"SEED VIABILITY PARAMETERS AND MATURITY INDICES IN GROUNDNUT (*Arachis hypogaea* L.) DURING KHARIF AND SUMMER"

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DECLARATION

This is to declare that the whole of the research work reported herein for the partial fulfillment of the requirement for the degree of Master of Science in Seed Science and Technology by the undersigned is the result of investigation done by me under the guidance and supervision of Dr. Sasidharan. N Associate Professor, Dept. of Agril. Botany , Anand Agricultural University, Anand and no part of work has been submitted for any other degree so far.

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ABSTRACT

The nature and extent of "Seed viability in groundnut (*Arachis hypogea* Linn.)" was studied in a set of fifty five genotypes of groundnut grown in Randomized complete block design with three replications at Department of Agril. Botany, B.A. College of Agriculture, AAU, Anand, during the *Kharif* and summer seasons of the year 2010. The observations were recorded on seventeen morphological and two biochemical characters *viz.*, germination count at 5^{th} day in field, germination count at 10^{th} day in field, plant height , primary branches, secondary branches, days to 50 % flowering**,** number of mature pods per plants, number of immature pods per plants, hundred seed weight, tightness of kernel in the hull shelling percent, sound mature kernel, harvest index, days of maturity, pod yield per plant , kernel yield per plant, shrivelled seed, protein content and oil content.

Abstract

The analysis of variance revealed significant differences among the genotypes for all the characters studied. This indicated the presence of sufficient variability in the experimental material. A wide range of phenotypic coefficient of variation was recorded for pod yield per plant and its components traits. Higher phenotypic and genotypic coefficient of variation were observed for days to pod yield per plant, plant hight, secondary branches per plant and shrivelled seed. In the present study magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as percentage of mean were found to be high for various characters. This indicated that additive gene action may be involved in the expression of these traits. Therefore, more emphasis should be laid on these component traits, during selection programme for further improvement of pod yield per plant.

High broad sense heritability estimates were recorded for most of traits *viz.*, hundred seed weight, secondary branches per plant, sound mature kernel, shelling percent and pod yield per plant indicating that these traits were less influenced by the environment. These traits can be improved by simple selection procedure. High genetic advance as percentage of mean was observed for pod yield per plant.

The seed viability studies indicated the effect of season and storage periods over the seed viability parameters. The genotypes behaved differently in different seasons and under different storage period. The summer groundnut seed lost the viability progressively under storage and

showed poor germination both in laboratory and field conditions. The groundnut seed stored for more than six months not only failed to germinate but developed fungal infection leading to total death. Bio-chemical parameters such as oil content and protein content also showed variation for season and storage conditions. Under storage both oil and protein showed marked reduction in their content. The variation were clearly observed in SDS PAGE analysis of protein and esterase isozymes.

Ten maturity indices based on pod and seed phenotypes applied to the fifty five genotypes under study revealed that phenotypic classes can be made which can characterise the genotypes for diversity analysis.

In the protein analysis total protein 769 bands were observed in fresh *Kharif* 2010 seed whereas 696 bands were observed in summer 2010. The PIC (Polymorphism Information Content) of both summer and *Kharif* 2010 seed was found to be 0.94. Esterase analysis showed 181 bands in the fresh *Kharif* 2010 seed while, 101 bands were recorded in summer 2010 seed. The lower PIC value observed in Kharif and summer seasons for esterase isozymes as compared to proteins indicated that genotypic characterisation using the latter may be more reliable than former.

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List of Abbreviations and Acronyms

%	Per cent
@	At the rate of
^{0}C	Degree Celsius
µg	Microgram
µl	Micro liter

AAU	Anand Agricultural University
Anon.	Anonymous
B.A.C.A	Bansilal Amritlal College of Agriculture
bp	Base pair
CD	Critical difference
cm	Centimeter
CV	Coefficient of variation
e.g	For example
et al.	*et allii* ; and coworkers
etc.	Etcetera
Fig.	Figure
g	Gram
GCV	Genotypic coefficient of variation
ha	Hectare
hrs	Hours
i.e.	That is
Kb	Kilo bases
M	Molar
mM	Millimolar
m^2	Meter square
max	Maximum
mg	Milligram
min	Minutes
ml	Milliliter
ng	Nanogram
nm	Nanometer
PCV	Phenotypic coefficient of variation
ppm	Parts per million
rpm	Revolutions per minute
S.Em	Standard Error of mean
Sr. No.	Serial Number
TBE	Tris Borate EDTA
viz.,	Namely
Vol.	Volume

I. INTRODUCTION

The Cultivated groundnut (*Arachis hypogaea* L.) is a self pollinated, annual, herbaceous legume growing upright and has indeterminate growth habits. Natural cross pollination occurs at the rate of 1-6 percent, due to typical flowers or action of bees. It is supposed to have originated in South America (Southern Bolivia/ North West Argentina region). The groundnut belongs to family *leguminosae,* sub-family *papilionoidae*, tribe *Aeshnomeneae*, sub-tribe *Styosanthinae*, genus *Arachis* and speces *hypogaea* . The genus name *Arachis* stems from a-rachis (Greek, meaning without spine) in reference to the absence of erect branch. The species name *hypogaea* stem from hupo-ge (Greek, meaning below the earth) and related to gynophore (flower stalk or peg) that grows down into the earth so that the pod develops underground.

The cultivated groundnut (*Arachis* hypogaea L.) can be divided broadly into two groups, i.e the 'bunch' and "spreading or semi-spreading" depending upon their branching pattern. The bunch groups consist of Spanish (sub.sp. *fastigiata* var. *vulgaris*) & Valencia (sub.sp. *fastigiat*a var. *fastigiata*) where as the spreading & semi- spreading groups consist of sub sp. Virginia bunch and Virginia runner respectively (Rao,1980). The bunch grows erect, possesses light green foliage, sequential branching and produce pods in clusters at the base of the plant. The seeds are non-dormant and roundish with light rose testa (deep rose or purple testa in Valencia). On the other hand Virginia group grows prostrate, spreading or semi-spreading, reproductive and vegetative branches alternating on the lateral branches with the main stem not bearing any inflorescence. The leaves are dark green in colour, the seeds are large showing dormancy. (Rao ,1980)

Introduction

Considerable variability exists in groundnut for morphological traits: seed size, (0.15 to more than 1.3 g seed^{-1}), seed color (white, light rose, rose, red purple, white blotched with purple red), number of seeds pod^{-1} (1-5), pod length (11-83 mm) and pod breadth (9-27) (Shorter & Simpson,1987).

Groundnut is an important oilseed crop. The oil content of kernels ranges between 40-50 % and is extensively used for cooking purposes. The groundnut oil is a rich source of vitamin A, B and E. Groundnut kernels are used in the roasted form for culinary purposes. Besides being an important source of vegetable oil, it is also used as an important source of food, feed, nutrition and fodder. Groundnut is also called as the "King" of oilseeds or "Wonder nut" and "Poor man's cashew nut". It contains on an average 40.1% fat, and 25.3% protein, which is about 1.3 times higher than meat, 2.5 times higher than eggs and 8 times higher than fruits.

Groundnut is commercially cultivated over 100 countries between latitude 40º N and 40º S. In Gujarat as per latest estimates, groundnut was sown in 16.7 lakh ha during *Kharif* 2010-11and the production recorded was about 20 to 22 lakh tones.

In India, edible oil consumption increased up to 6.0 million tonnes in 2010-11, which was about 14.71million tonnes in the previous year 2009-10. But edible oil import is also continued to increase and had reached to 92 lakh tonnes by the end of October, 2010. About 3.40 lakh tonnes of groundnut was exported in 2009-10 (Anon.2011). Although genetic potential of 25 to 30 q/ha

have been demonstrated for groundnut, the unit area production on national basis had remained constant at 8-9 q/ha for several years. And also the current average yield level of 1050 kg per hectare is deplorably low as compared to what is being obtained in most of the groundnut growing countries in the world.

Groundnut kernels are consumed as raw, boiled, roasted or fried and used in variety of culinary preparations like peanut butter, chocolate and *chikkis*. Groundnut is also used as animal feed and industrial raw material (oil cakes, fertilizer). Being a leguminous crop it also fixes atmospheric N which helps the following crop by improving soil fertility. Moreover, groundnut is relatively well adapted and produces higher yields under the low fertility and poor management conditions prevailing among small farmers. These multiple uses of groundnut make it an excellent cash crop for domestic markets as well as for foreign trade in several developing and developed countries.

Groundnut is cultivated as summer crop under assured irrigation in few states like Andhra Pradesh, Tamil Nadu, Gujarat, Maharashtra, Karnataka and Orissa. Unlike the South Indian states, in the states like Gujarat and Maharashtra where the winter months prevent early sowing of summer groundnut, the crop which is sown late towards the latter part of January or early February is invariably caught unawares in unseasonal rains experienced towards the crop maturity. Since the groundnut sown in these states belong to the Spanish bunch group lacking dormancy, it suffers from *insitu* germination

resulting in considerable yield loss. More over the crop harvested during the summer pass through a rainy season characterized by high humidity and less sun shine hours, preventing the produce to dry properly and tend to lose the viability progressively. Consequently, the seed from previous summer usually looses 50-60 percent viability over a period of six months and shows poor germination when sown again as a summer crop in the next season. However, none of the *Kharif* groundnut suffers from such drawbacks and retains its viability even when sown in the next *Kharif* season. Besides seed viability, another factor which influences the groundnut yield is seed maturity. Since the groundnut pods are formed sub-terranean, it is difficult to assess the optimum time for harvest. Therefore, identifying maturity indices, especially for short duration varieties is another prerogative for groundnut scientists. Keeping these facts in view, the present investigation was undertaken using 55 diverse Spanish bunch genotypes of groundnut with the following objectives:

1. To study the genetic variability for seed viability existing in groundnut.
2. To identify morphological, physiological and biochemical indices for seed maturity.
3. To study the variation in esterase isozyme banding patterns.
4. Protein profiling through SDS-PAGE.

II. REVIEW OF LITERATURE

The research experiment titled "Seed viability parameters and maturity indices in groundnut (*Arachis hypogaea L.*) during *Kharif* and Summer was conducted at the college farm, B.A. College of Agriculture, Anand Agricultural University , Anand during *Kharif* and Summer 2010. The review of literature available on various aspects included in this study is being discussed under different sub-heading as below.

2.1. SEED VIABILITY PARAMETERS

Nautiyal *et al.* (1990) studied 14 groundnut genotypes in *rabi,* summer and *kharif* seasons on viability and dormancy characters. They found loss of viability is more in *rabi /* summer produce, since within 4-5 months of storage, about 50% seeds loser viability. *Kharif* produce was found to retain viability for longer period than *Rabi /* summer produce.

Nautiyal and Zala (1991) studied different drying methods in six varieties of Spanish groundnut *viz.*, DOR (Directorate of Oilseed Research), shade and windrow methods. Results revealed that pods dried in the windrow lost viability rapidly while pods dried under DOR method maintained viability for long period.

Nautiyal and Ravindra (1996) studied the groundnut variety GG-2 during rabi and summer. The produce was dried using three different methods *viz.*, windrow, windrow-shade, and DOR methods and stored in polyethylene lined gunny bags with or without desiccant ($CaCl_2$ or silica gel, 10g kg^{-1} pods). He observed quick loss of viability in the windrow treatment and the retention of higher seed viability in the seeds dried by DOR method stored with $CaCl_2$.

Usberti and Gomes (1998) conducted research on seeds of the Brazilian cultivar Tatu (Valencia bunch type) at nine moisture levels (ranging from 2.4 to 12.8 %) and three storage temperature regimes (40, 50 and 65^0c). He obtained a reliable equation for groundnut seed longevity through the constants k_E=6.177, C_W=3.426, C_H=0.0304 and C_Q= 0.000453, where k_E is species constant, C_W is constant of logarithmic moisture term and indicate the response of seed longevity to moisture constant. C_H and C_Q are constant of linear and quadratic temperature term respectively and describe effect of storage temperature on seed longevity.

Sashtry *et al*. (2003) studied seed moisture content and storage facility for long term storage of groundnut. The results revealed that groundnut germplasm accessions stored at -18^0 c with the moisture content below 4% can also lose viability.

Basavegowda and Nanjareddy (2008) investigated prolonged seed viability of the groundnut cultivar KRG-1, grown during *rabi* or summer. Groundnut pods were stored using different packaging materials with or without desiccants. He observed that highest germination (72 %) was obtained in pod stored in polylined (300 gauge) gunny bag (PLGB) +silica gel (30g.kg-1 pod) and 63% germination was recorded in pods stored in simple gunny bag.

2.2. Morphological and Physiological maturity indices in groundnut.

Sanders *et al*. (1981) over viewed maturity methodologies and post harvest physiology of peanut. The maturity methodologies included indirect

methods (days after planting, heat units) and colour evaluation. He suggested that the physiological maturity can be studied using internal or external physiological & morphological characteristics of the hull, seed coat and seed.

Boote (1982) observed uniform stage descriptions developed for peanut, based on visually observable vegetative (V) and reproductive (R) events. They classified pods in different (R) stages, R1 (beginning bloom), R2 (beginning peg), R3 (beginning pod), R4 (full pod), R5 (beginning seed), R6 (full pod), R7 (beginning maturity), R8 (harvest maturity) and R9 (over mature pod). The stages were applicable to both *Spanish* and *Virginia* type cultivars.

Shorter and Simpson (1987) studied free arginine percentage of kernel, kernel: hull weight ratios, shell-out percentage, mean individual kernel weight and kernel moisture percentage during crop development to assess their usefulness as maturity indices. The decline in free arginine percentage and the increase in the kernel: hull weight ratio may be useful indicators of optimum maturity for Spanish-type cultivars.

Sheikh (1990) observed groundnut protein as an indicator of peanut seed maturity by examining protein profile. They harvested groundnut, 100 and 110 days after planting and pods were collected and classified in to various maturity categories by two methods. In the first method most mature seed was categorized as black while immature seed as white and in the second method the pods were split open and seeds were then classified into immature (I), low-intermediate (LI), intermediate A (IA), intermediate B (IB), color high-intermediate (HI), and mature (M) based on pericarp and testa.

Jayraj and Karivaratharaju (1992) determined seed viability and physiological maturity in different harvesting stages from four genotypes collected from TNAU, Coimbatore *viz.*, Co1, Co2, TMV12 and JL24. They observed that harvesting the seed before the attainment of physiological maturity recorded lesser viability and vigour potentials due to more number of immature seeds with relatively low degree of embryo development and high moisture content.

Borate *et al.* (1993) conducted an experiment on four different dates of sowing *viz.*. S1-1st February, S2- 1st March, S3- 1st April, and S4- 1st May and observed different sizes of seeds. Results indicated that number of one seeded, two seeded and three seeded mature pods/plant were maximum when the crop was raised from large seeded than those produced from small ungraded seeds.

Kakralya and Singh (1993) investigated five groundnut cultivars namely RS-1, MA-13, RSB-87, RG-141, under irrigated conditions for three years. They concluded that determination of proper stage from crop harvest is a key factor in quality seed production programme.

Singh and Oswalt. (1995) described the characters of three groundnut species *hypogaea* (Virginia), *fastigiata* (Valencia), and *vulgaris* (Spanish) for characters *viz.,* seeds pod, testa color, seed size, number of branches, seeds pod-1, pod constrictions and pod beak and classified groundnut species.

Patel *et al.* (1996) studied 12 varieties of peanut and classified them into three groups prominent *viz.,* slight and moderate depending up on the presence

or absence of pod beak and pod constriction. They classified 5 -prominent, 4-slight and 3 -moderate genotypes of groundnut.

Dey *et al.* (1999) studied the effect of three different drying procedures based on dry sound seed quality method and subdivided into three groups *viz.*, ELK(extra large kernels), SMK (sound maturity kernels) and SS (sound split kernels). Pods that possessed white inner pericarp, white seed coat and white hulls were classified as immature. They observed that only sound maturity kernels showed a higher germination (%) and better seedling growth under accelerated and ambient condition.

Ramadevi and Rao, (2005) observed the effect of seed size on physiological parameters and yield for several crops including groundnut. They conducted an experiment during *Rabi* 2002 on sandy clay loams with two groundnut cultivars (JL 24 and TPT 4) and five seed sizes (Bold, medium, small, shrivelled and ungraded seed). They concluded that pod yield was more in the plants from bold seed followed by medium sized seed while plants from shrivelled seed recorded less pod yield. Among the cultivars, JL 24 recorded higher pod yield (1671 kg/ha) compared to TPT 4 (1383 kg/ha). This might be due to higher number of pods per plant and seed index.

Rowland *et al.* (2006) attempted to assess and predict peanut seeds maturity under storage based on percentage of pods in each class of the maturing profile board. They harvested two rows sequentially in 2003 and 2004 on weekly basis and five plants were randomly collected. The plants were taken to the laboratory and approximately 150-200 pods were observed. The color

maturity board produced grouping of pods within individual color class columns.

Chunilal *et al.* (2007) studied 14 genotypes on different characters like maturity of a genotype assessed at the time of harvesting and was expressed in days. Per-day-productivity was estimated as a ratio of pod yield (kg ha-1) to time to maturity (TM) and expressed in kg day-1. Observations were also recorded on 100-seed weight (HSW), shelling outturn (SO) and sound mature seeds (SMS). From the results obtained in the present study, it is apparent that out of 14 advanced breeding lines evaluated at Junagadh, ICGV 96399 and ICGV 97245, recorded higher per-day-productivity and earliness in maturity over GG 2.

Ahmad and Rahim (2007) experimented on ten groundnut varieties (*viz.*. ICGS-147 , PG-759, PG-931, PI-3383, PG-4791, PG-951 , ICGV48448, PG-481, BARD-479, SP-96-check) during the year 2002-03 to find out the most suitable , well adapted, high and stable yielding variety for successful cultivation, considering characters *viz.,* days to maturity, plant height, pod length, 100-kernels weight, plant population and pod yield of groundnut varieties. They observed that varieties *viz.,* PG-479 and PI-338337 produced higher pod yield.

Sastry *et al.* (2007) conducted experiment on groundnut cultivar ICGS 11 for conservation of germplasm and seed storage facilities necessitating techniques that prolong seed longevity. He observed that initial seed viability of test samples is generally high and ranged between 98 and 100%. Upon storage,

there was a gradual loss in the germinability of seeds in all the treatments. Seeds stored at higher temperatures (50°C) and moisture content (10.1%) deteriorated faster compared to other treatments and complete loss of viability occurred within 10 days in both air- and vacuum-sealed conditions. However, seed survived up to 20 weeks when seed moisture content decreased from 10.1 to 3.4% under both conditions of storage at 50°C.

Promchote *et al.* (2008) examined seed viability and physiological maturity of two Thai cultivars *viz.,* Kaset-1 and Tainan-9. In nine maturity stages (5-13) physiological maturity of Kaset-1 was evident at stage 10 while in Tainan -9 it was attained at maturity stage-8. The seed viability of kaset-1 peanut reached a maximum 99 % at stage 8 while in Tainan -9, seed viability was higher than 95 % during stages 8 to 13.

Nautiyal *et al*. (2010) studied five genotypes (*viz.*, Kadiri-3, GAUG-10, ICGS-11, Girnar-1, and GG- 2.) Seeds lose their germinability more rapidly in seed lots harvested in summer season than those harvested in rainy season. They observed several physical, morphological and chemical characteristics of seed. Seeds before storage and after 12 months of storage were shelled and categorized based on the "shell-inside" color, i.e, over mature (OVM), optimally mature (OPM) immature (IMM), and a natural seed lot (NTL) was considered as control. They found that IMM seed percentage was higher in Virginia (15%) as compared to the Spanish types (10%). In addition, analysis of total sugars in seeds of different maturity stages showed that higher sugars in

IMM seeds may be responsible for imbibitional injury due to absorption of excessive water resulting in poor germination.

2.3. Biochemical indices: Oil content (%), protein content (%), esterase isozymes and protein profiling through SDS-PAGE:

Bianchi-Hall *et al*. (1994) conducted an investigation to assess diversity of protein profiles in peanuts for cultivar identification using SDS-PAGE and to determine the extent of variability of seed storage proteins (SSP) among samples of cultivars originating from different locations. The results of both studies indicated that it is possible to differentiate between subspecies but not to associate a particular profile with only one specific cultivar. Within subspecies, cultivars clustered in more than one group and most cultivars that grouped together were genetically related.

Galarao and Catalina Romero Lopes (1994) classified five different groundnut samples based on PAGE analysis of isozyme extracted from five different cultivar seeds. They showed fifteen bands.

Aung and Donald (1995) examined changes in esterase activity in un-imbibed and imbibed peanut seeds previously exposed to ambient storage conditions. They concluded that specific iso-esterases are prone to deterioration during ageing of peanut seeds and that other iso-esterases associated with germination are preferentially synthesized in deteriorated peanut seeds during imbibitions.

Hassanein (1999) studied response of salinity stress in peanut protein and esterase, and observed that maximum esterase activity in peanut cotyledon was detected one day after sowing. They also observed that esterase pattern did not change during seed germination.

Jain and Padamaja (2004) studied the induction of maturation protein in the germinating seed of groundnut by exogenous application of abscisic acid (ABA) and sodium chloride (NaCl). SDS-PAGE protein analysis revealed that protein of 65, 31 and 22 kda accumulated in abundance in embryos during late seed maturation. The expression of these proteins declined to undetectable level by fourth day during seed germination. The relative amounts of 65, 31 and 22kda proteins varied in the groundnut seed germinated in the presence of ABA and NaCl at different concentration. The results of SDS-PAGE analysis of seed protein revealed that 65, 31 and 22kda protein accumulated in abundance during final stage of the maturation in groundnut and declined during germination. Exogenous application of ABA or NaCl during germination resulted in the induction of maturation protein although the level varied depending on the concentration.

Valizadeh (2001) studied seed protein profiles of 47 accessions belonging to eleven species and four tribes of grain legumes by extracting the total proteins from ten single seeds in each accession and performing SDS-Polyacrylamide gel electrophoresis. They observed that all eleven species were clearly recognizable from their protein banding patterns, but only *Phaseolus vulgaris* expressed high intraspecific variations, followed by *Lathyrus sativus.*

Variation among accessions of other species was very limited. Finally the more distinct tribe Aeschynomeneae *(Arachis hypogaea* accessions) was observed as a separate cluster exhibiting a special banding pattern.

Yaw *et al.* (2008) studied twenty groundnut varieties belonging to *hypogaea* and *fastigiata* sub-species and observed days to 50 % flowering, days to maturity, pod yield, oil content and protein percentage. They found that days to 50% flowering differed from 26 to 29 days and days to maturity, 88 to 106 days. The mean oil content of Virginia types were slightly higher (49.7) than the Spanish types (43.7%).

Nautiyal and Kulkarni (2009) in a study involving two non-dormant groundnut cultivars, chico and GG-2 and three dormant cultivars *Viz.*, ICGS-76, ICGS-11 and GAUG-10, conducted SDS-PAGE analysis of protein obtained from the seeds of pre and post harvest stages of maturity. He concluded that several genes such as LEA are expressed during seed maturation and could play a role in acquisition of desiccation tolerance during maturation and drying.

Nkafamiya *et al.* (2010) examined the percentage oil yield and physicochemical properties of five different groundnut species, Valencia (Gargajiya), Virginia (Kampala Mubi and Michika) and Runner (Kwachamba brown and red) cultivated locally was determined. They observed that Gargajiya species yielded the highest amount of oil (37.80 ± 2.21%), closely followed by kampala michika (37.40 ± 3.20%) while kwachamba brown yielded the lowest percentage of oil (20.00 ± 2.06).

2.4 Genetic variability parameters:-

Genetic variability parameters such as Genotypic Co-efficient of Variation (GCV), Phenotypic Co-efficient of Variation(PCV), broad sense heritability (H^2) and genetic advance as percentage of mean (GA%) were assessed for 15 morphological characters. The literature available for these parameters is reviewed as under.

