	1.96	0.162
UG36	4.33	0.67	0.89	0.62	2.04	0.154	19.00	3.46	3.67	2.37	2.39	0.123	22.19	4.46	4.12	6.71	0.38	0.540	54.00	1.53	2.28	3.13	0.53	0.466
UG37	4.00	0.58	0.55	0.62	0.80	0.373	17.33	2.03	2.00	2.37	0.71	0.399	10.32	6.20	-7.75	6.71	1.34	0.248	52.33	3.53	0.62	3.13	0.04	0.844
UG38	4.33	0.67	0.89	0.62	2.04	0.154	13.67	2.19	-1.66	2.37	0.49	0.484	12.96	10.31	-5.11	6.71	0.58	0.447	55.33	1.67	3.62	3.13	1.34	0.248
UG39	3.00	0.58	-0.45	0.62	0.52	0.471	14.33	2.03	-1.00	2.37	0.18	0.675	25.35	7.47	7.28	6.71	1.18	0.279	48.00	2.31	-3.72	3.13	1.41	0.236
UG40	3.33	0.33	-0.11	0.62	0.03	0.855	10.67	2.60	-4.66	2.37	3.86	0.050	15.25	3.23	-2.82	6.71	0.18	0.675	56.67	1.45	4.95	3.13	2.50	0.114
UG41	3.67	0.88	0.22	0.62	0.13	0.723	13.67	1.76	-1.66	2.37	0.49	0.484	17.07	0.86	-1.00	6.71	0.02	0.881	54.00	5.20	2.28	3.13	0.53	0.466
UG42	3.00	0.58	-0.45	0.62	0.52	0.471	20.33	0.88	5.00	2.37	4.44	0.036	10.05	6.10	-8.02	6.71	1.43	0.232	52.33	2.33	0.62	3.13	0.04	0.844
UG43	3.00	0.58	-0.45	0.62	0.52	0.471	12.67	0.33	-2.66	2.37	1.26	0.263	26.28	6.69	8.21	6.71	1.50	0.222	53.00	3.00	1.28	3.13	0.17	0.682
UG44	3.00	0.58	-0.45	0.62	0.52	0.471	17.67	3.76	2.34	2.37	0.97	0.326	22.26	2.86	4.19	6.71	0.39	0.532	54.67	2.73	2.95	3.13	0.89	0.346
UG45	3.00	1.00	-0.45	0.62	0.52	0.471	15.33	4.70	0.00	2.37	0.00	0.999	11.91	5.99	-6.16	6.71	0.84	0.359	57.33	2.33	5.62	3.13	3.22	0.073
UG46	3.00	0.58	-0.45	0.62	0.52	0.471	12.67	0.33	-2.66	2.37	1.26	0.263	26.28	6.69	8.21	6.71	1.50	0.222	53.00	3.00	1.28	3.13	0.17	0.682
UG47	3.00	0.58	-0.45	0.62	0.52	0.471	17.67	3.76	2.34	2.37	0.97	0.326	22.26	2.86	4.19	6.71	0.39	0.532	54.67	2.73	2.95	3.13	0.89	0.346
UG48	3.00	1.00	-0.45	0.62	0.52	0.471	15.33	4.70	0.00	2.37	0.00	0.999	11.91	5.99	-6.16	6.71	0.84	0.359	57.33	2.33	5.62	3.13	3.22	0.073
UG49	3.67	0.88	0.22	0.62	0.13	0.723	19.00	3.06	3.67	2.37	2.39	0.123	11.53	2.98	-6.54	6.71	0.95	0.330	51.33	1.86	-0.38	3.13	0.02	0.903
UG50	3.67	0.88	0.22	0.62	0.13	0.723	15.33	2.96	0.00	2.37	0.00	0.999	11.61	3.35	-6.46	6.71	0.93	0.336	48.00	2.31	-3.72	3.13	1.41	0.236
UG51	2.67	0.67	-0.78	0.62	1.58	0.209	12.00	2.08	-3.33	2.37	1.97	0.161	2.08	2.08	-15.99	6.71	5.68	0.018	50.00	3.46	-1.72	3.13	0.30	0.584
UG52	4.00	0.58	0.55	0.62	0.80	0.373	13.67	2.40	-1.66	2.37	0.49	0.484	22.92	11.22	4.85	6.71	0.52	0.470	50.67	5.24	-1.05	3.13	0.11	0.737
UG53	4.00	0.58	0.55	0.62	0.80	0.373	18.00	2.52	2.67	2.37	1.26	0.261	16.35	5.32	-1.72	6.71	0.07	0.798	56.67	1.45	4.95	3.13	2.50	0.114
UG54	2.33	0.33	-1.11	0.62	3.23	0.073	17.33	3.71	2.00	2.37	0.71	0.399	26.36	12.23	8.29	6.71	1.53	0.217	50.67	2.19	-1.05	3.13	0.11	0.737
UG55	3.67	0.33	0.22	0.62	0.13	0.723	20.33	2.19	5.00	2.37	4.44	0.036	14.01	4.78	-4.06	6.71	0.37	0.545	56.33	3.48	4.62	3.13	2.18	0.141
UG56	4.00	1.00	0.55	0.62	0.80	0.373	14.00	2.65	-1.33	2.37	0.31	0.576	26.47	2.00	8.40	6.71	1.57	0.211	56.67	4.10	4.95	3.13	2.50	0.114
UG57	3.00	0.58	-0.45	0.62	0.52	0.471	13.33	1.45	-2.00	2.37	0.71	0.401	17.44	1.04	-0.63	6.71	0.01	0.925	44.67	1.86	-7.05	3.13	5.08	0.025
UG58	3.67	0.33	0.22	0.62	0.13	0.723	10.33	1.76	-5.00	2.37	4.43	0.036	24.11	5.01	6.04	6.71	0.81	0.369	52.67	1.45	0.95	3.13	0.09	0.762
UG59	3.67	0.33	0.22	0.62	0.13	0.723	14.00	2.08	-1.33	2.37	0.31	0.576	27.78	14.70	9.71	6.71	2.09	0.149	48.00	2.52	-3.72	3.13	1.41	0.236
UG60	3.67	0.33	0.22	0.62	0.13	0.723	11.33	2.40	-4.00	2.37	2.83	0.093	11.67	7.26	-6.40	6.71	0.91	0.340	56.33	3.18	4.62	3.13	2.18	0.141
UG61	3.00	1.00	-0.45	0.62	0.52	0.471	15.00	3.51	-0.33	2.37	0.02	0.890	21.66	9.31	3.59	6.71	0.29	0.593	54.00	3.79	2.28	3.13	0.53	0.466
UG62	4.00	0.58	0.55	0.62	0.80	0.373	13.00	4.36	-2.33	2.37	0.96	0.327	14.28	9.91	-3.79	6.71	0.32	0.573	45.33	0.88	-6.38	3.13	4.16	0.042
UG63	3.67	0.88	0.22	0.62	0.13	0.723	19.00	4.04	3.67	2.37	2.39	0.123	23.61	1.91	5.54	6.71	0.68	0.409	49.00	4.51	-2.72	3.13	0.75	0.386
UG64	4.00	0.00	0.55	0.62	0.80	0.373	18.00	5.57	2.67	2.37	1.26	0.261	19.01	2.49	0.94	6.71	0.02	0.889	50.67	4.70	-1.05	3.13	0.11	0.737
UG65	4.00	0.58	0.55	0.62	0.80	0.373	17.67	2.85	2.34	2.37	0.97	0.326	16.27	8.14	-1.80	6.71	0.07	0.788	53.00	2.89	1.28	3.13	0.17	0.682
UG66	3.33	0.33	-0.11	0.62	0.03	0.855	17.33	4.41	2.00	2.37	0.71	0.399	19.42	4.45	1.35	6.71	0.04	0.841	55.00	3.51	3.28	3.13	1.10	0.295
UG67	2.33	0.33	-1.11	0.62	3.23	0.073	12.67	1.20	-2.66	2.37	1.26	0.263	14.65	7.94	-3.42	6.71	0.26	0.610	52.67	2.33	0.95	3.13	0.09	0.762
UG68	3.67	0.88	0.22	0.62	0.13	0.723	16.33	1.86	1.00	2.37	0.18	0.673	11.43	5.95	-6.64	6.71	0.98	0.323	55.00	3.06	3.28	3.13	1.10	0.295
Grandmean	**3.57**	**0.05**			**1.10**	**0.249**	**14.90**	**0.19**			**2.05**	**0.000**	**21.84**	**0.84**			**11.20**	**0.00**	**52.06**	**0.27**			**2.790**	**0.00**

Appendix 5 (Cont'd)

Accessions	PPDN						LN						FSA						DFMP					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG69	3.33	0.88	-0.11	0.62	0.03	0.855	13.33	3.93	-2.00	2.37	0.71	0.401	17.57	4.48	-0.50	6.71	0.01	0.940	49.67	3.28	-2.05	3.13	0.43	0.513
UG70	2.67	0.33	-0.78	0.62	1.58	0.209	19.00	1.53	3.67	2.37	2.39	0.123	23.61	5.01	5.54	6.71	0.68	0.409	55.00	3.06	3.28	3.13	1.10	0.295
UG71	3.00	0.58	-0.45	0.62	0.52	0.471	17.33	3.71	2.00	2.37	0.71	0.399	24.55	12.77	6.48	6.71	0.93	0.335	47.67	2.67	-4.05	3.13	1.68	0.196
UG72	3.33	0.88	-0.11	0.62	0.03	0.855	16.00	2.08	0.67	2.37	0.08	0.778	25.04	8.26	6.97	6.71	1.08	0.299	55.33	4.10	3.62	3.13	1.34	0.248
UG73	3.33	0.88	-0.11	0.62	0.03	0.855	17.00	2.65	1.67	2.37	0.49	0.482	14.55	9.39	-3.52	6.71	0.28	0.600	53.67	3.67	1.95	3.13	0.39	0.534
UG74	2.67	0.33	-0.78	0.62	1.58	0.209	11.67	1.45	-3.66	2.37	2.38	0.124	14.95	4.02	-3.12	6.71	0.22	0.642	56.00	1.73	4.28	3.13	1.87	0.172
UG75	3.00	1.00	-0.45	0.62	0.52	0.471	17.33	1.67	2.00	2.37	0.71	0.399	20.67	8.79	2.60	6.71	0.15	0.698	53.67	0.33	1.95	3.13	0.39	0.534
UG76	3.67	0.67	0.22	0.62	0.13	0.723	13.00	3.06	-2.33	2.37	0.96	0.327	21.28	8.99	3.21	6.71	0.23	0.633	60.33	2.33	8.62	3.13	7.58	0.006
UG77	3.00	0.58	-0.45	0.62	0.52	0.471	14.00	3.51	-1.33	2.37	0.31	0.576	24.99	10.67	6.92	6.71	1.06	0.303	53.33	2.60	1.62	3.13	0.27	0.606
UG78	2.33	0.33	-1.11	0.62	3.23	0.073	12.33	1.20	-3.00	2.37	1.59	0.208	9.52	9.52	-8.55	6.71	1.62	0.203	54.00	1.53	2.28	3.13	0.53	0.466
UG79	3.33	0.88	-0.11	0.62	0.03	0.855	15.33	2.40	0.00	2.37	0.00	0.999	24.37	9.26	6.30	6.71	0.88	0.349	59.00	2.08	7.28	3.13	5.42	0.020
UG80	4.00	0.00	0.55	0.62	0.80	0.373	20.00	3.21	4.67	2.37	3.87	0.050	16.98	5.04	-1.09	6.71	0.03	0.871	56.67	3.18	4.95	3.13	2.50	0.114
UG81	4.00	0.58	0.55	0.62	0.80	0.373	16.00	3.21	0.67	2.37	0.08	0.778	19.50	3.82	1.43	6.71	0.05	0.832	52.67	3.33	0.95	3.13	0.09	0.762
UG82	4.00	0.58	0.55	0.62	0.80	0.373	16.00	4.73	0.67	2.37	0.08	0.778	22.54	5.64	4.47	6.71	0.44	0.506	51.33	3.84	-0.38	3.13	0.02	0.903
UG83	2.67	0.67	-0.78	0.62	1.58	0.209	12.00	2.00	-3.33	2.37	1.97	0.161	16.67	10.38	-1.40	6.71	0.04	0.834	48.33	2.85	-3.38	3.13	1.17	0.280
UG84	4.33	0.33	0.89	0.62	2.04	0.154	18.00	2.31	2.67	2.37	1.26	0.261	22.34	7.68	4.27	6.71	0.40	0.525	50.00	0.58	-1.72	3.13	0.30	0.584
UG85	4.67	0.33	1.22	0.62	3.87	0.050	15.67	4.84	0.34	2.37	0.02	0.887	10.40	3.40	-7.67	6.71	1.31	0.253	50.00	1.00	-1.72	3.13	0.30	0.584
UG86	3.33	0.88	-0.11	0.62	0.03	0.855	13.67	0.88	-1.66	2.37	0.49	0.484	16.35	10.42	-1.72	6.71	0.07	0.797	53.67	1.76	1.95	3.13	0.39	0.534
UG87	3.00	0.58	-0.45	0.62	0.52	0.471	16.67	1.45	1.34	2.37	0.32	0.574	13.03	6.60	-5.04	6.71	0.57	0.452	54.00	4.62	2.28	3.13	0.53	0.466
UG88	2.67	0.33	-0.78	0.62	1.58	0.209	17.33	1.76	2.00	2.37	0.71	0.399	20.69	3.91	2.62	6.71	0.15	0.696	52.00	1.15	0.28	3.13	0.01	0.928
UG89	3.67	0.33	0.22	0.62	0.13	0.723	13.00	3.61	-2.33	2.37	0.96	0.327	12.50	12.50	-5.57	6.71	0.69	0.407	51.00	2.00	-0.72	3.13	0.05	0.819
UG90	4.00	1.00	0.55	0.62	0.80	0.373	12.67	3.18	-2.66	2.37	1.26	0.263	13.68	6.85	-4.39	6.71	0.43	0.513	52.33	5.36	0.62	3.13	0.04	0.844
UG91	3.67	0.88	0.22	0.62	0.13	0.723	15.33	0.67	0.00	2.37	0.00	0.999	24.11	2.87	6.04	6.71	0.81	0.369	49.33	0.88	-2.38	3.13	0.58	0.447
UG92	3.33	0.33	-0.11	0.62	0.03	0.855	16.67	3.71	1.34	2.37	0.32	0.574	9.72	6.05	-8.35	6.71	1.55	0.214	53.67	1.67	1.95	3.13	0.39	0.534
UG93	3.00	0.58	-0.45	0.62	0.52	0.471	13.00	1.15	-2.33	2.37	0.96	0.327	21.10	9.29	3.03	6.71	0.20	0.652	50.33	2.67	-1.38	3.13	0.20	0.659
UG94	4.33	0.67	0.89	0.62	2.04	0.154	15.00	4.04	-0.33	2.37	0.02	0.890	10.58	6.28	-7.49	6.71	1.25	0.265	51.33	3.18	-0.38	3.13	0.02	0.903
UG95	4.67	0.33	1.22	0.62	3.87	0.050	13.00	1.73	-2.33	2.37	0.96	0.327	11.79	6.05	-6.28	6.71	0.88	0.350	52.00	2.65	0.28	3.13	0.01	0.928
UG96	4.33	0.33	0.89	0.62	2.04	0.154	19.67	0.88	4.34	2.37	3.34	0.068	11.27	6.90	-6.80	6.71	1.03	0.311	51.00	4.16	-0.72	3.13	0.05	0.819
UG97	4.00	0.58	0.55	0.62	0.80	0.373	10.33	1.45	-5.00	2.37	4.43	0.036	31.15	3.93	13.08	6.71	3.80	0.052	56.00	4.51	4.28	3.13	1.87	0.172
UG98	2.67	0.33	-0.78	0.62	1.58	0.209	12.00	2.08	-3.33	2.37	1.97	0.161	8.33	8.33	-9.74	6.71	2.11	0.147	56.33	2.33	4.62	3.13	2.18	0.141
UG99	4.00	0.58	0.55	0.62	0.80	0.373	15.33	2.67	0.00	2.37	0.00	0.999	29.63	10.31	11.56	6.71	2.97	0.086	48.00	4.04	-3.72	3.13	1.41	0.236
UG100	3.67	0.67	0.22	0.62	0.13	0.723	18.67	2.19	3.34	2.37	1.98	0.161	11.80	3.22	-6.27	6.71	0.87	0.350	53.33	2.40	1.62	3.13	0.27	0.606
UG101	4.67	0.33	1.22	0.62	3.87	0.050	13.33	3.71	-2.00	2.37	0.71	0.401	9.49	6.62	-8.58	6.71	1.64	0.202	57.67	2.60	5.95	3.13	3.62	0.058
UG102	4.33	0.67	0.89	0.62	2.04	0.154	12.00	2.08	-3.33	2.37	1.97	0.161	29.96	14.98	11.89	6.71	3.14	0.077	53.00	4.58	1.28	3.13	0.17	0.682
UG103	3.00	1.00	-0.45	0.62	0.52	0.471	16.67	3.84	1.34	2.37	0.32	0.574	28.79	6.12	10.72	6.71	2.55	0.111	46.67	3.48	-5.05	3.13	2.61	0.107
UG104	3.67	0.67	0.22	0.62	0.13	0.723	14.33	4.33	-1.00	2.37	0.18	0.675	22.46	9.02	4.39	6.71	0.43	0.513	50.67	5.17	-1.05	3.13	0.11	0.737
Grandmean	**3.57**	**0.05**			**1.10**	**0.249**	**14.90**	**0.19**			**2.05**	**0.000**	**21.84**	**0.84**			**11.20**	**0.00**	**52.06**	**0.27**			**2.790**	**0.00**

Appendix 5 (Cont'd)

