Project No 03: Enhancement and Management of Groundnut Genetic Resources

I. Year: 2016-17

1. Conservation of working collection

Nine Thousand One Hundred and Twenty Nine (9129) groundnut accessions have been maintained in the medium term cold storage (4±1°C; 30% RH) module. The accessions comprises of 1180 Virginia Runner; 1206 Virginia Bunch; 3198 Spanish Bunch; 1260 Valencia and 2285 intermediates/other types

2. Field maintenance of Wild *Arachis* germplasm

A total of 109 accessions in six sections *viz. Arachis* (44), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (5), *Procumbentes* (8) and *Rhizomatosae* (38) were maintained in the field gene bank. Seeds from annual species of section *Arachis* were harvested and conserved. The plants of six amphidiploid derivatives (Synthetic Groundnut) obtained from ICRISAT have been established the field for further use in crop improvement programme.

3. Distribution of germplasm accessions

In summer, 314 germplasm accessions including wild relatives of groundnut were supplied to 21 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of DGR (208), State Agricultural Universities (76) and AICRP-G (30) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in crossing programmes.

In kharif, a total of 315 germplasm accessions including wild relatives of groundnut were supplied to 10 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of DGR (15) and State Agricultural Universities (298) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in hybridisation programmes.

4. Multiplication of elite germplasm accessions

For seed enhancement, distribution and conservation, 645 accessions; WUE (177); South American collections (60; ARG; FST); general (42); high oil, high protein, low oil (10 accessions); DUS reference varieties (8); stem rot tolerant lines (348) have been multiplied in summer 2016 (Table 1).

One thousand four hundred and seventy one accessions (1471) have been rejuvenated and multiplied during *kharif* 2016. This comprised 189 composite collection of water use efficiency of ICAR-DGR; 177 water use efficient lines developed under ACIAR- ICRISAT-ICAR received from ICRISAT; 200 released varieties; 140 accessions belonging to South American collections; 720 accessions for rejuvenation and 45 accessions with unique morphological features (Table 1).

5. Morphological characterization

5.1 Characterisation of accessions supplied under Consortium Research Platform on Agro-Biodiversity project of ICAR

492 diverse accessions received under CRP-AB project were sown for multiplication and characterisation for 15 qualitative and 12 quantitative traits with two checks GG 2 and GG 20. Of these 5 accessions did not germinate and in 19 accessions there was no pod set. The results of 468 accessions including checks are briefly summarised below.

Pod yield per plant ranged from 1.0 g to 17.0 g and five accessions recorded the high yield namely ECs' 0557443 (17.0 g), 0557321 (8.8 g), 0557765 (7.0 g), 509768 (6.5g) and 0557324 (6.0g). For Hundred Seed Mass two accessions exhibited more than 50.0 g [(EC 509781, 51.9g); (EC509999, 50.0g)] while in 15 accessions it was >40 g. In 4 accessions it was <20.0 g; 200 accessions had 100-seed mass between 20-30g and 241 accessions were between 30-40g per 100-seeds.

For shelling outturn, three accessions recorded <40-50%; 37 accessions with 50-60% shelling; 256 accessions had between 60-70% shelling and 208 accessions recorded a shelling of 70-80%. The mean value for this trait was 68.6%.

Maturity duration varied between 101-115 days. The earliest being EC 509733 and the late being EC 509787.

Based on Principal Component Analysis revealed that the variation in the data could be assigned to six PCs'. The first two PCs could explain only 54.9% of the total variation in the population for the traits studied and the cumulative variation accounted by all the six PCs were 67% only indicating substantial role of environment on the traits studied. Eigen value was more than unity in five out of six vectors.

In PC1 the traits contributed for the variation based on the PC score were mostly the vegetative traits viz. dry fodder yield (0.88), haulm yield (0.86), number of secondary branches (0.65) and length of main axis (0.44). Among important yield related traits, variation due to pod yield was insignificant (0.09), whereas contribution of seed (0.55) and pod length (0.43) for the total variation was substantial.

In kharif 2016, a total of 1002 germplasm accessions received from NBPGR, New Delhi, have been characterized at this directorate for 28 specified traits. Out of these, 45 accessions did not germinate and in 39 accessions there was no pod formation. For pod yield, seven accessions, IC 0496438 (32.5 g), IC 0497639 (30.5 g), IC 0497734 (40.0 g), IC 0444572 (22.2 g), IC 0508915 (21.8 g), EC 557994 (21.3 g) and IC 0496544 (210.3g) were found high yielding. Four accessions were found having bold seeds (≥40g/10kernel) viz. IC 0496412 (48.0 g), IC 0497825 (44.0 g), EC 0557368 (44.0 g) and IC 0495730 (44.0 g). Shelling outturn was high (≥ 74%) in seven accessions { IC 0495721 (76.4%), IC 0495738 (76.3%), IC 0495803 (75.5%), IC 0495806 (75.3%), IC 0495875 (75.0%), IC 0444387(75.0%) and IC 0495647 (74.4%)}

Maturity duration in early types, EC 0558105 (106 d), IC 0495611, (106 d), IC 0495699 (106 d), EC 0558106 (107 d), EC 0558125 (107 d), IC 0495820 (107 d) and IC 0495825(107 d) was around 107 days. Three seeded pods were very high in seven accessions namely IC 0495721 (76.4%), IC 0495738 (76.3%), IC 0495803 (75.5%), IC 0495806 (75.3%), IC 0495875 (75.0%), IC 0444387(75.0%) and IC 0495647 (74.4%)

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5.2 Characterization of interspecific derivatives:

Seventeen interspecific derivatives mostly of *A.cardenasii***,** *A.duranensis* and *A. stenosperma*. Data on 17 qualitative 28 quantitative descriptor traits were recorded at appropriate growth stages of the crop. Days to initiation of flowering ranged from 17-24d; days to 50% flowering was between 20-27d; number of mature pods were between 6-16 per plant; pod yield in these derivatives ranged from 4.9 g (VG 0438) to 12.0 g (VG 0411) per plant. Hundred Seed Mass ranged from 27.8g (VG 1002) to 39.9g (VG 0420). The shelling outturn was in the range of 61.8% (VG 09405) to 70.7% (VG 09406).

5.3 Characterization of six candidate varieties as per DUS test guidelines under PPV & FRA

Six candidate varieties have been received from PPV & FRA, New Delhi for DUS characterisation during kharif 2016 viz. Western Vardan, Desi Mungfali 2, Hara Mungfali, Desi Mungfali Lal, Desi Lal and Desi Chiniya. These candidate varieties have been sown along with eight reference varieties as per DUS test guidelines The reference varieties utilized for DUS testing were: Spanish Bunch: GG 2 and SG 84 Valencia: Kopergaon 3 and Gangapuri; Virginia Bunch: GG 20 and BAU 13; and Virginia Runner: Punjab 1 and Somnath. Observations on 13 qualitative and 5 quantitative descriptor traits have been recorded.

6. Screening for low temperature and high tolerance under field conditions

The low temperatures (<18°C) at sowing of groundnut crop in summer/spring in northern India results in slow seedling emergence and poor plant stand. Delay in seedling emergence extends crop duration beyond 120 days, exposing the crop to high temperatures at reproductive phase and pod damage due to early onset of monsoon rains. Identification and incorporation of cold tolerance is therefore an important groundnut breeding objective.

Hence, to assess the low temperature tolerance at germination 195 released varieties and 184 mini-core accessions were screened under lab conditions during summer 2014. Of these 36 released varieties and 25 mini-core accessions which were identified as low temperature tolerant based on good (>90%) germination under lab conditions were planted in the field under three different sowing dates viz. early (19 Jan 2016); normal (3 Feb 2016) and late (16 March 2016) to evaluate effect of low and high temperature on germination and reproductive traits besides yield in comparison with normal (3 Feb 2016) sown conditions. Early sown crop was harvested on 25 May 2016 and normal sown was harvested on 26 May 2016. Late sown crop harvested was on 23 June 2016. This experiment has been repeated for the second year.