Kadam *et al*. (2007) computed variability, heritability and genetic advance using forty groundnut genotypes of different botanical groups. The GCV were high for kernel yield, pod yield, number of pods, number of branches, plant height and harvest index. High heritability coupled with high genetic advance was observed for pod yield and kernel yield.

Korat *et al*. (2009) evaluated eighty diverse genotypes of bunch groundnut in fourteen characters during summer for genetic parameters *viz.,* variability, heritability and genetic divergence. The estimates of PCV and GCV were high for number of secondary branches per plant and number of aerial pegs per plant. High heritability along with high genetic divergence as per cent of mean was observed for number of secondary branches per plant and number of aerial pegs per plant indicating that these traits are mainly governed by additive gene action and responsive to selection for further improvement of these traits.

III. MATERIALS AND METHODS

The proposed research work on "Seed viability parameters and maturity indices in groundnut *(Arachis hypogaea* L.) during *Kharif* & summer." was carried out at Department of Agril. Botany, B.A. College of Agriculture, AAU, Anand, during the *Kharif* and summer seasons of the year 2010. During this study, seed viability parameters morphological, physiological, and biochemical maturity indices for seed maturity and protein profiling through SDS-PAGE were attempted. Fifty five groundnut genotypes obtained from four research centers *viz.,* Directorate of Groundnut Research, Junagadh, Main Oil Seed Research Station, JAU, Junagadh, International Crops Research Institute for the Semi -Arid Tropics (ICRISAT), Patancheru (A.P) and Regional Research Station, AAU, Anand, were utilized for the present investigation. (Appen.3)

3.0. GENERAL INFORMATION

3.1. Location:

Anand Agricultural University, Anand, where the present investigations were undertaken is situated on 22˚- 35' north latitude and 72˚-55' east longitude and has an elevation of 45 meters above mean sea level.

3.2. Climate:

At Anand monsoon season is generally warm and moderately humid. It commences by the middle of June and ends in the middle of September. The average rainfall of the tract is about 762 mm. Monsoon in this area is often erratic and uncertain, both in respect of total rainfall and its distribution. Winter is fairly cool and dry, while the summer is quite hot.

3.3 Previous Crop:

The previous crop at the experimental site in *rabi* season was maize and in summer season the field was left fallow.

3.4. Cultural operations and after care:

3.4.1. Land preparation:

The land was brought to fine tilth with one deep ploughing and three harrowing.

The residues of the previous crop and weeds were removed from the experimental area.

3.4.2. Isolation Distance:

The experimental plots were isolated from groundnut fields by three meters to avoid contamination.

3.4.3. Fertilizer Application:

Nitrogen (N) and phosphorus (P) fertilizers were applied in the form of di-ammonium phosphate during summer (25 % N and 50 % P) and *Kharif* Season (12.5% N and 50% P) respectively. Entire quantity of recommended dose of fertilizers was applied in small furrows opened at definite row spacing with a marker. Fertilizers were applied and then covered with the soil.

3.4.4. Experimental design:

The field trail was laid out in RCBD (Randomized Complete Block Design) with three replications.

3.4.5. Seeds and sowing:

Shallow furrows were opened at five cm away from fertilizer rows and at 5 cm between the seeds and the seeds were hand dibbled in the furrows in 30 x 10 cm spacing.

3.4.6. After care:

The field observations involving the crops management, (interculturing, weeding, gap filling etc), irrigation and plant protection measures were done as per the recommendations for the crop as and when required.

3.4.7. Harvesting:

The crop was harvested at physiological maturity (105 days after sowing). Entire plants were uprooted from the net plot area of each treatment separately and spread in the field for drying. The pods were plucked from the plants. All dirt, soil impurities, and immature pods were removed and developed pods were completely sun dried for a period of one week. The pods were bagged to record seed yield and seed quality parameters.

3.5. Recording of observations:

The observations were recorded for seed viability parameters, morphological parameters, maturity indices and biochemical indices. All the field observations were based on five plants selected randomly for each genotype from each replication. Laboratory studies were conducted from sample drawn randomly from the seed lot of each genotype and each replication.

3.5.1. Seed viability Parameters:

3.5.1.1. Water imbibing capacity of seeds (mg/24 hrs).

The rate of imbibition was determined gravimetrically by weighing the individual seed at various time intervals (W1) during germination and also after drying them at 108°C to a constant weight (W2). The water absorbed (W1–W2) was calculated and expressed as g-1 seed (dry weight basis). (Nautiyal *et al*, 2010)

3.5.1.2. Germination count at 5^{th} & 10^{th} day (%).

The germination of 100 seeds was conducted as per ISTA rules (Anon, 1996) by adopting "between paper towels method" at 25 + 0.5°C and 80 per cent relative humidity. On 5th and 10th day, the number of normal seedlings were counted and expressed as germination percentage.

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

3.5.1.3. Shoot length after 10th day (cm).

On tenth day of germination test, ten randomly selected normal seedlings taken out carefully from each treatment and replication were measured from the tip of primary root to point of junction of the cotyledon. The average of ten seedlings was calculated and expressed as mean seedling length in centimetre

3.5.1.4. Root length after 10th day (cm).

Ten normal seedlings were randomly selected from each treatment and replication. The seedlings separated carefully from the paper towels used for laboratory germination were utilized for measuring the root length on 10th day. The root length was measured from collar region to the tip of the tap root with the help of a scale and average root length was computed and expressed in cm.

3.5.1.5. Root length and shoot length ratio at 10th day.

Five randomly selected seedling shoots and roots in each replication were used for recording root and shoot ratio at 10th day.

$$\text{Root shoot ratio} = \frac{\text{Mean length of five roots}}{\text{Mean length five shoots}}$$

3.5.1.6. Fresh Shoot and root weight (gm/seedling).

Ten random seedlings were selected and used for recording seedling fresh weight. (Evans and Bhatt, 1977).

3.5.1.7. Shoot and root dry weight (gm/seedling).

Ten randomly selected seedlings in each replication which were used for recording seedling length were also used for determining seedling dry weight. Seedlings were enveloped in butter paper bags sand dried in pre heated oven at 85°C temperature for 24 hours. After this, the paper bags were removed and cooled in desiccators for 30 minutes. Then the dry weight was recorded in milligrams and average was worked out and expressed as seedling dry weight in milligrams (Evans and Bhatt, 1977).

3.5.1.8. Seed vigour index.

Vigour index: Germinated seedlings were evaluated for vigour index (VI). The root and shoot length of germinated seedlings were measured and vigour index was calculated using the formula given by Girisha and Raju (2008).

$$VI = (MRL + MSL) \times PG$$

VI = Vigour index; MRL=Mean root length; MSL= Mean shoot length;

PG = Percentage germination.

3.5.1.9. Field emergence (%).

From each treatment randomly collected seeds were sown in three replications of 90 seeds each in a well prepared soil at 2.50 to 3.00 cm deep covered with soil. The single seed per hill was placed following 30 x 10 cm spacing. Irrigation was provided for the germination of the seeds. The number

of seedlings emerged in each row were counted on the 15th day and expressed in percentage.

$$\text{Field emergence (\%)} = \frac{\text{Number of seedling emergence at } 5^{th} \text{ and } 10^{th} \text{ days}}{\text{Total number of seeds sown}} \times 100$$

3.5.2. Morphology parameters:

3.5.2.1. Plant height (cm).

Height of the main axis from ground level to the apical leaflet was measured in cm and mean of ten random plants was recorded at maturity.

3.5.2.2. Number of primary branches.

Numbers of n+1branches borne on main axis were counted and mean of ten random plants was recorded.

3.5.2.3. Number of secondary branches.

Numbers of n+2 branches borne on main axis were counted and mean of ten random plants was recorded.

3.5.2.4. Days to 50 % flowering.

The days taken to 50 per cent flowering of the plants in the net plot from date of sowing was calculated for each genotype.

3.5.2.5. No of mature pods / plants.

Mean number of mature pods present at the time of harvest in five plants.

3.5.2.6. No of immature pods / plants.

Mean number of immature pods present at the time of harvest in five plants.

3.5.2.7. Hundred seed weight (gm).

100 seeds were randomly taken from each genotype and weighed and the weight was recorded in grams as 100 seed weight. (Nautiyal *et al,* 2010)

3.5.2.8. Tightness of kernel in the hull.

100 pods were randomly taken from each genotype and manually checked by pressing fingers on the hull for recording tightness of kernel in the hull.

3.5.2.9. Shelling turn out percent (%).

The shelling outturn was computed by taking 100 g random sample of dry pods of each genotype and it was shelled. Shelling outturn was computed by using the following formula.

$$\text{Shelling per cent (\%)} = \frac{\text{Kernel weight (g)}}{\text{Pod weight (g)}} \times 100$$

3.5.2.10. Sound mature kernel percentage (%).

In random sample of 100 kernels, the number of well developed and shrivelled were separated and counted and SMK per cent was computed by using the following formula.

$$\text{SMK (\%)} = \frac{\text{Number of well developed kernels}}{\text{Total number of kernels}} \times 100$$

3.5.2.11. Harvest index (%) .

The biological yield (total dry matter after harvesting and sun drying) and pod yield of each plant was recorded in grams and the harvest index was calculated as under:

Harvest index (%) =

3.5.2.12. Days of Maturity.

Numbers of days from the date of sowing to maturity.

3.5.2.13. Pod yield per plant (gm).

Mean dry weight of pods of ten random plants was recorded in gram.

3.5.2.14. Kernel yield per plant (gm).

Kernel yield per plant was computed by the following formula,

$$\text{Kernel yield (g)} = \frac{\text{Pod yield (g/plant) x Shelling (\%)}}{100}$$

3.5.2.15. Shrivelled seeds.

From each genotype 100 seeds were randomly selected in each replication and used for recording the number of shrivelled seeds.

3.5.3. Maturity indices:

Ten maturity indices as suggested by Timothy *et al*, were considered for determining the optimum maturity of groundnut.

3.5.3.1. Pod size

Observations were recorded on 100 pods selected from each genotype for their pod size and classified into three separate classes, *i.e.* Small, Medium and Large. (Chandran *et al*, 2003, Singh and Osualt,1995.)

3.5.3.2. Pod width (mm).

Mean of 10 mature pods in each genotype and replication for recording pod width (mm).

3.5.3.3. Pod length (mm).

Mean of 10 mature pods in each genotype and replication for recording pod length (mm).

3.5.3.4. Pod constriction.

One hundred pods of each genotype were observed for pod constriction and classified in to 5 separated classes *i.e.*, None, Slight, Moderate, Deep and Very deep.

3.5.3.5 Pod beak.

One hundred pods of each genotype per replication were studied for pod beak and classified into five classes, *i.e.*, Absent, Slight, Moderate, Prominent and Very prominent.

3.5.3.6. Seed size.

100 kernels were randomly selected from each genotype and classified in to three classes, *i.e.,* Small, Medium and Large.

3.5.3.7. Seed shape.

The genotypes are classified in to three classes for seed shape *i.e.* round, fusiform, and elongated.

3.5.3.8. Seed color.

The seed colour was visually observed one month after harvest and 16 phenotypic classes were made *i.e.*, off-white, light tan, tan, rose, salmon, Salmon with white flecks, salmon with white light tan flecks, salmon with white dark tan flecks, salmon with white purple fleck red, light red, dark red, red with white flecks, red with salmon flecks, purple, purple with salmon flecks and dark purple.

3.5.3.9. Seed length (mm):

Mean of 10 mature pods in each genotype and replication was used for recording seed length (mm).

3.5.3.10. Seed texture:

The seed texture of 100 kernels from each genotype was observed one month after harvest and two phenotypic classes were made i.e., Present and Absent.

3.5.4 Bio- chemical indices and protein profiling:

3.5.4.1. SDS PAGE:

The electrophoresis was carried out on vertical SDS-PAGE (12%) at 60 mA for 2 hours. The gel was washed to remove excess of SDS and stained for protein with 0.1% Coomassie brilliant blue G-250 in methanol, acetic acid and distilled water in the ratio of 40 : 10 : 50. The dye was dissolved in methanol and water component first, and then acetic acid was added. The gel was destined by using methanol, acetic acid and distilled water in the same ratio without dye (Sadasivam and Manickam, 2008).

Extraction of seed protein: The grains were ground to fine powder and 10mg of defatted seed powder was homogenized in 400 ul protein extraction buffer (Tris-HCl 0.05M, pH 8, 0.02% SDS, 30.3% urea, 1% β-mercaptoethanol). It was kept overnight at 40°C, the homogenates were centrifuged at 13,000 rpm for 10 minutes (Shuaib *et al*., 2007). The clear supernatant mixed with gel loading dye (with SDS) was loaded on to the gel. A

broad range protein marker (Fermentas) was also loaded along with the samples.

Preparation of solution for PAGE and SDS-PAGE: The reagents and buffers for PAGE analysis were prepared as per the procedure described by Sambrook *et al*., 1989.

(a) Stock acrylamide solution (30%):

29.2 g Acrylamide, 0.8 g N, N' – Methylene bis Acrylamide. Final volume made up to 100 ml with double distilled water.

(b) Stock 1.5 M Tris-HCl (pH 8.8):

Tris buffer (18.219 g) was dissolved in 70 ml double distilled water, pH was then adjusted to 8.8 with HCl and final volume was made up to 100 ml.

(c) Stock 0.5 M Tris-HCl (pH 6.8):

Tris buffer (6.05 g) was dissolved in 70 ml double distilled water, pH was then adjusted to 6.8 with HCl and final volume was made up to 100 ml.

(d) 10% SDS (Sodium Dodecyl Sulphate)

(e) 10% APS (Ammonium per sulphate) prepared fresh.

(f) TEMED (N, N, N' N'- Tetra methyl-ethelendiamine)

(g) Gel loading dye:

Tris buffer (6.8 pH) - 750 µl, Glycerol - 1 ml, 1% BPB - 500 µl. Make up the volume 5 ml with distilled water. For SDS-PAGE 1 ml (10% SDS) was added with above solutions and final volume was made up to 5 ml.

(h) Preparation of 8% running gel for isozymes (Native PAGE):

Double Distilled Water - 18.5ml, 30% Acrylamide - 10.7ml Tris buffer pH 8.8 (1.5M) - 10.0 ml 10% APS - 400 µl TEMED - 24 µl

(i) Preparation of 12% running gel for protein (SDS- PAGE):

Double Distilled Water - 13.2ml 30% Acrylamide - 16.0ml Tris buffer pH 8.8 (1.5M) - 10.0 ml, 10% SDS - 400µl, 10% APS - 400 µl TEMED - 16 µl.

(j) Preparation of 5% staking gel (10 ml for protein and isozymes):

Double Distilled Water - 6.8 ml, 30% Acrylamide - 1.7 ml, Tris buffer pH 6.8 (0.5M) - 1.25 ml, 10% SDS* - 100 µl, 10% APS - 100 µl, TEMED - 10 µl, *10 % SDS was not used for isozymes.

(k) Electrode buffer (pH 8.3):

Tris buffer 3 g (0.025 M) and 14.4 g Glycine (0.192 M) were dissolved in distilled water and finally adjusted to 1000 ml. For SDS-PAGE 10 ml of 10% SDS was added and finally volume was made up to 1000 ml.

3.5.4.2. Extraction of enzymes for electrophoresis (Esterase):

One fifty milligram leaves were homogenized with a pre-chilled mortar and pestle under ice cold condition in 2.0 ml of extraction buffer, containing 50 mM sodium phosphate buffer (pH 7.2) with 1% (w/v) polyvinylpyrolidone (PVP). The homogenates were centrifuged at 10,000 rpm for 15 min and supernatant was used for isozymes (Esterase). Electrophoresis was conducted on vertical slab gel PAGE. Electrophoresis was carried out at 60 mA for 80-120 minutes at 4˚C. The samples were loaded on the gel after mixing them with tracking dye. After electrophoretic run, the gels were washed and stained. The gels were photographed.

Esterase:

The gels were stained using sodium dihydrogen phosphate (2.8g), disodium hydrogen phosphate (1.1g), fast blue RR salt (0.2g), α-napthyl acetate

(0.03g) and double distilled water upto 200ml. The gels were kept under staining solution until bands appeared (Sadashivam and Manickam, 2008).

3.5.4.3. Protein Content (%):

The total protein content in the samples is estimated by Micro Kjeldal method in which the total nitrogen content in the sample is multiplied with 6.25 to obtain the crude protein value in the sample. (Sadasivam and Manickam,1996)

Principle:

In the Kjeldal method of nitrogen determination, the sample is digested with conc.H_2SO_4 Acid. The sulphuric acid act as dehydrating and oxidizing agent. Carbon in the sample is oxidized according to 2 H_2SO_4+C = CO_2 + 2SO_2+ 2H_2O and the nitrogen of the sample is transformed in to the ammonia . Carbon dioxide, water and sulphur dioxide escape and the ammonia is held back as ammonium ion (NH_4^+) in the form of ammonium sulphate. Sodium hydroxide is then added to solution, which transformed ammonium ion into ammonia (NH_3), which is distilled off, absorbed in a boric acid solution and titrated with standard sulphuric acid. On an average most proteins have 16 % nitrogen in their composition, in other words 1mg nitrogen equal 6.25 mg protein.

Reagents-

1. Sulphuric acid sp.gr.1.84, N-free.
2. catalyst mixture: Grind tougher in a mortar99.0 g of K_2S0_4, 4.1g of HgO and 0.8g of $CuSo_4$

3. Sodium hydroxide sodium thio-sulphate solution: Dissolved 50g NaOH and 5 G Na2So3.5H2O in distilled water and dilute to100 ml.
4. Boric acid solution: Dissolve 4 g in warm water and dilute to100ml.
5. Hydrochloric acid solution: 0.02N.
6. Methyl red-bromocresol green indicator solution: mix one part 0.2 % methyl red in ethanol with 2 parts 0.2% bromocresol green in ethanol.

Procedure:

1. Weight of 5.0g sample and transfer it to a digestion flask. Add 1 g of catalyst mixture and 2 ml of conc. Sulphuric acid.
2. Digest the sample till the solution becomes colourless (approx. 40 ml at $37^{O}C$).
3. After cooling add minimum quantity of water to dissolve solids and allow to cool.
4. Pipette 10 ml of boric acid solution into a 100 ml Erlenmeyer flask. Add 2-3 drops of indicator soln.
5. Transfer digest to distillation apparatus and rinse the flask 4 times with 2-3 ml distilled water.
6. Add 10ml sodium hydroxide- sodium-thiosulphate soln. to the distill and stem-distill until about 20 ml of distillate collects (20 min).
7. Lower the receiving flask and continue distillation one more minute. Wash the tip condenser with a few drops of water. Remove the receiving flask.
8. Titrate contents of receiving flask to grey end point or first appearance of violet colour.

9. Run a reagent blank with an equal volume of distilled water (without sample) and substract the titration volume from that of sample titer volume.

   Include one standard check of tyrosine by taking 10 mg of it.

Calculation : Calculate percentage of nitrogen as follows:

$$\% N = \frac{(\text{ml HCL - ml blank}) \times \text{normality} \times 100 \times 14.007}{\text{Mg sample}}$$

% protein = % N × 6.25 (or factor for a given grain)

3.5.4.4. Oil content (%):

Extraction of oil from the sample is done using standard Soxhlet units and oil content (%) determined using gravimetric methods.

Principle:

Oil is soluble in organic solvent like petroleum ether, hexane, ether, etc. These solvents can be used for the extraction of oils.

Materials:

1. Soxhlet oil extraction unit, 2. Water bath, 3.Oven.

Procedure:

Weigh 150 ml flat bottomed flask to a constant weight by heating the flask in an oven and cooling in a desiccator. Grind 10 gm of sample. Now transfer this to a thimble (Whatman), which is placed in the extraction unit. Plug the thimble with cotton plug. Add 100 ml hexane in the flask and put the whole assembly in its position and start the heating unit. Heat for about 4 hours to extract oil completely. Distil the extract to get the solvent. Evaporate rest of

the solvent on a water bath and finally in an oven. Cool the flask and weigh the content.

Difference in initial and final weight, provides the oil content of the material and the results are reported on % basis.

Extraction of total oil from seed:

The total oil is extracted by Soxhlet extraction using organic solvent like hexane or petroleum ether (60-80ºC).

Apparatus

1. Soxhlet extractor assembly, 2. Absorbent cotton, 3. Vacuum oven.

Reagents/ Glassware:

Hexane or petroleum ether, 150 ml round flat bottom flask, thimble, 4.Mortar and pestle.

Procedure:

Take 7-8 g seed in a mortar and crush it to fine powder with pestle. 5 g quantity of this powder is weighed accurately and rolled in a piece of filter paper to make a sample packet. Put this packet into thimble and cover it with absorbent cotton. The thimble is then placed into extraction flask of Soxhlet apparatus. Add organic solvent one and a half time the capacity of the extractor and extract oils in a weighed flask for a period of six hours at a condensation rate of five to six drops per second or for a period of 8 hours at two to three drops per second. Put off the heaters and remove thimble from the extractor. Wash the extractor once after heating the solvent and then distilled out the solvent. The flask is then transferred into vacuum oven maintained at 55 ºC for 24 hours. Remove the flask from oven and put into dessicator unit till it come

to room temperature. Weigh the flask and calculate percentage oil in sample. (Mehta and Lodha, 1979)

Calculation

$$\text{Oil percentage} = \frac{\text{Weight of flask + oil (-) Weight of flask}}{\text{5 g (sample)}} \times 100$$

3.6. Statistical analysis:

The overall mean values of different characters of five randomly selected plants were used for statistical analysis and statistical analysis was carried at the Department of Agricultural Statistics, B. A .College of Agriculture, Anand Agricultural University, Anand. The results of different characters studied were analyzed based on plot mean values for following statistical parameters.

(1) Analysis of variance for experimental design.

(2) Analysis of phenotypic, genotypic and error variance, phenotypic and genotypic co-efficient of variation, heritability (Broad sense)and genetic advance.

The mean values of five randomly selected plants were used for analysis of variance for all the characters using method described by Panse and Sukhatme (1984).

3.6.1 Analysis of variance for experimental design

The data obtained from each character were statistically analysed for randomized block design as per the method suggested by Panse and Sukhatme (1978). This analysis is based on the following linear model.

$$\mathbf{Y_{ij} = \mu + R_i + G_j + E_{ij}}$$

Where,

Y_{ij} = Value of j^{th} genotype in i^{th} replication

μ = General mean

R_i = Effect of i^{th} replication

G_j = Effect of j^{th} genotype

E_{ij} = Un-controlled variation or random error associated due to

j^{th} = Genotype in i^{th} replication.

The form of analysis of variance for randomized block design is as follows:

ANALYSIS OF VARIANCE

Source	d.f.	M.S.	EMS	F
Replication(r)	(r-1)		-	-
Genotype(g)	(g-1)	M_1	$б^2e + rб^2g$	M_1/M_2
Error	(r-1)(g-1)	M_2	$б^2e$	
Total	(rg-1)			

Where,

r = Number of replication

g = Number of genotypes

Significance of replication mean sum of squares and genotype sum of squares were tested against error mean sum of squares.

3. 6.2 Analysis of variance components

The genotypic, phenotypic and error variance were calculated as follows.

3. 6.2.1 Error variance ($б^2e$)

The mean square of error represented by the variation attributed to environmental causes. Environmental variance ($б^2e$) = Me

Where,

$б^2e$ = Error variance

Me = Mean square due to error

3. 6.3. Variability parameter

3. 6.3.1 Range

It is the difference between the lowest and the highest value for each character.

3. 6.3.2 Mean

The mean value of each character was worked out by dividing the totals with corresponding number of observations.

$$= \frac{\Sigma X_{ij}}{n}$$

Where,

= general mean,

X_{ij} = Observed value in j^{th} genotype in i^{th} replication

n = Number of observations,

Σ = Summation.

3. 6.3.3 Standard error of mean (S.Em.)

The standard error of mean was calculated with the help of following formula.

$$S.Em. = \sqrt{\sigma^2_e / r}$$

Where,

S.Em. = standard error of mean

σ^2_e = error mean square

r = number of replications

3. 6.3.4 Critical difference (C.D.)