Accessions	D50MP						NSPP						SL						SW					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
Asontem	63.52	0.53	3.40	0.83	16.61	0.000	15.37	0.34	2.68	0.49	29.63	0.000	7.44	0.03	0.84	0.15	31.06	0.000	6.19	0.05	1.93	0.14	187.94	0.000
Kirkhouse	59.13	0.91	-1.00	0.83	1.42	0.233	13.08	0.25	0.40	0.49	0.65	0.421	6.22	0.15	-0.38	0.15	6.19	0.013	4.07	0.13	-0.20	0.14	1.99	0.160
Padituya	62.83	0.82	2.70	0.83	10.49	0.001	9.37	0.20	-3.32	0.49	45.32	0.000	6.33	0.15	-0.27	0.15	3.28	0.071	4.25	0.15	-0.01	0.14	0.01	0.924
Wang Kae	54.48	0.75	-5.65	0.83	45.80	0.000	3.90	0.13	-8.78	0.49	317.26	0.000	11.14	0.13	4.54	0.15	900.96	0.000	7.42	0.03	3.16	0.14	505.32	0.000
UG1	30.00	0.00	-30.12	3.52	73.25	0.000	10.67	3.71	-2.02	2.08	0.94	0.333	5.68	0.13	-0.92	0.64	2.06	0.152	2.62	0.11	-1.64	0.59	7.69	0.006
UG2	59.00	4.36	-1.12	3.52	0.10	0.750	13.33	3.28	0.65	2.08	0.10	0.754	6.60	1.08	0.00	0.64	0.00	0.995	3.62	0.51	-0.65	0.59	1.19	0.276
UG3	52.33	0.88	-7.79	3.52	4.90	0.027	11.67	4.41	-1.02	2.08	0.24	0.625	5.70	0.44	-0.90	0.64	2.00	0.158	3.89	0.70	-0.37	0.59	0.39	0.532
UG4	60.33	6.77	0.21	3.52	0.00	0.952	13.00	3.51	0.32	2.08	0.02	0.879	7.69	0.98	1.09	0.64	2.92	0.088	4.52	1.00	0.26	0.59	0.19	0.662
UG5	60.33	2.33	0.21	3.52	0.00	0.952	12.33	2.85	-0.35	2.08	0.03	0.867	5.79	0.94	-0.81	0.64	1.61	0.205	3.48	0.30	-0.79	0.59	1.76	0.185
UG6	57.33	7.31	-2.79	3.52	0.63	0.428	17.00	0.58	4.32	2.08	4.31	0.038	6.63	1.04	0.03	0.64	0.00	0.958	3.82	0.74	-0.44	0.59	0.55	0.458
UG7	63.33	4.91	3.21	3.52	0.83	0.362	13.33	2.85	0.65	2.08	0.10	0.754	6.71	0.70	0.11	0.64	0.03	0.867	3.85	0.82	-0.41	0.59	0.49	0.486
UG8	61.00	4.04	0.88	3.52	0.06	0.803	10.00	5.00	-2.68	2.08	1.67	0.198	7.00	0.92	0.40	0.64	0.39	0.530	4.81	0.65	0.54	0.59	0.84	0.360
UG9	62.67	2.60	2.54	3.52	0.52	0.470	16.00	0.58	3.32	2.08	2.55	0.111	6.12	1.38	-0.48	0.64	0.56	0.456	3.86	0.99	-0.40	0.59	0.46	0.500
UG10	65.00	2.52	4.88	3.52	1.92	0.167	15.00	2.89	2.32	2.08	1.24	0.266	6.75	0.41	0.15	0.64	0.05	0.817	4.53	0.55	0.27	0.59	0.21	0.649
UG11	66.67	2.85	6.54	3.52	3.46	0.064	10.00	2.31	-2.68	2.08	1.67	0.198	4.40	0.45	-2.20	0.64	11.86	0.001	4.56	0.57	0.30	0.59	0.25	0.617
UG12	62.67	1.76	2.54	3.52	0.52	0.470	9.33	2.33	-3.35	2.08	2.60	0.108	7.83	1.03	1.23	0.64	3.70	0.055	4.18	1.22	-0.08	0.59	0.02	0.892
UG13	61.33	6.36	1.21	3.52	0.12	0.731	11.00	2.00	-1.68	2.08	0.66	0.419	5.76	0.39	-0.84	0.64	1.73	0.189	3.70	0.40	-0.57	0.59	0.92	0.339
UG14	53.00	2.65	-7.12	3.52	4.10	0.044	16.67	1.33	3.98	2.08	3.67	0.056	7.52	1.20	0.92	0.64	2.07	0.151	5.51	0.80	1.25	0.59	4.42	0.036
UG15	52.33	2.33	-7.79	3.52	4.90	0.027	17.67	0.88	4.98	2.08	5.75	0.017	6.87	1.40	0.27	0.64	0.18	0.668	3.96	1.36	-0.31	0.59	0.27	0.605
UG16	55.33	4.18	-4.79	3.52	1.85	0.174	12.67	4.10	-0.02	2.08	0.00	0.994	6.52	0.46	-0.08	0.64	0.02	0.897	4.60	1.01	0.34	0.59	0.33	0.567
UG17	60.00	1.53	-0.12	3.52	0.00	0.972	11.33	2.96	-1.35	2.08	0.42	0.517	7.02	0.45	0.42	0.64	0.43	0.513	3.96	0.78	-0.30	0.59	0.26	0.609
UG18	59.33	1.86	-0.79	3.52	0.05	0.823	16.33	3.67	3.65	2.08	3.08	0.080	6.83	0.50	0.23	0.64	0.13	0.718	4.81	0.37	0.55	0.59	0.85	0.357
UG19	59.33	4.41	-0.79	3.52	0.05	0.823	7.33	1.20	-5.35	2.08	6.62	0.010	7.50	0.34	0.90	0.64	2.01	0.157	5.29	0.96	1.03	0.59	3.02	0.083
UG20	51.33	1.45	-8.79	3.52	6.24	0.013	10.33	2.33	-2.35	2.08	1.28	0.259	5.70	0.20	-0.90	0.64	2.00	0.158	2.94	0.41	-1.32	0.59	4.96	0.026
UG21	62.67	0.33	2.54	3.52	0.52	0.470	12.33	2.40	-0.35	2.08	0.03	0.867	5.96	0.36	-0.64	0.64	0.99	0.319	4.61	0.74	0.34	0.59	0.33	0.563
UG22	66.00	4.93	5.88	3.52	2.79	0.096	11.67	1.67	-1.02	2.08	0.24	0.625	5.40	0.08	-1.20	0.64	3.54	0.061	3.04	0.16	-1.22	0.59	4.24	0.040
UG23	57.00	2.52	-3.12	3.52	0.79	0.375	13.33	0.88	0.65	2.08	0.10	0.754	7.41	0.92	0.81	0.64	1.62	0.204	3.85	0.93	-0.41	0.59	0.48	0.489
UG24	54.67	3.71	-5.46	3.52	2.40	0.122	12.00	1.53	-0.68	2.08	0.11	0.743	8.74	0.40	2.14	0.64	11.23	0.001	5.53	0.64	1.27	0.59	4.59	0.033
UG25	57.00	1.00	-3.12	3.52	0.79	0.375	15.00	2.52	2.32	2.08	1.24	0.266	6.77	0.49	0.17	0.64	0.07	0.785	4.07	0.66	-0.19	0.59	0.10	0.748
UG26	65.67	4.26	5.54	3.52	2.48	0.116	14.00	2.65	1.32	2.08	0.40	0.527	6.15	0.39	-0.45	0.64	0.50	0.481	4.65	0.63	0.39	0.59	0.43	0.511
UG27	60.00	3.00	-0.12	3.52	0.00	0.972	13.00	4.36	0.32	2.08	0.02	0.879	5.31	0.50	-1.29	0.64	4.11	0.043	2.93	0.23	-1.34	0.59	5.09	0.025
UG28	54.67	3.18	-5.46	3.52	2.40	0.122	12.33	0.88	-0.35	2.08	0.03	0.867	6.32	0.94	-0.28	0.64	0.19	0.665	3.82	0.86	-0.45	0.59	0.57	0.451
UG29	56.67	4.81	-3.46	3.52	0.96	0.327	11.33	3.76	-1.35	2.08	0.42	0.517	6.42	0.51	-0.18	0.64	0.08	0.775	5.33	0.62	1.07	0.59	3.24	0.073
UG30	55.67	4.91	-4.46	3.52	1.60	0.206	14.67	4.84	1.98	2.08	0.91	0.340	7.03	0.94	0.43	0.64	0.45	0.503	4.66	0.93	0.40	0.59	0.45	0.504
Grandmean	**60.07**	**0.30**			**2.630**	**0.00**	**11.72**	**0.20**			**5.220**	**0.00**	**7.10**	**0.08**			**10.760**	**0.00**	**4.78**	**0.07**			**7.580**	**0.00**

Appendix 5 (Cont'd)

Accessions	D50MP						NSPP						SL						SW					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG31	57.67	2.03	-2.46	3.52	0.49	0.486	13.33	3.48	0.65	2.08	0.10	0.754	7.35	0.96	0.75	0.64	1.37	0.242	4.77	0.76	0.50	0.59	0.72	0.397
UG32	55.00	3.06	-5.12	3.52	2.12	0.146	18.33	0.67	5.65	2.08	7.39	0.007	6.09	0.61	-0.51	0.64	0.63	0.428	4.46	0.59	0.20	0.59	0.11	0.736
UG33	60.33	1.86	0.21	3.52	0.00	0.952	11.33	2.03	-1.35	2.08	0.42	0.517	6.60	0.69	0.00	0.64	0.00	0.997	4.60	0.33	0.34	0.59	0.32	0.571
UG34	60.00	7.57	-0.12	3.52	0.00	0.972	15.67	2.03	2.98	2.08	2.06	0.152	5.99	0.63	-0.61	0.64	0.92	0.337	3.92	0.88	-0.34	0.59	0.34	0.562
UG35	56.00	1.15	-4.12	3.52	1.37	0.242	16.00	2.00	3.32	2.08	2.55	0.111	6.27	1.23	-0.33	0.64	0.26	0.609	4.28	1.24	0.02	0.59	0.00	0.978
UG36	61.00	4.00	0.88	3.52	0.06	0.803	15.00	3.21	2.32	2.08	1.24	0.266	7.69	0.27	1.09	0.64	2.92	0.088	4.76	0.71	0.50	0.59	0.71	0.400
UG37	60.33	4.10	0.21	3.52	0.00	0.952	15.67	2.40	2.98	2.08	2.06	0.152	6.19	0.55	-0.41	0.64	0.41	0.521	4.85	0.46	0.59	0.59	0.98	0.323
UG38	63.33	3.48	3.21	3.52	0.83	0.362	12.00	2.65	-0.68	2.08	0.11	0.743	7.64	1.48	1.04	0.64	2.66	0.103	3.42	0.61	-0.85	0.59	2.04	0.154
UG39	56.33	1.76	-3.79	3.52	1.16	0.282	11.00	2.65	-1.68	2.08	0.66	0.419	6.79	0.41	0.19	0.64	0.09	0.765	4.14	0.96	-0.12	0.59	0.04	0.835
UG40	62.67	3.28	2.54	3.52	0.52	0.470	9.00	2.08	-3.68	2.08	3.14	0.077	5.51	0.10	-1.09	0.64	2.90	0.089	3.72	0.86	-0.54	0.59	0.83	0.362
UG41	63.00	6.08	2.88	3.52	0.67	0.414	11.33	1.45	-1.35	2.08	0.42	0.517	7.10	0.70	0.50	0.64	0.61	0.436	4.66	0.62	0.40	0.59	0.45	0.504
UG42	64.00	2.08	3.88	3.52	1.21	0.271	18.33	1.67	5.65	2.08	7.39	0.007	6.05	0.45	-0.55	0.64	0.73	0.392	4.22	0.06	-0.04	0.59	0.00	0.946
UG43	63.33	3.84	3.21	3.52	0.83	0.362	9.33	0.88	-3.35	2.08	2.60	0.108	6.17	0.40	-0.43	0.64	0.45	0.504	4.86	0.66	0.59	0.59	1.00	0.318
UG44	64.33	2.96	4.21	3.52	1.43	0.232	13.67	2.91	0.98	2.08	0.22	0.636	7.10	0.89	0.50	0.64	0.61	0.436	5.03	0.74	0.77	0.59	1.67	0.197
UG45	63.33	2.03	3.21	3.52	0.83	0.362	13.67	4.37	0.98	2.08	0.22	0.636	6.66	0.81	0.06	0.64	0.01	0.924	3.88	0.75	-0.39	0.59	0.43	0.514
UG46	63.33	3.84	3.21	3.52	0.83	0.362	9.33	0.88	-3.35	2.08	2.60	0.108	6.17	0.40	-0.43	0.64	0.45	0.504	4.86	0.66	0.59	0.59	1.00	0.318
UG47	64.33	2.96	4.21	3.52	1.43	0.232	13.67	2.91	0.98	2.08	0.22	0.636	7.10	0.89	0.50	0.64	0.61	0.436	5.03	0.74	0.77	0.59	1.67	0.197
UG48	63.33	2.03	3.21	3.52	0.83	0.362	13.67	4.37	0.98	2.08	0.22	0.636	6.66	0.81	0.06	0.64	0.01	0.924	3.88	0.75	-0.39	0.59	0.43	0.514
UG49	59.67	2.33	-0.46	3.52	0.02	0.897	16.67	2.33	3.98	2.08	3.67	0.056	7.01	0.83	0.41	0.64	0.41	0.520	4.47	0.62	0.21	0.59	0.13	0.724
UG50	56.00	1.53	-4.12	3.52	1.37	0.242	13.67	2.91	0.98	2.08	0.22	0.636	6.56	0.44	-0.04	0.64	0.00	0.947	4.04	0.58	-0.22	0.59	0.14	0.706
UG51	57.33	3.84	-2.79	3.52	0.63	0.428	11.67	1.76	-1.02	2.08	0.24	0.625	7.86	0.22	1.26	0.64	3.91	0.049	5.54	0.23	1.27	0.59	4.61	0.032
UG52	59.67	4.70	-0.46	3.52	0.02	0.897	11.00	3.00	-1.68	2.08	0.66	0.419	7.33	0.93	0.73	0.64	1.31	0.253	3.77	0.82	-0.49	0.59	0.69	0.405
UG53	64.00	3.79	3.88	3.52	1.21	0.271	15.00	2.08	2.32	2.08	1.24	0.266	5.81	0.37	-0.79	0.64	1.55	0.215	3.29	0.43	-0.98	0.59	2.72	0.100
UG54	60.00	2.65	-0.12	3.52	0.00	0.972	13.67	4.48	0.98	2.08	0.22	0.636	5.41	0.47	-1.19	0.64	3.50	0.062	2.85	0.31	-1.41	0.59	5.69	0.018
UG55	62.67	6.17	2.54	3.52	0.52	0.470	17.33	1.45	4.65	2.08	5.01	0.026	7.02	0.29	0.42	0.64	0.44	0.507	4.21	0.98	-0.05	0.59	0.01	0.928
UG56	67.67	3.76	7.54	3.52	4.59	0.033	10.33	2.03	-2.35	2.08	1.28	0.259	7.94	1.25	1.34	0.64	4.44	0.036	5.86	0.54	1.59	0.59	7.23	0.008
UG57	50.67	1.67	-9.46	3.52	7.22	0.008	11.00	1.15	-1.68	2.08	0.66	0.419	6.97	0.74	0.37	0.64	0.34	0.558	3.11	0.25	-1.16	0.59	3.81	0.052
UG58	63.33	0.67	3.21	3.52	0.83	0.362	7.67	0.88	-5.02	2.08	5.82	0.016	6.50	1.09	-0.10	0.64	0.02	0.876	3.99	0.64	-0.27	0.59	0.21	0.649
UG59	57.33	1.76	-2.79	3.52	0.63	0.428	10.67	3.48	-2.02	2.08	0.94	0.333	6.76	0.79	0.16	0.64	0.06	0.801	3.94	0.71	-0.32	0.59	0.30	0.585
UG60	64.67	2.73	4.54	3.52	1.67	0.197	10.33	2.96	-2.35	2.08	1.28	0.259	5.11	0.29	-1.49	0.64	5.48	0.020	3.49	0.09	-0.77	0.59	1.69	0.194
UG61	63.33	4.63	3.21	3.52	0.83	0.362	12.33	3.84	-0.35	2.08	0.03	0.867	6.44	0.32	-0.16	0.64	0.06	0.807	4.21	0.42	-0.06	0.59	0.01	0.923
UG62	53.33	0.33	-6.79	3.52	3.72	0.054	11.00	4.04	-1.68	2.08	0.66	0.419	5.96	0.28	-0.64	0.64	0.99	0.319	3.09	0.24	-1.18	0.59	3.94	0.048
UG63	57.33	4.91	-2.79	3.52	0.63	0.428	14.67	3.38	1.98	2.08	0.91	0.340	6.68	0.34	0.08	0.64	0.02	0.899	4.02	0.49	-0.24	0.59	0.17	0.681
UG64	59.67	4.06	-0.46	3.52	0.02	0.897	14.33	4.26	1.65	2.08	0.63	0.428	5.93	0.79	-0.67	0.64	1.11	0.292	4.07	0.80	-0.19	0.59	0.11	0.744
UG65	60.00	5.69	-0.12	3.52	0.00	0.972	15.00	3.21	2.32	2.08	1.24	0.266	5.61	0.10	-0.99	0.64	2.42	0.120	3.77	0.30	-0.49	0.59	0.68	0.408
UG66	64.00	6.51	3.88	3.52	1.21	0.271	13.67	3.18	0.98	2.08	0.22	0.636	7.97	0.54	1.37	0.64	4.64	0.032	5.06	0.42	0.79	0.59	1.79	0.182
UG67	61.67	3.48	1.54	3.52	0.19	0.661	11.00	2.08	-1.68	2.08	0.66	0.419	5.62	0.18	-0.98	0.64	2.37	0.124	3.06	0.17	-1.20	0.59	4.13	0.043
UG68	64.00	3.06	3.88	3.52	1.21	0.271	14.33	1.20	1.65	2.08	0.63	0.428	4.89	0.57	-1.71	0.64	7.16	0.008	3.83	0.83	-0.43	0.59	0.53	0.468
Grandmean	**60.07**	**0.30**			**2.630**	**0.00**	**11.72**	**0.20**			**5.220**	**0.00**	**7.10**	**0.08**			**10.760**	**0.00**	**4.78**	**0.07**			**7.580**	**0.00**

Appendix 5 (Cont'd)