In 2016, the temperature was in the range of 10° to 30°C during the week followed by sowing. Subsequently, in February (15°C-31°C); March (20°C-37°C); April (22°C-38°C) and May (26°C-40°C) the effect of low temperature could not be ascertained on germination and reproductive traits. However, the temperature exceeded 40°C for only 14 days.

Among the 25 germplasm accessions evaluated, maturity duration in different dates of sowing ranged from 100-111d in early sown crop; 102-112 d in normal sown crop; and genotypes were

harvested uniformly at 100 DAS (June 23rd) in late sown crop. Pod yield per plant under early sown condition was 11.5 g (NRCG 14341); normal sown condition the pod yield recorded was 2.8 g (NRCG 14403); late sown condition 2.1 g (NRCG 14328). Pod yield advantage/gain when sown early and late separately in these germplasm was also assessed in comparison with normal sown crop. In early sown crop, out of 25 accessions, 14 accessions recorded high yields than when sown under normal sowing date. Of these 9 accessions had 30% more yield over normal date of sowing. The top six entries under this situation were NRCGs 14339, 14374, 14413, 14453, 14341 and 14492. Under late sown condition the yield reduction were very high which ranged from 21%-325%. Only two accessions, NRCGs 14492 (27.8%) and 14454 (8.3%) recorded higher yields over normal sown crop. One accession NRCG 14492 was identified promising under both under early and late sown conditions based on pod yield, emergence, days to maturity.

Among the 36 released varieties evaluated, maturity duration in different dates of sowing ranged from 100-110d in early sown crop; 102-110d in normal sown crop; and genotypes were harvested uniformly at 100 DAS (June 23rd) in late sown crop. Among the 36 released varieties evaluated, in early sown crop, 14 varieties exhibited higher yields than when sown under normal sowing date. Pod yield advantage/gain when sown early and late separately in these varieties was also assessed in comparison with normal sown crop. Of these five varieties (GPBD 4, Kopergaon-3, ALR-2, TAG 24, and TG 17 had recorded 1.5 times higher yields over those of normal sown crop. Seven other varieties, JL 220, Dh 86, Kisan, OG 52-1, Tirupati-4, GJG 9, and GG 8 exhibited 30% more yields over those of the normally planted crop. Under late sown conditions the yield reduction in these accessions ranged from 17%-350% over the normally planted crop. Yield advantage observed in eight varieties under late sown conditions over normal sown crop were MH 2 (64%), TAG 24 (50.0%), GG 8 (50.0%), Dh 86 (33.8%), TG 26 (18.1%), Kop-3 (17.3%), OG 52-1 (16.1%), and JGN 3 (4.0%).

7.0 Analysis of quality (oil, protein) of 317 working collection accessions

317 accessions of working collection have been evaluated for oil, and protein in kharif 2016. The oil content in 317 general accessions ranged from 43.3%-54.7%; protein content ranged from 23.7%-37.1%. Out of 317 accessions, 105 accessions had oil content more than 50%; and 23 accessions had oil content more than 52%. Of these 7 accessions (NRCGs' 11923, 12124, 11906, 8974, 5195, 11888, 12163) recorded oil content more than the benchmark variety TMV 10 which was so far the highest oil containing genotype i.e 52.8%. Six accessions (11981, 11960, 11979, 414, 11875, 12128) recorded more than 35% protein content.

8.0 screening for resistance to stem rot under sick plot conditions

In summer 2016, a total of 319 genotypes GG 20 mutants; AICRP-G genotypes; advanced breeding lines and interspecific derivatives were screened for resistance to stem rot under sick plot conditions. Altogether 29 genotypes were found promising with <20% stem rot incidence. In kharif 2016, a total of 288 genotypes viz. GG 20 mutants; AICRP-G genotypes; advanced breeding lines and interspecific derivatives were screened for resistance to stem rot under sick plot conditions. The disease incidence ranged from 0 to 100%. One genotype was found to be free of the disease (ISK 2016-1) and two (ICGV 05057; ICG 3053) recorded less than 10% disease incidence.

II. Year: 2015-16

1. Conservation of working collection

Nine Thousand One Hundred and Twenty Nine (9129) groundnut accessions have been maintained in the medium term cold storage (4±1°C; 30% RH) module. The accessions comprises of 1180 Virginia Runner; 1206 Virginia Bunch; 3198 Spanish Bunch; 1260 Valencia and 2285 intermediates/other types

2. Field maintenance of Wild *Arachis* germplasm

A total of 109 accessions in six sections *viz. Arachis* (44), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (5), *Procumbentes* (8) and *Rhizomatosae* (38) were maintained in the field gene bank. Seeds from annual species of section *Arachis* were harvested and conserved. Seeds of eight amphidiploid derivatives (Synthetic Groundnut) obtained from ICRISAT have been field established for further use in crop improvement programme.

3. Distribution of germplasm accessions

A total of 1014 germplasm accessions (730 accessions to 19 indentors in summer 2015) including wild relatives of groundnut were supplied to 36 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of DGR (830), State Agricultural Universities (181) and other ICAR Institutes (3) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in hybridisation programmes.

4. Multiplication of elite germplasm accessions

A total of 132 germplasm accessions (60 South American collections; 36 exotic collections; 21 interspecific derivatives; 15 DUS reference varieties) and 57 Marker Aided Back Cross derived Lines and seven check varieties were multiplied in summer 2015.

Two thousand one hundred and fifty four accessions (2154) have been rejuvenated and multiplied during *kharif* 2015. This comprised 905 accessions (207 HYB; 138 HYR; 327 VUL; 149 FST; 84 others) were of DGR-Gene Bank; 250 accessions received under Consortium Research Platform on Agro Bio-Diversity (CRP-AB) project; 187 ICRISAT-Mini Core accessions; 184 interspecific derivatives (AGL-Lines) obtained from ICRISAT and 305 accessions were received under Svalbard project.

5. Morphological characterization

5.1 Characterization of elite Valencia accessions

Twenty-eight large seeded accessions belonging to the ssp. *fastigiata* along with two check varieties were evaluated for 18 yield components in summer 2015. The design adopted was randomized block design with three replications. Days to initiation of flowering ranged from 23 (NRCG 13016) to 29 days (NRCG 794, 13066); days to 50% flowering ranged from 26 (NRCG 13016) to 32 days (NRCG 794, 9746); days to 75% flowering ranged from 30 (NRCG 13016, 4290) to 36 days (NRCG 13066); days to maturity of these accessions ranged from 102 (NRCG 14428) to 112 days (NRCG 4220, 9746). The maturity duration of the genotype which flowered early was 107 days. Pod yield ranged from 774 kg (NRCG 794) to 2937 kg (TPG 41) per ha. The other high yielding accessions were NRCG 1108 (2671 kg/ha) and NRCG 5177 (2598 kg/ha).

Shelling out-urun ranged between 55.0% (NRCG 9746) to 72.9% (TPG 41) and closely (72.7%) followed by NRCG 1108. Hundred-Seed Mass was in the range of 28.5 g (NRCG 794) to 56.9 g (TPG 41) followed by (47.3g) NRCG 5177. The accession, NRCG 1108 has been identified as promising for pod yield and high shelling.

5.2 Characterisation of interspecific derivatives

Seventeen interspecific derivatives mostly of *A.cardenasii***,** *A.duranensis* and *A. stenosperma* conserved in the gene bank were sown in a randomised block design. Data on 16 qualitative 29 quantitative descriptor traits were recorded at appropriate growth stages. Pod yield in these derivatives ranged from 8.5 g (VG 0410) to 12.5 g VG 09406. Hundred Seed Mass ranged from 28.5g (VG 0401) to 42.0 g (VG 09405). The shelling outturn was in the range of 66% (VG 09406).