Critical differences for all the characters were calculated to compare the treatment means as per the following formula.

$$C.D. = S.Em. \times \sqrt{2} \times t\ 0.05 \text{ at error d.f.}$$

3. 6.4 Genetic variability, heritability and genetic advance

3. 6.4.1. Phenotypic coefficient of variation (PCV %)

The phenotypic coefficient of variation, which measures the magnitude of phenotypic variation present in a particular character was estimated as per the formula suggested by Burton (1952).

PCV (%) =

Where,

$\hat{\sigma}^2_p$ = phenotypic variance

= mean of the character

3. 6.4.2. Genotypic coefficient of variation (GCV %)

The genotypic coefficient of variation, which measures the magnitude of genotypic variation present in a particular character was estimated as per the formula suggested by Burton (1952).

GCV (%) =

Where,

$\hat{\sigma}^2_g$ = genotypic variance

= mean of the character

3. 6.4.3. Heritability (Broad sense)

Heritability in broad sense, which is the ratio of genotypic variance and phenotypic variance, was calculated by using the formula suggested by Allard (1960).

$$\text{Heritability (\%)} = \frac{\hat{\sigma}^2 g}{\hat{\sigma}^2 g + \hat{\sigma}^2 e} \times 100$$

Where,

$\hat{\sigma}^2_g$ = genotypic

$\hat{\sigma}^2_e$ = error variance

3. 6.4.4. Expected genetic advance

The expected genetic advance under selection (Gs) at 5% selection intensity was estimated by adopting formula suggested by Allard (1960).

Where, Gs = k x x H

Gs = genetic advance under selection

k = selection differential (value of k at 5% selection intensity is 2.06)

= phenotypic standard deviation

H = heritability value of the character

3. 6.5.1. Statistical analysis of electrophoratic data:

The bands were scored for their presence (1) or absence (0) in each cultivar. Data entry was done in to a binary data matrix as discrete variables. Jaccard's similarity coefficient was used to compute pair-wise genetic similarity values. A dendrogram was generated based on similarity coefficients using Unweighted Pair Group Method with Arithmetic (UPGMA) mean. The computer package NTSYSpc (Numerical taxonomy system) version 2.0 (Rohlf, 1998) was used for cluster analysis.

3. 6.5.2. Isozyme and protein data analysis-

3. 6.5.2.1.Band scoring:

The relative mobility (Rm) of each band was calculated using the following formula:

$$Rm = \frac{\text{Distance travelled by the band}}{\text{Distance travelled by the tracking dye}}$$

The bands in each cultivar were identified by their Rm values. Based on presence or absence of a band in each cultivar, distinctiveness between particular cultivars was established. The intensity of bands was approximated visually as faint, light and intense.

IV. RESULTS AND DISCUSSION

The result obtained from the present investigation on "Seed viability parameters and maturity indices in groundnut (*Arachis hypogaea* L.) during *Kharif* and Summer is presented here under the following heads.

4.1 Mean performance of groundnut genotype for morphological and seed viability parameters.

4.2 Genetic parameters (genotypic and phenotypic coefficient of variation heritability and genetic advance).

4.3 Maturity indices.

4.4 Bio-chemical parameter (oil %, protein %, SDS PAGE and Esterase).

4.1. Mean performance of groundnut genotypes for morphological and seed viability parameters.

The analysis of variance for different parameters studied in the present investigation is given in Table 4.1. The analysis of variance revealed that mean squares due to genotype were highly significant for all the traits indicating the existence of wide variation among genotypes for different traits. Character wise mean performance is presented in Table 4.1.1.

4.1.1. Morphological parameters

The analysis of variance for seventeen quantitative traits is presented in the Table 4.1.1. The results of variability analysis are as under.

4.1.1.1. Germination count at 5th day (%):

Germination count at 5th day for 55 genotypes revealed the significant variation (Table 4.1.1.). The maximum germination count at 5th day was recorded in genotype ICGS-221 (28.67%) followed by ICGS-13942 (28.33%) and NRCG- 6707 (28.00%), while lowest germination count at 5th day was observed in ICGS-13052 (17.00%), ICGS-405 (17.67%) and NRCG- 9231 (18.33%).

4.1.1.2. Germination count at 10th day (%):

The analysis of variance of germination count 10th day showed significant variation (Table 4.1.1). The maximum germination of seed was recorded in ICGS-13128 (85.00%) followed by ICGS-13942 (81.70%) and AG-2006-14 (81.40%), whereas the genotype GG-4 (41.70%), ICGS 2738 (48.30%) and GG-15 (55.00%) recorded minimum germination count at 10th day.

4.1.1.3. Plant height (cm):

The highest plant height was recorded in ICGS-4729 (68.46cm) followed by ICGS-12625 (60.50cm.) and NRCG- 9747 (62.35cm), while the lowest plant height was observed in the genotype ICGS-297 (28.28cm) followed by GG-20 (29.41) and GG-12 (29.98).

4.1.1.4. Number of primary branches per plant:

The number of primary branches per plant ranged from5.00 to 7.53. The highest number of primary branches per plant was recorded in ICGS-2738 (7.53) followed by ICGS-4296 (7.47) and ICGS-13941 (7.33), while the lowest number of primary branches per plant was recorded in ICGS-799 (5.00), ICGS-156 (5.79) and ICGS-10554 (5.80).

4.1.1.5. Number of secondary branches per plant:

The significant variation was observed in number of secondary branches per plant. The highest number of secondary branches per plant was recorded from ICGS-221 (6.55) followed by NRCG- 9130 (6.44) and KADIRI-3 (6.35), while it was lower in number in GG-16 (2.69) followed by GG-5 (2.82) and GG-20 (2.93).

4.1.1.6. Days of 50 % flowering:

The days of 50 % flowering showed moderate range i.e 23.25 to 37.92 with general mean (34.07%).The variation among genotypes was found significant. Maximum days to 50% flowering was recorded in ICGS-221 (37.92 %) followed by JL-24 (31.91%) and GG-13 (31.81%), while it was minimum in ICGS-799 (23.25%) followed by GG-13 (31.18%) and JL-24 (31.95%).

4.1.1.7. No of mature pods per plants:

The number of mature pods per plant was observed in the range of 6.90 to 15.59. Lower number of mature pods per plant was found in ICGS-4750 (6.90) followed by ICGS-11615 (7.53) and NRCG- 9231 (8.17), while it was highest in ICGS-297 (15.59) followed by ICGS-2738 (12.83) and ICGS-13052 (12.50).

4.1.1.8. No of immature pods per plants:

The highest number of immature pods per plants was recorded in NRCG- 6663 (6.03) followed by NRCG- 9000 (5.60) and NRCG- 9747 (5.57), while the lowest number of immature pods per plant was recorded in GG-16 (2.53) followed by JL-24 (2.67) and GG-7 (2.83).

4.1.1.9. Hundred seeds weight (g):

Hundred seed weight was observed in the range of 43.65 to 120.25. Highest weight of hundred seed was observed in ICGS-10890 (120.25gm) followed by ICGS-4750 (109.45gm) and AG-2006-14 (99.76gm), while it was lowest in GG-16 (43.65gm) followed by ICGS-799 (45.24gm) and NRCG 9231 (55.75gm).

4.1.1.10. Tightness of kernel in the hull (%):

The tightness of kernel in the hull of fifty five genotypes ranges from 34.48 to 77.93. Lowest percentage of tightness of kernel in the hull was recorded in ICGS-4750 (34.48 %) followed by ICGS-11615 (37.67%) and ICGS-799 (42.00%), while it was highest in ICGS-297 (77.93%) followed by NRCG- 6563 (68.72%) and ICGS-4729 (67.85%).

4.1.1.11. Shelling out turn (%):

The analysis of variance of shelling out turn showed significant variation (Table 4.1.1). The maximum shelling out turn was recorded in ICGS-4849 (61.43%) followed by NRCG 9130 (57.98%) and NRCG 9747 (57.87%), while it was minimum in ICGS-221 (43.43%) followed by ICGS-7827 (46.77%) and ICGS-13128 (46.91%).

4.1.1.12. Sound mature kernel (%):

The sound mature kernel in all fifty five genotypes ranged from 73.90 to 92.47. The lowest value for sound mature kernel was recorded in GG-20 (73.90%) followed by ICGS-13128 (74.60%) and GG-13 (75.88%), while highest value was observed in ICGS-4849 (92.47%) followed by GG-4 (89.54%) and NRCG- 6682 (89.33%).

4.1.1.13. Harvest index (%):

The harvest index was observed in the range of 10.00 to 17.00. Lower harvest index was observed in NRCG- 6563 (10.00 %) and GG-7 (10.00 %) followed by ICGS-7827 (12.33%), while it was highest in ICGS-221 (17.00%) followed by NRCG- 9231 (17.00%) and ICGS-1179 (16.00%).

4.1.1.14. Days of Maturity:

Days to maturity is related with the time of flowering. Early time of flowering generally indicates early maturity which is a desirable feature. The number of days to maturity ranged from 94.33 to 121.33. The early maturity was found in NRCG- 6563 (94.33) followed by GG-2 (96.33) and GG-3 (97.00), while it was late in JL-24 (121.33) followed by ICGS-7827 (121) and TG-37 (118.67).

4.1.1.15. Pod yield per plant (gm):

The pod yield per plant in all fifty five genotypes ranged from 33.18 to 145.38. Lowest pod yield per plant was observed in ICGS-799 (33.18gm) followed by ICGS 156 (34.69gm) and ICGS-11615 (44.44gm), while it was highest in ICGS-10890 (145.38gm) followed by ICGS-297 (132.62gm) and NRCG- 9000 (113.71gm).

4.1.1.16. Kernel yield per plant (gm):

The significant variation was observed in kernel yield per plant. Highest kernel yield per plant was recorded in ICGS-297 (18.92 gm) followed by NRCG-6563 (18.61 gm) and NRCG-9000 (18.33 gm), while the lowest was recorded in ICGS-11615 (10.53 gm), followed by ICGS-4750 (10.63 gm) and NRCG-9185 (11.73 gm).

4.1.1.17. Shrivelled seeds (%):

The shrivelled seed percentage in all fifty five genotypes ranged from 10.00 to 37.00 and was found to be comparable. Lowest shrivelled seed percentage was recorded in GG-5 (10.00) followed by NRCG- 9185 (12.33) and it was highest in GG-16 (37.00) followed by NRCG 9000 (36.00) and NRCG- 6682 (33.67).

4.1.2. Seed Viability parameters.

The freshly harvested seed during summer 2010 and after three months of its storage was tested for seed viability parameters likewise freshly harvested seed from *Kharif* 2010 was also tested for seed viability parameters **(**Table **4.1.2.1, 4.1.2.2 and 4.1.2.3).**

4.1.2.1. Water imbibing capacity of seeds.

Water imbibition capacity of groundnut seed recorded for freshly harvested seed during summer 2010 and for the stored seed for a period of 3 months, gave significant differences indicating the genotypic variation for these characters. The highest water imbibing capacity was observed in the fresh seed of ICGS-11615 (1.97mg) as well as after 3 months of storage in the same genotype (1.30mg).

The same characters when observed in the fresh seed harvested during *Kharif*2010, the genotype AG-2006-15 (1.01mg) showed highest water imbibing capacity.

4.1.2.2. Germination count at 5th day.

Significant differences indicating the genotypic variation for this character was observed. The highest germination count at 5th day in freshly harvested seed as well as after 3 months of storage was observed in the genotype in freshly summer harvested seed of GG-14 (73.81%) and in stored seed for the period of three months (72.0%).

The same characters when observed in the freshly harvested seed of *Kharif* 2010 the highest performance was found in the genotype GG 14 (68.2%).

4.1.2.3. Germination count at 10th day.

Germination count showed the significant difference indicating the genotypic variation for this character. Highest germination count at 10th day was observed in the freshly harvested seed of summer sown groundnut 2010 and after 3 months of storage in the genotype *viz.,* NRCG 6707 (96.56%) and ICGS-221 (95.88%) respectively.

The same character when observed in the freshly harvested seed of *Kharif* 2010 sown genotypes, the genotype ICGS 2738 (95.04 %) had shown the highest performance.

4.1.2.4. Shoot length (cm) after 10th day.

Shoot length of groundnut seed recorded in the freshly harvested seed and for stored seed for a period of 3 months of summer 2010 exhibited the significant differences indicating the genotypic variation for this character. The highest shoot length was observed in the freshly harvested summer seed as well as after 3 months of storage in the genotype (KADIRI-3 7.28cm and 7.26cm respectively).

The same character when observed immediately after harvest of *Kharif* 2010 sown groundnut the highest shoot length was recorded in the genotype ICGS-4849 (7.11cm).

4.1.2.5. Root length (cm) after 10th day.

Significant differences indicating the genotypic variation for this character was observed. The highest germination count at 10th day was observed in the seed immediately after harvest as well as after 3 months of storage of summer 2010 sown groundnut in the genotype ICGS-4729 i.e 8.54cm and 8.50cm for respective conditions.

The same character when observed in the seed immediately after harvest of *Kharif* sown groundnut 2010, the genotype NRCG-9130 (8.40cm) showed the highest performance.

4.1.2.6. Root length and shoot length ratio at 10th day.

Root length and shoot length ratio of groundnut seed recorded immediately after harvest and for stored seed for a period of 3 months exhibited significant differences indicating the genotypic variation for this character. The highest root length and shoot length ratio was observed in the genotype BAV-13 immediately after harvest (2.85) as well as after 3 months of storage (2.77).

The same character when observed immediately after harvest for *Kharif* sown groundnut, the highest value was recorded in the genotype NRCG-6682 (2.70).

4.1.2.7. Fresh Shoot weight (gm/seedling).

Significant differences indicating the genotypic variation for this character was observed. The highest fresh shoot weight was observed in the genotype ICGS-1179 (0.98gm) and ICGS-4729 (0.91gm) and ICGS (0.91gm)

for summer seed immediately after harvest and for the stored seed for a period of 3 months respectively.

The same character when observed immediately after harvest of *Kharif* groundnut 2010 the genotype ICGS (0.91gm) recorded highest performance among all genotypes.

4.1.2.8. Dry shoot weight (gm/seedling).

Dry shoot weight of groundnut seed of summer 2010 was recorded in the freshly harvested seed and for stored seed for a period of 3 months exhibited significant differences indicating the genotypic variation for this character. The highest dry shoot weight was observed in the freshly harvested seed as well as after 3 months of storage in the genotype ICGS-2738 (0.91gm) and ICGS-13128 (0.73gm) and NRCG (0.73gm) respectively.

The same character when observed immediately after harvest of *Kharif* 2010 sown groundnut, the highest dry shoot weight was recorded in the genotype NRCG 9185 (0.65gm)

4.1.2.9. Fresh root weight (mg/seedling).

Significant differences indicating the genotypic variation for this character was evident. The highest fresh root weight was observed in the seed immediately after harvest as well as after 3 months of storage of summer 2010 sown groundnut in the same genotype GG-4 ie. 2.76 gm and 2.70 gm for respective conditions.

The same character when observed in the seed immediately after harvest of *Kharif* - 2010 sown groundnut, the genotype AG-2006-14 (2.64gm) showed the highest value.

4.1.2.10. Dry root weight (gm/seedling).

Dry root weight of groundnut seed recorded immediately after harvest and for stored seed for a period of 3 months exhibited significant differences indicating the genotypic variation for this character. The highest dry root weight was observed in the freshly harvested seed of summer groundnut 2010 genotype GAUG-10 (0.28mg) and after 3 months of storage of summer 2010 seed it was observed in the genotype GAUG-10 (0.26gm).

The same character when observed immediately after harvest for *Kharif* 2010 sown groundnut, the highest value was recorded in the genotype GAUG-10 (0.23gm).

4.1.2.11. Seed vigour index.

Significant differences indicating the genotypic variation for this character was observed. The highest seed vigour index in the summer seed immediately after harvest and in the stored seed for a period of 3 months was recorded in the genotypes NRCG-6707(1274.70) and GG-4 (1264.94) respectively.

The seed vigour index was found highest in the *Kharif* sown groundnut 2010 immediately after harvest for the genotype ICGS-13128 (1240.70).

4.2. Maturity indices.

Ten phenotypic characters such as pod constriction, pod size, seed size, seed shape, pod beak, pod width, pod length, seed color, seed texture and seed length were studied as per the guidelines from Directorate of Groundnut Research, ICAR, Junagadh (Anon.1999). Each character was divided into separate phenotypic classes and frequency of genotypes falling into each class determined. (Table 4.2.1 Fig4.2.2,and 4.2.3). The results are described as below

4.2.1. Pod constriction:

Four genotypes showed very deep pod constriction which was followed by 8, 10 and 24 genotypes with deep, moderate and slight constrictions. Nine genotypes did not show any pod constriction.

4.2.2. Pod size.

As many as 27 genotypes exhibited medium pod size, 24 large and 4 showed small pod size.

4.2. 3. Seed size

Out of three possible classes of seed size as many as 27 genotypes showed medium seed size followed by 24 large and 4 exhibited small seed size.

4.2.4. Seed shape

As many as 27 genotypes exhibited fusiform seed shape, 25 elongated and 3 showed round seed shape.

4.2.5. Pod beak

Among the 55 genotypes 20 were slight beak, 14 with beakless, 3 with prominent, 13 with moderate and 5 with very prominent pod beak were observed.

4.2. 6. Pod width

Out of 55 genotypes as many as 39 genotypes exhibited medium seed width, 11 with less and 5 showed the high seed width.

4.2.7. Pod length

Out of 55 genotypes 39 showed medium, 11 with short and 6 with long pod length was observed.

4.2.8. Seed color

Among the 55 genotypes 16 colour variants were observed. They were Tan (7), red with white flecks (7), red with salmon flecks (6), purple (4), salmon (3), salmon with white flecks(3), salmon with white purple flecks(3), purple with salmon flecks while(3), light tan (2), dark red (2), salmon with

white dark tan flecks(2), red, dark purple(2), off-white (1), rose (1), salmon with white light tan flecks (1) .

4.3. 9. Seed texture

Out of two possible classes of seed size as many as 51 genotypes showed presence of non smooth seed texture while in the remaining 4 this character was smooth.

4.2. 10. Seed length

Among the 55 genotypes 30 were medium followed by 14 with long, and 11 with short seed length were found.

4.3 Bio-chemical parameters (Oil %, Protein %, SDS PAGE, Analysis for protein and Esterases isozymes).

Bio- chemical parameters such as Oil %, Protein content (%) and SDS PAGE analysis for protein and esterase isozymes are good indicators for the degradation of the biological components during storage of summer groundnut seed. Oil and protein content estimated from fresh groundnut seed of Kharif and from summer groundnut seed stored for a period of six months showed significant differences among the genotypes. (Table 4.3.1) The results of these studies are described as under.

4.3.1. Oil content (%) and Oil colour:

Oil content (%) recorded in the summer groundnut seed (2010) showed significant differences among genotypes when stored for six months. The maximum oil content was found in ICGS 4849 (37.60%) in the stored summer seed. Whereas the minimum oil content was recorded in the genotype GAUG

10 (25.53%). For fresh seed of Kharif 2010, significant higher oil content was recorded in NRCG 6663 (50.31%), while minimum was recorded for the genotype ICGS 13941 (41.41%).

Regarding the colour (Fig 4.3.1 and 4.3.2) of oil extracted from fresh *Kharif* seed and summer seed stored for six months, significant colour variation were not observed among genotypes except that the colour of the oil from *Kharif* seed appeared more dark yellow as compared to that of stored summer seed.

4.3.2. Protein content (%):

Significant differences in protein content was observed among the genotypes of summer groundnut when stored for six months. The stored seed recorded higher protein content in genotype GG-2 (26.00) whereas the lower protein content was observed in NRCG 6563 (11.28%). In freshly harvested Kharif seed, significant higher protein content was found in the genotype GG 2 (29.26%) while, lower protein content was found in the genotype GG12 (18.93%).

4.3.3 SDS PAGE analysis for groundnut seed protein for similarity index and hierarchical clustering in stored summer and fresh Kharif seeds.

Fifty five groundnut seed protein samples from stored summer seed of 2010 and fresh Kharif seed of 2010 were subjected to SDS-PAGE analysis to examine the diversity and variations in protein profiles.

The SDS PAGE analysis (Table 4.3.3.1 and Fig 4.3.3.1.4 and 4.3.3.2) conducted for protein in fifty five groundnut genotypes for *Kharif* and stored summer seed revealed 100% polymorphism with polymorphic information content (PIC) value of 0.94 in both the cases. However the number of bands obtained from *Kharif* seed present was more (769) as compared to that of stored summer seed protein.

Results and Discussion

The data scored from protein was analyzed using Jaccard coefficient (1908) by using NTSYS software program and is given in Table 4.3.3.2 and 4.3.3.3. In case of Kharif 2010 the genetic similarity was found in the range of 0.333 to 1.00. The lowest genetic similarity was recorded in the genotype ICGS10554 (0.333) with GG-2, GG-3, GG-4 and GG-5 while thirty nine genotypes showed maximum (1.00) similarity (Table 4.3.3.2 and Figure 4.3.3.3). Genetic similarity was found in the range of 0.111 to 1.00 in summer 2010 seed. Lowest genetic similarity was recorded between genotype GG-4 (0.111) and ICGS1179 while forty one genotypes showed maximum genetic similarity (1.00) as shown in the Table 4.3.3.3 and figure 4.3.3.4.

Dendograms for cluster analysis for summer and *Kharif* 2010 were constructed based on UPGMA method by using Jaccard coefficient index. Fifty five groundnut genotypes from Kharif 2010 were grouped into three major clusters *viz.,* A, B and C which were further divided into other sub-clusters (Fig 4.3.3.3). First sub-cluster (A_1) comprised of three genotypes namely ICGS 7827, ICGS 7847, AG-2006-15. Second cluster (A_2) comprised of two genotypes *viz.,* ICGS 5016 and ICGS 4729. Cluster three (A_3) consisted of three genotypes namely AG-2006-14, ICGS 13941 and ICGS 126 25. Fourth cluster (A_4) comprised of three genotypes namely ICGS 13942, ICGS 10890 and ICGS 9157. Whereas fifth cluster (A_5) comprised of only one genotype i.e, ICGS 10554. The major cluster B was divided into three clusters. The first cluster (B_1) comprised of twenty five genotypes viz., NRCG 9949, NRCG 9747, ICGS 11615, ICGS 13128, ICGS 13033, ICGS 212, ICGS 297, ICGS

450, ICGS 799, ICGS 2738, ICGS 4729, ICGS 4729, ICGS KADIRI 3, BAV 13, ICGS 1179, ICGS 1703, ICGS 42 96, ICGS 4849,NRCG 6563, NRCG 6682, NRCG 6705, NRCG 9000, NRCG 9185 and NRCG 9231. The second (B_2) and third (B_3) clusters comprised of only one genotype namely ICGS 13052 and ICGS 156 respectively. In the last group C only one cluster was observed comprising of fifteen genotypes viz., ICGS 36, GAUG 10, GG 7, JL 24, TG 37, GG12, GG 13, GG 14, GG 15, GG 16, GG 20, GG 3, GG 2, GG 4 and GG 5.