Accessions	D50MP						NSPP						SL						SW					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG69	60.00	2.89	-0.12	3.52	0.00	0.972	11.33	3.93	-1.35	2.08	0.42	0.517	9.45	1.06	2.85	0.64	20.03	0.000	5.28	0.93	1.02	0.59	2.96	0.086
UG70	62.67	4.10	2.54	3.52	0.52	0.470	14.67	2.19	1.98	2.08	0.91	0.340	7.60	0.43	1.00	0.64	2.45	0.119	5.07	0.75	0.80	0.59	1.84	0.176
UG71	56.67	2.73	-3.46	3.52	0.96	0.327	14.00	4.51	1.32	2.08	0.40	0.527	6.83	0.41	0.23	0.64	0.13	0.722	4.01	0.76	-0.25	0.59	0.18	0.669
UG72	64.33	3.33	4.21	3.52	1.43	0.232	12.33	2.96	-0.35	2.08	0.03	0.867	5.44	0.51	-1.16	0.64	3.32	0.069	3.85	0.54	-0.41	0.59	0.49	0.486
UG73	63.00	4.04	2.88	3.52	0.67	0.414	15.00	3.61	2.32	2.08	1.24	0.266	7.15	0.77	0.55	0.64	0.75	0.386	5.30	0.50	1.04	0.59	3.06	0.081
UG74	66.00	1.15	5.88	3.52	2.79	0.096	10.00	1.53	-2.68	2.08	1.67	0.198	6.46	0.41	-0.14	0.64	0.05	0.827	4.50	0.64	0.23	0.59	0.15	0.694
UG75	61.00	1.15	0.88	3.52	0.06	0.803	14.00	2.65	1.32	2.08	0.40	0.527	6.46	0.85	-0.14	0.64	0.05	0.831	4.42	0.48	0.15	0.59	0.07	0.796
UG76	67.67	1.20	7.54	3.52	4.59	0.033	10.67	3.67	-2.02	2.08	0.94	0.333	6.56	0.71	-0.04	0.64	0.00	0.951	4.25	0.72	-0.01	0.59	0.00	0.982
UG77	62.67	1.67	2.54	3.52	0.52	0.470	11.00	4.04	-1.68	2.08	0.66	0.419	6.91	0.82	0.31	0.64	0.24	0.626	3.82	0.43	-0.44	0.59	0.56	0.454
UG78	63.00	0.58	2.88	3.52	0.67	0.414	11.00	1.00	-1.68	2.08	0.66	0.419	5.44	0.58	-1.16	0.64	3.29	0.071	4.11	1.05	-0.15	0.59	0.07	0.796
UG79	67.67	2.60	7.54	3.52	4.59	0.033	12.00	3.21	-0.68	2.08	0.11	0.743	6.89	0.47	0.29	0.64	0.21	0.645	4.49	1.22	0.22	0.59	0.14	0.707
UG80	63.67	6.12	3.54	3.52	1.01	0.315	16.33	2.03	3.65	2.08	3.08	0.080	6.46	0.67	-0.14	0.64	0.05	0.823	4.22	0.76	-0.05	0.59	0.01	0.937
UG81	63.67	2.85	3.54	3.52	1.01	0.315	13.00	3.06	0.32	2.08	0.02	0.879	5.94	0.28	-0.66	0.64	1.07	0.302	3.17	0.16	-1.09	0.59	3.41	0.066
UG82	61.33	4.91	1.21	3.52	0.12	0.731	12.67	4.06	-0.02	2.08	0.00	0.994	7.28	1.24	0.68	0.64	1.15	0.284	4.43	1.14	0.17	0.59	0.08	0.775
UG83	56.33	1.20	-3.79	3.52	1.16	0.282	9.67	1.20	-3.02	2.08	2.11	0.148	5.97	0.40	-0.63	0.64	0.96	0.327	4.51	0.46	0.24	0.59	0.17	0.682
UG84	57.33	3.84	-2.79	3.52	0.63	0.428	14.33	3.18	1.65	2.08	0.63	0.428	7.10	0.76	0.50	0.64	0.61	0.436	4.60	1.00	0.34	0.59	0.32	0.571
UG85	60.00	0.58	-0.12	3.52	0.00	0.972	14.33	4.67	1.65	2.08	0.63	0.428	5.32	0.24	-1.28	0.64	4.05	0.045	2.81	0.33	-1.45	0.59	5.99	0.015
UG86	62.67	1.76	2.54	3.52	0.52	0.470	11.33	1.20	-1.35	2.08	0.42	0.517	7.29	0.90	0.69	0.64	1.18	0.277	5.25	0.95	0.99	0.59	2.77	0.097
UG87	60.33	2.33	0.21	3.52	0.00	0.952	14.67	2.33	1.98	2.08	0.91	0.340	5.54	1.07	-1.06	0.64	2.74	0.098	5.36	0.64	1.10	0.59	3.42	0.065
UG88	61.67	1.76	1.54	3.52	0.19	0.661	13.67	1.20	0.98	2.08	0.22	0.636	8.13	0.72	1.53	0.64	5.74	0.017	4.48	0.63	0.21	0.59	0.13	0.720
UG89	57.67	4.06	-2.46	3.52	0.49	0.486	12.00	4.36	-0.68	2.08	0.11	0.743	6.03	0.19	-0.57	0.64	0.79	0.375	4.14	0.87	-0.12	0.59	0.04	0.835
UG90	60.00	6.24	-0.12	3.52	0.00	0.972	10.67	2.19	-2.02	2.08	0.94	0.333	5.44	0.17	-1.16	0.64	3.31	0.070	2.88	0.38	-1.38	0.59	5.45	0.020
UG91	58.33	0.88	-1.79	3.52	0.26	0.611	11.67	0.88	-1.02	2.08	0.24	0.625	6.19	0.69	-0.41	0.64	0.41	0.525	3.09	0.25	-1.17	0.59	3.92	0.048
UG92	63.00	1.73	2.88	3.52	0.67	0.414	14.67	2.33	1.98	2.08	0.91	0.340	6.28	0.50	-0.32	0.64	0.25	0.620	3.72	0.87	-0.55	0.59	0.85	0.357
UG93	59.00	1.53	-1.12	3.52	0.10	0.750	10.33	1.86	-2.35	2.08	1.28	0.259	6.34	0.54	-0.26	0.64	0.17	0.681	4.66	0.55	0.39	0.59	0.44	0.508
UG94	61.67	2.33	1.54	3.52	0.19	0.661	13.00	2.65	0.32	2.08	0.02	0.879	6.04	0.61	-0.56	0.64	0.77	0.381	3.65	0.13	-0.61	0.59	1.07	0.301
UG95	61.00	4.04	0.88	3.52	0.06	0.803	11.67	2.33	-1.02	2.08	0.24	0.625	6.96	0.81	0.36	0.64	0.31	0.576	4.49	0.97	0.22	0.59	0.14	0.707
UG96	59.33	4.26	-0.79	3.52	0.05	0.823	17.33	0.67	4.65	2.08	5.01	0.026	6.63	0.63	0.03	0.64	0.00	0.962	4.08	0.82	-0.18	0.59	0.09	0.761
UG97	59.00	3.79	-1.12	3.52	0.10	0.750	7.00	0.58	-5.68	2.08	7.47	0.007	6.79	0.66	0.19	0.64	0.09	0.769	4.68	0.97	0.41	0.59	0.49	0.486
UG98	65.33	2.40	5.21	3.52	2.19	0.140	11.33	2.73	-1.35	2.08	0.42	0.517	6.77	0.20	0.17	0.64	0.07	0.785	4.26	0.53	-0.01	0.59	0.00	0.991
UG99	56.00	2.31	-4.12	3.52	1.37	0.242	11.33	3.18	-1.35	2.08	0.42	0.517	6.75	0.49	0.15	0.64	0.06	0.809	4.04	0.85	-0.22	0.59	0.14	0.706
UG100	61.33	0.67	1.21	3.52	0.12	0.731	16.33	1.33	3.65	2.08	3.08	0.080	6.79	0.57	0.19	0.64	0.09	0.761	4.25	0.32	-0.01	0.59	0.00	0.982
UG101	67.33	2.19	7.21	3.52	4.20	0.041	11.67	2.85	-1.02	2.08	0.24	0.625	6.72	0.85	0.12	0.64	0.04	0.850	4.26	1.02	0.00	0.59	0.00	1.000
UG102	60.33	6.77	0.21	3.52	0.00	0.952	9.00	3.51	-3.68	2.08	3.14	0.077	6.66	1.03	0.06	0.64	0.01	0.928	4.92	0.97	0.66	0.59	1.23	0.269
UG103	52.00	4.00	-8.12	3.52	5.33	0.021	12.33	3.93	-0.35	2.08	0.03	0.867	5.91	0.24	-0.69	0.64	1.18	0.278	5.15	0.37	0.88	0.59	2.22	0.137
UG104	59.67	4.98	-0.46	3.52	0.02	0.897	11.33	3.93	-1.35	2.08	0.42	0.517	6.44	0.58	-0.16	0.64	0.06	0.803	4.36	1.01	0.10	0.59	0.03	0.871
Grandmean	**60.07**	**0.30**			**2.630**	**0.00**	**11.72**	**0.20**			**5.220**	**0.00**	**7.10**	**0.08**			**10.760**	**0.00**	**4.78**	**0.07**			**7.580**	**0.00**

Appendix 5 (Cont'd)

Accessions	ST						SWGT						YLD					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
Asontem	4.47	0.04	1.75	0.09	413.41	0.000	11.00	0.12	-4.59	0.62	54.90	0.000	110.01	1.18	0.00	0.00	54.90	0.000
Kirkhouse	2.57	0.06	-0.15	0.09	2.92	0.088	10.60	0.12	-4.99	0.62	64.80	0.000	106.04	1.24	0.00	0.00	64.80	0.000
Padituya	2.64	0.07	-0.08	0.09	0.77	0.380	6.82	0.03	-8.77	0.62	200.55	0.000	68.19	0.31	-0.01	0.00	200.55	0.000
Wang Kae	4.03	0.15	1.31	0.09	229.79	0.000	15.67	1.50	0.08	0.62	0.02	0.902	156.67	14.96	0.00	0.00	0.02	0.902
UG1	2.08	0.03	-0.64	0.36	3.13	0.077	14.51	0.46	-1.08	2.61	0.17	0.680	145.13	4.56	0.00	0.00	0.17	0.680
UG2	2.55	0.39	-0.17	0.36	0.21	0.647	16.49	0.82	0.90	2.61	0.12	0.731	164.90	8.21	0.00	0.00	0.12	0.731
UG3	2.40	0.28	-0.32	0.36	0.79	0.374	15.52	1.07	-0.07	2.61	0.00	0.979	155.20	10.68	0.00	0.00	0.00	0.979
UG4	3.05	0.35	0.33	0.36	0.84	0.360	17.05	1.03	1.46	2.61	0.31	0.577	170.50	10.29	0.00	0.00	0.31	0.577
UG5	2.32	0.25	-0.40	0.36	1.23	0.268	14.62	0.60	-0.97	2.61	0.14	0.710	146.17	6.02	0.00	0.00	0.14	0.710
UG6	2.61	0.37	-0.11	0.36	0.09	0.769	16.30	0.93	0.71	2.61	0.07	0.786	163.00	9.27	0.00	0.00	0.07	0.786
UG7	2.64	0.29	-0.08	0.36	0.05	0.819	15.18	1.06	-0.41	2.61	0.02	0.875	151.80	10.56	0.00	0.00	0.02	0.875
UG8	2.95	0.27	0.23	0.36	0.40	0.527	15.19	0.52	-0.40	2.61	0.02	0.879	151.93	5.18	0.00	0.00	0.02	0.879
UG9	2.50	0.59	-0.22	0.36	0.38	0.539	14.63	0.89	-0.96	2.61	0.14	0.713	146.30	8.88	0.00	0.00	0.14	0.713
UG10	2.82	0.05	0.10	0.36	0.08	0.784	16.10	0.77	0.51	2.61	0.04	0.846	160.97	7.68	0.00	0.00	0.04	0.846
UG11	2.24	0.25	-0.48	0.36	1.72	0.190	16.04	0.76	0.45	2.61	0.03	0.862	160.43	7.63	0.00	0.00	0.03	0.862
UG12	3.00	0.53	0.28	0.36	0.59	0.442	16.62	1.28	1.03	2.61	0.16	0.693	166.23	12.76	0.00	0.00	0.16	0.693
UG13	2.36	0.20	-0.36	0.36	0.96	0.327	15.08	0.78	-0.51	2.61	0.04	0.845	150.80	7.84	0.00	0.00	0.04	0.845
UG14	3.25	0.48	0.53	0.36	2.15	0.143	17.73	0.62	2.14	2.61	0.67	0.412	177.33	6.16	0.00	0.00	0.67	0.412
UG15	2.71	0.69	-0.01	0.36	0.00	0.978	14.87	1.85	-0.72	2.61	0.08	0.783	148.70	18.48	0.00	0.00	0.08	0.783
UG16	2.78	0.37	0.06	0.36	0.03	0.862	15.47	1.18	-0.12	2.61	0.00	0.964	154.73	11.81	0.00	0.00	0.00	0.964
UG17	2.75	0.31	0.03	0.36	0.01	0.942	15.83	1.02	0.24	2.61	0.01	0.926	158.33	10.19	0.00	0.00	0.01	0.926
UG18	2.91	0.22	0.19	0.36	0.27	0.602	16.26	0.35	0.67	2.61	0.07	0.798	162.60	3.45	0.00	0.00	0.07	0.798
UG19	3.20	0.32	0.48	0.36	1.74	0.187	17.44	1.31	1.85	2.61	0.50	0.479	174.43	13.09	0.00	0.00	0.50	0.479
UG20	2.16	0.13	-0.56	0.36	2.37	0.124	14.35	0.96	-1.24	2.61	0.23	0.634	143.47	9.64	0.00	0.00	0.23	0.634
UG21	2.64	0.24	-0.08	0.36	0.04	0.833	16.01	0.75	0.42	2.61	0.03	0.871	160.13	7.48	0.00	0.00	0.03	0.871
UG22	2.11	0.06	-0.61	0.36	2.79	0.096	14.69	0.25	-0.90	2.61	0.12	0.732	146.93	2.47	0.00	0.00	0.12	0.732
UG23	2.81	0.45	0.09	0.36	0.07	0.798	15.28	1.24	-0.31	2.61	0.01	0.907	152.83	12.40	0.00	0.00	0.01	0.907
UG24	3.57	0.21	0.85	0.36	5.42	0.020	18.65	0.95	3.06	2.61	1.37	0.242	186.53	9.50	0.00	0.00	1.37	0.242
UG25	2.72	0.29	0.00	0.36	0.00	0.993	16.68	0.78	1.09	2.61	0.18	0.676	166.83	7.76	0.00	0.00	0.18	0.676
UG26	2.70	0.17	-0.02	0.36	0.00	0.949	15.93	0.51	0.34	2.61	0.02	0.898	159.27	5.06	0.00	0.00	0.02	0.898
UG27	2.06	0.07	-0.66	0.36	3.30	0.070	15.14	1.13	-0.45	2.61	0.03	0.862	151.37	11.33	0.00	0.00	0.03	0.862
UG28	2.53	0.42	-0.19	0.36	0.26	0.608	15.93	1.74	0.34	2.61	0.02	0.898	159.27	17.36	0.00	0.00	0.02	0.898
UG29	2.94	0.26	0.22	0.36	0.35	0.552	16.10	0.75	0.51	2.61	0.04	0.844	161.03	7.53	0.00	0.00	0.04	0.844
UG30	2.92	0.46	0.20	0.36	0.31	0.576	15.64	1.13	0.05	2.61	0.00	0.984	156.43	11.34	0.00	0.00	0.00	0.984
Grandmean	**3.02**	**0.04**			**6.670**	**0.00**	**13.65**	**0.22**			**2.720**	**0.00**	**136.47**	**2.21**			**2.720**	**0.00**

Appendix 5 (Cont'd)

Accessions	ST						SWGT						YLD					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG31	3.03	0.40	0.31	0.36	0.73	0.394	16.18	0.95	0.59	2.61	0.05	0.821	161.83	9.51	0.00	0.00	0.05	0.821
UG32	2.64	0.20	-0.08	0.36	0.05	0.826	15.13	0.91	-0.46	2.61	0.03	0.860	151.30	9.11	0.00	0.00	0.03	0.860
UG33	2.80	0.11	0.08	0.36	0.04	0.833	15.21	0.64	-0.38	2.61	0.02	0.885	152.13	6.43	0.00	0.00	0.02	0.885
UG34	2.48	0.25	-0.24	0.36	0.44	0.509	14.86	0.75	-0.73	2.61	0.08	0.779	148.57	7.53	0.00	0.00	0.08	0.779
UG35	2.64	0.62	-0.08	0.36	0.05	0.826	14.60	1.96	-0.99	2.61	0.14	0.706	146.03	19.56	0.00	0.00	0.14	0.706
UG36	3.11	0.23	0.39	0.36	1.15	0.284	16.99	0.82	1.40	2.61	0.29	0.592	169.90	8.21	0.00	0.00	0.29	0.592
UG37	2.76	0.25	0.04	0.36	0.01	0.913	16.21	0.45	0.62	2.61	0.06	0.814	162.07	4.51	0.00	0.00	0.06	0.814
UG38	2.77	0.50	0.05	0.36	0.02	0.898	16.65	1.39	1.06	2.61	0.16	0.686	166.47	13.89	0.00	0.00	0.16	0.686
UG39	2.73	0.31	0.01	0.36	0.00	0.971	15.91	0.57	0.32	2.61	0.01	0.903	159.10	5.69	0.00	0.00	0.01	0.903
UG40	2.31	0.23	-0.41	0.36	1.27	0.260	15.51	0.49	-0.08	2.61	0.00	0.976	155.10	4.88	0.00	0.00	0.00	0.976
UG41	2.94	0.32	0.22	0.36	0.35	0.552	15.92	0.53	0.33	2.61	0.02	0.899	159.23	5.33	0.00	0.00	0.02	0.899
UG42	2.57	0.13	-0.15	0.36	0.17	0.680	14.56	0.14	-1.03	2.61	0.15	0.695	145.63	1.44	0.00	0.00	0.15	0.695
UG43	2.76	0.17	0.04	0.36	0.01	0.920	16.00	0.44	0.41	2.61	0.03	0.874	160.03	4.36	0.00	0.00	0.03	0.874
UG44	3.03	0.40	0.31	0.36	0.74	0.389	17.03	1.19	1.44	2.61	0.31	0.581	170.33	11.93	0.00	0.00	0.31	0.581
UG45	2.63	0.39	-0.09	0.36	0.06	0.812	16.00	0.57	0.41	2.61	0.02	0.875	160.00	5.74	0.00	0.00	0.02	0.875
UG46	2.76	0.17	0.04	0.36	0.01	0.920	16.00	0.44	0.41	2.61	0.03	0.874	160.03	4.36	0.00	0.00	0.03	0.874
UG47	3.03	0.40	0.31	0.36	0.74	0.389	17.03	1.19	1.44	2.61	0.31	0.581	170.33	11.93	0.00	0.00	0.31	0.581
UG48	2.63	0.39	-0.09	0.36	0.06	0.812	16.00	0.57	0.41	2.61	0.02	0.875	160.00	5.74	0.00	0.00	0.02	0.875
UG49	2.87	0.31	0.15	0.36	0.18	0.674	15.39	1.35	-0.20	2.61	0.01	0.940	153.93	13.54	0.00	0.00	0.01	0.940
UG50	2.65	0.24	-0.07	0.36	0.04	0.847	16.07	0.26	0.48	2.61	0.03	0.855	160.67	2.63	0.00	0.00	0.03	0.855
UG51	3.35	0.09	0.63	0.36	2.97	0.085	17.16	0.25	1.57	2.61	0.36	0.547	171.63	2.54	0.00	0.00	0.36	0.547
UG52	2.77	0.40	0.05	0.36	0.02	0.884	15.16	1.05	-0.43	2.61	0.03	0.868	151.57	10.48	0.00	0.00	0.03	0.868
UG53	2.28	0.20	-0.44	0.36	1.49	0.223	14.87	1.01	-0.72	2.61	0.08	0.782	148.67	10.14	0.00	0.00	0.08	0.782
UG54	2.07	0.04	-0.65	0.36	3.23	0.073	13.52	0.25	-2.07	2.61	0.63	0.429	135.23	2.50	0.00	0.00	0.63	0.429
UG55	2.81	0.29	0.09	0.36	0.06	0.812	15.95	1.10	0.36	2.61	0.02	0.892	159.47	11.02	0.00	0.00	0.02	0.892
UG56	3.45	0.42	0.73	0.36	4.03	0.045	16.87	1.34	1.28	2.61	0.24	0.625	168.67	13.36	0.00	0.00	0.24	0.625
UG57	2.52	0.25	-0.20	0.36	0.30	0.582	15.55	0.80	-0.04	2.61	0.00	0.988	155.50	8.01	0.00	0.00	0.00	0.988
UG58	2.62	0.26	-0.10	0.36	0.07	0.790	15.70	1.37	0.11	2.61	0.00	0.967	157.00	13.75	0.00	0.00	0.00	0.967
UG59	2.67	0.37	-0.05	0.36	0.02	0.898	15.72	1.38	0.13	2.61	0.00	0.960	157.20	13.84	0.00	0.00	0.00	0.960
UG60	2.15	0.06	-0.57	0.36	2.46	0.118	13.84	0.40	-1.75	2.61	0.45	0.502	138.37	3.96	0.00	0.00	0.45	0.502
UG61	2.66	0.14	-0.06	0.36	0.02	0.876	16.02	0.37	0.43	2.61	0.03	0.869	160.20	3.71	0.00	0.00	0.03	0.869
UG62	2.26	0.12	-0.46	0.36	1.58	0.210	13.79	0.58	-1.80	2.61	0.47	0.492	137.93	5.83	0.00	0.00	0.47	0.492
UG63	2.67	0.10	-0.05	0.36	0.02	0.898	15.78	0.34	0.19	2.61	0.01	0.942	157.80	3.42	0.00	0.00	0.01	0.942
UG64	2.50	0.33	-0.22	0.36	0.37	0.545	14.69	0.94	-0.90	2.61	0.12	0.730	146.87	9.35	0.00	0.00	0.12	0.730
UG65	2.34	0.06	-0.38	0.36	1.07	0.301	14.70	1.02	-0.89	2.61	0.12	0.734	147.03	10.18	0.00	0.00	0.12	0.734
UG66	3.26	0.07	0.54	0.36	2.18	0.141	17.21	0.44	1.62	2.61	0.38	0.536	172.10	4.41	0.00	0.00	0.38	0.536
UG67	2.17	0.05	-0.55	0.36	2.29	0.131	15.19	0.99	-0.40	2.61	0.02	0.877	151.87	9.90	0.00	0.00	0.02	0.877
UG68	2.18	0.34	-0.54	0.36	2.21	0.138	16.76	1.00	1.17	2.61	0.20	0.654	167.63	9.96	0.00	0.00	0.20	0.654
Grandmean	**3.02**	**0.04**			**6.670**	**0.00**	**13.65**	**0.22**			**2.720**	**0.00**	**136.47**	**2.21**			**2.720**	**0.00**