5.4 Characterisation of Farmer's varieties (Budhram Badam-1 and Gulabi) under PPV & FRA

The seeds of two candidate varieties "Budhram Badam 1" and "Gulabi" received under DUS Project have been sown in the *Kharif* season along with eight reference varieties in three replications as per DUS test guidelines. Reference varieties utilized were: ALR 2, JL 24 and TKG 19A in Spanish Bunch; MH 4 and Gangapuri in Valencia; BAU 13 in Virginia Bunch and: Punjab 1and Somnath in Virginia Runner.

Data on 13 qualitative 5 quantitative descriptor traits were recorded at appropriate growth stages as per test guidelines and submitted to PPV &FRA.

6. Screening for low temperature and high tolerance under field conditions

The low temperature (<18°C) at sowing of groundnut crop in summer/spring in northern India results in slow seedling emergence and poor plant stand. Delay in seedling emergence extends crop duration beyond 120 days, exposing the crop to high temperatures at reproductive phase and pod damage due to early onset of monsoon rains. Identification and incorporation of cold tolerance is therefore an important groundnut breeding objective. Hence, to assess the low temperature tolerance at germination 195 released varieties and 184 mini-core accessions of were screened under lab conditions during summer 2014. Of these 36 released varieties and 25 mini-core accessions which were identified as low temperature tolerant based on germination under lab conditions were planted in the field under two different sowing dates viz. early (27 Jan 2015) to evaluate effect of low temperature on germination and reproductive traits and late (16 March 2015) to evaluate the effect of high temperature on germination and reproductive traits besides yield.

However, the temperature was in the range of 10° to 30°C during the week followed by sowing. Subsequently, in February (13°C-37°C); March (18°C-36°C); April (21.6°C-39.4°C) and May (25.5°C-40.2°C) the effect of low temperature could not be ascertained on germination and reproductive traits. However the pod yield under this condition was 445 g (GJG 17), closely followed by ICGV 00350 (400g) per 3m row. Among the mini-core accessions NRCG 14383 (VUL) exhibited 320 g of pod yield and NRCG 14424 (305 g) per 3m row.

The temperature was in the range of 19.7° C to 39.2°C during the week followed by sowing of accessions meant for screening for high temperature tolerance. The temperature after sowing was

in the range of 21.6°C-39.4°C (April) and 25.5°C-40.2°C (May). Few promising accessions were identified both under early and late sown conditions (NRCG 14383, ALR 3, Kisan and TG 17; TAG 24, Dh 86, TG 26) based on field emergence, flowering duration and pod yield.

7.0 Screening for resistance to stem rot under sick plot conditions

One hundred and eighty-six genotypes comprising 41 released varieties; 72 TAG 24 mutants; 53 AICRP-G genotypes; 19 mini-core accessions have been screened for resistance to stem rot under sick plot conditions. The disease incidence at harvest was very high and ranged from 63.4% (GG 3) to 100% in most of the genotypes. None of the genotypes promising genotypes could be identified under summer conditions of 2015.

In *kharif* 2015, 589 genotypes viz. 417 genotypes received from ICRISAT; 124 interspecific derivatives; and 48 AICRP-G entries were screened for resistance to stem rot under sick plot conditions. The disease incidence ranged from nil (ICGV 00387) to 86% (ICGV 03397). The genotypes which exhibited <10% incidence at harvest were ICGVs' 07268, 02206, 00387, 97058, 03056, 07223 among advanced breeding lines; ISK I 2015-12, IVK I 2015-4, ASK 2015-2 among AICRP-G entries; and ICGV 11447 and VGs 0411, 0502, 0507, and 1012.

Based on screening of released varieties against stem rot in sick plots for over four years (2011-15) and eight seasons (kharif and *rabi*-summer seasons) promising genotypes for each state have been identified which exhibited field tolerance (incidence up to 30%) to this disease.

8.0 Estimation of oil and protein contents, fatty acid profiling of different germplasm accessions

317 accessions of working collection in all the four habit groups have been evaluated for oil and protein contents. The oil content in 317 accessions ranged from 43.3%-54.7% with an average of 49.1%. **P**rotein content ranged from 23.7%-37.1% with an average of 30.1%. The accession, NRCG 11875 had low oil and high protein contents (oil- 43.3%; protein-37.1%) while the Valencia accession NRCG 11923 had high oil and low protein contents (oil-54.7%; protein-23.7%).

In each of the four habit groups accessions with both low oil and high protein and high oil and low protein contents were identified. Among Spanish types, NRCG 12128 recorded low oil (43.3%) and high protein (36.1%) content. Another accession NRCG11927 registered high oil (50.3%) and low protein (29.7%) contents.

In case of Virginia bunch types analyzed, two accessions NRCG 414 (oil-44.5%; protein-35.4%) and NRCG 11981 (oil-44.7%; protein-35.4%) recorded low oil but high protein contents On the contrary, one accession, NRCG 12124 recorded high oil(53.8%) but with low (24.5%) protein contents.

Fatty acid composition in 113 accessions of all the four habit groups has been estimated using GCMS. The oleic acid content was in the range 38.1%-65.6% with an average of 49.2%. Linoleic acid content was in the range 15.1%-38.5% with an average of 28.8%. The O/L ratio was between 0.99-4.4 with an average value of 1.88. In each of the four habit groups accessions with high O/L accessions were identified. In the lone Valencia accession, the O/L ratio was 0.99.

The accessions with high O/L ratios were: among Spanish bunch types-TKG 19A (3.3); in Virginia bunch types- GG 20 (4.4); and in Virginia Runner types- UF 70 (4.1).

III. Year: 2014-15

1. Field maintenance of Wild *Arachis* germplasm

A total of 106 accessions under 6 sections *viz Arachis* (54), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (7), *Procumbentes* (6) and *Rhizomatosae* (40) were maintained in the field gene bank. Seeds from annual species of section *Arachis* were
harvested and conserved. Seeds of seven amphidiploid derivatives (Synthetic groundnut) obtained from ICRISAT have been field established for further use in crop improvement programme.

2. Acquisition, distribution and utilization of germplasm accessions

Two interspecific hybrid populations (pre-brThe origin of the se populations were: first, two different diploid wild species, one is of 'A' genome (*A. duranensis,* ICG 8138) and the other one is of 'B' genome (*A. batizocoi,* ICG 13160) have been crossed and the resultant hybrid (synthetic amphidiploid) were doubled to obtain a tetraploid hydrid derivative (*A. duranensis* x *A. batizocoi,* ISATGR 278-18). These populations will be seed enhanced during kharif 2015 and summer 2016.

A total of 517 germplasm accessions (112 accessions in summer 2014) including wild relatives of groundnut were supplied to 18 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of DGR (207), State Agricultural Universities (107) and others (203) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in crossing programmes.

3. Multiplication and conservation of germplasm accessions

3.1. Multiplication

A total of 87 accessions (Registered genetic stocks; 17 interspecific derivatives; and 31 other accessions) were multiplied in summer 2014.

Two thousand and twenty one accessions received from NBPGR, New Delhi under Svalbard Gene Bank (Global Seed Vault, Norway) programme have been rejuvenated through five AICRP-G centres (JAU- Junagadh, MPKV-Rahuri, UAS- Dharwad, ANGRAU- Kadiri and TNAU-Vridhachalam) during *kharif* and *rabi*-summer 2014. Of these 1642 accessions have been rejuvenated and seed enhancement is in progress.

One thousand germplasm accessions of base collections received from NBPGR under Consortium Research Platform on Agro-Biodiversity (CRP-AB) of ICAR have been rejuvenated and seed enhanced at DGR-Junagadh (350 accessions), ANGRAU-Kadiri (325 accessions) and TNAU-Vridhachalam (325 accessions). Of these 345 accessions multiplied by DGR Junagadh have been submitted for long term conservation at NBPGR.