Based on the data obtained from SDS PAGE analysis of protein from summer seeds (2010) fifty five genotypes four clusters viz., A,B, C and D were formed. Group A comprised of four sub-clusters namely A_1, A_2, A_3 and A_4. The first cluster (A_1) comprised of ten genotypes namely ICGS 4895, ICGS 1703, NRCG 6563, NRCG 6705, NRCG 6707, NRCG 9000, NRCG 9130, NRCG 9185, GG 6, NRCG 6682. Second cluster (A_2) comprised of nine genotypes *viz.,* GG 3, GG 4, GG 2, GAUG 10, JL 24, TG 37, GG 12, GG 13 and GG 20. The third cluster (A_3) comprised of four genotypes namely GG 15, GG 5, GG 16 and GG 7. Whereas fourth cluster (A_4) comprised of only one genotype *viz.,* ICGS 4296. Group B was divided in to two sub-clusters (B_1 and B_2). The first cluster (B_1) comprised of thirteen genotypes *viz.,* ICGS 4729, ICGS 5016, ICGS 7827, ICGS 5236, ICGS 7847, ICGS 9157, ICGS 10554, ICGS 10890, ICGS 12625, ICGS 13941, ICGS 13944, AG 2006 14 and AG 2006 15. The second cluster (B_2) consisted of fourteen genotypes namely NRCG 9747, NRCG 49231, NRCG 9949, ICGS 11615, ICGS 13052, ICGS 13128, ICGS

13033, ICGS 36, ICGS 156, ICGS 212, ICGS 297, ICGS 405, ICGS 799 and ICGS 2738. The group C contained only one genotype i.e, GG 14 and group D comprised of three genotypes *viz.,* KADIRI 3, BAV 13, and ICGS 1177. (Table 4.3.3.3 and figure 4.3.34.)

The protein characterisation studies using SDS PAGE analysis revealed various type of banding pattern for stored summer and fresh Kharif seeds. One hundred percent polymorphism was observed both in Kharif and summer with PIC value 0.94 in both cases.

However the number of polymorphic bands observed in fresh *Kharif* seeds (769) and stored summer seeds (696) were different indicating that protein denaturation must have occurred during storage.

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MATIRX

SYMMER

4.3.4. Esterase isozyme analysis for similarity index and hierarchical clustering in stored summer index and fresh Kharif seeds.

Esterase isozymes which are related to viability and germinability of seeds get progressively deactivated during storage (Hassanein 1999, Aung and Donald,1995).

SDS PAGE analysis was conducted for characterisation of fifty five groundnut genotypes in two sets i.e, summer seeds stored for six months and fresh *Kharif* seeds based on their esterase isozyme banding pattern. The data scored from esterase isozyme banding patterns was analyzed using Jaccard

coefficient (1908) by using NTSYS software program and are given in Tables 4.3.4.2 and 4.3.4.3 Genetic similarity was found in the range of 0.250 to 1.00 in both seeds of summer stored and fresh *Kharif* seeds. In case of Kharif 2010, the lowest (0.250) genetic similarity was recorded in the genotype GG 16 with GG-7,GAUG 10 , JL, 24, GG 16 and whereas the lowest genetic similarity of 0.250 was also observed between ICGS 11615 and ICGS13052, ICGS13128, ICGS 13128, ICGS 10554. Similar results were observed in the case of BAV 13 and ICGS 799, ICGS 5236, ICGS 7827, ICGS 9157, ICGS AG 2006 14 and AG 2006 15. It was observed that fourty six genotypes showed 100% genetic similarity (1.00) in this season (Table 4.3.4.2 and fig. 4.3.4.3).

Lowest genetic similarity (0.250) observed in summer 2010 was recorded between genotypes GG-2 and other eighteen genotypes viz., GG 2, GG 15, GG 20, NRCG 6682, NRCG 9000, NRCG 9130, NRCG 9231, NRCG 9949, ICGS 11615, ICGS 13025, ICGS 13128, ICGS 13033, ICGS 7827, ICGS 4157, ICGS 10554, ICGS 108920, ICGS 13941, AG 2006 14 and AG 2006 15. Fifty three genotypes showed maximum genetic similarity (1.00) as shown in the Table 4.3.4.3 and Fig. 4.3.4.4.

Dendograms were constructed based on UPGMA method by using Jaccard coefficient index. Fifty five groundnut genotypes of Kharif were grouped into three groups *viz.,* A, B and C which were than classified into sub-clusters. The major cluster A was divided into sub-clusters viz., A_1, and A_2. The first cluster comprised of twenty one genotypes namely GG 16, GG 20, GG 4, GG 3, GG 13, ICGS 405, ICGS 5016, ICGS 5236, ICGS 7827, ICGS 9157, ICGS 13942, AG 2006 14, AG 2006 15, GG 7, GG 5, GAUG 10, GG 15,

NRCG 9949, ICGS 116115, ICGS 13052 and JL 24. The second cluster A_2 comprised of twenty five genotypes *viz.,* GG 2, TG 37, GG 14, BAV 13, ICGS 4849, NRCG 6563, NRCG 6663, NRCG 6682, NRCG 6705, NRCG 6707, NRCG 9000, NRCG 9185, NRCG 9231, ICGS 221, ICGS 297, ICGS 799, ICGS 2738, ICGS 10554, KADIRI-3, GG-12, ICGS 1179, ICGS 1703, ICGS 4296, NRCG 9130 and NRCG 9747. In cluster B group only one sub-cluster was observed which comprised of eight genotypes viz., ICGS 13033, ICGS 36, ICGS 156, ICGS 4729, ICGS 4750, ICGS 10890, ICGS 12625 and ICGS 1394. The cluster C comprised only one genotype i.e, ICGS 13941. (Fig. 4.3.4.3)

In the case of summer 2010, groundnut genotypes were grouped into four major clusters, i.e, A, B, C, and D. The cluster A was further sub-divided in to four sub-clusters i.e, A_1, A_2, A_3 and A_4. The group (A_1) comprised of two genotypes viz., GG 20 and GG16. The cluster (A_2) comprised of eleven genotypes namely GG 4, GG 3, GG 13, ICGS 405, ICGS 5016, ICGS 5236, ICGS 7827, ICGS 9157, ICGS 13942, AG 2006 14 and AG 2006 15. In the third cluster (A_3) seven genotypes viz., GG 7, GG 5, GAUG 10, GG 15, NRCG 9949, ICGS 11615 and ICGS 13052 were observed. Fourth cluster (A_4) comprised of eighteen genotypes namely JL 24, GG 2, TG 37, GG 14, BAV 13, ICGS 4849, NRCG 6563, NRCG 6663, NRCG 6682, NRCG 6705, NRCG 6707, NRCG 9000, NRCG 9185, NRCG 9231, NRCG 221, NRCG 297, NRCG 799 and NRCG 2738.

The B grouped contained only one cluster with the genotype ICGS 10554. In C group also only one cluster was seen comprising fifteen genotypes viz., KADIRI 3, GG 12, ICGS1179, ICGS 1703, ICGS 4296, NRCG 9130,

NRCG 9747, ICGS 13128, ICGS 13033, ICGS 36, ICGS 156, ICGS 4729, ICGS 4750, ICGS 10890 and ICGS 12625. In D group also only one cluster comprising one single genotype i.e. ICGS 13941 was observed. (Fig. 4.3.4.4.)

Similarly isozyme studies also indicated that the storage of summer seed contributed to less number of polymorphic bands in summer (101) as compared to *Kharif* (181). The lower PIC values observed for isozyme i.e, 0.73 (*Kharif*) and 0.69 (summer) indicated that characterisation using protein may give a more reliable estimate rather than isozymes. (Table 4.3.4.1 Figs. 4.3.4.1.and 4.3.4.2)

On the whole it can be concluded from this study that SDS PAGE analysis can be a robust technique for genetic diversity analysis as well as study the degree of protein and isozyme degradation during prolonged storage. However biochemical markers such as protein and isozyme are environmental sensitive and may not be as reliable an estimate like molecular markers which can be attempted for generating more authentic information.

4.4. Variance components

The phenotypic, genotypic and environmental components of variances were calculated for all the seventeen morphological characters under study and utilised for calculating genetic parameters such as GCV (%), PCV (%), Genetic advance GA (%), as percentage of mean and broad sense heritability (H^2%) presented in Table 4.4.

4.4.1. Genotypic and phenotypic coefficient of variation

The genotypic and phenotypic coefficients of variation for all the traits are presented in Table 4.4.

The genotypic coefficient of variation (GCV) for various traits is a measurement expressed in percentage, therefore is a reliable estimate for measuring relative magnitude of genotypic variation in a given population for different traits. Higher expression of genotypic coefficient of variation was observed in seven traits *viz.,* pod yield per plant (25.62), plant height (22.89), secondary branches (21.83), shrivelled seeds (21.33), kernel yield per plant (19.18) and hundred seed weight (17.71). The moderate genotypic coefficients of variations were observed for the characters *viz*., number of mature pods per plant (13.23) primary branches per plant (11.95), days to maturity (11.43), germination count at 5th day (10.58) and number of immature pods per plant (10.40). germination count at 10th day (9.73), shelling out turn percent (6.74), harvest index (6.73), sound mature kernel (5.61) and days to 50% flowering (3.75).

Similar, results were also reported by Boote (1982), Shorter and Simpson (1987), Nautiyal *et al.* (1990) , Nautiyal and Zala (1991) and Nautiyal and Ravindra (1996) for pod yield per plant and its components traits in groundnut.

4.4.2. Phenotypic coefficient of variation (PCV).

The phenotypic variation is not a precise criteria for judging the amount of genotypic variation present in population.

The estimates of phenotypic coefficient of variation ranged from 5.97 (Sound mature kernel %) to 28.62 (Pod yield per plant) Characters such as shrivelled seeds (26.54), plant height (25.61), kernel yield per plant (24.47) and secondary branches per plant (22.69) exhibited high phenotypic coefficient of variation. Whereas phenotypic coefficient of variations were moderate for tightness of kernel in the hull **(**18.06**),** number of mature pods per plants (18.05), 100 seed weight (17.94), germination count at 10^{th} day (16.47), days to maturity (14.60), germination count at 10^{th} day (13.63), number of immature pods per plants (13.53) and primary branches per plant (13.43). Days to 50% flowering (9.29), harvest index (7.44) and shelling per cent (7.24) showed low phenotypic coefficient of variation.

It was inferred that for the all characters the genotypic variance was close to phenotypic variance indicating that the environmental variance is playing a minimum role for the expression of these traits (Table 4.4). This indicated that phenotypic variability may be considered as a reliable measure of genotypic variability for atleast these characters. To compare different quantitative and qualitative traits in respect to phenotypic and genotypic variability, the (PCV) and (GCV) variations were worked out. The results revealed that the magnitude of genetic variability was very close to phenotypic variability for most of the agronomic and quality traits viz., number of secondary branches per plant, hundred seed weight, shelling turn out percentage, sound mature kernel and harvest index. This indicated that phenotypic variability was largely due to genetic differences for above traits

4.4.3. Broad sense Heritability (H^2%) .

The phenotypic coefficient of variation and genotypic coefficient of variation are not sufficient to indicate the proportion of total heritable variation. Therefore the estimates of heritability were obtained for confirming the above traits.

Genotypic coefficients of variation estimate the amount of genetic variation for a particular character. However, it does not determine the proportion of heritable variation from the total variation. The characters having high heritability could be improved directly through selection procedure, since they are less affected by the environment.

The estimates of heritability as percentage in broad sense for all the characters under study are presented in Table 4.4. High heritability values were recorded for most of the characters such as hundred seed weight (97.00), secondary branches per plant (93.00), sound mature kernel (88.00), shelling per cent (87.00), harvest index (82.00), plant height (80.00), pod yield per plant (80.00), shriveled seeds (80.00), primary branches per plant (79.00). kernel yield per plant (62.00), days to maturity (61.00), germination count at 5^{th} day (60.00), number of immature pods per plant (59.00), tightness of kernel in the hull **(**57.00**)** and number of mature pods per plant (54.00). Germination count at 10^{th} day (35.00) and days to 50 % flowering (16.00), exhibited low heritability.

Similar results were obtained by Yaw *et al.* (2008) and Kadam *et al*. (2007)

4.4.4. Genetic advance.

In the present investigation genetic advance was estimated for all the traits (Table 4.4). Genetic advance was highest for pod yield per plant (36.79), whereas hundred seed weight (26.18) showed moderate expected genetic

advance. The low genetic advance was observed for kernel yield per plant (1.16). Similar results were obtained by Ramadevi and Rama Rao, (2005) and Chunilal *et al.* (2007) for hundred seeds weight and Ahmad and Rahim (2007) for days to maturity, plant height, pod length, 100 kernels weight and plant height confirming the findings of the present investigation.

A perusal of genetic parameters such as GCV, PCV, heritability and genetic advance indicated that many morphological characters such as 100 seed weight, pod yield per plant, secondary branches, sound maturity kernel (%) etc. showed high GCV and also high heritability. Therefore these characters can be considered for improvement of groundnut.

The major factor responsible for limited success in increasing the groundnut pod yield has been the narrow genetic base of material available. It has been observed that the 55 genotypes involved in this investigation were collected from different geographical regions of India and therefore showed considerable variability for all the characters. Earlier workers such as Kadam *et al*. (2007) and Korat *et al. (*2009) have reported genetic variability in indigenous germplasm of groundnut and have quantified it through statistical tools.

A comparison between the germination percentage of genotypes of fresh summer seeds, summer seed stored for three months and fresh *Kharif* seeds showed varying trends which can be attributed to the effect of season and storage periods over germinability. In fresh summer seeds, highest germination percentage was observed in the genotype NRCG 6707 (96.56%) where as in

the three month storage summer seed it was ICGS 221 (95.88) and Kharif fresh seed it was ICGS 2738 (95.04%).

The highest germination percentage exhibited by NRCG 6707 (96.56%) in fresh summer seed as compared to its germination percentage in three month storage seed (94.60) showed the reduction in the germinability has set in at the start itself. Higher weight of genotype such as in case of NRCG 6707 (87.51 gm) may also have contributed to higher germination percentage. Sashtry *et al*. (2003) observed positive correlation between seed weight or seed size with germination and seedling vigour index.

The seedling growth parameters like shoot length, root length, and dry weight of seedling showed a significant difference due to seasons. This can be attributed to the higher 100 seed weight of seeds, which obviously produced better seedlings. Vigour index was statistically significant due to seasons. Higher seedling vigour index in fresh summer 2010 produced seeds was due to seeds being heavy with better food reserve which gave a higher germination percentage, root and shoot length. Therefore increased vigour index values were found to be of prime importance and is an important criteria for good plant stand. Similar results for such seasonal variation on quality parameters were also reported by Basavegowda and Nanjareddy (2008), Sastry *et al.* (2007) and Promchote *et al.* (2008).

The biochemical parameters such as oil content and protein content also was found to be affected by seasonal variations. In fresh Kharif seeds the highest oil content was registered by the genotype NRCG 6663 (50.31%). However in the summer groundnut genotypes stored for six months the highest

oil content was only 37.60% (ICGS 4849). The same trend was also observed for protein content (%). The highest protein content was registered in the variety GG-2 for both Kharif (29.26) and summer (26.00) but with significant reduction in the lower.

This difference may be due to abiotic factors such as rainfall, and other environmental parameters creating variation in seed quality parameters such as germination, seedling vigour index and 100 seed weight. Similar results for difference in oil content and protein content due to seasons was reported by Valizadeh (2001), Yaw *et al.* (2008) and Nkafamiya *et al.* (2010).

4.5.6. Variability

The knowledge of the nature and magnitude of variation present in base material is of great importance for effective selection of superior genotypes from breeding material. Hence, it is essential that base population should possess a large amount of heritable variation.

Varietal differences were found to be significant for all the characters in the present study, indicating presence of considerable amount of variability (Table 4.1.). Significant variation was observed for different traits *viz.,* pod yield per plant, plant height, secondary branches, shrivelled seeds, kernel yield per plant and hundred seed weight. The significant variation for these six yield related traits observed in the base population could be utilized to improve this crop by using simple breeding methods. The range of phenotypic variability was also found to be high for all the characters.

VI. SUMMARY AND CONCLUSION

The present investigation was carried out to estimate magnitude of "Seed viability parameters and maturity indices in groundnut *(Arachis hypogaea* L.) during *Kharif* & Summer."

The experimental material used for the present study comprised of fifty five groundnut genotypes. These genotypes were provided by Directorate of Groundnut Research, Junagadh, Main Oil Seed Research Station, JAU, Junagadh, International Crops Research Institute for the Semi -Arid Tropics (ICRISAT), Patancheru (A.P) and Regional Research Station, AAU, Anand.

Fifty five genotypes of groundnut were sown in un-replicated during summer 2010. A part of the groundnut produce harvested from summer 2010 was stored in cloth bags for laboratory studies. The rest of the groundnut produce was sown in Kharif 2010 in a Randomised complete Block Design (RCBD) in three replications.

Each entry was accommodated in shallow furrows opened at five cm away from fertilizer rows and at 5 cm between the seeds and the seeds hand dibbled in the furrows in 30 x 10 cm spacing.

Data were recorded on five randomly selected plants of each entry per replication for 17 characters *viz.,* germination percentage 5th day, germination percentage 10th day, plant height, number of primary branches per plant, number of secondary branches per plant, days to 50% flowering, number of mature pods per plant, number of immature pods per plant, hundred seed

weight, tightness of kernel in the hull, shelling turn out percent, sound mature kernel, harvest index, days to maturity, pod yield per plant, kernel yield per plant, shriveled seed, oil percentage and protein percentage. The method advocated by Panse and Sukhatme (1978) was followed to estimate variability parameters.

The stored seed from summer 2010 was observed for seed viability parameters both in fresh seed as well as after three months of storage. Eleven parameters such as seed imbibition capacity, seed germination count at 5^{th} and 10^{th} day, shoot and root length, shoot and root weight, shoot and root weight ratio, shoot and root dry weight and seed vigour index were studied. The same set of observations were studied in fresh Kharif 2010 seed also.

The SDS PAGE analysis for seed protein and esterase isozyme of fresh Kharif groundnut produce as well as the summer seed stored for six months was conducted to know the variation in protein and isozyme bands under storage.

The results of this study and the conclusions which can be drawn from it are as summarised below.

[1] The analysis of variance revealed significant differences among the genotypes for all the characters studied. This indicated the presence of sufficient variability in the experimental material.

[2] A wide range of phenotypic variability as indicated by high GCV and PCV value was recorded for pod yield per plant and its components traits.

[3] Higher phenotypic and genotypic variances as indicated by high GCV and PCV values were observed for days to 50 % flowering, days to maturity, pod yield per plant, oil percent and protein percent. Genotypic variance was found greater than environmental component of variance.

[4] In the present study high magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (H^2) and genetic advance as percentage of mean were recorded for various characters viz., pod yield per plant, hundred seed weight, harvest index, plant height and shelling turn out percent. This indicated that additive gene action was involved in the expression of these traits. Therefore more emphasis should be laid on these component traits, during selection programme for further improvement of pod yield per plant.

[5] High broad sense heritability estimates were recorded for most of traits *viz.,* hundred seed mass, secondary branches per plant, sound mature percentage, kernel yield per plant, harvest index, shelling turn out percent, pod yield per plant, shriveled seeds and plant height, indicating that these traits were less influenced by the environment. These traits can be improved by simple selection procedure.

[6] High genetic advance as percentage of mean was observed for pod yield per plant and harvest index and shriveled seeds. Which indicated the necessity of utilising these traits for crop improvement for groundnut.

[7] The seed viability studies indicated the effect of season and storage periods over the seed viability parameters. The genotypes behaved differently in different seasons and under different storage period. The summer groundnut seed lost the viability progressively under storage and showed poor germinability both in laboratory and field conditions. The groundnut seed stored for more than six months not only failed to germinate but developed fungal infection leading to total death.(Appendix No .I)

[8] Bio-chemical parameters such as oil content and protein content also showed variation for season and storage conditions. Under storage both oil and protein showed marked reduction in their content. The variation were clearly observed in SDS PAGE analysis of protein and esterase isozymes.

[9] Ten maturity indices represented by pod and seed phenotypes were applied to the 55 groundnut genotypes and separate phenotypic classes were made and genotypic frequencies were observed. The study revealed clear cut phenotypic classes which can be helpful for genetic diversity analysis and DUS testing.

[10] SDS PAGE Analysis.

SDS PAGE analysis of groundnut seed protein and esterase isozyme for summer and Kharif revealed that considerable number of genotypes showed maximum similarity (1.00) irrespective of the seasons which was forth one for summer and thirty nine for *Kharif.* Cluster analysis

using Jaccard co-efficient (NTSYS software) revealed three and four major clusters in Kharif and summer respectively. It was observed that genotypes with common phylogeny and geographical orientation tend to cluster together.

Similarly for esterase isozyme, fifty three and forty six genotypes showed 100 % genetic similarity between them. In this case also, Kharif and summer groundnut produced three and four clusters respectively.

The protein characterisation studies using SDS PAGE analysis revealed various type of banding pattern for stored summer and fresh *Kharif* seeds. One hundred percent polymorphism was observed both in *Kharif* and summer with PIC value 0.94 in both cases.

However the number of polymorphic bands observed in fresh Kharif seeds (769) and stored summer seeds (696) were different indicating that protein denaturation must have occurred during storage .

Similarly isozyme studies also indicated that the storage of summer seed contributed to less number of polymorphic bands in summer (101) as compared to Kharif (181). The lower PIC values observed for isozyme i.e, 0.73 (*Kharif*) and 0.69 (summer) indicate that characterisation using protein may give a more reliable estimate rather than isozymes.

On the whole, it can be concluded from this study that SDS PAGE analysis can be a robust technique for genetic diversity analysis as well as to study the degree of protein and isozyme in degradation during prolonged storage.

However biochemical markers such as protein and isozyme are

environmental sensitive and may not be as reliable an estimate like molecular markers which can be attempted for generating more authentic information.

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APPENDIX-II: Geographic and edaphic details of Anand.

Particulars	Details
Geographic situation	
Elevation	45.1 meter
Latitude	22^0-36’ N
Longitude	72^0-55’ E
Characteristics of soil	
(A) Mechanical properties	
1. Coarse sand (%)	0.9
2. Fine sand (%)	85.59
3. Silt (%)	6.25
4. Clay (%)	4.75
5. Texture class	Loamy sand
(B) Physical properties	
1. Bulk density (g/cc)	1.51
2. Particle density (g/cc)	2.65
3. Porosity (%)	43.40
4. Field capacity (%)	20.00
5. Permanent wilting point (%)	9.80
(C) Chemical properties	
1. Organic carbon (%)	0.15
2. Total nitrogen (%)	0.36
3. Available P (kg/ha)	88.20
4. Available K (kg/ha)	209.00
5. pH	≅ 7.7
EC dsm^{-1} (at 25^0 C) *0.11*	

APPENDIX-II: List of groundnut genotypes.

Apen. III: List of groundnut genotypes.

Sr. No.	Name of Genotype	Sources	Sr, No.	Name of Genotype	Sources
1	GG-2	Main Oilseed Research Station, Junagadh (GUJ).	43	ICGS-11615	Directorate of Groundnut Research Junagadh (GUJ)
2	GG-3		44	ICGS-13052	
3	GG-4		45	ICGS-13128	
4	GG-5		46	ICGS-13033	
5	GG-7		47	ICGS-36	
6	GAUG-10		48		
7	JL-24		49		
8	TG-37		50		
9	GG-12		51	ICGS-156	International Crops Research Institut for the Semi-Arid Tropics, Hyderabad, (AP).
10	GG-13		52	ICGS-221	
11	GG-14		53	ICGS-297	
12	GG-15		54	ICGS-405	
13	GG-16		55	ICGS-799	
14	GG-20		56	ICGS-2738	
15	BAV-13		57	ICGS-4729	
16	KADIRI-3		58	ICGS-4750	
17			59	ICGS-5016	
18			60	ICGS-5236	
19			61	ICGS-7827	
20			62	ICGS-9157	
21			63	ICGS-10554	
22			64	ICGS-10890	
23			65	ICGS-12625	
24			66	ICGS-13941	
25			67	ICGS-13942	
26	ICGS-1179	Directorate of Groundnut Research Junagadh (GUJ)	68		
27	ICGS-1703		79		
28	ICGS-4296		70		
29	ICGS-4849		71		
30	NRCG- 6563		72		
31	NRCG 6663		73		
32	NRCG 6682		74		
33	NRCG 6705		75		
34	NRCG 6707		76	AG-2006-14	Regional Research Station, AAU, Anand (GUJ).
35	NRCG 9000		77	AG-2006-15	
36	NRCG 9130		78		
37	NRCG 9185		79		
38	NRCG 9747		80		
39	NRCG 9949		81		
40			82		
41					
42					

Table 4.1. Analysis of variance for seventeen morphological characters in groundnut.