Appendix 5 (Cont'd)

Accessions	**ST**						**SWCT**						**YLD**					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG69	3.68	0.33	0.96	0.36	7.02	0.008	19.35	0.74	3.76	2.61	2.07	0.151	193.50	7.39	0.00	0.00	2.07	0.151
UG70	3.17	0.29	0.45	0.36	1.51	0.220	17.16	0.78	1.57	2.61	0.36	0.549	171.57	7.80	0.00	0.00	0.36	0.549
UG71	2.71	0.28	-0.01	0.36	0.00	0.971	15.99	1.40	0.40	2.61	0.02	0.877	159.93	14.00	0.00	0.00	0.02	0.877
UG72	2.32	0.22	-0.40	0.36	1.19	0.276	13.39	1.11	-2.20	2.61	0.71	0.399	133.87	11.09	0.00	0.00	0.71	0.399
UG73	3.12	0.31	0.40	0.36	1.19	0.276	15.75	0.58	0.16	2.61	0.00	0.951	157.50	5.78	0.00	0.00	0.00	0.951
UG74	2.74	0.26	0.02	0.36	0.00	0.964	16.54	0.06	0.95	2.61	0.13	0.715	165.43	0.64	0.00	0.00	0.13	0.715
UG75	2.72	0.27	0.00	0.36	0.00	1.000	16.76	1.38	1.17	2.61	0.20	0.655	167.60	13.84	0.00	0.00	0.20	0.655
UG76	2.70	0.25	-0.02	0.36	0.00	0.963	15.69	0.74	0.10	2.61	0.00	0.970	156.90	7.37	0.00	0.00	0.00	0.970
UG77	2.68	0.27	-0.04	0.36	0.01	0.920	16.65	0.35	1.06	2.61	0.17	0.684	166.53	3.51	0.00	0.00	0.17	0.684
UG78	2.39	0.40	-0.33	0.36	0.84	0.360	14.58	1.22	-1.01	2.61	0.15	0.700	145.83	12.16	0.00	0.00	0.15	0.700
UG79	2.84	0.42	0.12	0.36	0.11	0.735	15.93	2.25	0.34	2.61	0.02	0.898	159.27	22.48	0.00	0.00	0.02	0.898
UG80	2.67	0.36	-0.05	0.36	0.02	0.883	16.44	0.44	0.85	2.61	0.10	0.746	164.37	4.39	0.00	0.00	0.10	0.746
UG81	2.28	0.06	-0.44	0.36	1.47	0.227	14.39	0.97	-1.20	2.61	0.21	0.647	143.93	9.71	0.00	0.00	0.21	0.647
UG82	2.93	0.59	0.21	0.36	0.33	0.564	14.14	1.70	-1.45	2.61	0.31	0.578	141.37	16.97	0.00	0.00	0.31	0.578
UG83	2.62	0.21	-0.10	0.36	0.08	0.783	16.20	0.57	0.61	2.61	0.06	0.815	162.03	5.72	0.00	0.00	0.06	0.815
UG84	2.92	0.44	0.20	0.36	0.31	0.576	17.40	0.70	1.81	2.61	0.48	0.489	174.00	6.96	0.00	0.00	0.48	0.489
UG85	2.03	0.11	-0.69	0.36	3.57	0.060	13.98	0.58	-1.61	2.61	0.38	0.539	139.83	5.77	0.00	0.00	0.38	0.539
UG86	3.14	0.44	0.42	0.36	1.31	0.252	16.75	0.58	1.16	2.61	0.20	0.658	167.47	5.79	0.00	0.00	0.20	0.658
UG87	2.73	0.42	0.01	0.36	0.00	0.986	13.50	1.48	-2.09	2.61	0.64	0.423	134.97	14.80	0.00	0.00	0.64	0.423
UG88	3.15	0.14	0.43	0.36	1.42	0.234	15.72	0.41	0.13	2.61	0.00	0.959	157.23	4.10	0.00	0.00	0.00	0.959
UG89	2.54	0.27	-0.18	0.36	0.24	0.627	12.48	0.46	-3.11	2.61	1.42	0.235	124.80	4.65	0.00	0.00	1.42	0.235
UG90	2.08	0.14	-0.64	0.36	3.10	0.079	14.29	0.47	-1.30	2.61	0.25	0.619	142.90	4.68	0.00	0.00	0.25	0.619
UG91	2.32	0.24	-0.40	0.36	1.21	0.272	15.22	0.47	-0.37	2.61	0.02	0.887	152.20	4.67	0.00	0.00	0.02	0.887
UG92	2.50	0.34	-0.22	0.36	0.38	0.539	17.05	0.83	1.46	2.61	0.31	0.577	170.50	8.30	0.00	0.00	0.31	0.577
UG93	2.75	0.13	0.03	0.36	0.01	0.935	15.71	0.33	0.12	2.61	0.00	0.963	157.10	3.32	0.00	0.00	0.00	0.963
UG94	2.42	0.18	-0.30	0.36	0.67	0.415	17.05	0.33	1.46	2.61	0.31	0.576	170.53	3.27	0.00	0.00	0.31	0.576
UG95	2.86	0.44	0.14	0.36	0.16	0.694	17.47	1.57	1.88	2.61	0.52	0.472	174.70	15.72	0.00	0.00	0.52	0.472
UG96	2.68	0.36	-0.04	0.36	0.01	0.912	14.99	0.66	-0.60	2.61	0.05	0.819	149.93	6.60	0.00	0.00	0.05	0.819
UG97	2.87	0.40	0.15	0.36	0.16	0.687	17.20	1.23	1.61	2.61	0.38	0.538	172.00	12.34	0.00	0.00	0.38	0.538
UG98	2.76	0.18	0.04	0.36	0.01	0.920	16.13	0.75	0.54	2.61	0.04	0.836	161.30	7.52	0.00	0.00	0.04	0.836
UG99	2.70	0.31	-0.02	0.36	0.00	0.963	14.49	1.10	-1.10	2.61	0.18	0.674	144.90	10.96	0.00	0.00	0.18	0.674
UG100	2.76	0.07	0.04	0.36	0.01	0.913	15.74	0.95	0.15	2.61	0.00	0.953	157.43	9.50	0.00	0.00	0.00	0.953
UG101	2.74	0.47	0.02	0.36	0.00	0.949	15.45	1.71	-0.14	2.61	0.00	0.958	154.53	17.11	0.00	0.00	0.00	0.958
UG102	2.89	0.48	0.17	0.36	0.23	0.634	17.46	0.34	1.87	2.61	0.51	0.474	174.63	3.38	0.00	0.00	0.51	0.474
UG103	2.77	0.03	0.05	0.36	0.02	0.898	15.97	0.40	0.38	2.61	0.02	0.884	159.73	4.00	0.00	0.00	0.02	0.884
UG104	2.70	0.39	-0.02	0.36	0.00	0.956	15.51	1.27	-0.08	2.61	0.00	0.976	155.10	12.66	0.00	0.00	0.00	0.976
Grandmean	**3.02**	**0.04**			**6.670**	**0.00**	**13.65**	**0.22**			**2.720**	**0.00**	**136.47**	**2.21**			**2.720**	**0.00**

Appendix 6: Marginal analysis showing accessions that significantly (P<0.05) performed below and above the grandmean for phytochemical traits

Accessions	GAL						VAN						PCA					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
Asontem	0.01	0.00	-0.28	0.01	979.76	0.000	0.67	0.00	0.17	0.00	9392.28	0.000	1.05	0.00	0.26	0.01	1058.36	0.000
Kirkhouse	0.20	0.00	-0.09	0.01	102.59	0.000	0.28	0.00	-0.23	0.00	17197.72	0.000	0.37	0.00	-0.42	0.01	2743.51	0.000
Padituya	0.01	0.00	-0.28	0.01	979.76	0.000	0.67	0.00	0.17	0.00	9392.28	0.000	1.05	0.00	0.26	0.01	1058.36	0.000
Wang Kae	0.32	0.00	0.02	0.01	6.33	0.012	0.07	0.00	-0.43	0.00	63578.74	0.000	0.01	0.00	-0.77	0.01	9493.26	0.000
UG1	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG2	0.21	0.00	-0.08	0.04	4.88	0.028	0.27	0.00	-0.24	0.01	1084.40	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG3	0.32	0.00	0.02	0.04	0.27	0.604	0.08	0.00	-0.43	0.01	3486.27	0.000	0.02	0.00	-0.77	0.03	521.02	0.000
UG4	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG5	1.52	0.58	1.22	0.04	1021.16	0.000	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG6	2.52	0.00	2.22	0.04	3369.69	0.000	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG7	2.52	0.00	2.22	0.04	3369.69	0.000	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG8	2.52	0.00	2.22	0.04	3369.69	0.000	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG9	2.52	0.00	2.22	0.04	3369.69	0.000	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG10	0.56	0.00	0.26	0.04	45.51	0.000	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG11	0.26	0.00	-0.03	0.04	0.75	0.388	0.17	0.00	-0.33	0.01	2097.96	0.000	0.19	0.00	-0.60	0.03	320.26	0.000
UG12	0.65	0.00	0.36	0.04	86.17	0.000	0.17	0.00	-0.33	0.01	2097.96	0.000	0.19	0.00	-0.60	0.03	320.26	0.000
UG13	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG14	3.37	0.00	3.08	0.04	6439.91	0.000	6.78	0.00	6.27	0.01	742954.21	0.000	11.52	0.00	10.73	0.03	102455.01	0.000
UG15	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG16	0.47	0.00	0.18	0.04	21.10	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG17	0.30	0.05	0.00	0.04	0.00	0.962	1.19	0.08	0.69	0.01	8921.58	0.000	1.94	0.15	1.15	0.03	1178.28	0.000
UG18	0.21	0.00	-0.09	0.04	5.69	0.017	1.02	0.00	0.52	0.01	5063.69	0.000	1.65	0.00	0.86	0.03	658.07	0.000
UG19	0.28	0.03	-0.01	0.04	0.14	0.706	0.14	0.05	-0.37	0.01	2546.46	0.000	0.69	0.48	-0.10	0.03	8.55	0.004
UG20	0.26	0.00	-0.04	0.04	1.12	0.292	0.19	0.00	-0.32	0.01	1932.87	0.000	0.21	0.00	-0.58	0.03	296.23	0.000
UG21	0.10	0.00	-0.20	0.04	27.52	0.000	0.48	0.00	-0.03	0.01	15.00	0.000	0.71	0.00	-0.08	0.03	5.22	0.023
UG22	0.21	0.00	-0.09	0.04	5.69	0.017	1.02	0.00	0.52	0.01	5063.69	0.000	1.65	0.00	0.86	0.03	658.07	0.000
UG23	0.21	0.00	-0.08	0.04	4.88	0.028	0.27	0.00	-0.24	0.01	1084.40	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG24	0.47	0.00	0.18	0.04	21.10	0.000	0.27	0.00	-0.24	0.01	1084.40	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG25	0.47	0.00	0.18	0.04	21.10	0.000	0.27	0.00	-0.24	0.01	1084.40	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG26	0.35	0.00	0.06	0.04	2.19	0.139	0.01	0.00	-0.50	0.01	4656.67	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG27	0.26	0.00	-0.04	0.04	1.12	0.292	0.19	0.00	-0.32	0.01	1932.87	0.000	0.21	0.00	-0.58	0.03	296.23	0.000
UG28	0.23	0.00	-0.07	0.04	3.33	0.069	0.24	0.00	-0.27	0.01	1340.17	0.000	0.30	0.00	-0.49	0.03	209.45	0.000
UG29	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG30	0.17	0.00	-0.13	0.04	11.05	0.001	0.34	0.00	-0.16	0.01	495.68	0.000	0.48	0.00	-0.31	0.03	83.38	0.000
Grandmean	**0.23**	**0.02**			**235.98**	**0.000**	**0.47**	**0.02**			**9149.49**	**0.000**	**0.72**	**0.04**			**1251.69**	**0.000**

Appendix 6 (Cont'd)

Accessions	GAL						VAN						PCA					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG31	0.38	0.00	0.09	0.04	5.23	0.023	0.34	0.00	-0.16	0.01	495.68	0.000	0.48	0.00	-0.31	0.03	83.38	0.000
UG32	0.28	0.00	-0.01	0.04	0.13	0.716	0.14	0.00	-0.37	0.01	2558.84	0.000	0.13	0.00	-0.66	0.03	387.15	0.000
UG33	0.00	0.00	-0.29	0.04	57.96	0.000	0.78	0.00	0.27	0.01	1365.55	0.000	1.22	0.00	0.43	0.03	166.84	0.000
UG34	0.47	0.00	0.17	0.04	19.37	0.000	0.78	0.00	0.27	0.01	1365.55	0.000	1.22	0.00	0.43	0.03	166.84	0.000
UG35	0.00	0.00	-0.29	0.04	57.96	0.000	0.66	0.00	0.15	0.01	446.80	0.000	1.02	0.00	0.24	0.03	49.40	0.000
UG36	0.17	0.00	-0.13	0.04	11.05	0.001	0.34	0.00	-0.16	0.01	495.68	0.000	0.48	0.00	-0.31	0.03	83.38	0.000
UG37	0.21	0.00	-0.08	0.04	4.88	0.028	0.27	0.00	-0.24	0.01	1084.40	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG38	0.47	0.00	0.18	0.04	21.10	0.000	0.27	0.00	-0.24	0.01	1084.40	0.000	0.35	0.00	-0.44	0.03	171.68	0.000
UG39	0.29	0.00	-0.01	0.04	0.08	0.774	0.13	0.00	-0.37	0.01	2633.81	0.000	0.12	0.00	-0.67	0.03	398.01	0.000
UG40	0.38	0.00	0.09	0.04	5.23	0.023	0.13	0.00	-0.37	0.01	2633.81	0.000	0.12	0.00	-0.67	0.03	398.01	0.000
UG41	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG42	0.25	0.00	-0.05	0.04	1.52	0.218	1.10	0.00	0.60	0.01	6755.83	0.000	1.79	0.00	1.00	0.03	885.73	0.000
UG43	0.17	0.00	-0.13	0.04	11.05	0.001	0.34	0.00	-0.16	0.01	495.68	0.000	0.48	0.00	-0.31	0.03	83.38	0.000
UG44	0.28	0.00	-0.01	0.04	0.13	0.716	0.14	0.00	-0.37	0.01	2558.84	0.000	0.13	0.00	-0.66	0.03	387.15	0.000
UG45	0.23	0.00	-0.07	0.04	3.33	0.069	0.24	0.00	-0.27	0.01	1340.17	0.000	0.30	0.00	-0.49	0.03	209.45	0.000
UG46	0.02	0.00	-0.27	0.04	50.27	0.000	0.61	0.00	0.10	0.01	189.93	0.000	0.93	0.00	0.14	0.03	18.40	0.000
UG47	0.35	0.00	0.06	0.04	2.19	0.139	0.01	0.00	-0.50	0.01	4656.67	0.000	0.93	0.00	0.14	0.03	18.40	0.000
UG48	0.61	0.00	0.31	0.04	67.35	0.000	0.01	0.00	-0.50	0.01	4656.67	0.000	0.93	0.00	0.14	0.03	18.40	0.000
UG49	0.26	0.00	-0.04	0.04	1.12	0.291	0.19	0.00	-0.32	0.01	1932.87	0.000	0.21	0.00	-0.58	0.03	296.23	0.000
UG50	0.23	0.03	-0.07	0.04	3.28	0.071	0.24	0.05	-0.27	0.01	1349.16	0.000	0.30	0.09	-0.49	0.03	210.77	0.000
UG51	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG52	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG53	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG54	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG55	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG56	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG57	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG58	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG59	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG60	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG61	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG62	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG63	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG64	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG65	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG66	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG67	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG68	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
Grandmean	**0.23**	**0.02**			**235.98**	**0.000**	**0.47**	**0.02**			**9149.49**	**0.000**	**0.72**	**0.04**			**1251.69**	**0.000**

Appendix 6 (Cont'd)

Accessions	GAL						VAN						FCA					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG69	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG70	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG71	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG72	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG73	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG74	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG75	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG76	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG77	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG78	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG79	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG80	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG81	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG82	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG83	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG84	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG85	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG86	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG87	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG88	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG89	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG90	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG91	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG92	0.20	0.00	-0.09	0.04	5.77	0.017	0.28	0.00	-0.23	0.01	966.66	0.000	0.37	0.00	-0.42	0.03	154.21	0.000
UG93	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG94	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG95	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG96	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG97	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG98	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG99	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG100	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG101	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG102	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG103	0.01	0.00	-0.28	0.04	55.07	0.000	0.67	0.00	0.17	0.01	527.93	0.000	1.05	0.00	0.26	0.03	59.49	0.000
UG104	0.32	0.03	0.02	0.04	0.33	0.568	0.13	0.00	-0.37	0.01	2633.81	0.000	0.12	0.00	-0.67	0.03	398.01	0.000
Grandmean	**0.23**	**0.02**			**235.98**	**0.000**	**0.47**	**0.02**			**9149.49**	**0.000**	**0.72**	**0.04**			**1251.69**	**0.000**

Appendix 6 (Cont'd)