For seed enhancement, distribution and conservation 10 diverse set of 942 accessions have been multiplied in *kharif* 2014. They are: Composite Collection of Water Use Efficient/drought

tolerant accessions (189 accessions); release varieties of India (195 Nos.); Mini-core collection (184 accessions); a sub-set of DGR working collection (167 accessions); interspecific derivatives (17 Nos.); large seeded Virginia accessions (30 Nos.); morphological variants (45 accessions); elite genotypes of AICRP-G (53 nos.); promising mutants of GG 20 (12 Nos.) and others (49 accessions). Four hundred and eighty three accessions of working collection have been rejuvenated and seed enhanced in *kharif* 2014. In addition, 30 DUS reference varieties have been multiplied for seed enhancement in kharif 2014.

4. Morphological characterization and evaluations

4.1 Summer 2014

a) Characterisation of composite collection for drought tolerance

A total of 189 diverse accessions have been characterised for 34 descriptor traits (12 qualitative; 22 quantitative) in summer 2014 in an augmented block design. For important yield and its component traits the promising accessions identified were: NRCG 12649 (11.5g) and NRCG 12423 (6.4g) for high pod yield; NRCG 14410 (75.0%), NRCG 12065 (75.0%), NRCG 12377 (71.4%), NRCG 12348 (70.5%), and NRCG 12561 (70.3%) for high shelling; NRCG 5405 (64.0 g); TIR 27 (57.2 g), TIR 39 (56.0 g), NRCG 12177 (56.0 g) and NRCG 12109 (54.0 g) for large seed size; and NRCG 10922 (98 days), NRCG 14451 (98 days), NRCG 11346 (98 days), NRCG 11532 (98 days) and NRCG 11275 (99 days) for early maturity.

b. Evaluation of Spanish bunch large seeded accessions for summer season

Twenty-eight large seeded accessions belonging to the ssp. *fastigiata* along with two check varieties were evaluated for 16 yield components in summer 2014. The design adopted was randomized block design with three replications. The days to maturity of these accessions ranged from 111 to 121 days. Five accessions viz., NRCGs' 11878, 11880, 11886, 11926, and 13324 exhibited early maturity (110 days). One accession (NRCG 13324; 1800 kg/ha) recorded a high pod yield and shelling (69.8%), hundred seed mass (52.5 g); coupled with early (111d) maturity.

c. Evaluation of Valencia accessions for table purpose

From 2000 Valencia accessions available based on minimal passport data, 200 accessions were short-listed on the basis of country of origin. These accessions belonged to 15 different countries. These accessions were screened visually at the time of harvest for pod yield and pod features. On the basis of high yield, 25 accessions were short-listed and evaluated in a replicated randomised block design for sixteen agronomic and yield traits during summer 2014.

The days to maturity of the accessions ranged from 110 to 115 days. Most of the accessions were poor yielders (<1000 kg/ha) but two accessions, NRCG 14163 (1110 kg/ha) and NRCG 14478 (1080 kg/ha) recorded a pod yield of about 1100 kg/ha with moderate shelling outturn (~67%) and coupled with medium maturity (112 d). The accession, NRCG 14163 over two summer seasons recorded the highest pod yield, and shelling outturn. Hundred seed mass was high (50.8 g) in one accession NRCG 14332. These accessions will be assessed for their amino acid and fatty acid compositions.

4.2 *Kharif* 2014

4.2.1 Evaluation of large seeded Virginia (spreading/semi-spreading) accessions

Thirty large seeded accessions including two checks were sown in a randomised block design with three replications. The maturity of these accessions were medium- which ranged from 114-118 days. Five accessions were significantly superior over the best check, Somnath with a high pod and kernel yield. These accessions were: NRCG 10059 (2912 kg of pod and 2074 kg of kernel/ha); NRCG 10085 (2902 of pod and 1899 kg of kernel/ha); NRCG 12132 (2804 of pod and 1746 kg of kernel/ha); NRCG 12048 (2568 of pod and 1603 kg of kernel/ha) and NRCG 12114 (2400 of pod and 1558 kg of kernel/ha). Among these accessions, one accession NRCG 10059 had a very high (71.2%) shelling; two accession NRCG 10085 (47.3 g) and NRCG 12048 (42.1g) had large seed size; and one accession long and elliptical seed shape (2.3; as determined by seed length/width ratio).

4.2.2 Evaluation of Valencia accessions for table purpose

Another set of twenty-five Valencia accessions have been evaluated for sixteen agronomic and yield traits in a randomised block design with three replications with two check varieties. Two accessions NRCG 14815 (4859 kg/ha) and NRCG 14274 (4450 kg/ha) recorded significant high pod yield over the best check, Gangapuri (3900 kg/ha). However for kernel yield, only one accession NRCG 14815 recorded significant higher kernel yield (3102 kg/ha) over the best check Gangapuri (2729 kg/ha).

5.0 Analysis of quality (oil, protein and sugar) of 1000 working collection accessions

1000 accessions of working collection have been evaluated for oil, protein and sugar. These accessions belonged to 62 countries. The botanical group of these accessions were: 226 Valencia; 442 Spanish bunch; 193 Virginia bunch; 117 Virginia Runner; and 3 intermediate types.

The oil content in 987 accessions ranged from 44.4%-55.6%; protein content ranged from 21.3%-35.6%; and the sugar content ranged from 2.9%-6.6%. Out of 1000 accessions, 105 accessions oil content having more than 52%. Of these 16 accessions recorded more than the benchmark variety TMV 10 which was so far the highest oil containing genotype i.e 52.8%. 407 accessions recorded more than 30% protein content of which eight accessions recorded >34% protein; and 425 accessions recorded more than 6% sugar content of which 24 accessions had >6% sugar content. The top five accessions in each of these categories are provided below.

Table 1. Promising accessions identified for quality traits

S.No.	Traits	Top five accessions (NRCGs)	Value
1	High oil (%)	7040 6999 1476 12328 3817	55.60% 55.00% 54.90% 54.90% 54.80%
2	High protein (%)	7128 12523	35.60% 35.20%

		5239 7063 12666	34.70% 34.60% 34.40%
3	High sugar (%)	7063 12317 7128 1632 5239	6.58% 6.53% 6.39% 6.35% 6.33%

One accessions Ah 347/5 recorded the lowest oil content (44.4%). Three accessions, NRCGs 7063, 7128 and 5239 recorded both high protein and sugar contents.

6.0 Screening for low temperature tolerance at germination under lab conditions

The low temperatures (<18C) at sowing in the winter (rabi-summer) groundnut crop in India result in slow seedling emergence and poor plant stand. Delay in seedling emergence extends crop duration beyond 120 days, exposing the crop to high temperatures at reproductive phase and pod damage due to early onset of monsoon rains. Identification and incorporation of cold tolerance are therefore important groundnut breeding objectives Hence, to assess the low temperature tolerance at germination of 195 released varieties and 167 accessions of working collection an experiment was conducted under lab conditions. The seeds planted in a roll towel were incubated at 12°C day-night and germination after 10 days were counted.

Altogether 39 varieties have shown germination up to 80% under incubation at 12°C after 10 days. Of which 15 varieties exhibited 100% germination under the above conditions. The popular varieties grown during rabi-summer and which exhibited 100% germination were MH 2, MH 4, Kopergaon 3, ICGV 00350, OG 52-1 and TAG 24, TG 26, Dh 86, TG 37A etc.

Among the accessions of working collection, 40 accessions exhibited germination up to 80% under incubation at 12°C of which nine accessions viz. NRCGs 14367 (FST), 14403 (FST), 14419 (FST), 14450 (FST), 14481 (FST), 14484 (FST), 14360 (HYB) 14341 (HYR), and 14383 (VUL) exhibited 100% germination under the above conditions. These accessions will be grown under field conditions to validate the results.