Source of variation	Mean sum of square		
	Replication	Genotype	Error
	2	54	110
Germination count at 5th day in field.	10.90	16.24*	2.43
Germination count at 10th day in field	2.04	3.08*	0.56
Plant height (cm).	0.45	1.65*	0.13
primary branches	0.24	2.93*	0.08
secondary branches	6.93	8.42*	1.88
Days to 50 % flowering.	29.28	502.11*	4.49
No of Mature pods / plants	15.90	10.52*	1.83
No of Immature pods / plants	78.36	7.56*	1.42
100seed weight (g).	35.37	28.86*	11.07
Tightness of kernel in the hull.	28.94	66.86*	2.84
Shelling per cent (S %).	0.01	0.04*	0.001
Sound mature kernel (SMK%)	179.14	40.36*	1.94
Harvest index (%)	15.50	182.03*	12.57
Days of Maturity.	24.47	13.30*	8.39
Pod yield per plant (g).	2.42	0.84*	0.02
Kernel yield per plant (g).	2.18	1.86*	0.32
Shrivelled seeds	1149.74	218.48*	43.69

*** Significant at 0.05 degree freedom.**

Table 4.1.1. Mean performance of groundnut genotype for various morphological parameters. (*Kharif* 2011)

Sr. No.	Parameters	Germination count at 5th day in field	Germination count at 10th day in field.	Plant height (cm).	Number of primary branches.	Number of secondary branches	Days to 50 % flowering.	No of Mature pods / plants	No of Immature pods / plants.	100seed weight (g).
	Genotypes	1	2	3	4	5	6	7	8	9
1	**GG-2**	25.67	68.30	32.38	5.33	4.06	34.51	10.80	3.40	68.38
2	**GG-3**	21.67	68.30	45.25	5.80	4.41	33.58	11.70	4.47	74.00
3	**GG-4**	27.00	41.70	33.52	5.77	5.14	33.15	9.13	3.40	71.83
4	**GG-5**	25.67	71.70	35.54	5.40	2.82	33.52	11.23	3.27	74.65
5	**GG-7**	27.33	81.70	33.39	6.16	4.94	34.95	10.81	2.83	66.96
6	**GAUG-10**	24.33	75.00	31.73	5.41	3.56	34.48	9.91	4.67	66.25
7	**JL-24**	27.33	81.70	38.03	5.40	4.12	31.91	12.31	2.67	67.07
8	**TG-37**	20.00	81.70	44.15	5.47	4.49	32.43	12.05	3.07	67.60
9	**GG-12**	25.33	81.70	29.98	5.20	3.66	33.31	10.99	3.93	64.19
10	**GG-13**	20.00	81.70	45.16	5.07	4.24	31.81	10.94	3.20	64.57
11	**GG-14**	27.67	78.30	33.31	5.73	4.43	33.48	12.68	3.07	81.28
12	**GG-15**	25.33	55.00	37.62	6.51	5.08	36.49	13.20	3.33	78.63
13	**GG-16**	24.67	81.70	38.96	5.33	2.69	34.48	12.77	2.53	43.65
14	**GG-20**	28.33	75.00	29.41	5.13	2.93	33.88	10.27	3.67	76.27
15	**BAV-13**	23.33	75.00	59.56	5.80	3.33	35.16	12.45	3.10	76.04
16	**KADIRI-3**	26.00	65.00	33.68	7.10	6.35	33.15	12.17	3.40	65.63
17	**ICGS-1179**	23.33	65.00	50.98	5.50	5.07	32.35	9.95	5.47	74.37
18	**ICGS-1703**	26.67	65.00	53.59	6.05	4.60	35.14	9.27	3.67	83.73
19	**ICGS-4296**	26.33	78.30	44.28	7.47	5.61	35.03	12.56	3.13	75.14
20	**ICGS-4849**	23.33	75.00	33.22	6.50	4.19	34.82	10.13	3.47	72.59
21	**NRCG-6563**	27.67	68.30	44.55	5.53	3.48	37.32	13.74	4.87	68.58
22	**NRCG--6663**	23.33	78.30	31.77	5.88	4.30	36.62	11.13	6.03	70.92
23	**NRCG--6682**	27.33	41.70	34.36	6.87	6.01	33.29	11.77	5.47	69.47
24	**NRCG--6705**	25.00	71.70	30.09	7.27	5.33	34.52	10.72	3.57	69.25
25	**NRCG-6707**	28.00	81.70	39.16	5.33	5.22	32.48	10.16	3.73	87.51
26	**NRCG-9000**	23.67	75.00	49.22	5.79	3.84	35.48	12.73	5.60	68.07
27	**NRCG-9130**	25.67	81.70	50.70	5.48	6.44	36.47	11.53	3.13	68.26
28	**NRCG-9185**	26.33	71.70	32.37	5.47	4.48	32.59	8.40	3.33	68.85
29	**NRCG-9231**	18.33	58.30	33.73	5.22	4.28	36.18	8.17	3.60	55.75
30	**NRCG-9747**	25.00	68.30	62.35	6.13	3.81	34.28	12.45	5.57	65.32
31	**NRCG-9949**	27.00	78.30	33.28	5.47	3.77	32.16	10.46	3.67	67.87

Table 4.1.1.Contd..

Sr. No	Parameters	Germination count at 5th day in field	Germination count at 10th day in field.	Plant height (cm).	Number of primary branches.	Number of secondary branches	Days to 50 % flowering.	No of Mature pods / plants	No of Immature pods / plants.	100seed weight (g).
	Genotypes	1	2	3	4	5	6	7	8	9
32	**ICGS-11615**	26.33	65.00	32.28	5.20	5.36	33.16	7.53	3.00	66.65
33	**ICGS-13052**	17.00	68.30	34.52	6.40	5.35	33.46	12.50	5.07	74.88
34	**ICGS-13128**	21.67	85.00	44.36	5.13	3.25	34.15	10.74	3.53	92.26
35	**ICGS-13033**	28.33	81.70	38.26	5.40	4.23	33.48	10.15	3.93	64.18
36	**ICGS-36**	26.00	78.30	33.98	6.33	3.47	35.16	11.73	3.23	68.93
37	**ICGS-156**	26.33	71.70	52.04	5.79	4.49	34.08	11.18	3.40	62.99
38	**ICGS-221**	28.67	68.30	45.88	7.19	6.55	37.92	11.07	3.10	81.86
39	**ICGS-297**	27.67	68.30	28.28	6.20	5.03	35.97	15.59	3.33	85.32
40	**ICGS-405**	17.67	61.70	33.76	7.30	5.34	33.58	10.57	3.47	66.35
41	**ICGS-799**	27.33	68.30	43.04	5.00	4.32	23.25	8.40	3.33	45.24
42	**ICGS-2738**	18.33	48.30	33.20	7.53	3.40	34.59	12.83	3.40	67.49
43	**ICGS-4729**	17.67	75.00	68.46	7.23	5.32	34.94	12.47	4.17	85.08
44	**ICGS-4750**	27.33	65.00	33.06	5.44	3.60	32.17	6.90	3.73	109.45
45	**ICGS-5016**	28.33	81.70	32.42	6.75	6.35	32.15	13.43	3.47	70.31
46	**ICGS-5236**	28.00	58.30	30.28	6.20	4.02	34.48	9.13	4.00	69.16
47	**ICGS-7827**	26.33	81.70	32.42	5.27	3.13	33.48	12.65	3.20	69.39
48	**ICGS-9157**	24.67	58.30	33.45	6.61	5.76	36.78	12.28	3.63	71.07
49	**ICGS-10554**	26.33	65.00	30.69	5.80	3.55	33.88	10.40	3.23	80.94
50	**ICGS-10890**	27.67	78.30	32.43	5.50	4.28	32.16	12.08	4.60	120.25
51	**ICGS-12625**	27.67	75.00	60.50	7.20	5.49	34.93	11.76	3.50	59.66
52	**ICGS-13941**	22.00	75.00	41.28	7.33	5.53	37.13	13.54	3.20	65.50
53	**ICGS-13942**	28.33	81.70	37.44	5.87	4.47	34.48	11.00	3.87	74.11
54	**AG-2006-14**	25.67	81.40	38.14	5.40	3.46	35.48	9.02	4.27	99.76
55	**AG-2006-15**	24.67	81.10	32.48	5.17	3.20	33.15	10.00	3.53	97.27
General mean		**17**	**41.70**	**39.05**	**5.96**	**4.47**	**34.07**	**11.15**	**4.28**	**72.74**
Minimum		**25.03**	**71.73**	**28.28**	**5.00**	**2.69**	**23.25**	**6.90**	**2.53**	**43.65**
Maximum		**28.67**	**85.00**	**68.46**	**7.53**	**6.55**	**37.92**	**15.59**	**6.03**	**120.25**
S.Ed		**0.09**	**0.43**	**0.21**	**0.16**	**0.79**	**1.22**	**0.78**	**0.69**	**1.92**
C.D at 0.05		**2.25**	**1.21**	**0.59**	**0.44**	**2.22**	**3.43**	**2.19**	**1.93**	**5.39**
CV%		**8.33**	**13.29**	**11.49**	**6.13**	**6.20**	**8.50**	**12.28**	**8.66**	**2.91**

Table 4.1.1. Contd..

	Parameters	Tightness of kernel in the hull.	Shelling per cent (S %).	(SMK%).	Harvest index (%)	Days of Maturity.	Pod yield per plant (g).	Kernel yield per plant (g).	Shrivelled seeds.
	Genotypes	10	11	12	13	14	15	16	17
1	**GG-2**	54.00	52.54	76.81	15.00	96.33	69.76	14.20	29.00
2	**GG-3**	58.48	56.13	78.21	13.67	97.00	78.67	16.16	23.00
3	**GG-4**	45.67	56.10	89.54	11.33	100.00	63.46	12.53	21.00
4	**GG-5**	56.13	54.43	82.65	12.67	117.33	82.79	14.49	10.00
5	**GG-7**	54.05	54.89	84.33	10.00	99.67	71.62	13.64	19.00
6	**GAUG-10**	49.53	53.10	89.43	11.67	105.67	58.74	14.57	18.00
7	**JL-24**	61.57	49.80	82.54	15.33	121.33	78.75	14.98	14.00
8	**TG-37**	60.25	48.21	85.99	14.33	118.67	73.68	15.12	24.00
9	**GG-12**	54.93	50.98	84.10	11.33	112.33	64.31	14.92	23.00
10	**GG-13**	54.72	56.21	75.88	15.33	118.00	70.57	14.14	25.00
11	**GG-14**	63.40	50.17	76.99	11.33	117.67	102.36	15.75	26.00
12	**GG-15**	66.00	47.67	84.92	13.00	102.00	98.66	16.53	28.00
13	**GG-16**	63.83	54.88	76.12	14.33	118.00	42.98	15.30	37.00
14	**GG-20**	51.33	52.33	73.90	13.33	116.33	77.23	13.93	25.00
15	**BAV-13**	62.25	47.61	75.53	13.00	101.33	94.13	15.55	27.67
16	**KADIRI-3**	65.94	50.65	85.09	12.33	116.00	81.76	15.57	31.67
17	**ICGS-1179**	49.73	57.52	81.20	16.00	116.67	66.42	15.41	32.67
18	**ICGS-1703**	46.33	55.66	85.32	14.00	108.33	75.79	12.93	23.67
19	**ICGS-4296**	62.80	52.66	78.02	11.67	100.67	92.41	15.69	15.67
20	**ICGS-4849**	49.99	61.43	92.47	10.67	117.33	66.68	13.60	15.67
21	**NRCG-6563**	68.72	51.50	82.86	10.00	94.33	85.32	18.61	17.67
22	**NRCG--6663**	55.67	57.91	80.44	13.33	115.00	70.66	17.17	22.67
23	**NRCG--6682**	58.83	57.43	89.33	13.67	119.00	77.30	17.23	33.67
24	**NRCG--6705**	53.62	53.77	87.88	13.33	116.67	72.28	14.29	12.67
25	**NRCG-6707**	50.78	53.22	79.87	14.33	118.33	67.45	13.89	17.00
26	**NRCG-9000**	63.67	52.54	85.54	13.00	116.33	113.71	18.33	36.00
27	**NRCG-9130**	57.65	57.98	85.77	15.00	118.00	74.08	14.66	23.33
28	**NRCG-9185**	42.00	56.64	86.43	13.67	109.00	55.66	11.73	12.33
29	**NRCG-9231**	40.83	54.10	76.90	17.00	106.67	40.21	11.77	22.33
30	**NRCG-9747**	62.27	57.87	77.77	15.00	118.00	80.85	18.02	15.33
31	**NRCG-9949**	52.30	50.76	81.77	13.00	118.00	68.58	14.13	14.33

Table 4.1.1. Contd..

Sr. No.	Parameters	Tightness of kernel in the hull.	Shelling per cent (S %).	(SMK%).	Harvest index (%)	Days of Maturity.	Pod yield per plant (g).	Kernel yield per plant (g).	Shrivelled seeds.
	Genotypes	10	11	12	13	14	15	16	17
32	**ICGS-11615**	37.67	48.31	84.43	13.00	99.00	44.44	10.53	18.33
33	**ICGS-13052**	62.50	56.34	77.00	14.33	114.33	84.87	17.57	18.33
34	**ICGS-13128**	53.70	46.91	74.60	13.67	118.00	97.59	14.27	28.33
35	**ICGS-13033**	50.75	48.98	87.75	14.67	113.67	65.54	14.08	29.33
36	**ICGS-36**	58.67	54.66	84.35	16.00	117.33	74.87	14.97	35.33
37	**ICGS-156**	55.90	48.76	84.86	13.33	118.67	34.69	14.58	23.33
38	**ICGS-221**	55.33	43.43	79.50	17.00	104.33	91.22	14.17	22.33
39	**ICGS-297**	77.93	52.31	79.54	14.00	104.67	132.62	18.92	21.33
40	**ICGS-405**	52.83	54.10	86.86	13.33	115.33	68.52	14.03	25.00
41	**ICGS-799**	42.00	56.11	76.55	13.67	118.33	33.18	11.73	23.67
42	**ICGS-2738**	64.13	53.34	84.42	13.33	116.67	80.01	16.23	25.67
43	**ICGS-4729**	67.85	50.66	84.44	14.00	118.33	103.69	16.63	26.67
44	**ICGS-4750**	34.48	57.87	76.54	15.00	118.33	75.68	10.63	12.67
45	**ICGS-5016**	67.17	51.57	84.44	15.67	115.33	89.23	16.90	24.67
46	**ICGS-5236**	45.67	56.14	86.43	15.67	104.00	60.10	13.13	35.67
47	**ICGS-7827**	63.23	46.77	84.10	12.33	121.00	86.83	15.85	24.67
48	**ICGS-9157**	61.42	56.09	79.31	15.00	115.33	93.05	15.92	22.67
49	**ICGS-10554**	52.00	55.21	86.41	14.33	117.00	84.37	13.63	25.67
50	**ICGS-10890**	60.42	52.67	85.11	14.67	117.67	145.38	16.68	33.67
51	**ICGS-12625**	58.78	50.21	86.34	14.67	98.33	62.71	15.26	31.67
52	**ICGS-13941**	65.83	47.37	79.72	15.67	106.00	86.82	16.74	32.67
53	**ICGS-13942**	55.00	57.52	76.32	14.67	99.67	82.58	14.87	29.67
54	**AG-2006-14**	45.08	53.87	91.07	12.33	107.33	88.58	13.28	26.67
55	**AG-2006-15**	50.00	53.59	75.65	14.67	113.33	98.68	13.53	26.67
General mean		**55.92**	**53.08**	**82.35**	**111.67**	**14.89**	**77.86**	**3.74**	**24.02**
Minimum		**34.48**	**43.43**	**73.90**	**10.00**	**94.33**	**33.18**	**10.53**	**10**
Maximum		**77.93**	**61.43**	**92.47**	**17.00**	**121.33**	**145.38**	**18.92**	**37**
S.Ed		**0.97**	**0.02**	**0.97**	**2.05**	**1.67**	**0.09**	**0.33**	**3.82**
C.D at 0.05		**2.72**	**0.07**	**2.72**	**5.74**	**4.69**	**0.25**	**0.92**	**10.71**
C.V. %		**11.82**	**2.63**	**2.04**	**3.17**	**9.09**	**12.75**	**14.19**	**4.56**

Table 4.1.2.1. Mean performances of groundnut genotypes for various seed viability parameters (Fresh seed of Summer 2010).

Sr. No.	Parameters	Water imbibing capacity	Germination count at 5th day	Germination count at 10th day	Root length(cm)	Shoot length (cm).	Root length and shoot length ratio	Fresh Shoot weight (gm/seedling).	Dry Shoot weight (gm/seedling).	Fresh root weight (gm/seedling).	Dry root weight (gm)	Seed vigour index.
	Genotypes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	**GG-2**	1.50	68.31	90.04	6.63	3.78	1.71	0.50	0.39	1.55	0.18	999.49
2	**GG-3**	1.06	69.03	91.37	4.59	4.14	1.11	0.53	0.42	2.28	0.19	846.22
3	**GG-4**	0.95	61.76	84.52	5.84	3.98	1.41	0.70	0.59	2.76	0.27	962.92
4	**GG-5**	0.84	50.94	77.99	5.77	4.64	1.22	0.48	0.37	1.77	0.20	800.09
5	**GG-7**	0.95	48.16	83.74	3.77	2.94	1.30	0.65	0.54	1.62	0.20	618.52
6	**GAUG-10**	1.06	44.84	90.73	5.44	4.03	1.41	0.62	0.51	2.32	0.28	934.47
7	**JL-24**	1.24	54.03	91.60	7.21	2.84	2.61	0.58	0.47	1.79	0.20	895.39
8	**TG-37**	1.03	44.40	86.76	7.24	3.37	2.18	0.45	0.22	0.83	0.11	905.90
9	**GG-12**	1.15	52.64	84.77	3.49	2.51	1.40	0.59	0.48	2.00	0.18	643.77
10	**GG-13**	1.11	50.50	91.44	3.62	6.81	0.85	0.52	0.41	1.95	0.19	1012.07
11	**GG-14**	1.07	73.81	93.17	4.79	4.73	1.00	0.46	0.35	1.72	0.22	885.22
12	**GG-15**	1.06	48.22	84.03	3.42	4.36	0.79	0.52	0.41	1.99	0.14	744.58
13	**GG-16**	1.03	50.80	85.23	4.53	4.95	0.93	0.59	0.48	1.99	0.24	902.47
14	**GG-20**	0.90	40.47	85.37	5.54	5.26	1.04	0.49	0.38	2.13	0.23	969.02
15	**BAV-13**	0.98	61.90	89.67	6.97	2.56	2.85	0.92	0.37	1.52	0.18	843.21
16	**KADIRI-3**	0.93	61.37	84.56	5.83	7.28	0.81	0.91	0.46	1.55	0.15	1068.54
17	**ICGS-1179**	0.96	45.98	85.86	5.77	3.23	1.77	0.98	0.42	1.82	0.16	809.28
18	**ICGS-1703**	0.85	56.41	85.04	4.92	2.73	1.81	0.57	0.17	1.02	0.11	815.69
19	**ICGS-4296**	0.95	67.16	92.62	4.74	3.27	1.43	0.87	0.43	1.08	0.10	742.62
20	**ICGS-4849**	0.78	50.70	77.98	4.64	4.80	0.97	0.96	0.52	1.47	0.18	873.87
21	**NRCG-6563**	0.90	54.98	87.41	6.01	2.98	2.05	0.91	0.30	1.31	0.15	844.45
22	**NRCG--6663**	0.99	58.02	95.51	3.70	2.80	1.31	0.78	0.50	1.74	0.20	703.05
23	**NRCG--6682**	0.93	66.68	93.34	4.73	5.17	0.92	0.93	0.34	1.55	0.12	945.06
24	**NRCG--6705**	0.95	63.18	89.20	5.47	3.98	1.40	0.91	0.60	1.68	0.21	865.24
25	**NRCG-6707**	0.98	63.99	96.56	8.43	4.09	2.12	0.86	0.47	2.36	0.17	1274.70
26	**NRCG-9000**	0.81	47.29	84.13	8.47	5.20	1.62	0.83	0.43	2.22	0.13	1052.87
27	**NRCG-9130**	0.88	43.78	89.08	5.14	3.60	1.41	0.81	0.51	2.35	0.11	931.04
28	**NRCG-9185**	1.28	56.52	84.51	4.49	4.99	0.89	0.53	0.40	1.82	0.17	940.28
29	**NRCG-9231**	1.66	50.17	87.64	4.60	3.69	1.22	0.75	0.62	2.28	0.14	795.81
30	**NRCG-9747**	0.99	47.22	82.22	5.67	4.41	1.08	0.86	0.73	2.47	0.25	708.81
31	**NRCG-9949**	0.87	55.98	89.10	6.50	3.52	1.84	0.49	0.36	1.50	0.17	936.98

Table 4.1.2.1. Contd..

Sr. No.	Parameters	Water imbibing capacity	Germination count at 5th day	Germination count at 10th day	Root length(cm)	Shoot length (cm).	Root length and shoot length ratio	Fresh Shoot weight (gm/seedling).	Dry Shoot weight (gm/seedling).	Fresh root weight (gm/seedling).	Dry root weight (gm)	Seed vigour index.
	Genotypes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
32	**ICGS-11615**	1.97	47.42	85.50	5.36	6.14	0.80	0.55	0.42	1.64	0.19	924.49
33	**ICGS-13052**	1.12	56.12	91.88	6.79	4.79	1.37	0.73	0.60	1.72	0.16	1052.83
34	**ICGS-13128**	0.97	52.13	72.41	7.01	6.02	1.22	0.54	0.41	2.06	0.22	919.99
35	**ICGS-13033**	0.93	51.17	85.99	5.77	5.63	1.13	0.97	0.84	1.36	0.15	1041.81
36	**ICGS-36**	1.31	55.21	85.54	4.89	3.47	1.34	0.95	0.81	1.82	0.18	769.00
37	**ICGS-156**	1.22	50.30	76.94	6.22	3.89	1.41	0.89	0.76	1.43	0.21	849.76
38	**ICGS-221**	1.47	47.26	90.86	6.71	4.72	1.66	0.84	0.71	1.57	0.20	1050.70
39	**ICGS-297**	1.03	58.26	84.60	7.24	5.68	1.29	0.64	0.51	1.36	0.18	1026.87
40	**ICGS-405**	0.88	55.31	84.89	7.60	3.68	2.10	0.66	0.53	1.78	0.22	898.72
41	**ICGS-799**	0.97	48.12	76.98	5.42	4.52	1.21	0.92	0.82	1.67	0.23	894.81
42	**ICGS-2738**	0.89	44.38	82.91	6.59	5.47	1.21	0.97	0.91	1.59	0.19	954.51
43	**ICGS-4729**	1.06	41.78	85.63	8.54	4.82	1.76	0.92	0.81	1.60	0.21	1084.93
44	**ICGS-4750**	0.89	51.64	94.03	7.96	3.38	2.40	0.93	0.83	1.40	0.21	1103.83
45	**ICGS-5016**	0.84	53.36	84.37	5.23	3.69	1.43	0.87	0.77	1.89	0.22	702.95
46	**ICGS-5236**	0.87	38.19	72.67	5.68	4.59	1.24	0.91	0.81	2.20	0.27	759.80
47	**ICGS-7827**	0.98	50.53	87.94	4.96	3.64	1.36	0.88	0.78	1.47	0.15	855.44
48	**ICGS-9157**	0.77	54.04	84.97	6.71	4.77	1.42	0.91	0.81	1.67	0.19	963.18
49	**ICGS-10554**	0.96	52.61	91.18	8.03	5.42	1.48	0.97	0.87	1.79	0.15	1118.09
50	**ICGS-10890**	0.86	60.13	88.63	4.47	3.59	1.24	0.88	0.78	1.52	0.18	789.84
51	**ICGS-12625**	1.00	51.64	81.34	4.57	6.57	0.73	0.92	0.82	1.81	0.20	926.58
52	**ICGS-13941**	0.88	54.24	85.40	3.78	4.57	0.84	0.71	0.61	1.53	0.19	818.90
53	**ICGS-13942**	1.23	54.54	91.41	7.03	3.60	1.95	0.78	0.68	1.52	0.20	1069.77
54	**AG-2006-14**	0.89	52.37	88.04	5.38	2.82	1.89	0.93	0.83	1.68	0.22	761.03
55	**AG-2006-15**	1.00	47.89	62.42	4.40	3.80	1.16	0.61	0.51	1.30	0.13	632.78
General mean		**0.58**	**53.4**	**86.00**	**5.71**	**4.28**	**1.41**	**0.75**	**0.56**	**1.74**	**0.19**	**895.31**
Minimum		**0.77**	**38.19**	**62.42**	**3.42**	**2.51**	**0.79**	**0.45**	**0.17**	**0.83**	**0.10**	**618.52**
Maximum		**1.97**	**73.81**	**96.56**	**8.54**	**7.28**	**2.85**	**0.98**	**0.91**	**2.76**	**0.28**	**1274.70**
S.Ed		**0.031**	**0.12**	**0.43**	**0.29**	**0.09**	**0.06**	**0.07**	**0.07**	**0.15**	**0.02**	**16.17**
C.D at 0.05		**0.088**	**0.35**	**1.23**	**0.83**	**0.27**	**0.18**	**0.19**	**0.19**	**0.42**	**0.06**	**45.43**
C.V. %		**2.39**	**4.09**	**4.23**	**4.91**	**3.88**	**2.87**	**2.14**	**4.09**	**3.91**	**3.11**	**3.15**

Table 4.1.2.2. Seed viability parameters (after 3 months of storage of summer 2010 seed.)