Accessions	RUT						QUE						GLY					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
Asontem	11.85	0.00	-1.65	0.04	1720.14	0.000	1.72	0.00	-0.24	0.01	1720.15	0.000	15.40	0.00	-526.91	0.10	29100000.00	0.000
Kirkhouse	16.55	0.00	3.05	0.04	5849.30	0.000	2.42	0.00	0.45	0.01	5849.30	0.000	5.46	0.00	-536.85	0.10	30200000.00	0.000
Padituya	11.85	0.00	-1.65	0.04	1720.14	0.000	1.72	0.00	-0.24	0.01	1720.15	0.000	4483.34	0.00	3941.03	0.10	1630000000.00	0.000
Wang Kae	22.10	0.00	8.59	0.04	46490.62	0.000	3.24	0.00	1.27	0.01	46490.65	0.000	3.59	0.00	-538.72	0.10	30500000.00	0.000
UG1	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	15.40	0.00	-526.91	0.41	1640000.00	0.000
UG2	13.61	0.00	0.11	0.17	0.41	0.520	1.98	0.00	0.02	0.02	0.41	0.520	1.12	0.00	-541.19	0.41	1730000.00	0.000
UG3	8.79	0.00	-4.71	0.17	784.82	0.000	1.27	0.00	-0.70	0.02	784.82	0.000	20.11	0.00	-522.20	0.41	1610000.00	0.000
UG4	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	9.11	0.00	-533.20	0.41	1680000.00	0.000
UG5	11.25	0.00	-2.25	0.17	179.10	0.000	1.63	0.00	-0.33	0.02	179.10	0.000	14.15	0.00	-528.16	0.41	1650000.00	0.000
UG6	11.25	0.00	-2.25	0.17	179.10	0.000	1.63	0.00	-0.33	0.02	179.10	0.000	53.42	0.00	-488.89	0.41	1410000.00	0.000
UG7	11.25	0.00	-2.25	0.17	179.10	0.000	1.63	0.00	-0.33	0.02	179.10	0.000	28.21	0.00	-514.10	0.41	1560000.00	0.000
UG8	11.25	0.00	-2.25	0.17	179.10	0.000	1.63	0.00	-0.33	0.02	179.10	0.000	12.54	0.00	-529.77	0.41	1660000.00	0.000
UG9	11.25	0.00	-2.25	0.17	179.10	0.000	1.63	0.00	-0.33	0.02	179.10	0.000	7.93	0.00	-534.38	0.41	1690000.00	0.000
UG10	6.64	0.00	-6.86	0.17	1666.97	0.000	0.95	0.00	-1.02	0.02	1666.97	0.000	20.19	0.00	-522.12	0.41	1610000.00	0.000
UG11	10.92	0.00	-2.58	0.17	236.36	0.000	1.58	0.00	-0.38	0.02	236.36	0.000	20.63	0.00	-521.68	0.41	1610000.00	0.000
UG12	10.92	0.00	-2.58	0.17	236.36	0.000	1.58	0.00	-0.38	0.02	236.36	0.000	4.64	0.00	-537.67	0.41	1710000.00	0.000
UG13	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	3.36	0.00	-538.95	0.41	1720000.00	0.000
UG14	20.13	0.00	6.63	0.17	1554.80	0.000	2.95	0.00	0.98	0.02	1554.80	0.000	25.44	0.00	-516.87	0.41	1580000.00	0.000
UG15	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	78.57	0.00	-463.74	0.41	1270000.00	0.000
UG16	17.34	0.00	3.83	0.17	520.19	0.000	2.53	0.00	0.57	0.02	520.19	0.000	5.71	0.00	-536.60	0.41	1700000.00	0.000
UG17	12.46	1.69	-1.04	0.17	38.40	0.000	1.81	0.25	-0.15	0.02	38.40	0.000	10.24	5.34	-532.07	0.41	1670000.00	0.000
UG18	9.08	0.00	-4.42	0.17	690.80	0.000	1.31	0.00	-0.65	0.02	690.80	0.000	20.91	0.00	-521.40	0.41	1610000.00	0.000
UG19	10.78	0.14	-2.72	0.17	261.86	0.000	1.56	0.02	-0.40	0.02	261.86	0.000	11.64	3.21	-530.67	0.41	1660000.00	0.000
UG20	10.92	0.00	-2.58	0.17	236.36	0.000	1.58	0.00	-0.38	0.02	236.36	0.000	17.22	0.00	-525.09	0.41	1630000.00	0.000
UG21	11.32	0.00	-2.18	0.17	167.70	0.000	1.64	0.00	-0.32	0.02	167.70	0.000	7.70	0.00	-534.61	0.41	1690000.00	0.000
UG22	16.62	0.00	3.12	0.17	344.67	0.000	2.43	0.00	0.46	0.02	344.67	0.000	9.63	0.00	-532.68	0.41	1680000.00	0.000
UG23	13.61	0.00	0.11	0.17	0.41	0.520	1.98	0.00	0.02	0.02	0.41	0.520	1.12	0.00	-541.19	0.41	1730000.00	0.000
UG24	10.10	0.00	-3.40	0.17	408.95	0.000	1.46	0.00	-0.50	0.02	408.95	0.000	41.35	0.00	-500.96	0.41	1480000.00	0.000
UG25	10.10	0.00	-3.40	0.17	408.95	0.000	1.46	0.00	-0.50	0.02	408.95	0.000	30.32	0.00	-511.99	0.41	1550000.00	0.000
UG26	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	11.60	0.00	-530.71	0.41	1660000.00	0.000
UG27	10.00	0.00	-3.50	0.17	433.83	0.000	1.45	0.00	-0.52	0.02	433.83	0.000	31.40	0.00	-510.91	0.41	1540000.00	0.000
UG28	20.22	0.00	6.72	0.17	1596.04	0.000	2.96	0.00	0.99	0.02	1596.04	0.000	.	.	-541.19	0.41		
UG29	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	1.12	0.00	-524.94	0.41	1730000.00	0.000
UG30	20.01	0.00	6.51	0.17	1500.66	0.000	2.93	0.00	0.96	0.02	1500.66	0.000	17.37	0.00	-524.94	0.41	1630000.00	0.000
Grandmean	**14.39**	**0.16**	**-0.67**	**0.03**	**889.16**	**0.000**	**2.10**	**0.02**			**889.16**	**0.000**	**792.42**	**75.48**			**32900000.00**	**0.000**

Appendix 6 (Cont'd)

Accessions	**RUT**						**QUE**						**GLY**					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG31	9.83	0.00	-3.68	0.17	478.19	0.000	1.42	0.00	-0.54	0.02	478.19	0.000	17.37	0.00	3762.09	0.41	1630000.00	0.000
UG32	16.62	0.00	3.12	0.17	344.67	0.000	2.43	0.00	0.46	0.02	344.67	0.000	4304.40	0.00	-536.02	0.41	83600000.00	0.000
UG33	14.15	0.00	0.65	0.17	14.80	0.000	2.06	0.00	0.10	0.02	14.80	0.000	6.29	0.00	-522.80	0.41	1700000.00	0.000
UG34	22.45	0.00	8.94	0.17	2829.94	0.000	3.29	0.00	1.32	0.02	2829.94	0.000	19.51	0.00	-537.46	0.41	1610000.00	0.000
UG35	14.13	0.00	0.63	0.17	14.14	0.000	2.06	0.00	0.09	0.02	14.14	0.000	4.85	0.00	-530.83	0.41	1710000.00	0.000
UG36	11.91	0.00	-1.59	0.17	90.00	0.000	1.73	0.00	-0.24	0.02	90.00	0.000	11.48	0.00	-500.96	0.41	1660000.00	0.000
UG37	10.10	0.00	-3.40	0.17	408.95	0.000	1.46	0.00	-0.50	0.02	408.95	0.000	41.35	0.00	-536.27	0.41	1480000.00	0.000
UG38	20.22	0.00	6.72	0.17	1596.04	0.000	2.96	0.00	0.99	0.02	1596.04	0.000	6.04	0.00	-523.24	0.41	1700000.00	0.000
UG39	14.13	0.00	0.63	0.17	14.14	0.000	2.06	0.00	0.09	0.02	14.14	0.000	19.07	0.00	-522.09	0.41	1620000.00	0.000
UG40	13.71	0.00	0.21	0.17	1.56	0.212	2.00	0.00	0.03	0.02	1.56	0.212	20.22	0.00	-509.89	0.41	1610000.00	0.000
UG41	14.15	0.00	0.65	0.17	14.80	0.000	2.06	0.00	0.10	0.02	14.80	0.000	32.42	0.00	-529.77	0.41	1540000.00	0.000
UG42	13.61	0.00	0.11	0.17	0.41	0.520	1.98	0.00	0.02	0.02	0.41	0.520	12.54	0.00	-536.85	0.41	1660000.00	0.000
UG43	10.10	0.00	-3.40	0.17	408.95	0.000	1.46	0.00	-0.50	0.02	408.95	0.000	5.46	0.00	-536.87	0.41	1700000.00	0.000
UG44	9.61	0.00	-3.89	0.17	536.68	0.000	1.39	0.00	-0.58	0.02	536.68	0.000	5.44	0.00	-523.24	0.41	1700000.00	0.000
UG45	20.22	0.00	6.72	0.17	1596.04	0.000	2.96	0.00	0.99	0.02	1596.04	0.000	19.07	0.00	-503.80	0.41	1620000.00	0.000
UG46	6.30	0.00	-7.20	0.17	1833.54	0.000	0.90	0.00	-1.06	0.02	1833.54	0.000	38.51	0.00	-514.86	0.41	1500000.00	0.000
UG47	20.01	0.00	6.51	0.17	1500.66	0.000	2.93	0.00	0.96	0.02	1500.66	0.000	27.45	0.00	-520.32	0.41	1570000.00	0.000
UG48	9.83	0.00	-3.68	0.17	478.19	0.000	1.42	0.00	-0.54	0.02	478.19	0.000	21.99	0.00	-527.46	0.41	1600000.00	0.000
UG49	10.92	0.00	-2.58	0.17	236.36	0.000	1.58	0.00	-0.38	0.02	236.36	0.000	14.85	0.00	-441.35	0.41	1640000.00	0.000
UG50	12.82	1.90	-0.68	0.17	16.49	0.000	1.86	0.28	-0.10	0.02	16.49	0.000	100.96	0.00	-538.68	0.41	1150000.00	0.000
UG51	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	3.63	0.00	-532.14	0.41	1710000.00	0.000
UG52	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	10.17	0.00	-536.60	0.41	1670000.00	0.000
UG53	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	5.71	0.00	-526.08	0.41	1700000.00	0.000
UG54	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	16.23	0.00	-509.89	0.41	1630000.00	0.000
UG55	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	32.42	0.00	-534.47	0.41	1540000.00	0.000
UG56	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	7.84	0.00	-540.18	0.41	1690000.00	0.000
UG57	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	2.13	0.00	-530.60	0.41	1720000.00	0.000
UG58	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	11.71	0.00	-532.39	0.41	1660000.00	0.000
UG59	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	9.92	0.00	-537.57	0.41	1670000.00	0.000
UG60	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	4.74	0.00	-533.03	0.41	1710000.00	0.000
UG61	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	9.28	0.00	-534.87	0.41	1680000.00	0.000
UG62	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	7.44	0.00	-538.21	0.41	1690000.00	0.000
UG63	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	4.10	0.00	-531.41	0.41	1710000.00	0.000
UG64	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	10.90	0.00	-531.46	0.41	1670000.00	0.000
UG65	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	10.85	0.00	-538.41	0.41	1670000.00	0.000
UG66	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	3.90	0.00	-538.80	0.41	1710000.00	0.000
UG67	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	3.51	0.00	-536.94	0.41	1710000.00	0.000
UG68	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	5.37	0.00	-511.68	0.41	1700000.00	0.000
Grandmean	**14.39**	**0.16**	**-0.67**	**0.03**	**889.16**	**0.000**	**2.10**	**0.02**			**889.16**	**0.000**	**792.42**	**75.48**			**32900000.00**	**0.000**

Appendix 6 (Cont'd)

Accessions	RUT Mean	sem	con	sec	F	P	QUE Mean	sem	con	sec	F	P	GLY Mean	sem	con	sec	F	P
UG69	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	30.63	0.00	-521.05	0.41	1550000.00	0.000
UG70	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	21.26	0.00	-536.96	0.41	1600000.00	0.000
UG71	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	5.35	0.00	-534.61	0.41	1700000.00	0.000
UG72	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	7.70	0.00	-515.06	0.41	1690000.00	0.000
UG73	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	27.25	0.00	-520.32	0.41	1570000.00	0.000
UG74	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	21.99	0.00	-536.70	0.41	1600000.00	0.000
UG75	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	5.61	0.00	-532.28	0.41	1700000.00	0.000
UG76	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	10.03	0.00	-538.78	0.41	1670000.00	0.000
UG77	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	3.53	0.00	-530.83	0.41	1710000.00	0.000
UG78	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	11.48	0.00	-534.81	0.41	1660000.00	0.000
UG79	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	7.50	0.00	4777.30	0.41	1690000.00	0.000
UG80	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	5319.61	0.00	6677.14	0.41	135000000.00	0.000
UG81	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	7219.45	0.00	3907.91	0.41	263000000.00	0.000
UG82	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	4450.22	0.00	6357.54	0.41	90200000.00	0.000
UG83	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	6899.85	0.00	3762.09	0.41	239000000.00	0.000
UG84	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	4304.40	0.00	-536.02	0.41	83600000.00	0.000
UG85	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	6.29	0.00	4377.59	0.41	1700000.00	0.000
UG86	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	4919.90	0.00	2638.01	0.41	113000000.00	0.000
UG87	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	3180.32	0.00	-532.16	0.41	41100000.00	0.000
UG88	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	10.15	0.00	7205.88	0.41	1670000.00	0.000
UG89	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	7748.19	0.00	-528.02	0.41	307000000.00	0.000
UG90	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	14.29	0.00	-538.89	0.41	1650000.00	0.000
UG91	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	3.42	0.00	-519.13	0.41	1720000.00	0.000
UG92	16.55	0.00	3.05	0.17	328.78	0.000	2.42	0.00	0.45	0.02	328.78	0.000	23.18	0.00	3016.30	0.41	1590000.00	0.000
UG93	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	3558.61	0.00	-529.60	0.41	53700000.00	0.000
UG94	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	12.71	0.00	-453.73	0.41	1660000.00	0.000
UG95	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	88.58	0.00	-510.91	0.41	1220000.00	0.000
UG96	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	31.40	0.00	-441.35	0.41	1540000.00	0.000
UG97	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	100.96	0.00	-536.60	0.41	1150000.00	0.000
UG98	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	5.71	0.00	-537.88	0.41	1700000.00	0.000
UG99	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	4.43	0.00	-540.51	0.41	1710000.00	0.000
UG100	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	1.80	0.00	-527.20	0.41	1730000.00	0.000
UG101	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	15.11	0.00	-536.06	0.41	1640000.00	0.000
UG102	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	6.25	0.00	-537.10	0.41	1700000.00	0.000
UG103	11.85	0.00	-1.65	0.17	96.69	0.000	1.72	0.00	-0.24	0.02	96.69	0.000	5.21	0.00	-526.91	0.41	1700000.00	0.000
UG104	13.99	0.14	0.49	0.17	8.54	0.004	2.04	0.02	0.07	0.02	8.54	0.004	15.40	0.00	0.07	0.02	1640000.00	0.000
Grandmean	**14.39**	**0.16**	**-0.67**	**0.03**	**889.16**	**0.000**	**2.10**	**0.02**			**889.16**	**0.000**	**792.42**	**75.48**			**32900000.00**	**0.000**

Appendix 6 (Cont'd)

Accessions	LSER						LHIS						ASP						LLYS				
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	F	P
Asontem	30.46	0.00	2.80	0.66	17.99	0.000	0.00	0.00	-5.46	0.14	1473.77	0.000	30.41	0.00	-38.15	1.52	631.28	0.000					
Kirkhouse	0.00	0.00	-27.66	0.66	1748.43	0.000	0.00	0.00	-5.46	0.14	1473.77	0.000	0.00	0.00	-68.56	1.52	2038.78	0.000					
Padituya	10.67	0.00	-16.99	0.66	659.53	0.000	0.00	0.00	-5.46	0.14	1473.77	0.000	4.50	0.00	-64.06	1.52	1779.93	0.000					
Wang Kae	190.16	0.00	162.50	0.66	60371.55	0.000	0.00	0.00	-5.46	0.14	1473.77	0.000	40.59	0.00	-27.97	1.52	339.33	0.000					
UG1	30.46	0.00	2.80	2.78	1.02	0.314	0.00	0.00	-5.46	0.60	82.84	0.000	30.41	0.00	-38.15	6.40	35.48	0.000					
UG2	23.81	0.00	-3.85	2.78	1.91	0.167	0.00	0.00	-5.46	0.60	82.84	0.000	19.48	0.00	-49.08	6.40	58.73	0.000					
UG3	23.85	0.00	-3.81	2.78	1.87	0.172	0.00	0.00	-5.46	0.60	82.84	0.000	154.85	0.00	86.29	6.40	181.53	0.000					
UG4	6.89	0.00	-20.77	2.78	55.81	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	23.98	0.00	-44.58	6.40	48.45	0.000					
UG5	0.00	0.00	-27.66	2.78	98.99	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	37.34	0.00	-31.22	6.40	23.76	0.000					
UG6	23.59	0.00	-4.07	2.78	2.14	0.144	55.81	0.00	50.35	0.60	7030.68	0.000	225.62	0.00	157.06	6.40	601.39	0.000					
UG7	17.00	0.00	-10.66	2.78	14.69	0.000	21.75	0.00	16.29	0.60	735.64	0.000	62.24	0.00	-6.32	6.40	0.97	0.324					
UG8	23.02	0.00	-4.64	2.78	2.78	0.096	0.00	0.00	-5.46	0.60	82.84	0.000	104.87	0.00	36.31	6.40	32.14	0.000					
UG9	11.85	0.00	-15.81	2.78	32.33	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	109.22	0.00	40.66	6.40	40.30	0.000					
UG10	5.83	0.00	-21.83	2.78	61.65	0.000	18.40	0.00	12.94	0.60	464.12	0.000	28.81	0.00	-39.75	6.40	38.52	0.000					
UG11	9.63	0.00	-18.03	2.78	42.05	0.000	13.73	0.00	8.27	0.60	189.49	0.000	33.39	0.00	-35.17	6.40	30.16	0.000					
UG12	1.19	0.00	-26.47	2.78	90.65	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	5.58	0.00	-62.98	6.40	96.70	0.000					
UG13	9.42	0.00	-18.24	2.78	43.04	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	46.44	0.00	-22.12	6.40	11.93	0.001					
UG14	28.14	0.00	0.48	2.78	0.03	0.862	15.66	0.00	10.20	0.60	288.32	0.000	99.81	0.00	31.25	6.40	23.81	0.000					
UG15	.	.	-27.03	2.78			0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG16	0.63	0.00	-2.66	2.78	94.53	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	58.17	0.00	-10.39	6.40	2.63	0.105					
UG17	25.00	2.78	2.90	2.78	0.91	0.340	9.11	9.11	3.65	0.60	36.86	0.000	56.24	1.37	-12.32	6.40	3.70	0.055					
UG18	30.56	0.00	58.63	2.78	1.09	0.297	27.33	0.00	21.87	0.60	1326.13	0.000	53.50	0.00	-15.06	6.40	5.53	0.019					
UG19	86.28	41.63	32.32	2.78	444.87	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	194.33	97.16	125.77	6.40	385.62	0.000					
UG20	59.98	0.00	-27.43	2.78	135.24	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	52.54	0.00	-16.02	6.40	6.26	0.013					
UG21	0.23	0.00	11.33	2.78	97.35	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	6.60	0.00	-61.96	6.40	93.60	0.000					
UG22	38.99	0.00	-3.85	2.78	16.63	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	37.87	0.00	-30.69	6.40	22.96	0.000					
UG23	23.81	0.00	158.81	2.78	1.91	0.167	0.00	0.00	-5.46	0.60	82.84	0.000	19.48	0.00	-49.08	6.40	58.73	0.000					
UG24	186.47	0.00	172.73	2.78	3264.42	0.000	51.04	0.00	45.58	0.60	5761.53	0.000	267.86	0.00	199.30	6.40	968.37	0.000					
UG25	200.39	0.00	-5.08	2.78	3861.75	0.000	26.90	0.00	21.44	0.60	1274.49	0.000	581.97	0.00	513.41	6.40	6426.21	0.000					
UG26	22.58	0.00	-21.61	2.78	3.33	0.069	0.00	0.00	-5.46	0.60	82.84	0.000	38.28	0.00	-30.28	6.40	22.35	0.000					
UG27	6.05	0.00	-3.85	2.78	60.41	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	60.91	0.00	-7.65	6.40	1.43	0.233					
UG28	.	.	-20.40	2.78			10.14	0.00	4.68	0.60	60.63	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG29	23.81	0.00	-20.40	2.78	1.91	0.167	0.00	0.00	-5.46	0.60	82.84	0.000	19.48	0.00	-49.08	6.40	58.73	0.000					
UG30	7.26	0.00	8.57	2.78	53.84	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
Grandmean	**40.84**	**2.61**			**855.45**	**0.000**	**3.14**	**0.38**			**386.14**	**0.000**	**47.42**	**3.20**			**239.58**	**0.000**	**0.154**	**0.089**		**482.33**	**0.000**

Appendix 6 (Cont'd)