7.0 screening for resistance to stem rot under sick plot conditions

Four hundred and thirty five genotypes comprising 195 released varieties; 144 GG 20 M5 mutants; 84 AICRP-G genotypes; 12 advanced breeding lines were screened for resistance to stem rot under sick plot conditions. Altogether 32 genotypes (12 GG 20 mutants; 6 AICRP-G genotypes; 14 released varieties have been found promising with <20% stem rot incidence.

Of these promising genotypes, eight GG 20 mutants (<10%); one AICRP-G genotype JSP 59 (9.1%), and seven released varieties, BG 2, ICGS 76, RS 138, VRI 3 (<5%), Karad 4-11 (5.6%), and TMV 1 (7.1%) and TMV 3 (7.7%) recorded less than 10% incidence of the disease.

IV. Year: 2013-14

1. Field maintenance of wild *Arachis* germplasm

A total of 106 accessions in 6 sections *viz Arachis* (46), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (4), *Procumbentes* (9) and *Rhizomatosae* (39) were maintained in the field gene bank. The seeds and cuttings of these species were supplied to different indenters.

2. Acquisition and distribution of germplasm accessions

During the year 2013, a total of 23 inter specific derivatives and 62 accessions/cultivars have been newly acquired. A few seeds of seven amphidiploids namely: *Arachis cardenasii x Arachis villosa; Arachis batizocoi x Arachis kuhlmannis; Arachis correntina x Arachis helodes; Arachis helodes x Arachis pusilla; Arachis duranensis x Arachis stenosperma; Arachis duranensis x Arachis cardenasii; Arachis stenosperma x Arachis cardenasii* have also been acquired from TNAU, Vridhachalam.

Sixteen diverse synthetics (doubled amphidiploids), 12 made from crosses involving eight different wild species of 'A' genome and four double synthetics, involving double crosses with six different 'A' genome wild species, were also been obtained from ICRIST, Patancheru for establishment, multiplication and further use in crop improvement programmes.

Distribution of germplasm

A total of 1415 accessions were supplied to 34 groundnut scientists viz. DGR (1094), SAUs (19), AICRP-G (185), and other ICAR institutes (117) for crop improvement programme to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in crossing programmes.

3. Multiplication and conservation of composite collection for water use efficiency and DUS reference varieties

A total of 106 accessions were multiplied in summer 2013 and conserved. Two released varieties (TG 26 and Somnath) have also been multiplied for seed enhancement. In *kharif* 2013, a total of 1434 accessions were multiplied for seed enhancement and conservation for long term storage at NBPGR, New Delhi and for medium term storage at this directorate. These included:

- general accessions (420),
- DGR mini-core collection (167),
- ICRISAT Mini-Core collection (184),
- accessions repatriated from ICRISAT (431),
- released varieties (187),
- morphological variants (45)

A total of 2021 germplasm accessions received from NBPGR, New Delhi, under Svalbard Gene Bank programme were also got multiplied through five different AICRP-G centres viz. ARS, Kadiri, UAS Dharwad, TNAU, Vridhachalam, JAU, Junagadh and MPKV, Rahiri. Of these a total of 1642 accessions have been rejuvenated and seeds of 219 accessions having sufficient quantity have been deposited with NBPGR, New Delhi for conservation. About 250 g each of 471 accessions of base collection have been deposited with NBPGR, New Delhi for long term conservation.

4. Characterisation of germplasm

During summer and *kharif* seasons, a reference set comprising of 189 accessions; 28 large seeded Spaish bunch accessions; 23 table purpose Valencia types were characterised for different descriptor traits. In addition in kharif season, a set of 70 newly released cultivars were characterised for 19 DUS reference traits as per the National Test Guidelines. The results are briefly presented below.

a. Reference collection for water use efficiency

A reference set comprising of 189 accessions representing maximum genetic variability for the drought tolerant traits viz, Specific leaf area, SPAD chlorophyll metre reading, root and canopy architecture, and stomatal density were characterised for 37 descriptor traits (13 qualitative and 24 quantitative traits). The design adopted was Augmented Block Design both in summer and *kharif* season during the year 2013.

In summer, the variation for the yield and its components indicated that the days to maturity of the accessions ranged from 93 (NRCG 10967) to 108 days (NRCG 12357). Five accessions, NRCGs 10967, 10922, 666, 201 and 7443 exhibited early maturity (<100 days) under summer condition. Pod yield ranged from 0.5 g (NRCG 10191) to 13.9 g plant^{-1} (NRCG 12922) closely followed by CS 287 (12.6 g plant^{-1}) and TIR 39 (12.5 g plant^{-1}). Hundred Seed Mass ranged as low as 20.6 g (NRCG 12642) to as large as 78.4 g (NRCG 5404). Altogether five accessions (NRCGs 7443, 12377, 12348, 5405, 12433) exhibited a hundred seed mass of more than 55 g. Shelling out-turn ranged from 44.4% (NRCG 14410) to 75.4% (NRCG 12423).

In ***kharif*** season, the accessions matured around 110 days, the early (103 d) being NRCG 12642 and the late maturing (123 d) being NRCG 14427. The pod yield in these accessions ranged as low as 1.5 g (NRCG 6064) to 10.6 g (NRCG 12713). Hundred seed mass ranged widely from 20.0 g (NRCG 666) to 68.8 g (NRCG 5405). The shelling outturn ranged from 47.1% (NRCG 12736) to 82.5 (NRCG 2190). However, the seed weight of this accession NRCG 2190 was small (34.0 g/100 kernel). Thirty six accessions recorded a high shelling outturn of more than 70%.

b. **Large seeded accessions**

Twenty-eight large seeded accessions belonging to the ssp *fastigiata* along with two check varieties were characterised for 16 descriptor traits in summer 2013. The design adopted was randomized block design with two replications. The days to maturity of these accessions ranged from 96 (NRCG 11922) to 102 days (NRCG 11929). Four other accessions viz., NRCGs' 11871, 11878, 11971, 11860 also exhibited early maturity (<100 days). Pod yield ranged from 3.9 g (NRCG 11922) to 15.3 g plant^{-1} (NRCG 11885). Hundred Seed Mass ranged as low as 29.0 g (NRCG 13324) to 53.8 g (NRCG 11860). Three other accessions, NRCG 11956, 11971 and 12069 exhibited hundred seed mass of more than 50 g. Shelling out-turn ranged from 54.1% (NRCG 11869) to 72.3% (NRCG 11971). One accession, NRCG 11860 was found promising for pod yield, Hundred Seed Mass coupled with early maturity.

Twenty-eight large seeded accessions belonging to the ssp *hypogaea* along with two check varieties were characterised for 17 descriptor traits in *kharif* 2013. The design adopted was randomized block design with two replications. The days to maturity of these accessions ranged from 115 (NRCG 12131) to 124 days (NRCG 11977). Pod yield ranged from 2.4 g (NRCG

12083) to 13.6 g plant^{-1} (NRCG 10059). Hundred Seed Mass ranged as low as 47.0 g (NRCG 11960) to 76.5 g (NRCG 12139). Twelve other accessions, had hundred seed mass 60 g and above. Shelling out-turn ranged from 58.3% (NRCG 11976) to 74.6% (NRCG 10059). One accession, NRCG 10059 was found promising for pod yield, and Hundred Seed Mass.

c. Characterisation of Valencia accessions for table purpose

From 2000 Valencia accessions available based on minimal passport data, 200 accessions were short-listed on the basis of country of origin. These accessions belonged to 15 different countries. These accessions were screened visually at the time of harvest for pod yield and pod features. On the basis of high yield, 23 accessions were short-listed and evaluated in a replicated randomised block design for sixteen agronomic and yield traits during summer and kharif 2013.