Results and Discussion

Sr. No.	Parameters	Water imbibing capacity	Germination count at 5th day	Germination count at 10th day	Root length(cm)	Shoot length (cm).	Root length and shoot length ratio	Fresh Shoot wt. (mg/seedling).	Shoot dry wt. (mg/seedling).	Fresh root wt. (mg/seedling).	Root dry weight	Seed vigour index.

	Genotypes	1	2	3	4	5	6	7	8	9	10	11
1	**GG-2**	0.83	69.10	81.40	6.70	3.71	1.66	0.57	0.39	1.63	0.16	939.32
2	**GG-3**	0.39	68.20	74.60	4.57	4.13	1.10	0.84	0.42	2.24	0.17	700.05
3	**GG-4**	0.28	63.80	82.10	5.80	4.13	1.16	0.65	0.59	2.7	0.25	1122.84
4	**GG-5**	0.17	51.70	81.90	5.80	4.62	1.19	0.54	0.37	1.76	0.18	725.91
5	**GG-7**	0.28	48.00	84.30	3.80	2.92	1.35	0.58	0.54	1.71	0.18	644.05
6	**GAUG-10**	0.39	45.80	90.70	5.43	4.00	1.51	0.49	0.51	2.33	0.26	985.1
7	**JL-24**	0.57	53.40	92.00	7.14	2.78	2.74	0.68	0.47	1.77	0.18	742.35
8	**TG-37**	0.36	44.70	84.80	7.02	3.33	2.20	0.68	0.22	0.88	0.09	741.14
9	**GG-12**	0.48	53.10	72.80	3.47	2.53	1.40	0.70	0.48	2.01	0.17	749.77
10	**GG-13**	0.44	50.70	85.60	3.57	6.73	0.58	0.77	0.41	1.95	0.17	961.3
11	**GG-14**	0.40	72.00	81.10	4.77	4.69	0.97	0.68	0.35	1.75	0.19	667.87
12	**GG-15**	0.39	48.20	85.80	3.40	4.37	0.81	0.64	0.41	2.00	0.12	852.22
13	**GG-16**	0.36	51.20	75.20	4.50	4.96	0.95	0.62	0.48	2.07	0.21	899.71
14	**GG-20**	0.23	40.90	94.60	5.53	5.17	1.02	0.73	0.38	2.13	0.21	1061.85
15	**BAV-13**	0.31	63.50	84.80	7.00	2.67	2.77	0.51	0.37	1.47	0.16	695.72
16	**KADIRI-3**	0.26	61.40	81.60	5.90	7.26	0.81	0.86	0.46	1.70	0.13	873.19
17	**ICGS-1179**	0.29	46.10	83.90	5.80	3.15	1.81	0.66	0.42	2.27	0.15	759.22
18	**ICGS-1703**	0.18	56.10	87.30	4.87	2.77	1.79	0.43	0.17	1.69	0.10	1059.7
19	**ICGS-4296**	0.28	67.00	83.70	4.73	3.20	1.42	0.69	0.43	0.75	0.09	562.62
20	**ICGS-4849**	0.11	50.90	86.10	4.63	4.75	0.97	0.52	0.52	1.30	0.16	1119.6
21	**NRCG-6563**	0.23	55.10	94.40	6.03	3.01	2.10	0.69	0.30	1.52	0.14	925.56
22	**NRCG--6663**	0.32	57.60	93.40	3.70	2.75	1.31	0.70	0.50	1.39	0.19	772.87
23	**NRCG--6682**	0.26	66.90	91.90	4.70	5.10	0.93	0.70	0.34	1.92	0.12	860.9
24	**NRCG--6705**	0.28	62.70	87.10	5.40	3.93	1.44	0.74	0.60	1.35	0.20	779.16
25	**NRCG-6707**	0.31	63.60	94.60	8.40	3.97	2.26	0.67	0.47	1.85	0.17	1264.94
26	**NRCG-9000**	0.14	47.20	90.60	8.50	5.18	1.62	0.84	0.43	2.56	0.13	845.72
27	**NRCG-9130**	0.21	44.10	97.40	5.13	3.60	1.37	0.80	0.51	2.25	0.11	1204.61
28	**NRCG-9185**	0.61	55.70	85.30	4.57	4.97	0.90	0.90	0.40	2.35	0.16	1128.5
29	**NRCG-9231**	0.99	50.30	74.20	4.80	3.67	1.22	0.71	0.62	1.48	0.12	737.2
30	**NRCG-9747**	0.32	47.50	94.60	7.30	4.33	1.06	0.58	0.73	2.64	0.23	610.09
31	**NRCG-9949**	0.20	8.48	81.40	4.80	3.57	1.30	0.53	0.36	2.29	0.15	729.19

Table 4.1.2.2. contd.

Sr. No.	**Parameters**	Water imbibing capacity	Germination count at 5th day	Germination count at 10th day	Root length(cm)	Shoot length (cm).	Root length/ shoot length	Fresh Shoot wt. (mg/seedling).	Shoot dry wt. (mg/seedling) .	Fresh root wt. (mg/seedling).	Root dry weight	Seed vigour index.

	Genotypes	1	2	3	4	5	6	7	8	9	10	11
32	**ICGS-11615**	1.30	47.40	75.70	6.47	6.13	0.83	0.42	0.66	1.13	0.18	691.74
33	**ICGS-13052**	0.45	54.90	87.50	7.27	4.77	1.37	0.6	0.4	1.95	0.14	921.09
34	**ICGS-13128**	0.30	52.20	47.20	6.43	5.97	1.25	0.41	0.73	1.56	0.20	387.86
35	**ICGS-13033**	0.26	51.90	84.10	4.60	5.70	1.11	0.84	0.3	1.31	0.14	933.64
36	**ICGS-36**	0.64	55.90	90.60	5.47	3.50	1.34	0.84	0.48	1.83	0.16	856.41
37	**ICGS-156**	0.55	50.30	81.00	7.87	3.87	1.46	0.76	0.39	1.41	0.19	1042.79
38	**ICGS-221**	0.80	47.60	95.88	4.43	4.77	1.63	0.71	0.36	1.57	0.18	864.81
39	**ICGS-297**	0.36	58.30	91.30	7.13	5.73	1.28	0.51	0.31	1.36	0.17	861.85
40	**ICGS-405**	0.21	56.10	83.50	7.50	3.73	2.12	0.53	0.54	1.77	0.20	648.42
41	**ICGS-799**	0.30	47.90	82.20	5.37	4.57	1.21	0.82	0.35	1.65	0.21	1090.43
42	**ICGS-2738**	0.22	44.40	91.60	6.57	5.40	1.22	0.91	0.42	1.60	0.17	932.58
43	**ICGS-4729**	0.39	41.80	94.80	8.50	4.77	1.76	0.91	0.56	1.57	0.18	976.45
44	**ICGS-4750**	0.22	51.50	94.60	7.79	3.43	2.40	0.83	0.51	1.47	0.19	1062.7
45	**ICGS-5016**	0.17	52.80	91.60	5.20	3.67	1.43	0.77	0.48	1.90	0.20	549.65
46	**ICGS-5236**	0.20	38.10	75.90	5.73	4.57	1.25	0.81	0.57	2.21	0.25	708.57
47	**ICGS-7827**	0.31	50.80	94.00	4.97	3.63	1.35	0.78	0.43	1.39	0.13	991.45
48	**ICGS-9157**	0.10	54.30	93.10	6.73	4.80	1.43	0.81	0.60	1.67	0.17	922.85
49	**ICGS-10554**	0.29	53.00	83.70	8.00	5.37	1.48	0.87	0.44	1.83	0.13	678.14
50	**ICGS-10890**	0.19	60.60	84.40	4.50	3.57	1.26	0.78	0.37	1.51	0.16	793.93
51	**ICGS-12625**	0.33	51.80	76.50	4.50	6.60	0.79	0.82	0.38	1.77	0.17	797.6
52	**ICGS-13941**	0.21	54.80	94.70	3.73	4.50	0.86	0.61	0.38	1.53	0.16	986.1
53	**ICGS-13942**	0.56	53.80	86.10	7.00	3.55	1.96	0.68	0.41	1.53	0.17	1087.09
54	**AG-2006-14**	0.22	52.90	94.70	5.43	2.77	1.90	0.83	0.53	1.67	0.20	779.74
55	**AG-2006-15**	0.33	47.20	90.80	4.40	3.81	1.16	0.51	0.62	1.26	0.11	992.36
General mean		**0.49**	**51.00**	**86.2**	**8.62**	**4.26**	**1.41**	**68.83**	**0.45**	**1.74**	**0.167**	**859.65**
Minimum		**0.10**	**38.10**	**47.2**	**4.72**	**2.53**	**0.58**	**0.69**	**0.17**	**0.75**	**0.09**	**387.86**
Maximum		**1.30**	**72.00**	**95.88**	**8.50**	**7.26**	**2.77**	**0.91**	**0.73**	**2.70**	**0.26**	**1264.94**
S.Ed		**0.014**	**0.012**	**0.14**	**0.16**	**0.084**	**0.037**	**0.33**	**0.41**	**0.0058**	**0.82**	**86.29**
C.D at 0.05		**0.041**	**0.36**	**0.40**	**3.52**	**0.24**	**0.11**	**0.9**	**0.87**	**0.016**	**5.99**	**241.89**
C.V %		**4.21**	**4.14**	**2.24**	**3.68**	**3.41**	**4.62**	**5.02**	**4.43**	**5.2**	**3.05**	**4.56**

Table 4.1.2.3 Seed viability parameters (Fresh seed of Kharif 2010)

Sr. No.	Parameters	Water imbibing	Germination count at 5th	Germination count at10th	Shoot length(cm)	Root length	Root length and shoot	Fresh Shoot weight	Dry Shoot weight	Fresh root weight	Dry Shoot weight	Seed vigour index.

		capacity	day	day		(cm).	length ratio	(mg/seedling	(mg/seedling).	(mg/seedling).	(mg/seedling).	
	Genotypes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	**GG-2**	0.06	66.88	78.84	4.80	6.73	1.41	0.81	0.60	1.67	0.13	968.49
2	**GG-3**	0.11	65.98	72.04	4.75	4.63	0.98	0.52	0.45	1.52	0.14	815.22
3	**GG-4**	0.14	61.58	79.54	5.18	8.20	1.64	0.84	0.43	2.25	0.22	931.92
4	**GG-5**	0.17	49.48	79.34	3.67	5.20	1.42	0.77	0.48	1.9	0.15	769.09
5	**GG-7**	0.18	45.78	81.74	2.77	4.87	1.76	0.43	0.15	0.71	0.15	587.52
6	**GAUG-10**	0.19	43.58	88.14	3.57	7.30	2.05	0.53	0.36	1.13	0.23	903.47
7	**JL-24**	0.19	51.18	89.44	3.57	4.50	1.26	0.78	0.37	1.51	0.15	864.39
8	**TG-37**	0.20	42.48	82.24	3.60	5.13	1.43	0.80	0.51	2.35	0.06	874.9
9	**GG-12**	0.20	50.88	70.24	4.57	5.73	1.25	0.81	0.57	2.21	0.14	612.77
10	**GG-13**	0.21	48.48	83.04	3.73	7.50	2.01	0.53	0.54	1.77	0.14	981.07
11	**GG-14**	0.21	69.78	78.54	4.50	3.73	0.83	0.61	0.38	1.53	0.16	854.22
12	**GG-15**	0.22	45.98	83.24	4.13	5.80	1.44	0.65	0.59	2.59	0.09	713.58
13	**GG-16**	0.22	48.98	72.64	5.40	6.57	1.22	0.71	0.42	1.60	0.18	871.47
14	**GG-20**	0.22	38.68	92.04	3.43	7.79	2.28	0.83	0.51	1.47	0.18	938.02
15	**BAV-13**	0.22	61.28	82.24	2.77	5.43	1.97	0.83	0.53	1.67	0.13	812.21
16	**KADIRI-3**	0.23	59.18	79.04	5.17	5.53	1.08	0.73	0.38	2.13	0.10	1037.54
17	**ICGS-1179**	0.23	43.88	81.34	3.01	6.03	2.00	0.69	0.30	1.39	0.12	775.28
18	**ICGS-1703**	0.25	53.88	84.74	5.70	6.43	1.13	0.84	0.30	1.31	0.07	781.69
19	**ICGS-4296**	0.26	64.78	81.14	2.92	3.80	1.31	0.58	0.54	1.71	0.06	708.62
20	**ICGS-4849**	0.26	48.68	83.54	7.11	5.90	0.83	0.86	0.46	1.7	0.13	839.87
21	**NRCG-6563**	0.26	52.88	91.84	5.10	4.70	0.92	0.70	0.34	1.35	0.11	810.45
22	**NRCG--6663**	0.27	55.38	94.84	3.20	4.73	1.48	0.69	0.43	1.3	0.16	669.05
23	**NRCG--6682**	0.29	64.68	89.34	2.37	7.00	2.70	0.51	0.37	1.47	0.09	911.06
24	**NRCG--6705**	0.29	60.48	84.54	3.15	5.80	1.85	0.66	0.42	1.69	0.17	831.24
25	**NRCG-6707**	0.29	61.38	92.04	5.37	8.00	1.49	0.87	0.44	1.83	0.14	1240.7
26	**NRCG-9000**	0.30	44.98	88.04	3.93	5.40	1.37	0.74	0.60	1.85	0.1	1018.87
27	**NRCG-9130**	0.30	41.88	94.84	3.97	8.40	2.14	0.67	0.47	2.56	0.08	897.04
28	**NRCG-9185**	0.30	53.48	82.74	5.97	7.27	1.22	0.71	0.65	2.27	0.13	906.28
29	**NRCG-9231**	0.30	48.08	71.64	4.57	5.37	1.18	0.82	0.35	1.65	0.09	761.81
30	**NRCG-9747**	0.31	45.28	92.04	2.75	3.70	1.35	0.70	0.50	1.92	0.2	674.81
31	**NRCG-9949**	0.31	62.60	78.84	3.63	4.97	1.37	0.78	0.43	1.39	0.12	902.98

Table 4.1.2.3 contd..

Sr. No.	**Parameters**	Water imbibing capacity	Germination count at 5th day	Germination count at 10th day	Shoot length(cm)	Root length (cm).	Root length and shoot ratio	Fresh Shoot weight (mg/seedling	Dry Shoot weight (mg/seedling).	Fresh root weight (mg/seedling).	Dry Shoot weight (mg/seedling)	Seed vigour index.

	Genotypes	1	2	3	4	5	6	7	8	9	10	11
32	**ICGS-11615**	0.32	45.15	73.14	4.33	4.80	1.11	0.78	0.63	2.29	0.15	890.49
33	**ICGS-13052**	0.33	52.65	84.94	3.33	7.20	2.16	0.68	0.22	0.88	0.11	1018.83
34	**ICGS-13128**	0.33	49.95	44.64	3.81	4.40	1.16	0.71	0.62	1.26	0.17	885.99
35	**ICGS-13033**	0.34	49.65	81.54	6.60	4.50	0.68	0.82	0.38	1.77	0.11	1003.81
36	**ICGS-36**	0.36	53.65	88.04	4.96	4.50	0.91	0.62	0.48	2.07	0.13	731
37	**ICGS-156**	0.36	48.05	78.44	5.73	7.13	1.25	0.51	0.31	1.36	0.16	811.76
38	**ICGS-221**	0.38	45.35	76.84	4.13	4.57	1.11	0.84	0.42	2.24	0.15	1012.7
39	**ICGS-297**	0.39	56.05	88.74	4.00	5.43	1.36	0.49	0.51	2.33	0.14	988.87
40	**ICGS-405**	0.39	53.85	80.94	4.37	3.14	0.78	0.64	0.41	2.00	0.17	860.72
41	**ICGS-799**	0.39	45.65	79.64	4.77	8.31	1.78	0.91	0.56	1.57	0.18	856.81
42	**ICGS-2738**	0.41	42.15	95.04	4.69	4.77	1.02	0.68	0.35	1.75	0.14	916.51
43	**ICGS-4729**	0.43	39.55	92.24	6.73	3.57	0.53	0.77	0.41	1.95	0.15	1046.93
44	**ICGS-4750**	0.45	49.25	92.04	4.77	6.47	1.36	0.60	0.40	1.56	0.16	1065.83
45	**ICGS-5016**	0.48	50.55	89.04	2.53	3.47	1.37	0.70	0.48	2.01	0.17	664.95
46	**ICGS-5236**	0.55	35.85	73.34	3.87	5.47	1.42	0.76	0.39	1.41	0.22	721.8
47	**ICGS-7827**	0.56	48.55	91.44	3.55	7.00	1.97	0.68	0.41	1.53	0.10	817.44
48	**ICGS-9157**	0.57	52.05	90.54	2.78	7.14	2.58	0.68	0.47	1.77	0.14	925.18
49	**ICGS-10554**	0.64	50.75	81.14	3.50	4.60	1.31	0.84	0.48	1.83	0.10	1080.09
50	**ICGS-10890**	0.65	58.35	81.84	4.97	4.43	0.89	0.79	0.40	1.48	0.13	751.84
51	**ICGS-12625**	0.76	49.55	73.94	4.62	5.80	1.26	0.54	0.37	1.76	0.14	888.58
52	**ICGS-13941**	0.79	52.55	92.14	3.71	6.70	1.81	0.57	0.39	1.63	0.13	780.9
53	**ICGS-13942**	0.80	51.55	83.54	4.77	7.87	1.65	0.71	0.36	1.57	0.14	1031.77
54	**AG-2006-14**	0.99	50.65	92.14	3.67	4.57	1.25	0.71	0.62	2.64	0.17	723.03
55	**AG-2006-15**	1.01	44.95	88.24	6.13	4.80	0.78	0.42	0.66	1.95	0.08	594.78
General mean		**0.36**	**50.40**	**83.60**	**4.27**	**5.70**	**1.42**	**0.68**	**0.45**	**1.75**	**0.14**	**860.65**
Minimum		**0.06**	**35.85**	**44.64**	**2.37**	**3.14**	**0.53**	**0.38**	**0.15**	**0.71**	**0.06**	**587.52**
Maximum		**1.01**	**69.78**	**95.04**	**7.11**	**8.40**	**2.70**	**0.91**	**0.73**	**2.64**	**0.23**	**1240.7**
S.Ed		**0.01**	**1.50**	**0.12**	**0.12**	**0.10**	**0.07**	**0.02**	**0.08**	**0.01**	**0.011**	**0.07**
C.D at 0.05		**0.03**	**4.20**	**0.34**	**0.33**	**0.29**	**0.19**	**0.07**	**0.21**	**0.03**	**0.034**	**0.19**
C.V %		**5.85**	**48.50**	**4.84**	**4.88**	**3.52**	**4.11**	**2.27**	**6.02**	**4.21**	**3.22**	**4.56**

Table 4.3.1 Oil and Protein percentage in fresh seed of Kharif 2010 and after six months of storage of summer 2010 seed.

Sr.		Fresh seed of Kharif- 2010	Summer- 2010 seed stored for six months

No	Genotype	Oil %	Protein %	Oil %	Protein %
1	**GG-2**	46.18	29.26	31.47	26.00
2	**GG-3**	41.70	24.79	36.69	21.52
3	**GG-4**	41.69	28.12	31.28	24.33
4	**GG-5**	48.39	27.43	34.49	23.87
5	**GG-7**	42.48	28.77	33.56	25.95
6	**GAUG-10**	45.68	28.39	25.53	24.47
7	**JL-24**	43.79	24.96	35.27	18.43
8	**TG-37**	43.38	21.73	35.26	19.75
9	**GG-12**	49.19	18.93	34.94	15.07
10	**GG-13**	44.10	20.17	31.35	15.28
11	**GG-14**	45.74	22.13	27.42	16.60
12	**GG-15**	44.06	20.47	37.37	14.00
13	**GG-16**	41.94	19.19	37.05	16.17
14	**GG-20**	46.78	22.62	36.51	18.67
15	**BAV-13**	43.41	20.59	35.61	17.75
16	**KADIRI-3**	50.18	19.85	32.40	14.06
17	**ICGS-1179**	43.15	23.99	28.24	17.27
18	**ICGS-1703**	49.05	20.12	32.68	13.67
19	**ICGS-4296**	44.89	20.80	33.33	17.20
20	**ICGS-4849**	48.57	21.64	37.60	16.01
21	**NRCG-6563**	43.86	23.56	34.94	11.28
22	**NRCG--6663**	50.31	21.20	33.55	15.33
23	**NRCG--6682**	49.38	24.19	34.34	21.17
24	**NRCG--6705**	44.65	23.37	33.49	20.38
25	**NRCG-6707**	43.77	24.95	31.04	21.22
26	**NRCG-9000**	47.56	21.11	32.42	16.33
27	**NRCG-9130**	47.20	21.68	36.33	12.35
28	**NRCG-9185**	49.15	28.05	32.25	24.00
29	**NRCG-9231**	50.16	24.80	35.30	21.17
30	**NRCG-9747**	47.18	22.35	34.53	17.73
31	**NRCG-9949**	45.68	28.39	32.34	24.45

Table 4.3.1 Contd...

Sr. No	Genotype	Fresh seed of Kharif- 2010		Summer- 2010 seed stored for six months	
		Oil %	Protein %	Oil %	Protein %
32	**ICGS-11615**	50.21	24.27	32.01	22.33
33	**ICGS-13052**	46.18	21.65	31.64	17.50
34	**ICGS-13128**	45.91	23.11	35.77	16.30
35	**ICGS-13033**	44.33	23.63	37.58	19.25
36	**ICGS-36**	49.79	21.75	32.93	18.33
37	**ICGS-156**	45.78	23.38	32.82	14.10
38	**ICGS-221**	42.46	21.71	33.71	19.67
39	**ICGS-297**	45.47	25.69	32.25	20.07
40	**ICGS-405**	42.38	20.88	31.63	17.17
41	**ICGS-799**	43.89	27.25	34.73	24.00
42	**ICGS-2738**	47.85	22.31	32.40	15.87
43	**ICGS-4729**	47.08	21.46	33.63	12.15
44	**ICGS-4750**	49.50	22.59	28.67	20.52
45	**ICGS-5016**	47.49	25.83	32.16	21.83
46	**ICGS-5236**	46.37	21.26	33.85	19.33
47	**ICGS-7827**	46.51	21.45	33.19	16.77
48	**ICGS-9157**	43.70	20.61	32.44	18.58
49	**ICGS-10554**	49.99	22.94	27.71	20.00
50	**ICGS-10890**	45.62	24.15	31.30	19.58
51	**ICGS-12625**	46.97	21.29	33.46	19.22
52	**ICGS-13941**	41.41	28.17	31.55	14.17
53	**ICGS-13942**	44.40	27.61	28.30	21.00
54	**AG-2006-14**	48.67	23.33	31.22	18.92
55	**AG-2006-15**	48.52	24.66	35.61	20.00
General mean		**46.10**	**23.33**	**33.08**	**18.58**
Minimum		**41.41**	**18.93**	**25.53**	**11.28**
Maximum		**50.31**	**29.26**	**37.60**	**26.00**
S.Ed		**1.56**	**1.17**	**1.14**	**0.93**
CD at 0.05		**4.39**	**3.39**	**3.19**	**2.62**
CV%		**4.41**	**5.00**	**4.41**	**4.89**

Table 4.3.3 .1 Details of polymorphism for protein studies in 55 groundnut genotypes for *Kharif* (Fresh) and stored summer seed through SDS-PAGE analysis.