Accessions	LSER						LHIS						ASP						LYS			
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**F**	**P**
UG31	7.26	0.00	-25.62	2.78	53.84	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000				
UG32	36.23	0.00	-4.36	2.78	9.52	0.002	23.53	0.00	18.07	0.60	905.24	0.000	31.61	0.00	-36.95	6.40	33.29	0.000	0.00	0.00	1.22	0.000
UG33	2.04	0.00	-14.03	2.78	84.92	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	3.41	0.00	-65.15	6.40	103.48	0.000				
UG34	23.30	0.00	-23.53	2.78	2.45	0.118	31.63	0.00	26.17	0.60	1899.02	0.000	38.18	0.00	-30.38	6.40	22.50	0.000				
UG35	13.63	0.00	158.81	2.78	25.46	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000				
UG36	4.13	0.00	-1.48	2.78	71.63	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	110.39	0.00	41.83	6.40	42.66	0.000				
UG37	186.47	0.00	-0.85	2.78	3264.42	0.000	51.04	0.00	45.58	0.60	5761.53	0.000	267.86	0.00	199.30	6.40	968.37	0.000				
UG38	.	.	-13.50	2.78			0.00	0.00	-5.46	0.60	82.84	0.000	13.54	0.00	-55.02	6.40	73.80	0.000				
UG39	26.18	0.00	-4.64	2.78	0.28	0.596	0.00	0.00	-5.46	0.60	82.84	0.000	98.08	0.00	29.52	6.40	21.24	0.000				
UG40	26.81	0.00	-1.48	2.78	0.09	0.761	0.00	0.00	-5.46	0.60	82.84	0.000	108.32	0.00	39.76	6.40	38.54	0.000				
UG41	14.16	0.00	-10.23	2.78	23.57	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	138.32	0.00	69.76	6.40	118.64	0.000				
UG42	23.02	0.00	-16.84	2.78	2.78	0.096	0.00	0.00	-5.46	0.60	82.84	0.000	104.87	0.00	36.31	6.40	32.14	0.000				
UG43	.	.	8.66	2.78			0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000				
UG44	.	.	100.25	2.78			6.87	0.00	1.41	0.60	5.48	0.020	0.00	0.00	-68.56	6.40	114.60	0.000				
UG45	26.18	0.00	-17.92	2.78	0.28	0.596	0.00	0.00	-5.46	0.60	82.84	0.000	98.08	0.00	29.52	6.40	21.24	0.000				
UG46	17.43	0.00	0.29	2.78	13.53	0.000	5.86	0.00	0.40	0.60	0.43	0.511	138.06	0.00	69.50	6.40	117.76	0.000				
UG47	10.82	0.00	59.72	2.78	36.68	0.000	17.67	0.00	12.21	0.60	413.21	0.000	59.09	0.00	-9.47	6.40	2.19	0.140				
UG48	36.32	0.00	-27.03	2.78	9.72	0.002	3.43	0.00	-2.03	0.60	11.49	0.001	164.28	0.00	95.72	6.40	223.37	0.000				
UG49	127.91	0.00	53.16	2.78	1300.87	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	291.49	0.00	222.93	6.40	1211.61	0.000				
UG50	9.74	0.00	-13.50	2.78	41.54	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	16.51	0.00	-52.05	6.40	66.05	0.000				
UG51	27.95	0.00	-18.00	2.78	0.01	0.916	0.00	0.00	-5.46	0.60	82.84	0.000	24.80	0.00	-43.76	6.40	46.69	0.000				
UG52	87.38	0.00	-21.98	2.78	461.67	0.000	0.86	0.00	-4.60	0.60	58.82	0.000	387.50	0.00	318.94	6.40	2479.95	0.000				
UG53	0.63	0.00	10.33	2.78	94.53	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	58.17	0.00	-10.39	6.40	2.63	0.105				
UG54	80.82	0.00	-19.80	2.78	365.83	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	118.39	0.00	49.83	6.40	60.53	0.000				
UG55	14.16	0.00	9.50	2.78	23.57	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	138.32	0.00	69.76	6.40	118.64	0.000				
UG56	9.66	0.00	26.55	2.78	41.91	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	46.21	0.00	-22.35	6.40	12.18	0.001				
UG57	5.68	0.00	-27.66	2.78	62.50	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	27.90	0.00	-40.66	6.40	40.31	0.000				
UG58	37.99	0.00	-27.66	2.78	13.82	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	67.88	0.00	-0.68	6.40	0.01	0.915				
UG59	7.86	0.00	-15.09	2.78	50.72	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000				
UG60	37.16	0.00	-10.84	2.78	11.69	0.001	0.00	0.00	-5.46	0.60	82.84	0.000	174.78	0.00	106.22	6.40	275.07	0.000				
UG61	54.21	0.00	71.07	2.78	91.27	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	3.89	0.00	-64.67	6.40	101.96	0.000				
UG62	0.00	0.00	-23.07	2.78	98.99	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000				
UG63	0.00	0.00	-5.94	2.78	98.99	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000				
UG64	12.57	0.00	-19.62	2.78	29.45	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	100.95	0.00	32.39	6.40	25.58	0.000				
UG65	16.82	0.00	-23.44	2.78	15.19	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	88.49	0.00	19.93	6.40	9.68	0.002				
UG66	98.73	0.00	-18.05	2.78	653.82	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	410.39	0.00	341.83	6.40	2848.70	0.000				
UG67	4.59	0.00	-27.43	2.78	68.85	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	15.27	0.00	-53.29	6.40	69.23	0.000				
UG68	21.72	0.00	-8.10	2.78	4.56	0.033	5.10	0.00	-0.36	0.60	0.37	0.544	15.48	0.00	-53.08	6.40	68.69	0.000				
Grandmean	**40.84**	**2.61**			**855.45**	**0.000**	**3.14**	**0.38**			**386.14**	**0.000**	**47.42**	**3.20**			**239.58**	**0.000**	**0.154**	**0.089**	**2.33**	**0.000**

Appendix 6 (Cont'd)

Accessions	LSER						VHIS						ASP						LLYS				
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	F	P
UG69	8.04	0.00	8.66	2.78	49.80	0.000	0.81	0.00	-4.65	0.60	60.10	0.000	91.64	0.00	23.08	6.40	12.99	0.000	0.00	0.00		1.22	0.000
UG70	4.22	0.00	-26.02	2.78	71.08	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	47.97	0.00	-20.59	6.40	10.34	0.001					
UG71	9.61	0.00	18.28	2.78	42.14	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	23.54	0.00	-45.02	6.40	49.41	0.000					
UG72	0.23	0.00	-4.12	2.78	97.35	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	6.60	0.00	-61.96	6.40	93.60	0.000					
UG73	19.56	0.00	-23.53	2.78	8.48	0.004	0.00	0.00	-5.46	0.60	82.84	0.000	98.57	0.00	30.01	6.40	21.96	0.000					
UG74	36.32	0.00	-27.66	2.78	9.72	0.002	3.43	0.00	-2.03	0.60	11.49	0.001	164.28	0.00	95.72	6.40	223.37	0.000					
UG75	1.64	0.00	-0.15	2.78	87.59	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG76	45.94	0.00	-18.76	2.78	43.27	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	173.54	0.00	104.98	6.40	268.68	0.000					
UG77	23.54	0.00	-9.31	2.78	2.19	0.140	0.00	0.00	-5.46	0.60	82.84	0.000	9.01	0.00	-59.55	6.40	86.46	0.000					
UG78	4.13	0.00	32.04	2.78	71.63	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	110.39	0.00	41.83	6.40	42.66	0.000					
UG79	0.00	0.00	8.57	2.78	98.99	0.000	2.52	0.00	-2.94	0.60	24.05	0.000	12.75	0.00	-55.81	6.40	75.94	0.000					
UG80	27.51	0.00	-25.62	2.78	0.00	0.958	3.20	0.00	-2.26	0.60	14.23	0.000	49.33	0.00	-19.23	6.40	9.02	0.003					
UG81	8.90	0.00	40.99	2.78	45.53	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	82.20	0.00	13.64	6.40	4.54	0.034					
UG82	18.35	0.00	14.93	2.78	11.21	0.001	18.79	0.00	13.33	0.60	492.52	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG83	59.70	0.00	-27.66	2.78	132.91	0.000	11.63	0.00	6.17	0.60	105.43	0.000	22.75	0.00	-45.81	6.40	51.16	0.000	28.910	0.000	28.642	81.45	0.000
UG84	36.23	0.00	-7.57	2.78	9.52	0.002	23.53	0.00	18.07	0.60	905.24	0.000	31.61	0.00	-36.95	6.40	33.29	0.000					
UG85	2.04	0.00	-12.80	2.78	84.92	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	3.41	0.00	-65.15	6.40	103.48	0.000					
UG86	68.65	0.00	-27.66	2.78	217.51	0.000	31.31	0.00	25.85	0.60	1852.85	0.000	6.92	0.00	-61.64	6.40	92.63	0.000					
UG87	42.59	0.00	-10.51	2.78	28.87	0.000	24.48	0.00	19.02	0.60	1002.96	0.000	77.03	0.00	8.47	6.40	1.75	0.187					
UG88	0.00	0.00	-13.38	2.78	98.99	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	4.91	0.00	-63.65	6.40	98.77	0.000					
UG89	20.09	0.00	-25.18	2.78	7.41	0.007	11.02	0.00	5.56	0.60	85.60	0.000	25.92	0.00	-42.64	6.40	44.33	0.000					
UG90	14.86	0.00	-16.33	2.78	21.19	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG91	0.00	0.00	-21.61	2.78	98.99	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG92	17.15	0.00	-17.92	2.78	14.28	0.000	4.73	0.00	-0.73	0.60	1.50	0.222	110.26	0.00	41.70	6.40	42.39	0.000					
UG93	14.28	0.00	-27.66	2.78	23.15	0.000	17.87	0.00	12.41	0.60	426.86	0.000	125.90	0.00	57.34	6.40	80.16	0.000					
UG94	2.48	0.00	-8.99	2.78	82.03	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG95	11.33	0.00	-16.58	2.78	34.49	0.000	19.25	0.00	13.79	0.60	527.12	0.000	2.82	0.00	-65.74	6.40	105.36	0.000					
UG96	6.05	0.00	-25.02	2.78	60.41	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	60.91	0.00	-7.65	6.40	1.43	0.233					
UG97	9.74	0.00	-25.82	2.78	41.54	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	16.51	0.00	-52.05	6.40	66.05	0.000					
UG98	0.00	0.00	-24.63	2.78	98.99	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG99	18.67	0.00	2.80	2.78	10.45	0.001	4.11	0.00	-1.35	0.60	5.09	0.025	48.45	0.00	-20.11	6.40	9.86	0.002					
UG100	11.08	0.00	-72.52	31.16	35.56	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	49.90	0.00	-18.66	6.40	8.49	0.004					
UG101	2.64	0.00	14.93	31.16	80.99	0.000	5.50	0.00	0.04	0.60	0.00	0.953	51.29	0.00	-17.27	6.40	7.27	0.007					
UG102	1.84	0.00	-226.88	31.16	86.25	0.000	12.16	0.00	6.70	0.60	124.34	0.000	0.43	0.00	-68.13	6.40	113.16	0.000					
UG103	3.03	0.00	-140.67	31.16	78.48	0.000	0.00	0.00	-5.46	0.60	82.84	0.000	0.00	0.00	-68.56	6.40	114.60	0.000					
UG104	30.46	0.00	21.46	31.16	1.02	0.314	0.00	0.00	-5.46	0.60	82.84	0.000	30.41	0.00	-38.15	6.40	35.48	0.000					
Grandmean	**40.84**	**2.61**			**855.45**	**0.000**	**3.14**	**0.38**			**386.14**	**0.000**	47.42	**3.20**			**239.58**	**0.000**	**0.154**	**0.089**		**482.33**	**0.000**

Appendix 6 (Cont'd)

Accessions	LMET						LASP						ISOLEU					
	Mean	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
Asontem	25.76	0.00	-75.19	2.50	906.63	0.000	0.00	0.00	-0.12	0.00	262070.58	0.000	0.85	0.00	-4.73	0.31	230.54	0.000
Kirkhouse	32.07	0.00	-68.88	2.50	760.84	0.000	0.00	0.00	-0.12	0.00	262070.58	0.000	2.98	0.00	-2.60	0.31	69.57	0.000
Padituya	52.29	0.00	-48.66	2.50	379.71	0.000	0.00	0.00	-0.12	0.00	262070.58	0.000	2.87	0.00	-2.71	0.31	75.59	0.000
Wang Kae	88.41	0.00	-12.54	2.50	25.22	0.000	0.00	0.00	-0.12	0.00	262070.58	0.000	0.43	0.00	-5.15	0.31	273.34	0.000
UG1	25.76	0.00	-75.19	10.53	50.96	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.85	0.00	-4.73	1.31	12.96	0.000
UG2	105.70	0.00	4.75	10.53	0.20	0.652	0.00	0.00	-0.12	0.00	14730.64	0.000	5.50	0.00	-0.08	1.31	0.00	0.954
UG3	142.49	0.00	41.54	10.53	15.55	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	2.01	0.00	-3.57	1.31	7.38	0.007
UG4	143.42	0.00	42.47	10.53	16.26	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	2.61	0.00	-2.97	1.31	5.10	0.024
UG5	135.25	0.00	34.30	10.53	10.60	0.001	0.00	0.00	-0.12	0.00	14730.64	0.000	3.16	0.00	-2.42	1.31	3.39	0.066
UG6	200.10	0.00	99.15	10.53	88.61	0.000	11.22	0.00	11.10	0.00	134000000.00	0.000	0.15	0.00	-5.43	1.31	17.08	0.000
UG7	25.54	0.00	-75.41	10.53	51.26	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.26	0.00	-5.32	1.31	16.40	0.000
UG8	101.89	0.00	0.94	10.53	0.01	0.929	0.00	0.00	-0.12	0.00	14730.64	0.000	0.09	0.00	-5.49	1.31	17.46	0.000
UG9	95.13	0.00	-5.82	10.53	0.31	0.581	0.00	0.00	-0.12	0.00	14730.64	0.000	1.13	0.00	-4.45	1.31	11.47	0.001
UG10	111.68	0.00	10.73	10.53	1.04	0.309	0.00	0.00	-0.12	0.00	14730.64	0.000	1.11	0.00	-4.47	1.31	11.57	0.001
UG11	158.02	0.00	57.07	10.53	29.36	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	1.29	0.00	-4.29	1.31	10.66	0.001
UG12	125.75	0.00	24.80	10.53	5.54	0.019	0.00	0.00	-0.12	0.00	14730.64	0.000	1.33	0.00	-4.25	1.31	10.46	0.001
UG13	20.85	0.00	-80.10	10.53	57.83	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.63	0.00	-4.95	1.31	14.19	0.000
UG14	192.61	0.00	91.66	10.53	75.73	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.78	0.00	2.20	1.31	2.82	0.094
UG15	82.87	0.00	-18.08	10.53	2.95	0.087	0.00	0.00	-0.12	0.00	14730.64	0.000	0.10	0.00	-5.48	1.31	17.40	0.000
UG16	81.70	0.00	-19.25	10.53	3.34	0.068	0.00	0.00	-0.12	0.00	14730.64	0.000	0.85	0.00	-4.73	1.31	12.96	0.000
UG17	278.38	117.68	177.43	10.53	283.76	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	57.46	19.92	51.88	1.31	1561.72	0.000
UG18	43.01	0.00	-57.94	10.53	30.26	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	17.62	0.00	12.04	1.31	84.15	0.000
UG19	225.20	108.12	124.25	10.53	139.16	0.000	0.01	0.01	-0.10	0.00	11277.86	0.000	0.07	0.00	-5.50	1.31	17.57	0.000
UG20	66.21	0.00	-34.74	10.53	10.88	0.001	0.00	0.00	-0.12	0.00	14730.64	0.000	0.49	0.00	-5.09	1.31	15.01	0.000
UG21	78.81	0.00	-22.14	10.53	4.42	0.036	0.00	0.00	-0.12	0.00	14730.64	0.000	1.94	0.00	-3.64	1.31	7.67	0.006
UG22	148.40	0.00	47.45	10.53	20.29	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.83	0.00	2.25	1.31	2.95	0.087
UG23	105.70	0.00	4.75	10.53	0.20	0.652	0.00	0.00	-0.12	0.00	14730.64	0.000	5.50	0.00	-0.08	1.31	0.00	0.954
UG24	305.63	0.00	204.68	10.53	377.62	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	2.14	0.00	-3.44	1.31	6.85	0.009
UG25	216.67	0.00	115.72	10.53	120.70	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	10.57	0.00	4.99	1.31	14.47	0.000
UG26	114.23	0.00	13.28	10.53	1.59	0.208	0.00	0.00	-0.12	0.00	14730.64	0.000	0.64	0.00	-4.94	1.31	14.14	0.000
UG27	87.65	0.00	-13.30	10.53	1.59	0.207	0.00	0.00	-0.12	0.00	14730.64	0.000	6.53	0.00	0.95	1.31	0.53	0.468
UG28	0.00	0.00	-100.95	10.53	91.86	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.18	0.00	-5.40	1.31	16.89	0.000
UG29	105.70	0.00	4.75	10.53	0.20	0.652	0.00	0.00	-0.12	0.00	14730.64	0.000	5.50	0.00	-0.08	1.31	0.00	0.954
UG30	85.81	0.00	-15.14	10.53	2.07	0.151	0.00	0.00	-0.12	0.00	14730.64	0.000	0.21	0.00	-5.37	1.31	16.71	0.000
Grandmean	**79.11**	**2.50**			**50.96**	**0.000**	**0.07**	**0.03**			**1270000.00**	**0.000**	**3.96**	**0.33**			**59.33**	**0.000**

Appendix 6 (Cont'd)