The days to maturity of the accessions ranged from 103 (MH 2) to 116 days (NRCG 14445). Pod yield ranged from 2.2 g (MH 2) to 7.5 g plant^{-1} (NRCG 14278). Hundred Seed Mass ranged from 30.5g (MH 2) to 53.0 g (NRCG 14815). Shelling out-turn ranged from 42.0% (MH 2) to 70.0% (NRCG 14232). One accession, NRCG 14163 was found promising for pod yield, shelling outturn coupled with early maturity.

5. Identification of promising entries for quality traits

Four hundred germplasm accessions were evaluated for five quality traits viz. protein, oil, sugars, fatty acid composition and phenol. For oil content the range observed was from 44.4% (NRCG 7128) to 54.9% (NRCG 1476). Protein content was in the range of 21.6% (NRCG 3817) to 35.6% (NRCG 7128). Sugar content ranged between 3.59% (NRCG 1476) to 6.58 (NRCG 7063). Phenols were in the range of 0.21% (NRCG 2514) to 0.31% (NRCG 1476). The free amino acids were between 0.07% (NRCG 3817) to 0.16 (NRCG 1451). The accession, NRCG 3817, protein and free amino acid contents were low. While the accession, NRCG 1476 recorded the highest oil content and phenol but with low sugar content. One Spanish Bunch accession NRCG 6213 was found to have low oil (45.5%) coupled with high protein (34.6%)

In a separate set of 98 Virginia accessions, oil content and O/L ratio were analysed. In these accessions, the oil content ranged from 42.4% (NRCG 14431) to 54.5% (NRCG 14366) followed by NRCG 14359 (54.4%). The O/L ratio was in the range of 1.0 (NRCG 14345) to 2.86 (NRCG 14466).

Among the 60 large seeded accessions evaluated, in the Spanish Bunch accessions, the range observed for oil content was 45.5% (NRCG 6213)-52.1% (NRCG 10580). Four more accessions showed oil content of more than 50% were: NRCG 11716 (51.8%), NRCG 10943 (50.8%), NRCG 11273 (50.3%), and NRCG 11909 (50.2%). For protein content the value observed was 26.9% (NRCG 10580) to 34.1% (NRCG 6213). Thus the accession NRCG 10580 had high oil coupled with low protein. The other six accessions which recorded high protein content (>30%) were: NRCG 11651 (33.9%), NRCG 10655 (32.7%), NRCG 11183 (32.4%), NRCG 12213 (32.3%), NRCG 12383 (31.5%), NRCG 12731 (31.1%).

Similarly in Virginia type large seeded accessions, the range observed was 44.6% (NRCG 12447) -54.8% (NRCG 12107) for oil content whereas for protein the values were 22.7% (NRCG 17760) to 34.8% (NRCG 12447). Thus the accession NRCG 12447 had low oil content coupled with high protein and can be used as a donor in breeding confectionery types.

6. Screening of germplasm for tolerance of soil borne diseases (stem rot and collar rot) under sick plot condition and nematodes

a. For tolerance to stem rot

In summer, 654 genotypes were screened for the tolerance of stem rot in sick plots. The soil population of *S. rolfsii* was $18.6x10^3$ cfu. Four genotypes, MH 1, RS 138, GG 6, Dh 101 with <10% disease incidence at harvest; seven viz., Kopergaon, Mallika, VG 0401, M 37, VG 0433, ICGS 1, VG 1002 with 10-20% disease incidence; and eight Dh 8, Dh 40, M 548, M 13, M 197, VG 0103, Dh 86, GJG 31 with 21-30% disease incidence were identified as promising. Twenty TAG 24 mutants in M5 family have been found promising against stem rot.

In kharif, 704 genotypes were screened for the tolerance of stem rot in sick plots. The soil population of *S. rolfsii* was $28.6x10^3$ cfu. Four genotypes, UF 70-103, Kadiri 5, MIII, and VRI 5 exhibited <10% disease incidence at harvest; five genotypes viz., CSMG 884, AK 265, M 548, VG 9816, and TGLPS 3 with 10-20% disease incidence; and six genotypes ICG FDRS 4, ICG FDRS 10, GG 3, TMV 3, GPBD 4, and HNG 69 with 21-30% disease incidence were identified as promising. Twenty TAG 24 mutants in M5 family have been found promising against stem rot. Two germplasm accessions, NRCG 14356 and NRCG 14428 exhibited 10-20% incidence were found promising.

b. For tolerance to collar rot (*Aspergillus niger*)

160 mini-core germplasm accessions and three released varieties were screened against *A. flavus* under sick plot along with two known resistant varieties, OG 52-1 and J 11 in *kharif* 2013. The seedling mortality was observed in these genotypes after 30 days of germination. The seedling mortality ranged from 0% (NRCG 14339) to 40.9% (NRCG14352). In resistant genotypes, the pod infection was 15% in OG 52-1 and 27% in J11. Four accessions, NRCGs 14339, 14372, 14373. 14469 recorded less than 10% seedling mortality. Among the released varieties the released variety TG 1 recorded the lowest incidence of 11%.

c. Tolerance to nematodes

Seven hundred and seventy six accessions, 448 accessions at JAU Junagadh, and 318 accessions at Anand were screened for over three years for tolerance of *M. arenaria* and *M. javanica* through All India Network Project on Nematodes (AINPN). At Junagadh, seven genotypes viz., NRCG 14424; JVB 2114; JSSP HPS 28; OG 953, OG 951, K 1274, KGN 33 were found resistant against *M. arenaria.* Eleven genotypes, ICGs 13048, 11187, 13006, 11206, 11429, 13120, OG 52-1, Somnath, Chitra, Kaushal and M 13 were found resistant against *M. javanica.*

V. Year: 2012-13

1. Field maintenance of wild *Arachis* germplasm

A total of 115 accessions in 6 sections *viz Arachis* (54), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (7), *Procumbentes* (6) and *Rhizomatosae* (40) were maintained in the field gene bank. The seeds and cuttings of these species were supplied to different indenters.

2. Acquisition and distribution of germplasm accessions

During 2012, fourteen inter specific derivatives (VG 0401, VG 0410, VG 0411, VG 0430, VG 0437, VG 0438, VG 0439, VG 0448, VG 09410, VG 09405, VG 09406, VG 1002, VG 1005, VG 1009) and five accessions/cultivars have been newly acquired. A few seeds of seven amphidiploids namely: *Arachis cardenasii x Arachis villosa; Arachis batizocoi x Arachis kuhlmannis; Arachis correntina x Arachis helodes; Arachis helodes x Arachis pusilla; Arachis duranensis x Arachis stenosperma; Arachis duranensis x Arachis cardenasii; Arachis stenosperma x Arachis cardenasii* were also acquired.

A total of six hundred accessions were supplied to 28 groundnut scientists of DGR (573), SAUs (25) and others (2) for crop improvement programme to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and for using in crossing programmes.

3. Multiplication and conservation of composite collection for water use efficiency and DUS reference varieties

Eighty-four accessions and advanced breeding lines having desirable morpho-physiological traits which were identified earlier were multiplied during summer 2012. Two released varieties (TG 26 and Somnath) were multiplied for seed enhancement. In *kharif*, 1424 accessions were multiplied for seed enhancement. These included: voucher samples (284), DGR mini-core collection (167), exotic accessions (59), new germplasm accessions (47), accessions repatriated from ICRISAT (223), released varieties (173), large-seeded accessions (30), 28 accessions having low carbon isotope discrimination ($\Delta^{13}C$) and others (413).

Multiplication of a total of two thousand accessions, received from NBPGR, were also arranged at five AICRP-G centres (TNAU, Vridhachalam, ANGRAU Kadiri, UAS Dharwad, MPKV Rahuri and JAU Junagadh).