Results and Discussion

Sr. No	Markers	Seed season	Monomorphic band	Polymorphic bands (A)	Total (B)	Polymorphic band %, A/B× 100	PIC value
1	Protein	Fresh Kharif 2010 seed	0	769	769	100 %	0.94
		Summer 2010 seed	0	696	696	100 %	0.94

Table 4.3.4.1. Details of polymorphism for Esterase isozyme studies in 55 groundnut genotypes for *Kharif* (Fresh) and stored summer seed through SDS-PAGE analysis.

Sr. No	Markers	Seed season	Monomorphic band	Polymorphic bands (A)	Total (B)	Polymorphic band %, A/B× 100	PIC value
1	Esterases	Fresh Kharif 2010 seed	0	181	181	100 %	0.73
		Summer 2010 seed	0	101	101	100 %	0.69

Table 4.4. Genetic parameters (Kharif 2010)

Sr. No	Character	GCV (%)	PCV (%)	H^2 (%)	GA (% mean)
1	Germination count at 5th day in field.	10.58	13.63	60.00	1.47
2	Germination count at 10th day in field	9.73	16.47	35.00	2.96
3	Plant height (cm).	22.89	25.61	80.00	16.46
4	Primary branches	11.95	13.43	79.00	1.30
5	Secondary branches	21.83	22.69	93.00	1.93
6	Days to 50 % flowering.	3.75	9.29	16.00	1.06
7	No of Mature pods / plants	13.23	18.05	54.00	2.23
8	No of Immature pods / plants	10.40	13.53	59.00	2.27
9	100seed weight (g).	17.71	17.94	97.00	26.18
10	Tightness of kernel in the hull.	13.65	18.06	57.00	11.89

11	Shelling per cent (S %).	6.74	7.24	87.00	6.87
12	Sound mature kernel (SMK%)	5.61	5.97	88.00	8.95
13	Harvest index (%)	6.73	7.44	82.00	14.00
14	Days to Maturity.	11.43	14.60	61.00	2.74
15	Pod yield per plant (g).	25.62	28.62	80.00	36.79
16	Kernel yield per plant (g).	19.18	24.47	62.00	1.16
17	Shrivelled seeds	21.33	26.54	80.00	13.44

Table 4.2. Frequency distribution of groundnut genotypes belonging to different phenotypic classes.

Sr. No.	Characters	Class	No. of genotypes
1.	Pod constriction	None	09
		Slight	24
		Moderate	10
		Deep	08
		Very deep	04
2.	Pod size.	Small	04
		Medium	27
		Large	24
3.	Seed size	Small	04
		Medium	27
		Large	24
4.	Seed shape	Round	03
		Fusiform	27
		Elongated	25
5.	Pod beak.	Absent	14
		Slight	20
		Moderate	13
		Prominent	03
		Very prominent	05
6.	Pod Weight	Short (2.00-2.99cm)	11
		Medium (3.00-3.99cm)	39
		Long (4.00-4.99cm)	05
7.	Pod Length	Short (2.00-2.99cm)	11
		Medium (3.00-3.99cm)	39
		Long (4.00-4.99cm)	05
8.	Seed color	Off-white	01
		Light tan	02
		Tan	07
		Rose	01
		Salmon	03
		Salmon with white flecks	03
		Salmon with white light tan flecks	01
		Salmon with white dark tan flecks	02
		Salmon with white purple flecks	03
		Red	02
		Light red	06
		Dark red	02
		Red with white flecks	07
		Red with salmon flecks	06
		Purple	04
		Purple with salmon flecks	03
		Dark purple	02
9.	Seed texture	Non -smooth	51
		smooth	04
10.	Seed length	Short (0.70-.84mm)	11
		Medium (0.85-0.99mm)	30
		Long (1.00-1.14mm)	25

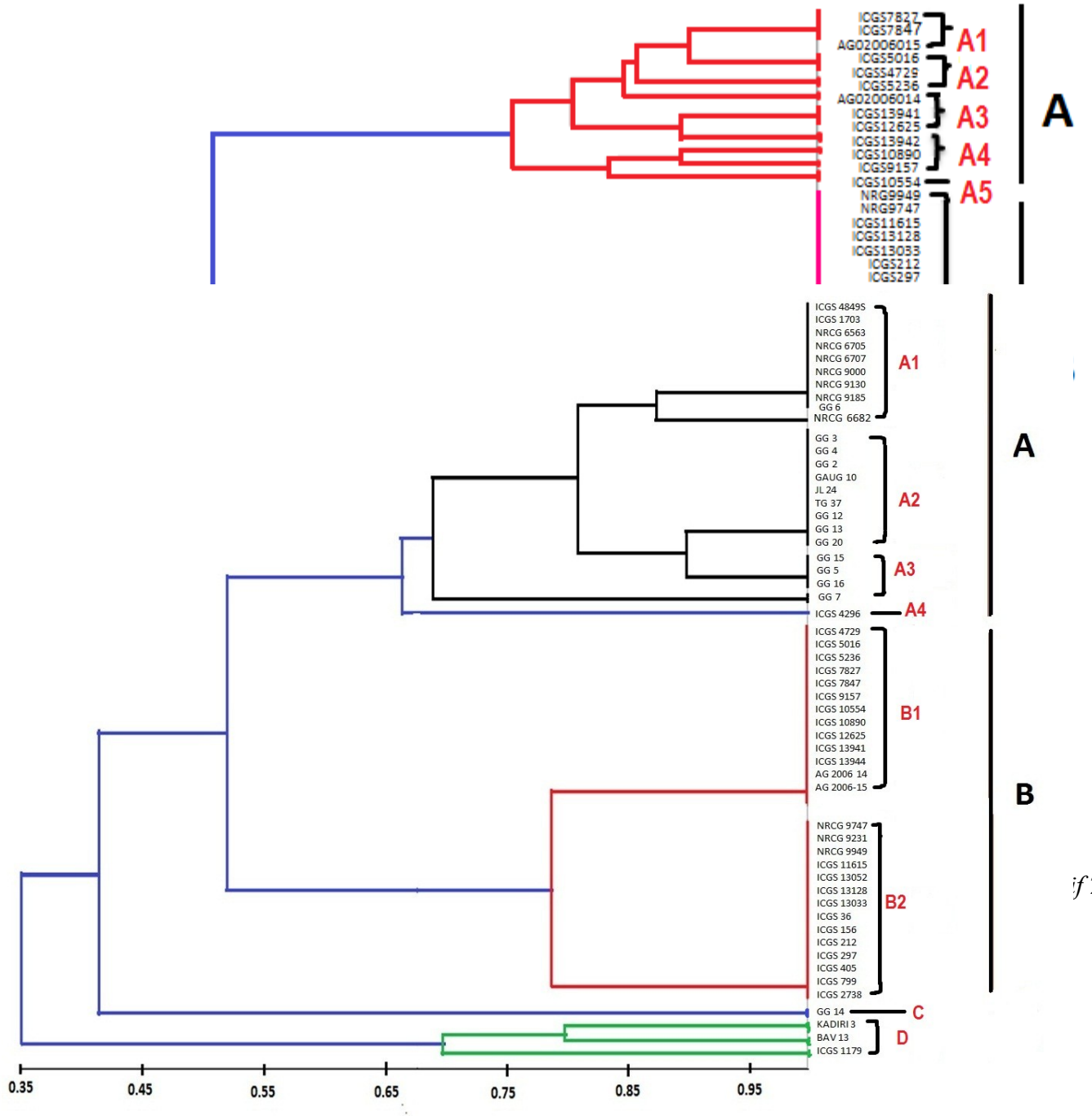
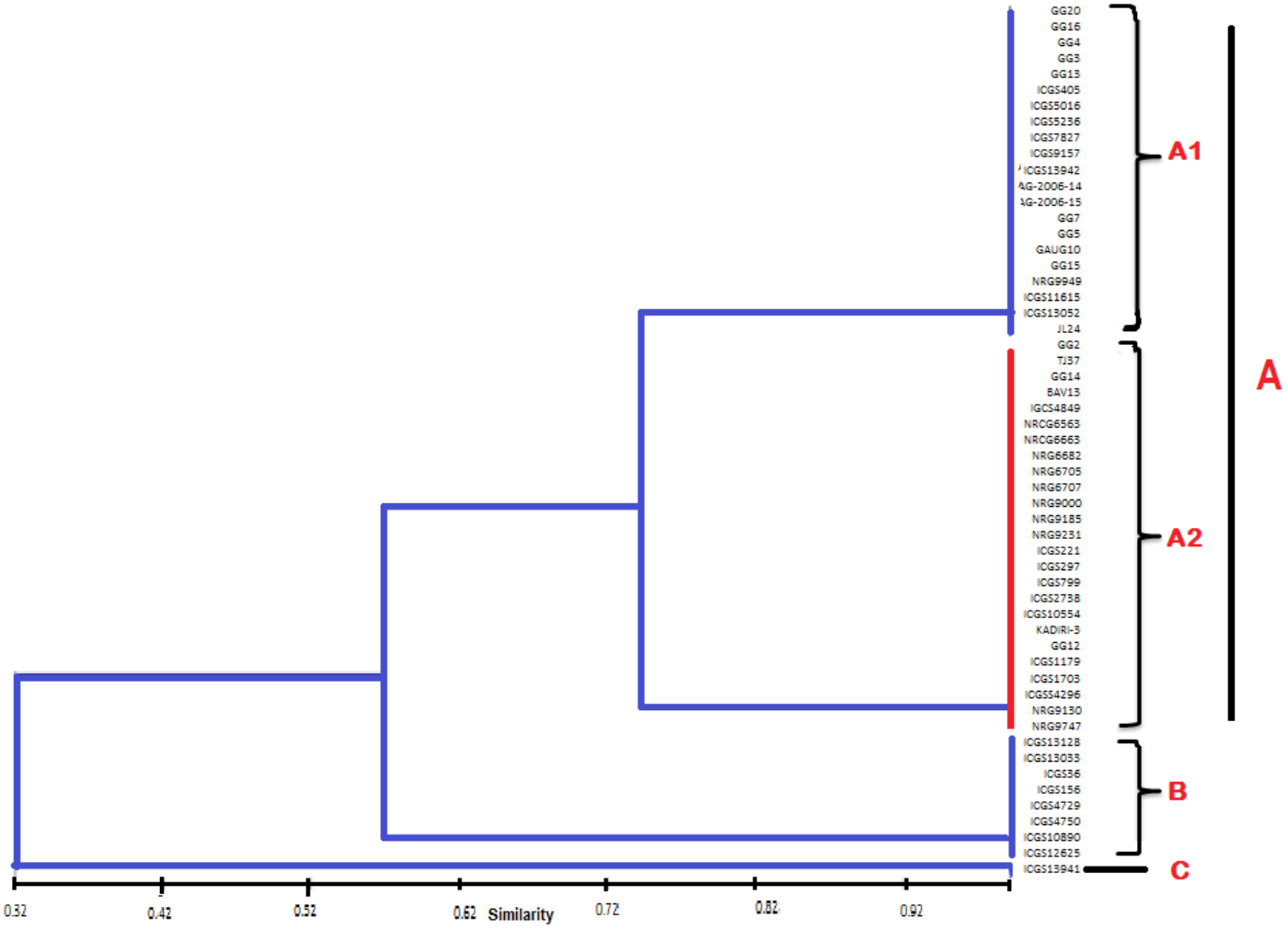


Fig.4.3.3.3. D

f 2010).

Fig.4.3.3.4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GG7
GG5
GAUG10
GG15
NRG9949
ICGS11615
ICGS13052
JL24
GG2
TJ37
GG14
BAV13
IGCS4849
NRCG6563
NRCG6663
NRG6682
NRG6705
NRG6707
NRG9000
NRG9185
NRG9231
ICGS221
ICGS297
ICGS799
ICGS2738
ICGS10554
KADIRI-3
GG12
ICGS1179
ICGS1703
ICGS4296
NRG9130
NRG9747
ICGS13128
ICGS13033
ICGS36
ICGS156
ICGS4729
ICGS4750
ICGS10890
ICGS12625
ICGS13941
A1
A2
A
B
C
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0.42
0.52
0.62
Similarity
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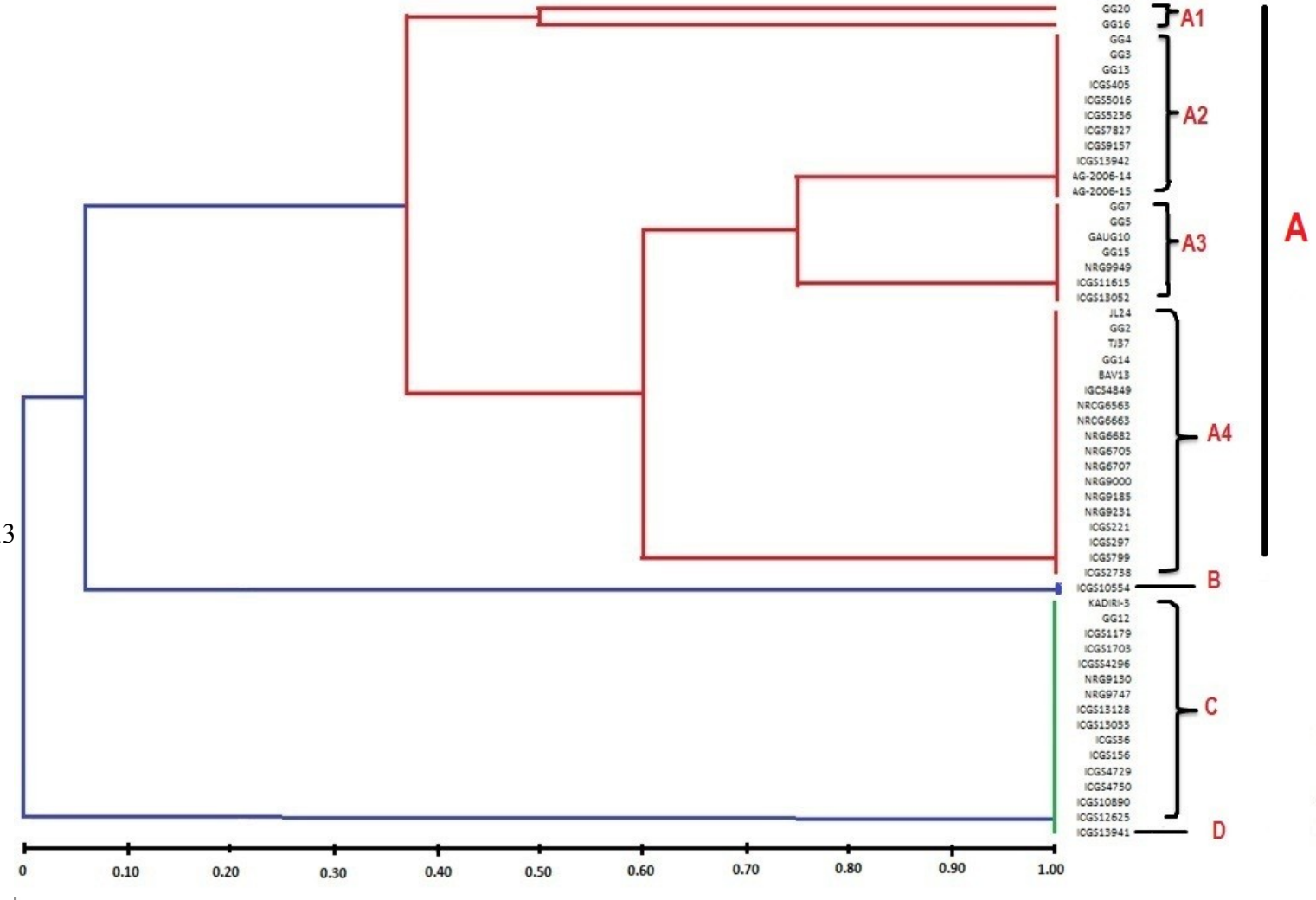
0.82
0.92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AG-2006-15
GG7
GG5
GAUG10
GG15
NRG9949
ICGS11615
ICGS13052
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TJ37
GG14
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KADIRI-3
GG12
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NRG9747
ICGS13128
ICGS13033
ICGS36
ICGS156
ICGS4729
ICGS4750
ICGS10890
ICGS12625
ICGS13941
A1
A2
A3
A4
A
B
C
D
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Fig.4.3.4.3 0).

Fig 4.3.4.4. Dendogram for esterase isozymes in fifty five groundnut genotypes developed through SDS PAGE analysis (Summer 2010).

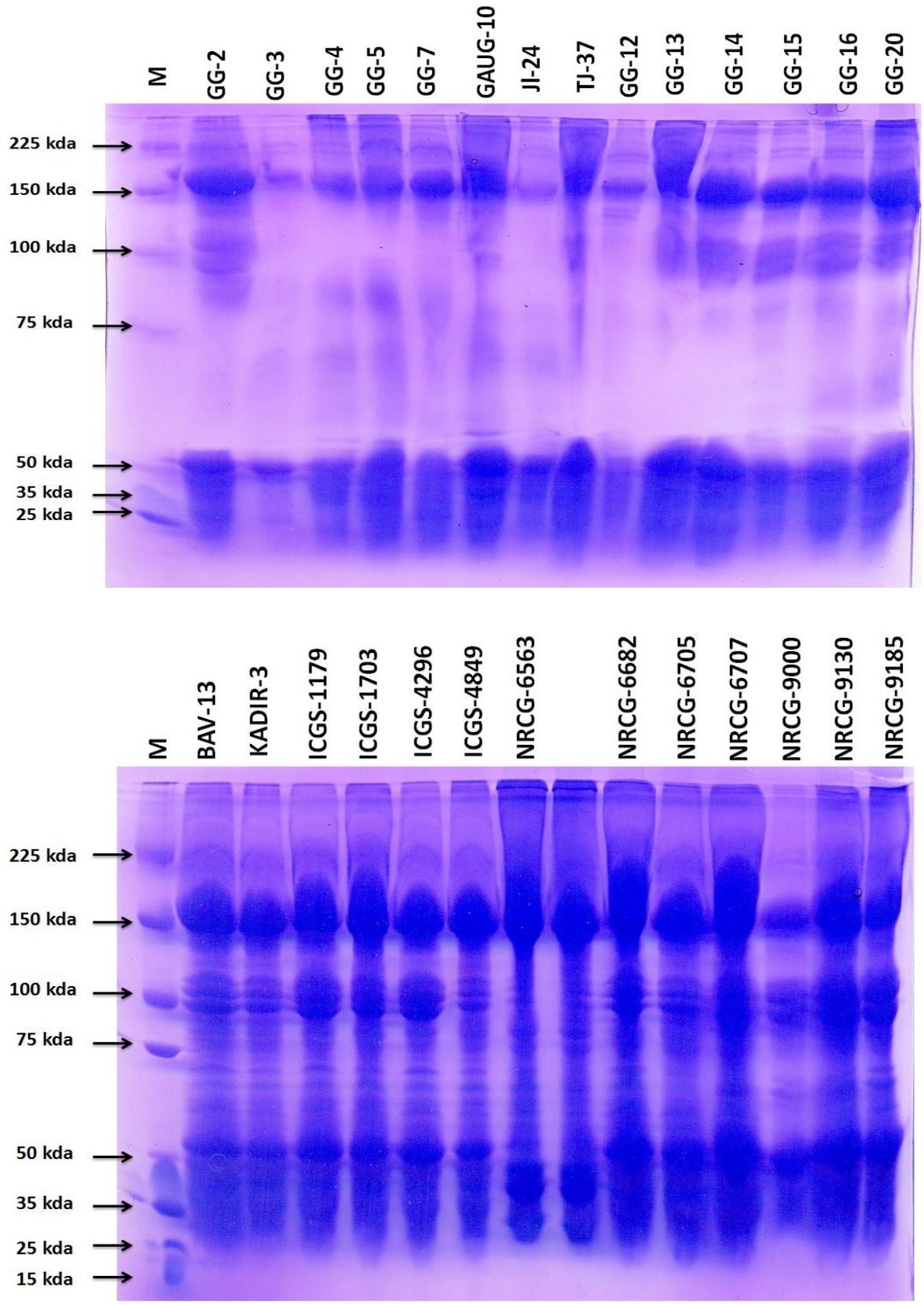
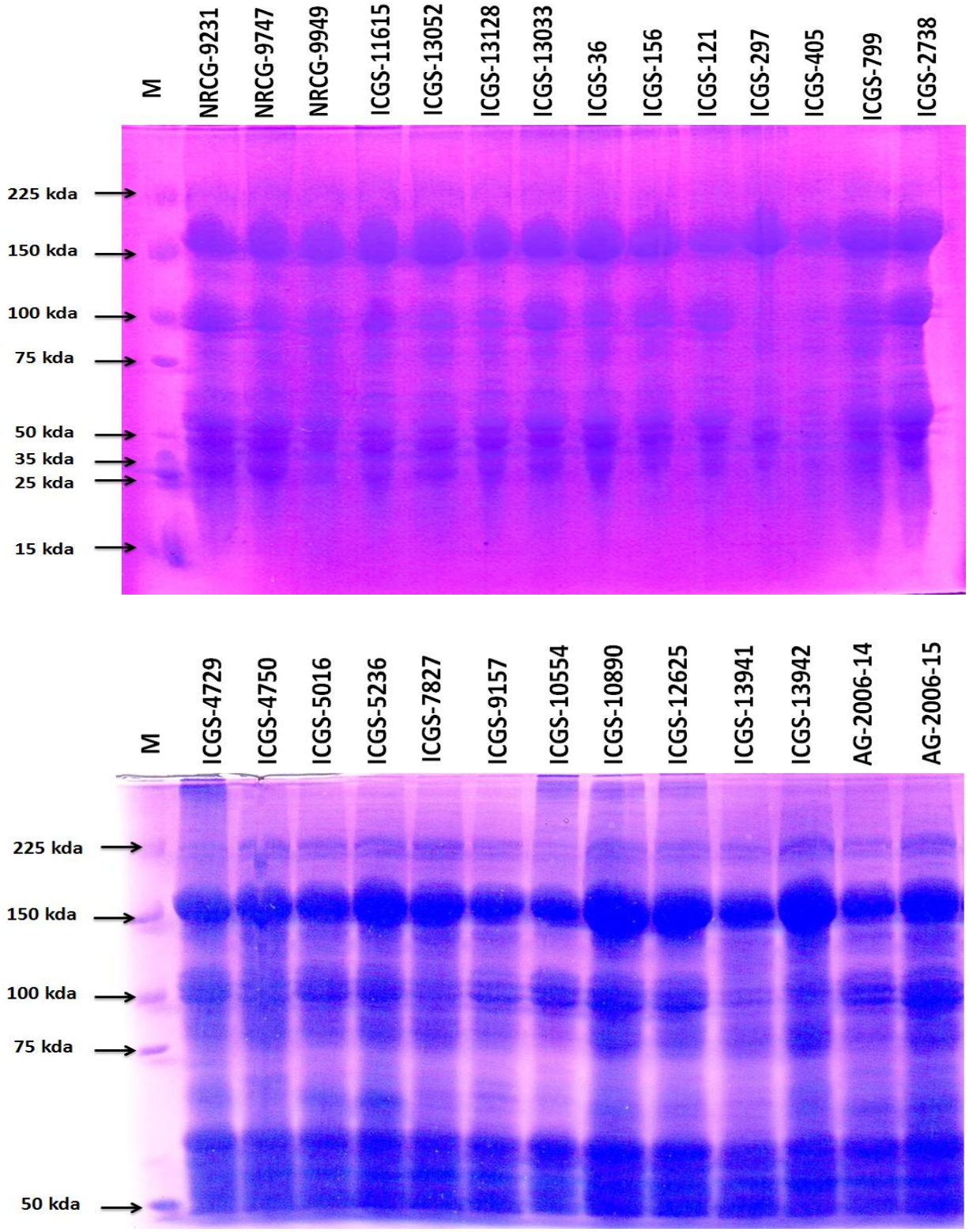


Fig. 4.3.3.2 Protein profile of 55 groundnut genotypes from stored summer seed (2010).