Accessions	LMET Mean	sem	con	sec	F	P	LASP Mean	sem	con	sec	F	P	ISOLEU Mean	sem	con	sec	F	P
UG31	85.81	0.00	-15.14	10.53	2.07	0.151	0.00	0.00	-0.12	0.00	14730.64	0.000	0.21	0.00	-5.37	1.31	16.71	0.000
UG32	48.72	0.00	-52.23	10.53	24.59	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	25.43	0.00	19.85	1.31	228.68	0.000
UG33	36.65	0.00	-64.30	10.53	37.27	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.88	0.00	2.30	1.31	3.08	0.080
UG34	196.73	0.00	95.78	10.53	82.69	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.77	0.00	-4.81	1.31	13.40	0.000
UG35	69.45	0.00	-31.50	10.53	8.94	0.003	0.00	0.00	-0.12	0.00	14730.64	0.000	0.18	0.00	-5.40	1.31	16.89	0.000
UG36	108.73	0.00	7.78	10.53	0.55	0.461	0.00	0.00	-0.12	0.00	14730.64	0.000	8.62	0.00	3.04	1.31	5.38	0.021
UG37	305.63	0.00	204.68	10.53	377.62	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	2.14	0.00	-3.44	1.31	6.85	0.009
UG38	32.54	0.00	-68.41	10.53	42.18	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.46	0.00	-5.12	1.31	15.19	0.000
UG39	110.39	0.00	9.44	10.53	0.80	0.371	0.00	0.00	-0.12	0.00	14730.64	0.000	1.43	0.00	-4.15	1.31	9.97	0.002
UG40	57.45	0.00	-43.50	10.53	17.06	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	13.35	0.00	7.77	1.31	35.06	0.000
UG41	159.84	0.00	58.89	10.53	31.26	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.16	0.00	1.58	1.31	1.46	0.228
UG42	101.89	0.00	0.94	10.53	0.01	0.929	0.00	0.00	-0.12	0.00	14730.64	0.000	0.09	0.00	-5.49	1.31	17.46	0.000
UG43	32.07	0.00	-68.88	10.53	42.77	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	2.98	0.00	-2.60	1.31	3.91	0.049
UG44	82.59	0.00	-18.36	10.53	3.04	0.082	0.00	0.00	-0.12	0.00	14730.64	0.000	0.04	0.00	-5.54	1.31	17.78	0.000
UG45	110.39	0.00	9.44	10.53	0.80	0.371	0.00	0.00	-0.12	0.00	14730.64	0.000	1.43	0.00	-4.15	1.31	9.97	0.002
UG46	130.88	0.00	29.93	10.53	8.07	0.005	0.17	0.00	0.05	0.00	3149.89	0.000	10.38	0.00	4.80	1.31	13.39	0.000
UG47	118.33	0.00	17.38	10.53	2.72	0.100	0.00	0.00	-0.12	0.00	14730.64	0.000	0.56	0.00	-5.02	1.31	14.60	0.000
UG48	104.54	0.00	3.59	10.53	0.12	0.733	0.00	0.00	-0.12	0.00	14730.64	0.000	13.21	0.00	7.63	1.31	33.81	0.000
UG49	333.32	0.00	232.37	10.53	486.71	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.07	0.00	-5.51	1.31	17.59	0.000
UG50	144.77	0.00	43.82	10.53	17.31	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	13.58	0.00	8.00	1.31	37.17	0.000
UG51	8.22	0.00	-92.73	10.53	77.51	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.03	0.00	-5.55	1.31	17.85	0.000
UG52	120.17	0.00	19.22	10.53	3.33	0.069	0.00	0.00	-0.12	0.00	14730.64	0.000	0.09	0.00	-5.49	1.31	17.46	0.000
UG53	81.70	0.00	-19.25	10.53	3.34	0.068	0.00	0.00	-0.12	0.00	14730.64	0.000	0.85	0.00	-4.73	1.31	12.96	0.000
UG54	116.78	0.00	15.83	10.53	2.26	0.134	0.00	0.00	-0.12	0.00	14730.64	0.000	0.18	0.00	-5.40	1.31	16.89	0.000
UG55	159.84	0.00	58.89	10.53	31.26	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.16	0.00	1.58	1.31	1.46	0.228
UG56	125.54	0.00	24.59	10.53	5.45	0.020	0.00	0.00	-0.12	0.00	14730.64	0.000	0.67	0.00	-4.91	1.31	13.96	0.000
UG57	83.19	0.00	-17.76	10.53	2.84	0.092	0.00	0.00	-0.12	0.00	14730.64	0.000	0.12	0.00	-5.46	1.31	17.27	0.000
UG58	122.76	0.00	21.81	10.53	4.29	0.039	0.00	0.00	-0.12	0.00	14730.64	0.000	0.12	0.00	-5.46	1.31	17.27	0.000
UG59	83.96	0.00	-16.99	10.53	2.60	0.107	0.00	0.00	-0.12	0.00	14730.64	0.000	0.10	0.00	-5.48	1.31	17.40	0.000
UG60	95.02	0.00	-5.93	10.53	0.32	0.574	0.00	0.00	-0.12	0.00	14730.64	0.000	0.10	0.00	-5.48	1.31	17.40	0.000
UG61	90.36	0.00	-10.59	10.53	1.01	0.315	0.00	0.00	-0.12	0.00	14730.64	0.000	2.61	0.00	-2.97	1.31	5.10	0.024
UG62	73.73	0.00	-27.22	10.53	6.68	0.010	0.00	0.00	-0.12	0.00	14730.64	0.000	5.69	0.00	0.11	1.31	0.01	0.931
UG63	65.22	0.00	-35.73	10.53	11.51	0.001	0.00	0.00	-0.12	0.00	14730.64	0.000	0.07	0.00	-5.51	1.31	17.59	0.000
UG64	130.30	0.00	29.35	10.53	7.76	0.006	0.00	0.00	-0.12	0.00	14730.64	0.000	3.51	0.00	-2.07	1.31	2.48	0.116
UG65	90.82	0.00	-10.13	10.53	0.93	0.337	0.00	0.00	-0.12	0.00	14730.64	0.000	0.09	0.00	-5.49	1.31	17.46	0.000
UG66	134.97	0.00	34.02	10.53	10.43	0.001	0.00	0.00	-0.12	0.00	14730.64	0.000	0.96	0.00	-4.62	1.31	12.36	0.001
UG67	125.56	0.00	24.61	10.53	5.46	0.020	0.00	0.00	-0.12	0.00	14730.64	0.000	0.62	0.00	-4.96	1.31	14.25	0.000
UG68	178.91	0.00	77.96	10.53	54.78	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	1.02	0.00	-4.56	1.31	12.04	0.001
Grandmean	**79.11**	**2.50**			**50.96**	**0.000**	**0.07**	**0.03**			**1270000.00**	**0.000**	**3.96**	**0.33**			**59.33**	**0.000**

Appendix 6 (Cont'd)

Accessions	LMET						LASP						ISOLEU					
	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P	Mean	sem	con	sec	F	P
UG69	132.03	0.00	31.08	10.53	8.71	0.003	0.00	0.00	-0.12	0.00	14730.64	0.000	0.77	0.00	-4.81	1.31	13.40	0.000
UG70	140.76	0.00	39.81	10.53	14.29	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	12.78	0.00	7.20	1.31	30.11	0.000
UG71	102.12	0.00	1.17	10.53	0.01	0.912	0.00	0.00	-0.12	0.00	14730.64	0.000	3.39	0.00	-2.19	1.31	2.77	0.097
UG72	78.81	0.00	-22.14	10.53	4.42	0.036	0.00	0.00	-0.12	0.00	14730.64	0.000	1.94	0.00	-3.64	1.31	7.67	0.006
UG73	135.00	0.00	34.05	10.53	10.45	0.001	0.00	0.00	-0.12	0.00	14730.64	0.000	0.11	0.00	-5.47	1.31	17.33	0.000
UG74	104.54	0.00	3.59	10.53	0.12	0.733	0.00	0.00	-0.12	0.00	14730.64	0.000	13.21	0.00	7.63	1.31	33.81	0.000
UG75	81.72	0.00	-19.23	10.53	3.33	0.069	0.00	0.00	-0.12	0.00	14730.64	0.000	0.04	0.00	-5.54	1.31	17.78	0.000
UG76	112.47	0.00	11.52	10.53	1.20	0.275	0.00	0.00	-0.12	0.00	14730.64	0.000	0.62	0.00	-4.96	1.31	14.25	0.000
UG77	122.38	0.00	21.43	10.53	4.14	0.043	0.00	0.00	-0.12	0.00	14730.64	0.000	4.69	0.00	-0.89	1.31	0.46	0.500
UG78	108.73	0.00	7.78	10.53	0.55	0.461	0.00	0.00	-0.12	0.00	14730.64	0.000	8.62	0.00	3.04	1.31	5.38	0.021
UG79	101.82	0.00	0.87	10.53	0.01	0.934	0.00	0.00	-0.12	0.00	14730.64	0.000	0.66	0.00	-4.92	1.31	14.02	0.000
UG80	194.07	0.00	93.12	10.53	78.16	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.60	0.00	2.02	1.31	2.38	0.124
UG81	133.19	0.00	32.24	10.53	9.37	0.002	0.00	0.00	-0.12	0.00	14730.64	0.000	12.02	0.00	6.44	1.31	24.09	0.000
UG82	103.98	0.00	3.03	10.53	0.08	0.774	0.00	0.00	-0.12	0.00	14730.64	0.000	26.17	0.00	20.59	1.31	246.05	0.000
UG83	185.49	0.00	84.54	10.53	64.42	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	48.74	0.00	43.16	1.31	1080.89	0.000
UG84	48.72	0.00	-52.23	10.53	24.59	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	25.43	0.00	19.85	1.31	228.68	0.000
UG85	36.65	0.00	-64.30	10.53	37.27	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	7.88	0.00	2.30	1.31	3.08	0.080
UG86	58.78	0.00	-42.17	10.53	16.03	0.000	0.76	0.00	0.64	0.00	451760.63	0.000	5.46	0.00	-0.12	1.31	0.01	0.930
UG87	56.92	0.00	-44.03	10.53	17.47	0.000	0.38	0.00	0.26	0.00	75834.57	0.000	49.60	0.00	44.02	1.31	1124.39	0.000
UG88	26.06	0.00	-74.89	10.53	50.55	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.97	0.00	-4.61	1.31	12.31	0.001
UG89	68.84	0.00	-32.11	10.53	9.29	0.002	0.00	0.00	-0.12	0.00	14730.64	0.000	17.15	0.00	11.57	1.31	77.71	0.000
UG90	25.70	0.00	-75.25	10.53	51.04	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	3.90	0.00	-1.68	1.31	1.63	0.202
UG91	16.53	0.00	-84.42	10.53	64.24	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.82	0.00	-4.76	1.31	13.12	0.000
UG92	63.91	0.00	-37.04	10.53	12.37	0.001	0.00	0.00	-0.12	0.00	14730.64	0.000	1.16	0.00	-4.42	1.31	11.31	0.001
UG93	93.65	0.00	-7.30	10.53	0.48	0.489	0.01	0.00	-0.11	0.00	12305.25	0.000	4.80	0.00	-0.78	1.31	0.35	0.555
UG94	28.88	0.00	-72.07	10.53	46.82	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.42	0.00	-5.16	1.31	15.42	0.000
UG95	7.29	0.00	-93.66	10.53	79.07	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	17.05	0.00	11.47	1.31	76.38	0.000
UG96	87.65	0.00	-13.30	10.53	1.59	0.207	0.00	0.00	-0.12	0.00	14730.64	0.000	6.53	0.00	0.95	1.31	0.53	0.468
UG97	144.77	0.00	43.82	10.53	17.31	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	13.58	0.00	8.00	1.31	37.17	0.000
UG98	39.12	0.00	-61.83	10.53	34.46	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	1.21	0.00	-4.37	1.31	11.06	0.001
UG99	22.17	0.00	-78.78	10.53	55.94	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.66	0.00	-4.92	1.31	14.02	0.000
UG100	12.02	0.00	-88.93	10.53	71.29	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.21	0.00	-5.37	1.31	16.71	0.000
UG101	36.36	0.00	-64.59	10.53	37.60	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	15.18	0.00	9.60	1.31	53.51	0.000
UG102	90.32	0.00	-10.63	10.53	1.02	0.313	0.00	0.00	-0.12	0.00	14730.64	0.000	0.14	0.00	-5.44	1.31	17.14	0.000
UG103	8.96	0.00	-91.99	10.53	76.28	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	1.24	0.00	-4.34	1.31	10.91	0.001
UG104	25.76	0.00	-75.19	10.53	50.96	0.000	0.00	0.00	-0.12	0.00	14730.64	0.000	0.85	0.00	-4.73	1.31	12.96	0.000
Grandmean	**79.11**	**2.50**			**50.96**	**0.000**	**0.07**	**0.03**			**1270000.00**	**0.000**	**3.96**	**0.33**			**59.33**	**0.000**

Appendix 6 (Cont'd)

Accessions	LLEU Mean	sem	con	sec	F	P	ITRY Mean	sem	con	sec	F	P	DLBPHE Mean	sem	con	sec	F	P	LTRY Mean	sem	con	sec	F	P
Asontem	0.00	0.00	-1.82	0.00	6600000.00	0.000	15.26	0.00	21.46	7.39	8.44	0.004	0.00	17.13	191.91	-13.76	0.99	0.000	356.13	0.00	21.46	7.39	8.44	0.004
Kirkhouse	0.00	0.00	-1.82	0.00	6600000.00	0.000	12.10	0.00	-225.23	7.39	929.32	0.000	0.00	23.99	48.28	-6.90	0.99	0.000	109.44	0.00	-225.23	7.39	929.32	0.000
Padituya	25.80	0.00	23.98	0.00	1150000000.00	0.000	34.15	0.00	-45.61	7.39	38.11	0.000	0.00	56.66	672.60	25.77	0.99	0.000	289.06	0.00	-45.61	7.39	38.11	0.000
Wang Kae	0.00	0.00	-1.82	0.00	6600000.00	0.000	14.53	0.00	841.22	7.39	12963.62	0.000	0.00	37.40	42.89	6.51	0.99	0.000	1175.89	0.00	841.22	7.39	12963.62	0.000
UG1	0.00	0.00	-1.82	0.00	371124.37	0.000	15.26	0.00	21.46	31.16	0.47	0.491	0.00	17.13	10.79	-13.76	4.19	0.001	356.13	0.00	21.46	31.16	0.47	0.491
UG2	0.00	0.00	-1.82	0.00	371124.37	0.000	13.92	0.00	142.58	31.16	20.93	0.000	0.00	41.84	6.82	10.95	4.19	0.009	477.25	0.00	142.58	31.16	20.93	0.000
UG3	0.00	0.00	-1.82	0.00	371124.37	0.000	17.73	0.00	95.49	31.16	9.39	0.002	0.00	45.71	12.50	14.82	4.19	0.000	430.16	0.00	95.49	31.16	9.39	0.002
UG4	0.00	0.00	-1.82	0.00	371124.37	0.000	18.11	0.00	398.75	31.16	163.72	0.000	0.00	45.48	12.12	14.59	4.19	0.001	733.42	0.00	398.75	31.16	163.72	0.000
UG5	0.00	0.00	-1.82	0.00	371124.37	0.000	16.00	0.00	96.28	31.16	9.54	0.002	0.00	33.64	0.43	2.75	4.19	0.513	430.95	0.00	96.28	31.16	9.54	0.002
UG6	0.00	0.00	-1.82	0.00	371124.37	0.000	14.47	0.00	51.22	31.16	2.70	0.101	0.00	35.15	1.03	4.26	4.19	0.310	385.89	0.00	51.22	31.16	2.70	0.101
UG7	0.00	0.00	-1.82	0.00	371124.37	0.000	15.33	0.00	-62.45	31.16	4.02	0.046	0.00	24.97	2.00	-5.92	4.19	0.158	272.22	0.00	-62.45	31.16	4.02	0.046
UG8	0.00	0.00	-1.82	0.00	371124.37	0.000	13.25	0.00	481.43	31.16	238.66	0.000	0.00	9.28	26.60	-21.61	4.19	0.000	816.10	0.00	481.43	31.16	238.66	0.000
UG9	0.00	0.00	-1.82	0.00	371124.37	0.000	11.81	0.00	15.96	31.16	0.26	0.609	0.00	11.83	20.69	-19.06	4.19	0.000	350.63	0.00	15.96	31.16	0.26	0.609
UG10	0.00	0.00	-1.82	0.00	371124.37	0.000	12.76	0.00	200.16	31.16	41.25	0.000	0.00	39.56	4.28	8.67	4.19	0.039	534.83	0.00	200.16	31.16	41.25	0.000
UG11	0.00	0.00	-1.82	0.00	371124.37	0.000	14.02	0.00	152.01	31.16	23.79	0.000	0.00	14.42	15.45	-16.47	4.19	0.000	486.68	0.00	152.01	31.16	23.79	0.000
UG12	0.00	0.00	-1.82	0.00	371124.37	0.000	14.38	0.00	-225.82	31.16	52.51	0.000	0.00	11.91	20.52	-18.98	4.19	0.000	108.85	0.00	-225.82	31.16	52.51	0.000
UG13	0.00	0.00	-1.82	0.00	371124.37	0.000	12.18	0.00	-128.35	31.16	16.96	0.000	0.00	10.54	23.59	-20.35	4.19	0.000	206.32	0.00	-128.35	31.16	16.96	0.000
UG14	0.00	0.00	-1.82	0.00	371124.37	0.000	11.53	0.00	493.32	31.16	250.59	0.000	0.00	71.40	93.43	40.51	4.19	0.000	827.99	0.00	493.32	31.16	250.59	0.000
UG15	0.00	0.00	-1.82	0.00	371124.37	0.000	13.21	0.00	-155.24	31.16	24.82	0.000	0.00	34.87	0.90	3.98	4.19	0.343	179.43	0.00	-155.24	31.16	24.82	0.000
UG16	0.00	0.00	-1.82	0.00	371124.37	0.000	14.71	0.00	-235.01	31.16	56.87	0.000	0.00	11.67	21.04	-19.22	4.19	0.000	99.66	0.00	-235.01	31.16	56.87	0.000
UG17	0.00	0.00	-1.82	0.00	371124.37	0.000	23.36	0.99	686.16	31.16	484.80	0.000	0.99	153.15	851.12	122.26	4.19	0.000	1020.83	472.61	686.16	31.16	484.80	0.000
UG18	0.00	0.00	-1.82	0.00	371124.37	0.000	25.34	0.00	-259.06	31.16	69.11	0.000	0.00	25.99	1.37	-4.90	4.19	0.243	75.61	0.00	-259.06	31.16	69.11	0.000
UG19	0.05	0.05	-1.77	0.00	352868.33	0.000	7.79	3.78	-230.35	31.16	54.64	0.000	3.78	1.12	50.46	-29.77	4.19	0.000	104.32	14.35	-230.35	31.16	54.64	0.000
UG20	0.00	0.00	-1.82	0.00	371124.37	0.000	12.49	0.00	-83.85	31.16	7.24	0.007	0.00	6.92	32.73	-23.97	4.19	0.000	250.82	0.00	-83.85	31.16	7.24	0.007
UG21	0.00	0.00	-1.82	0.00	371124.37	0.000	11.97	0.00	-66.07	31.16	4.50	0.035	0.00	24.06	2.66	-6.83	4.19	0.104	268.60	0.00	-66.07	31.16	4.50	0.035
UG22	0.00	0.00	-1.82	0.00	371124.37	0.000	16.27	0.00	-4.53	31.16	0.02	0.885	0.00	40.08	4.81	9.19	4.19	0.029	330.14	0.00	-4.53	31.16	0.02	0.885
UG23	0.00	0.00	-1.82	0.00	371124.37	0.000	13.92	0.00	142.58	31.16	20.93	0.000	0.00	41.84	6.82	10.95	4.19	0.009	477.25	0.00	142.58	31.16	20.93	0.000
UG24	0.00	0.00	-1.82	0.00	371124.37	0.000	36.17	0.00	821.90	31.16	695.58	0.000	0.00	82.42	151.18	51.53	4.19	0.000	1156.57	0.00	821.90	31.16	695.58	0.000
UG25	0.00	0.00	-1.82	0.00	371124.37	0.000	16.61	0.00	-271.79	31.16	76.06	0.000	0.00	29.34	0.14	-1.55	4.19	0.711	62.88	0.00	-271.79	31.16	76.06	0.000
UG26	0.00	0.00	-1.82	0.00	371124.37	0.000	11.54	0.00	-86.15	31.16	7.64	0.006	0.00	25.12	1.90	-5.77	4.19	0.169	248.52	0.00	-86.15	31.16	7.64	0.006
UG27	0.00	0.00	-1.82	0.00	371124.37	0.000	20.44	0.00	-187.27	31.16	36.11	0.000	0.00	29.18	0.17	-1.71	4.19	0.683	147.40	0.00	-187.27	31.16	36.11	0.000
UG28	0.00	0.00	-1.82	0.00	371124.37	0.000	0.00	0.00	18.45	31.16	0.35	0.554	0.00	20.80	5.80	-10.09	4.19	0.016	353.12	0.00	18.45	31.16	0.35	0.554
UG29	0.00	0.00	-1.82	0.00	371124.37	0.000	13.92	0.00	142.58	31.16	20.93	0.000	0.00	41.84	6.82	10.95	4.19	0.009	477.25	0.00	142.58	31.16	20.93	0.000
UG30	0.00	0.00	-1.82	0.00	371124.37	0.000	13.85	0.00	-99.24	31.16	10.14	0.002	0.00	29.20	0.16	-1.69	4.19	0.686	235.43	0.00	-99.24	31.16	10.14	0.002
UG31	0.00	0.00	-1.82	0.00	371124.37	0.000	13.85	0.00	-99.24	31.16	10.14	0.002	0.00	29.20	0.16	-1.69	4.19	0.686	235.43	0.00	-99.24	31.16	10.14	0.002
UG32	0.00	0.00	-1.82	0.00	371124.37	0.000	20.20	0.00	68.53	31.16	4.84	0.028	0.00	55.69	35.01	24.80	4.19	0.000	403.20	0.00	68.53	31.16	4.84	0.028
UG33	0.00	0.00	-1.82	0.00	371124.37	0.000	11.80	0.00	-26.77	31.16	0.74	0.391	0.00	31.78	0.04	0.89	4.19	0.833	307.90	0.00	-26.77	31.16	0.74	0.391
UG34	0.00	0.00	-1.82	0.00	371124.37	0.000	24.09	0.00	-265.82	31.16	72.76	0.000	0.00	25.13	1.89	-5.76	4.19	0.170	68.85	0.00	-265.82	31.16	72.76	0.000
UG35	0.00	0.00	-1.82	0.00	371124.37	0.000	12.60	0.00	-22.68	31.16	0.53	0.467	0.00	14.77	14.80	-16.12	4.19	0.000	311.99	0.00	-22.68	31.16	0.53	0.467
Grandmean	**3.79**	**0.48**			**25000000.00**	**0.000**	**17.60**	**0.32**			**201.61**	**0.000**	**0.32**	**32.13**	**35.92**			**0.000**	**397.63**	**14.29**			**201.61**	**0.000**