4. Characterisation of germplasm

a. Reference collection for water use efficiency

Out of 5577 accessions (5000 general; 184 ICRISAT mini core; 129 DGR mini-core; 54 having diverse canopy architecture; and 213 stable water-use efficient breeding lines) evaluated for different traits, 189 accessions have been used for developing the reference/composite collection (core group). These accessions/lines belong to *fastigiata*, *vulgaris*, *hypogaea* (semi-spreading) and *hypogaea* (spreading) botanical types. Based on various morpho-physiological traits such as specific leaf area or leaf thickness, canopy dimensions (spread and height), leaf folding and changes in leaf angles during mid-day stress, stomatal density on the upper and lower surfaces of the leaf, and canopy and leaf temperatures, chlorophyll contents, SPAD chlorophyll meter readings, leaf desiccation rate, leaf RWC and water potential, and parameters of chlorophyll

fluorescence, and root traits such as root length primary and secondary, and root length density at different soil depths under normal and water deficit conditions a reference set of 189 accessions representing maximum genetic variability among all the traits studied has been developed under the externally funded project on, "Evaluation of Groundnut Germplasm for Morphological, Physiological and Molecular Characters/Traits Associated with Drought Tolerance for Enhancing Productivity in Rain-dependent System" under NFBSRA.

This reference set has extensively been characterised for 13 qualitative and 24 quantitative traits in *kharif* 2012. The variability for the yield and its components indicated that the days to maturity ranged from 101 (NRCG 12922) to 128 days (NRCG 14356); pod yield from 0.5 g (NRCG 14451) to 13.8 g plant^{-1} (JUG 27) closely followed by NRCGs' 5405 and 12177 (12.3 g plant^{-1}). Hundred Seed Mass ranged from as low as 18.0 g (ICG 4747) to as high as 60.2 g (NRCG 12177). Shelling out-turn ranged from 52.1% (NRCG 12581) to 81.5% (NRCG 10541).

b. Large seeded accessions

Twenty-eight large seeded accessions belonging to the ssp *hypogaea* along with two check varieties M13 and GG 20 were characterised for 16 yield and its component traits in *kharif* 2012. The design adopted was a randomized block design with two replications. The days to maturity of these accessions ranged from 117 (NRCGs' 4775, 12083, 12447) to 122 (NRCGs' 12056, 12107, 12806). Pod yield ranged from 2.9 g (NRCG 12499) to 12.1 g plant^{-1} (NRCG 272). Hundred Seed Mass ranged from 34.8 g (NRCG 12499) to 59.8 g (NRCG 12107). Shelling out-turn ranged from 57.2% (NRCG 12447) to 78.6% (NRCG 12107). Although the accession, NRCG 12107 was late maturing but the shelling outturn and HSM were high.

c. Characterisation of mini-core accessions of the subspecies *fastigiata*

Sixty mini-core accessions belonging to the subspecies *fastigiata* were characterised for 13 traits during summer and *kharif* 2012. The design adopted was augmented block design. The duration of maturity ranged from 98 days (NRCG 14493) to 105 days (NRCGs' 14329, 14407, and 14477). The other accessions which exhibited early maturity (99 days) were NRCG 14399 and NRCG 14425. The pod yield was highest (15.0 g plant^{-1}) in NRCG 14433 and lowest (2.3 g plant^{-1}) in NRCG 14385. Hundred Seed Mass ranged from 20.0 g (NRCG 14425) to 51.0 g (NRCG 14461). Shelling out-turn ranged from 51.0% (NRCG 14482) to 75.8% (NRCG 14405).

While in *kharif*, the duration of maturity ranged from 103 days (NRCG 14425) to 115 days (NRCGs' 14329, 14363, and 14420). The accessions NRCG 14329 was found to be late maturing consecutively in both summer and *kharif* seasons. The pod yield was highest (12.5 g plant^{-1}) in NRCG 14480 and lowest (1.7 g plant^{-1}) in NRCG 14381. Hundred Seed Mass ranged from 20.5 g (NRCG 14368) to 49.4 g (NRCG 14329). One accession NRCG 14425 exhibited low hundred seed mass both in summer (20.0 g) and *kharif* (24.0 g) seasons. Shelling out-turn ranged from 60.0% (NRCG 14485) to 79.1% (NRCG 14387). The shelling outturn of the accession NRCG 14405 was high in both summer (75.8%) and *kharif* (77.1%) season.

5. Evaluation of genotypes with low carbon isotopic discrimination ($\Delta^{13}C$), for yield and physiological traits under moisture deficit conditions during summer 2012

Twenty-eight genotypes comprising 12 varieties, 7 from ICRISAT mini-core collection and 9 from subset of DGR working collection all which exhibited low $\Delta^{13}C$ values (around 18.0) were studied for 16 yield component traits, physiological traits (SLA and SCMR), and biomass production under moisture deficit and irrigated conditions in summer 2012. The check varieties used were GG 2 and ICGV 87846. This experiment has been carried out over two years during summer seasons while over one year in kharif season. The pooled results are provided below.

The changes in SLA studied at 10, 20 and 30 days after imposing the moisture deficit stress (DAIS) over those of regularly irrigated indicated that the SLA decreased initially (10 DAIS) irrespective of the genotypes. The reduction in SLA after 10 DAIS ranged from 0.7% (GG-2) to 19.5% (Kadiri-3). This trend, however, got changed 20 DAIS in that the reduction in SLA was the least (0.1) in TG 1 to and highest (12.6%) in TMV 10. Interestingly six genotypes exhibited increase in SLA which ranged between 1.3% (T64) to 11.5% (DSG 1).

ANOVA worked out for pod yield and its related traits revealed that there were significant differences among the genotypes for all the yield traits during each year and over years. The days to maturity among the released varieties under irrigated condition ranged from 106 (DRG 12) to 121 days (DSG 1). While under moisture deficit stress conditions, the days to maturity was unaffected (106 days) in case of DRG 12. On the contrary, the maturity was delayed in the variety TG 1 by 6 days under moisture deficit stress conditions.

The pod yield plant^{-1} was the lowest in the variety TMV 10 under both irrigated (3.0 g) and moisture deficit stress (1.2 g) conditions. The pod yield was the highest (18.8 g plant^{-1}) in the variety BG 2 under irrigated condition. While under moisture deficit stress condition the check variety ICGV 86764 recorded the highest pod yield (8.1 g plant^{-1}) followed by GG 2 (7.3 g plant^{-1}).

Hundred seed mass ranged from 34.6g (TMV 10) to 53.8g (T 64) under irrigated conditions. Where as under moisture deficit stress condition the values ranged from 24.5g (DSG 1) to 29.2g (T 64). While the shelling outturn was 54.6% in TG 1 and 68.6% in DRG 12 under irrigated condition. While the shelling outturn was as low as 40.4% in GAUG 10 and as high as 67.8% in TMV 10 under moisture deficit conditions.

Among the germplasm accessions evaluated, the duration of maturity under regularly irrigated conditions ranged from 110 days (NRCG 404) to 118 days (NRCG 14432). While under the moisture deficit stress conditions, the duration was rather unaffected (110 days) in case of NRCG 404. While two accessions NRCG 14342 and NRCG 12138 matured late (116 days).

The pod yield plant^{-1} was the lowest (2.5g) in NRCG 14352 and highest (10.5g) in NRCG 14395 under irrigated condition. Whereas under moisture deficit stress condition it was the lowest (0.7

g) in NRCG 14390 and highest (5.5g) in NRCG 14355. Hundred seed mass ranged from 26.0g (NRCG 11924) to 55.2g (NRCG 14395) under irrigated conditions. While under moisture deficit stress condition the values ranged from 20.4g (NRCG 12393) to 31.0g (NRCG 12138). The shelling outturn was as low as 47.5% in NRCG 14395 and 62.6% in NRCG 11942 under irrigated condition. It was very low (31.4%) in NRCG 14442 and highest (51.3%) in NRCG 11924 under moisture deficit stress conditions.