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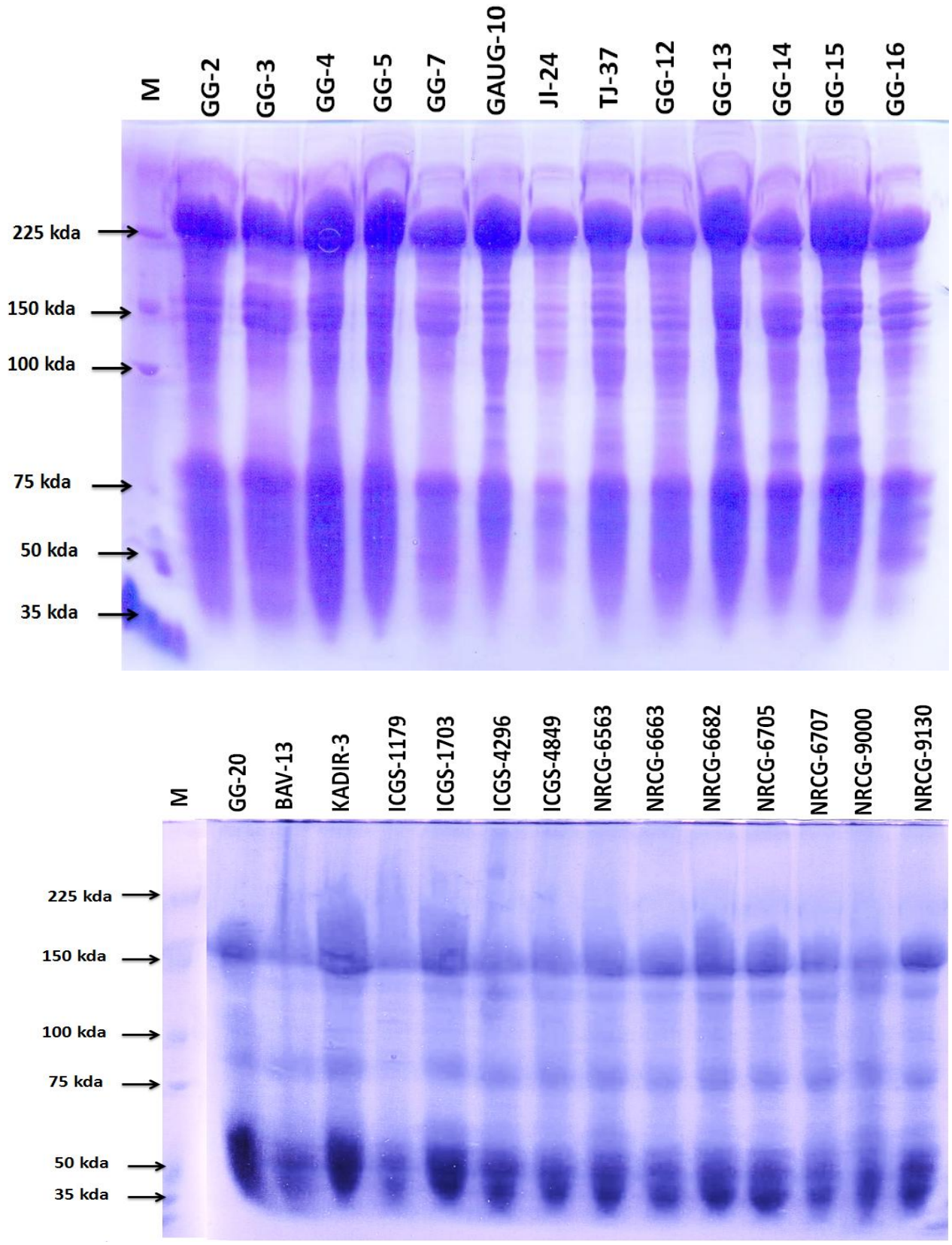
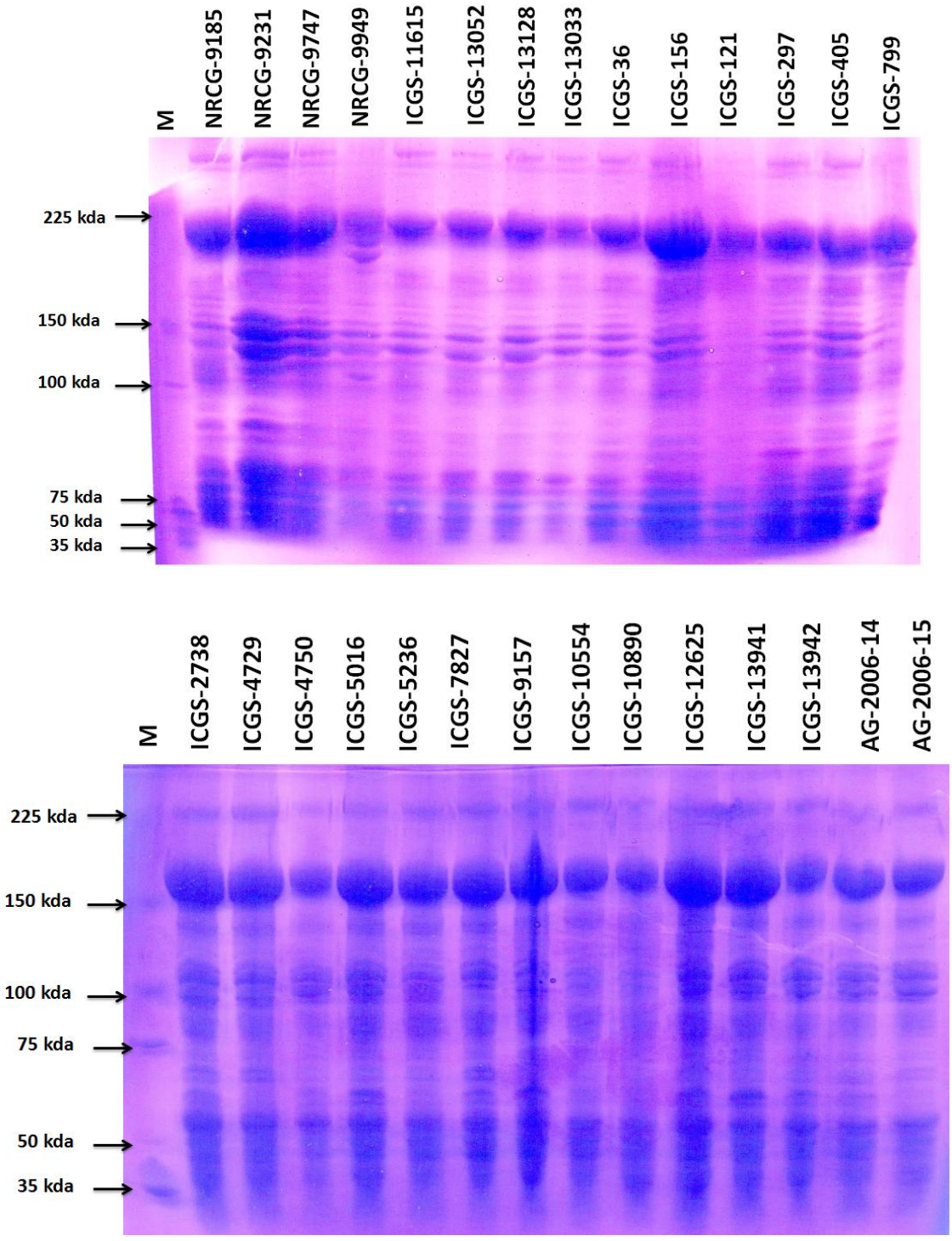


Fig. 4.3.3.1 Protein profile of 55 groundnut genotypes from *Kharif* 2010



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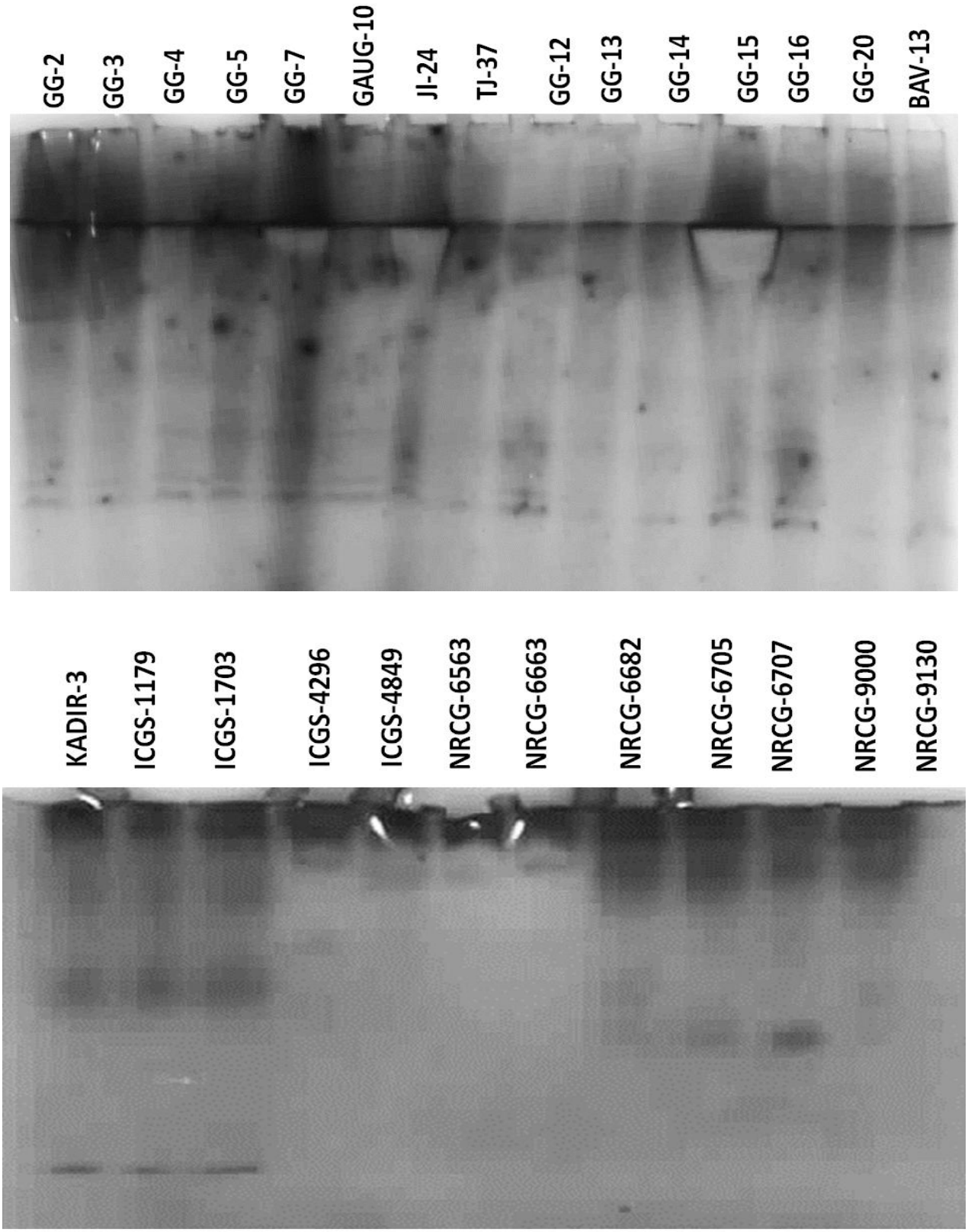
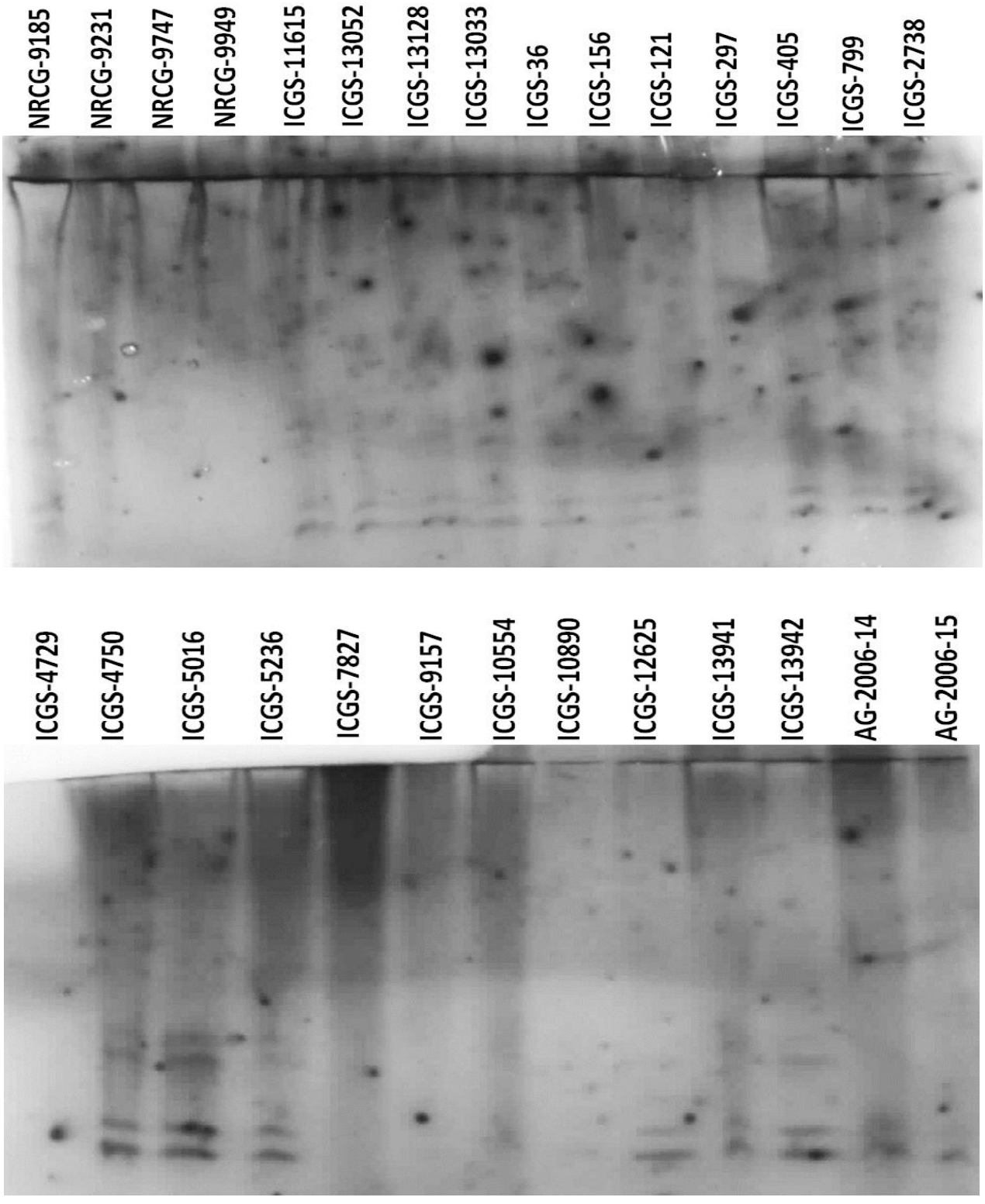


Fig. 4.3.4.2 Esterase isozymes banding pattern in 55 groundnut genotypes from stored summer seed (2010).



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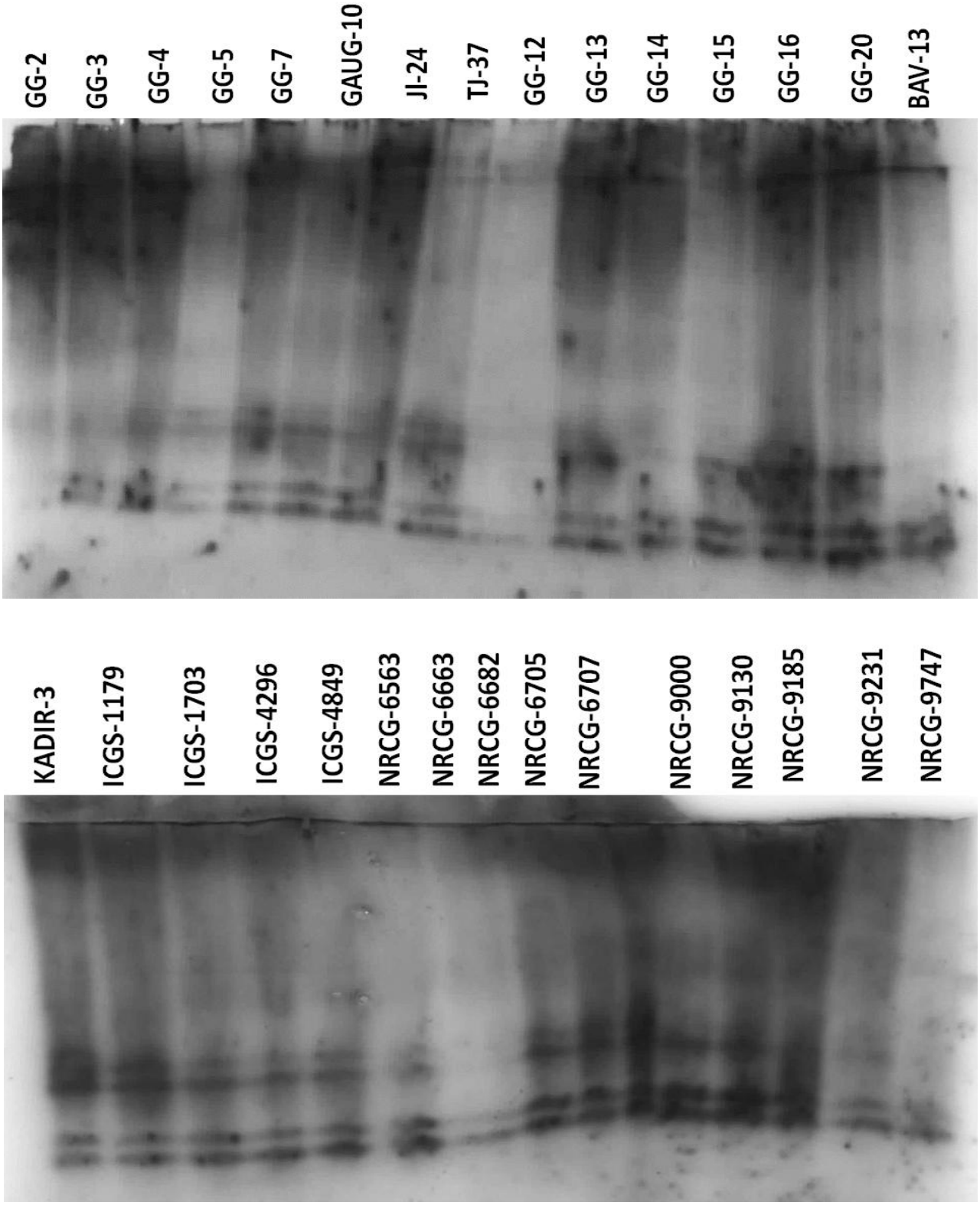

Fig. 4.3.4.1 Esterase isozyme banding pattern in 55 groundnut genotypes (*Kharif* 2010)

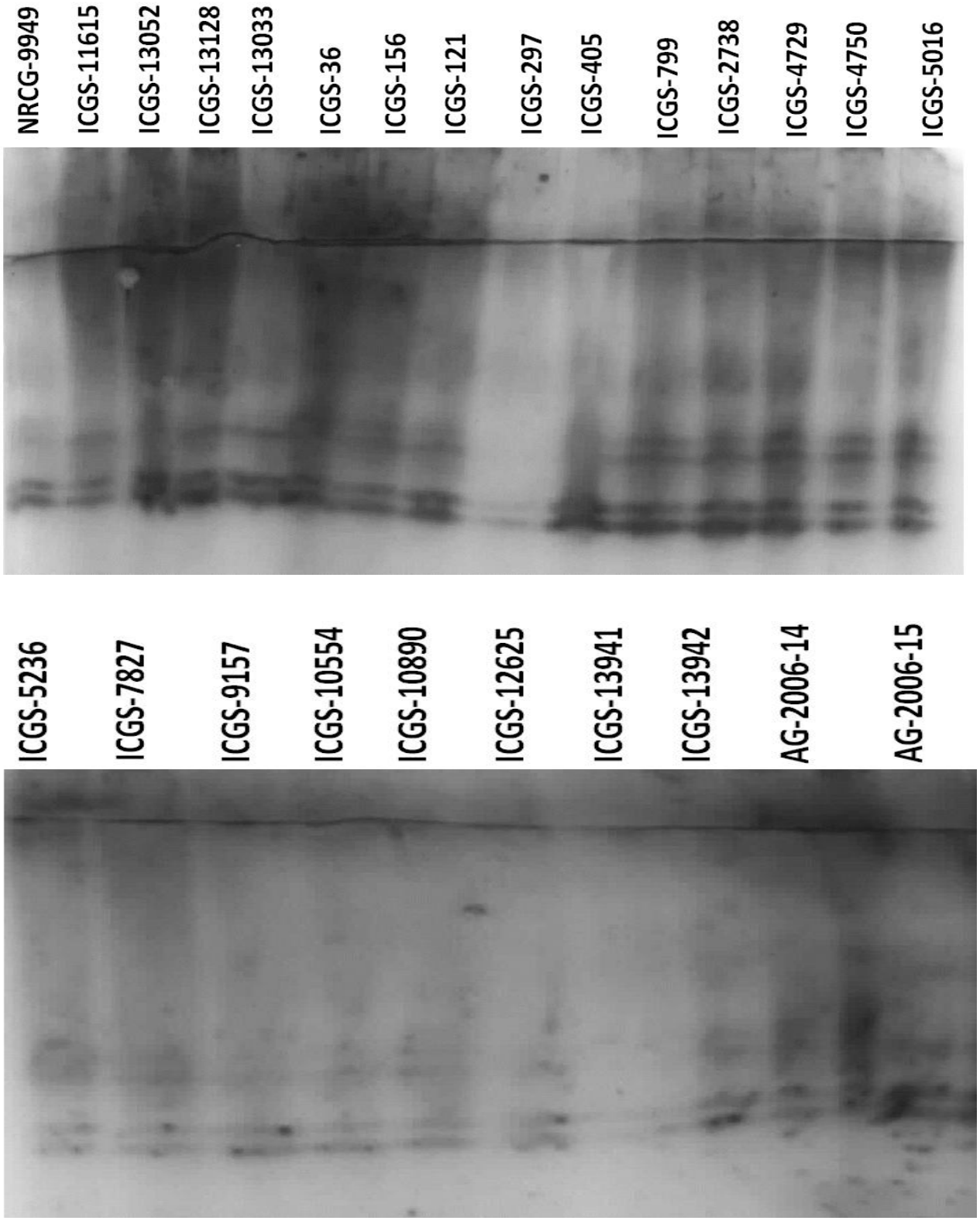

Fig. 4.3.4.1 Contd..