Appendix 6 (Cont'd)

	LLEU						ITRY						DLBPHF						LTRY					
Accessions	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG36	0.00	0.00	-1.82	0.00	371124.37	0.000	12.60	0.00	-22.68	31.16	0.53	0.467	0.00	14.77	14.80	-16.12	4.19	0.000	311.99	0.00	-22.68	31.16	0.53	0.467
UG37	0.00	0.00	-1.82	0.00	371124.37	0.000	36.17	0.00	821.90	31.16	695.58	0.000	0.00	82.42	151.18	51.53	4.19	0.000	1156.57	0.00	821.90	31.16	695.58	0.000
UG38	0.00	0.00	-1.82	0.00	371124.37	0.000	13.78	0.00	-150.23	31.16	23.24	0.000	0.00	50.70	22.34	19.81	4.19	0.000	184.44	0.00	-150.23	31.16	23.24	0.000
UG39	0.00	0.00	-1.82	0.00	371124.37	0.000	13.01	0.00	399.10	31.16	164.01	0.000	0.00	56.81	38.25	25.92	4.19	0.000	733.77	0.00	399.10	31.16	164.01	0.000
UG40	0.00	0.00	-1.82	0.00	371124.37	0.000	13.14	0.00	-185.38	31.16	35.39	0.000	0.00	25.95	1.39	-4.94	4.19	0.239	149.29	0.00	-185.38	31.16	35.39	0.000
UG41	0.00	0.00	-1.82	0.00	371124.37	0.000	15.03	0.00	132.23	31.16	18.00	0.000	0.00	19.66	7.19	-11.23	4.19	0.008	466.90	0.00	132.23	31.16	18.00	0.000
UG42	0.00	0.00	-1.82	0.00	371124.37	0.000	13.25	0.00	481.43	31.16	238.66	0.000	0.00	9.28	26.60	-21.61	4.19	0.000	816.10	0.00	481.43	31.16	238.66	0.000
UG43	0.00	0.00	-1.82	0.00	371124.37	0.000	12.10	0.00	-225.23	31.16	52.24	0.000	0.00	23.99	2.71	-6.90	4.19	0.100	109.44	0.00	-225.23	31.16	52.24	0.000
UG44	0.00	0.00	-1.82	0.00	371124.37	0.000	16.46	0.00	-155.31	31.16	24.84	0.000	0.00	30.10	0.04	-0.79	4.19	0.850	179.36	0.00	-155.31	31.16	24.84	0.000
UG45	0.00	0.00	-1.82	0.00	371124.37	0.000	13.01	0.00	399.10	31.16	164.01	0.000	0.00	56.81	38.25	25.92	4.19	0.000	733.77	0.00	399.10	31.16	164.01	0.000
UG46	0.00	0.00	-1.82	0.00	371124.37	0.000	15.85	0.00	-229.94	31.16	54.44	0.000	0.00	18.10	9.32	-12.79	4.19	0.002	104.73	0.00	-229.94	31.16	54.44	0.000
UG47	0.00	0.00	-1.82	0.00	371124.37	0.000	13.72	0.00	-175.93	31.16	31.87	0.000	0.00	18.72	8.44	-12.17	4.19	0.004	158.74	0.00	-175.93	31.16	31.87	0.000
UG48	0.00	0.00	-1.82	0.00	371124.37	0.000	16.70	0.00	-171.87	31.16	30.42	0.000	0.00	16.20	12.29	-14.69	4.19	0.001	162.80	0.00	-171.87	31.16	30.42	0.000
UG49	0.00	0.00	-1.82	0.00	371124.37	0.000	16.00	0.00	96.28	31.16	9.54	0.002	0.00	33.64	0.43	2.75	4.19	0.513	430.95	0.00	96.28	31.16	9.54	0.002
UG50	0.00	0.00	-1.82	0.00	371124.37	0.000	20.45	0.00	54.63	31.16	3.07	0.080	0.00	46.54	13.94	15.65	4.19	0.000	389.30	0.00	54.63	31.16	3.07	0.080
UG51	0.00	0.00	-1.82	0.00	371124.37	0.000	11.75	0.00	-233.01	31.16	55.91	0.000	0.00	5.55	36.57	-25.34	4.19	0.000	101.66	0.00	-233.01	31.16	55.91	0.000
UG52	0.00	0.00	-1.82	0.00	371124.37	0.000	11.58	0.00	-293.64	31.16	88.79	0.000	0.00	15.75	13.06	-15.14	4.19	0.000	41.03	0.00	-293.64	31.16	88.79	0.000
UG53	0.00	0.00	-1.82	0.00	371124.37	0.000	14.71	0.00	-235.01	31.16	56.87	0.000	0.00	11.67	21.04	-19.22	4.19	0.000	99.66	0.00	-235.01	31.16	56.87	0.000
UG54	0.00	0.00	-1.82	0.00	371124.37	0.000	15.03	0.00	-44.29	31.16	2.02	0.156	0.00	41.83	6.81	10.94	4.19	0.009	290.38	0.00	-44.29	31.16	2.02	0.156
UG55	0.00	0.00	-1.82	0.00	371124.37	0.000	15.03	0.00	132.23	31.16	18.00	0.000	0.00	19.66	7.19	-11.23	4.19	0.008	466.90	0.00	132.23	31.16	18.00	0.000
UG56	0.00	0.00	-1.82	0.00	371124.37	0.000	17.31	0.00	-286.36	31.16	84.44	0.000	0.00	26.49	1.10	-4.40	4.19	0.294	48.31	0.00	-286.36	31.16	84.44	0.000
UG57	0.00	0.00	-1.82	0.00	371124.37	0.000	11.63	0.00	-249.97	31.16	64.34	0.000	0.00	17.33	10.48	-13.56	4.19	0.001	84.70	0.00	-249.97	31.16	64.34	0.000
UG58	0.00	0.00	-1.82	0.00	371124.37	0.000	14.20	0.00	122.01	31.16	15.33	0.000	0.00	24.55	2.29	-6.34	4.19	0.131	456.68	0.00	122.01	31.16	15.33	0.000
UG59	0.00	0.00	-1.82	0.00	371124.37	0.000	12.86	0.00	-5.57	31.16	0.03	0.858	0.00	12.46	19.35	-18.43	4.19	0.000	329.10	0.00	-5.57	31.16	0.03	0.858
UG60	0.00	0.00	-1.82	0.00	371124.37	0.000	14.09	0.00	-254.73	31.16	66.82	0.000	0.00	15.91	12.78	-14.98	4.19	0.000	79.94	0.00	-254.73	31.16	66.82	0.000
UG61	0.00	0.00	-1.82	0.00	371124.37	0.000	13.96	0.00	-286.64	31.16	84.60	0.000	0.00	1.12	50.48	-29.77	4.19	0.000	48.03	0.00	-286.64	31.16	84.60	0.000
UG62	0.00	0.00	-1.82	0.00	371124.37	0.000	13.51	0.00	-99.04	31.16	10.10	0.002	0.00	9.81	25.31	-21.08	4.19	0.000	235.63	0.00	-99.04	31.16	10.10	0.002
UG63	0.00	0.00	-1.82	0.00	371124.37	0.000	11.64	0.00	360.44	31.16	133.77	0.000	0.00	35.90	1.43	5.01	4.19	0.233	695.11	0.00	360.44	31.16	133.77	0.000
UG64	0.00	0.00	-1.82	0.00	371124.37	0.000	16.76	0.00	-95.66	31.16	9.42	0.002	0.00	27.75	0.56	-3.14	4.19	0.454	239.01	0.00	-95.66	31.16	9.42	0.002
UG65	0.00	0.00	-1.82	0.00	371124.37	0.000	15.75	0.00	-26.70	31.16	0.73	0.392	0.00	21.38	5.15	-9.51	4.19	0.024	307.97	0.00	-26.70	31.16	0.73	0.392
UG66	0.00	0.00	-1.82	0.00	371124.37	0.000	16.51	0.00	-291.62	31.16	87.57	0.000	0.00	15.42	13.63	-15.47	4.19	0.000	43.05	0.00	-291.62	31.16	87.57	0.000
UG67	0.00	0.00	-1.82	0.00	371124.37	0.000	17.11	0.00	-56.48	31.16	3.28	0.071	0.00	26.28	1.21	-4.61	4.19	0.272	278.19	0.00	-56.48	31.16	3.28	0.071
UG68	0.00	0.00	-1.82	0.00	371124.37	0.000	19.97	0.00	-264.16	31.16	71.85	0.000	0.00	25.11	1.90	-5.78	4.19	0.168	70.51	0.00	-264.16	31.16	71.85	0.000
UG69	0.00	0.00	-1.82	0.00	371124.37	0.000	17.17	0.00	6.07	31.16	0.04	0.846	0.00	33.73	0.46	2.84	4.19	0.499	340.74	0.00	6.07	31.16	0.04	0.846
Grandmean	**3.79**	**0.48**			**25000000.00**	**0.000**	**17.60**	**0.32**			**201.61**	**0.000**	**0.32**	**32.13**	**35.92**			**0.000**	**397.63**	**14.29**			**201.61**	**0.000**

Appendix 6 (Cont'd)

	LLEU						ITRY						DLBPHE						LTRY					
Accessions	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**	**Mean**	**sem**	**con**	**sec**	**F**	**P**
UG70	0.00	0.00	-1.82	0.00	371124.37	0.000	12.27	0.00	-116.06	31.16	13.87	0.000	0.00	25.49	1.66	-5.40	4.19	0.198	218.61	0.00	-116.06	31.16	13.87	0.000
UG71	0.00	0.00	-1.82	0.00	371124.37	0.000	14.75	0.00	-247.05	31.16	62.85	0.000	0.00	27.19	0.78	-3.70	4.19	0.377	87.62	0.00	-247.05	31.16	62.85	0.000
UG72	0.00	0.00	-1.82	0.00	371124.37	0.000	11.97	0.00	-66.07	31.16	4.50	0.035	0.00	24.06	2.66	-6.83	4.19	0.104	268.60	0.00	-66.07	31.16	4.50	0.035
UG73	0.00	0.00	-1.82	0.00	371124.37	0.000	14.62	0.00	34.98	31.16	1.26	0.262	0.00	38.12	2.97	7.23	4.19	0.085	369.65	0.00	34.98	31.16	1.26	0.262
UG74	0.00	0.00	-1.82	0.00	371124.37	0.000	16.70	0.00	-171.87	31.16	30.42	0.000	0.00	16.20	12.29	-14.69	4.19	0.001	162.80	0.00	-171.87	31.16	30.42	0.000
UG75	0.00	0.00	-1.82	0.00	371124.37	0.000	12.79	0.00	-229.03	31.16	54.01	0.000	0.00	21.25	5.30	-9.64	4.19	0.022	105.64	0.00	-229.03	31.16	54.01	0.000
UG76	0.00	0.00	-1.82	0.00	371124.37	0.000	15.94	0.00	232.93	31.16	55.87	0.000	0.00	26.51	1.09	-4.38	4.19	0.296	567.60	0.00	232.93	31.16	55.87	0.000
UG77	0.00	0.00	-1.82	0.00	371124.37	0.000	16.09	0.00	-207.43	31.16	44.31	0.000	0.00	26.55	1.07	-4.34	4.19	0.301	127.24	0.00	-207.43	31.16	44.31	0.000
UG78	0.00	0.00	-1.82	0.00	371124.37	0.000	16.91	0.00	187.20	31.16	36.08	0.000	0.00	27.25	0.76	-3.64	4.19	0.385	521.87	0.00	187.20	31.16	36.08	0.000
UG79	0.00	0.00	-1.82	0.00	371124.37	0.000	13.68	0.00	88.21	31.16	8.01	0.005	0.00	7.44	31.32	-23.45	4.19	0.000	422.88	0.00	88.21	31.16	8.01	0.005
UG80	0.00	0.00	-1.82	0.00	371124.37	0.000	21.73	0.00	-89.80	31.16	8.30	0.004	0.00	70.09	87.49	39.20	4.19	0.000	244.87	0.00	-89.80	31.16	8.30	0.004
UG81	28.16	0.00	26.34	0.00	77800000.00	0.000	29.91	0.00	-97.86	31.16	9.86	0.002	0.00	46.77	14.35	15.88	4.19	0.000	236.81	0.00	-97.86	31.16	9.86	0.002
UG82	0.00	0.00	-1.82	0.00	371124.37	0.000	26.73	0.00	-156.76	31.16	25.30	0.000	0.00	36.52	1.80	5.63	4.19	0.180	177.91	0.00	-156.76	31.16	25.30	0.000
UG83	21.97	0.00	20.15	0.00	45600000.00	0.000	31.56	0.00	331.65	31.16	113.26	0.000	0.00	60.79	50.90	29.90	4.19	0.000	666.32	0.00	331.65	31.16	113.26	0.000
UG84	0.00	0.00	-1.82	0.00	371124.37	0.000	20.20	0.00	68.53	31.16	4.84	0.028	0.00	55.69	35.01	24.80	4.19	0.000	403.20	0.00	68.53	31.16	4.84	0.028
UG85	0.00	0.00	-1.82	0.00	371124.37	0.000	11.80	0.00	-26.77	31.16	0.74	0.391	0.00	31.78	0.04	0.89	4.19	0.833	307.90	0.00	-26.77	31.16	0.74	0.391
UG86	0.00	0.00	-1.82	0.00	371124.37	0.000	32.04	0.00	487.93	31.16	245.15	0.000	0.00	68.00	78.41	37.11	4.19	0.000	822.60	0.00	487.93	31.16	245.15	0.000
UG87	0.00	0.00	-1.82	0.00	371124.37	0.000	28.29	0.00	109.11	31.16	12.26	0.001	0.00	52.52	26.63	21.63	4.19	0.000	443.78	0.00	109.11	31.16	12.26	0.001
UG88	0.00	0.00	-1.82	0.00	371124.37	0.000	15.40	0.00	-168.06	31.16	29.08	0.000	0.00	13.90	16.44	-16.99	4.19	0.000	166.61	0.00	-168.06	31.16	29.08	0.000
UG89	13.87	0.00	12.05	0.00	16300000.00	0.000	21.52	0.00	-82.11	31.16	6.94	0.009	0.00	52.89	27.55	22.00	4.19	0.000	252.56	0.00	-82.11	31.16	6.94	0.009
UG90	0.00	0.00	-1.82	0.00	371124.37	0.000	14.49	0.00	-31.96	31.16	1.05	0.306	0.00	21.86	4.65	-9.03	4.19	0.032	302.71	0.00	-31.96	31.16	1.05	0.306
UG91	0.00	0.00	-1.82	0.00	371124.37	0.000	13.04	0.00	-242.13	31.16	60.37	0.000	0.00	16.39	11.98	-14.50	4.19	0.001	92.54	0.00	-242.13	31.16	60.37	0.000
UG92	0.00	0.00	-1.82	0.00	371124.37	0.000	22.97	0.00	-241.21	31.16	59.91	0.000	0.00	37.41	2.42	6.52	4.19	0.121	93.46	0.00	-241.21	31.16	59.91	0.000
UG93	106.58	0.00	104.76	0.00	1230000000.00	0.000	46.48	0.00	288.42	31.16	85.66	0.000	0.00	89.66	196.66	58.77	4.19	0.000	623.09	0.00	288.42	31.16	85.66	0.000
UG94	0.00	0.00	-1.82	0.00	371124.37	0.000	13.31	0.00	153.86	31.16	24.38	0.000	0.00	15.02	14.35	-15.87	4.19	0.000	488.53	0.00	153.86	31.16	24.38	0.000
UG95	0.00	0.00	-1.82	0.00	371124.37	0.000	14.19	0.00	38.72	31.16	1.54	0.215	0.00	15.62	13.28	-15.27	4.19	0.000	373.39	0.00	38.72	31.16	1.54	0.215
UG96	0.00	0.00	-1.82	0.00	371124.37	0.000	20.44	0.00	-187.27	31.16	36.11	0.000	0.00	29.18	0.17	-1.71	4.19	0.683	147.40	0.00	-187.27	31.16	36.11	0.000
UG97	0.00	0.00	-1.82	0.00	371124.37	0.000	20.45	0.00	54.63	31.16	3.07	0.080	0.00	46.54	13.94	15.65	4.19	0.000	389.30	0.00	54.63	31.16	3.07	0.080
UG98	0.00	0.00	-1.82	0.00	371124.37	0.000	15.59	0.00	-244.46	31.16	61.54	0.000	0.00	16.08	12.50	-14.81	4.19	0.000	90.21	0.00	-244.46	31.16	61.54	0.000
UG99	0.00	0.00	-1.82	0.00	371124.37	0.000	13.47	0.00	-143.42	31.16	21.18	0.000	0.00	18.21	9.16	-12.68	4.19	0.003	191.25	0.00	-143.42	31.16	21.18	0.000
UG100	0.00	0.00	-1.82	0.00	371124.37	0.000	12.95	0.00	-72.52	31.16	5.42	0.020	0.00	18.86	8.25	-12.03	4.19	0.004	262.15	0.00	-72.52	31.16	5.42	0.020
UG101	0.00	0.00	-1.82	0.00	371124.37	0.000	20.41	0.00	14.93	31.16	0.23	0.632	0.00	46.78	14.37	15.89	4.19	0.000	349.60	0.00	14.93	31.16	0.23	0.632
UG102	0.00	0.00	-1.82	0.00	371124.37	0.000	14.35	0.00	-226.88	31.16	53.00	0.000	0.00	15.78	13.01	-15.11	4.19	0.000	107.79	0.00	-226.88	31.16	53.00	0.000
UG103	0.00	0.00	-1.82	0.00	371124.37	0.000	13.40	0.00	-140.67	31.16	20.38	0.000	0.00	9.35	26.43	-21.54	4.19	0.000	194.00	0.00	-140.67	31.16	20.38	0.000
UG104	0.00	0.00	-1.82	0.00	371124.37	0.000	15.26	0.00	21.46	31.16	0.47	0.491	0.00	17.13	10.79	-13.76	4.19	0.001	356.13	0.00	21.46	31.16	0.47	0.491
Grandmean	**3.79**	**0.48**			**25000000.00**	**0.000**	**17.60**	**0.32**			**201.61**	**0.000**	**0.32**	**32.13**	**35.92**			**0.000**	**397.63**	**14.29**			**201.61**	**0.000**