While in *kharif*, only 16 yield related traits were studied as moisture deficit stress could not be imposed at specific stages of crop growth as can be done in summer season. The duration of maturity in released varieties was 112 days in GG 2 and 123 days in BG 2. Pod yield ranged from 5.3 g (DSG 1) to 10.7 g plant^{-1} (T 64). Hundred Seed Mass ranged from 31.3 g (DSG 1) to 48.3 g (TG 1). Shelling out-turn ranged from 64.9% in TG 1 and 73.3% in DRG 12.

Among the germplasm accessions duration of maturity ranged from 119 days (NRCG 11924) to 124 days (NRCG 666). Pod yield ranged from 2.3 g (NRCG 14390) to 15.8 g plant^{-1} (NRCG 8963). Hundred Seed Mass ranged from 25.2 g (NRCG 666) to 48.3 g (NRCG 8963). Shelling outturn ranged from 54.6% (NRCG 666) to 72.6% (NRCG 11942). The germplasm accession NRCG 666 was a poor yielder in spite of its late maturity and had shrivelled seeds thus leading to poor shelling outturn.

6. Screening of Valencia accessions for table purpose

From 2000 Valencia accessions available in the working collection, 200 accessions were short-listed based on minimal passport data. These accessions belonged to 15 different countries. These accessions were screened visually at the time of harvest for better pod features and pod yield. On the basis of high yield, 51 accessions were short-listed and evaluated in a replicated randomised block design for sixteen agronomic and yield traits during summer and *kharif* 2012.

In summer 2012, duration of maturity of the accessions ranged from 123 days (NRCGs' 14328, 143332 and 14481) to 130 days (NRCG 14775). Pod yield ranged from 3.2 g (NRCG 14243) to 13.3g plant^{-1} (NRCG 14163). The accession NRCG 14163 over two summer seasons recorded the highest pod yield of 13 g plant^{-1}. Hundred Seed Mass ranged from 27.0 g (NRCG 14328) to 58.0 g (NRCG 14765). Shelling out-turn ranged from 49.0% (NRCG 14328) to 88.8% (NRCG 14484).

While in *kharif*, these 51 accessions were evaluated in a replicated randomised block design for fourteen agronomic and yield traits. The duration of the accessions were early than those of summer season and ranged from 105 days (NRCG 14344) to 118 days (NRCG 14815). Pod yield ranged from 1.3 g (NRCG 14445) to 8.1 g plant^{-1} (NRCG 14274). Hundred Seed Mass ranged from 18.2 g (NRCG 14451) to 58.4 g (NRCG 14332). Shelling out-turn ranged from 58.3% (NRCG 14815) to 72.5% (NRCG 14163).

8. Screening of germplasm against soil borne pathogens

a. For tolerance of stem rot (*Sclerotium rolfsii*)

Thirty two Spanish bunch germplasm accessions of mini-core collection in summer 2012 and 60 mini-core germplasm accessions; 184 released varieties and 4 interspecific hybrid derivatives in kharif 2012 were screened for tolerance of stem rot in sick plot.

The accession, NRCG 14499 recorded a low level (25%) of incidence in summer as against 25-100% level of incidence in various genotypes. In *kharif* 2012, the accession NRCG 14396 recorded below 10% disease incidence. In case of four inter specific derivatives screened, NRCG CS 425 and VG 09074 recorded below 20% incidence.

b. For tolerance of collar rot (*Aspergillus niger*)

In *kharif* 2012, 60 mini-core germplasm accessions and three released varieties were screened against *A. flavus* in a sick plot along with two known resistant varieties, OG 52-1 and JCG 88 in *kharif* 2012. The seedling mortality was observed in these genotypes after 30 days of germination.

The seedling mortality ranged from 0% (NRCG 14339) to 40.9% (NRCG14352). Four accessions, NRCGs 14339, 14372, 14373. 14469 recorded less than 10% seedling mortality. Out of 12 mutant GG 20 families, one family was found free of seedling mortality.

VI. Year: 2011-12

Field maintenance of Wild *Arachis* germplasm

A total of 115 accessions in 6 sections *viz Arachis* (54), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (7), *Procumbentes* (6) and *Rhizomatosae* (40) were maintained in the field gene bank. The seeds and cuttings of these species were supplied to different indenters.

Acquisition, distribution of germplasm accessions

A total of 2670 germplasm accessions including wild relatives of groundnut were supplied to 41 indenters for use in the crop improvement programme. These germplasm accessions were supplied to the scientists of DGR (817), State Agricultural Universities (1786) and AICRP-G centres (50) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in crossing programmes. Fourteen accessions (4 released varieties; 10 amphidiploids) were newly acquired.

Multiplication and conservation of composite collection for water use efficiency and DUS reference varieties

A total of 189 diverse germplasm accessions and advanced breeding lines having desirable morpho-physiological traits which were identified earlier were multiplied during summer 2011. Ten DUS reference varieties have also been multiplied. In *kharif*, 1211 accessions were multiplied. These included voucher samples, NRCG mini-core collection, exotic accessions, new germplasm, repatriated accessions, released varieties and large-seeded accessions.

Characterisation of large-seeded accessions, high WUE accessions, exotic collection

Fifty-one large seeded accessions, 59 exotic accessions, 75 mini-core accessions and 30 WUE accessions were sown under two replications for characterisation. However, due to axcessive rainfall in the season the yield levels were low (<10 g/plant) in most of the accessions. Hence, for proper characterisation of the vegetative, reproductive and pod traits this activity will be repeated during *kharif* 2012.

Evaluation of genotypes with low $\Delta^{13}C$, for yield and physiological traits under moisture deficit conditions during summer 2011

Twenty-eight genotypes which included 12 released varieties, 7 ICRISAT mini-core collection and 9 accessions of subset of NRCG working collection which exhibited low $\Delta^{13}C$ values (around 18.0) were studied for yield components, physiological traits like SLA and SCMR under moisture deficit and under irrigated conditions in summer 2011. The check varieties used were GG 2 and ICGV 87846.

The genotypes were grown in a randomised block design with two replications. The irrigation water was withheld for 30 days from 40 DAS till 70 DAS. Soil moisture content at 15 cm depth was 20.8, 14.2, 12.5% at 10, 20 and 30 days after imposing stress while the corresponding values at 30 cm soil depth was 18.5, 15.7 and 12.3% respectively. The soil temperature increased progressively from 36.0 to 42.0˚C during the stress period.

The SLA and SCMR studied (measured or determined??) 10, 20 and 30 days after imposing the water stress indicated that the SCMR increased initially and there after got reduced in all the genotypes under both moisture deficit and irrigated conditions. However, the magnitude of increase in SLA differed under the moisture deficit stress and irrigated conditions (Table 1). In case of SLA, the genotypes under irrigation initially recorded high SLA but subsequently exhibited lower values except for ICGV 86590 which exhibited a declining trend across the stages (Table 2). The observed increase in the SLA after 20 days of water stress was due mainly to the reduction in leaf weight while subsequent reduction in SLA after 30 days of stress was due to increase in leaf weight with a concomitant reduction in leaf area.

ANOVA worked out for pod yield and its related traits revealed that there were significant differences among the genotypes for all the yield traits studied. The pod yield plant^{-1} under irrigated condition was in the range of 3 g (NRCG 666) to 20.5 g (ICGV 86590) while under stress the values ranged from 1.6 g (NRCG 12138) to 8.9 g (ICGV 86590) closely followed by ICGV 87846 with 8.5 g. Among the promising genotypes identified the observed reduction in pod yields due to moisture deficit was in the range of 25.7% to 56.6% (Table 3). It was observed that causes for the low yields realised in the germplasm studied were due mainly to reduction in number of pods per plant and 100-seed mass indicating the greater role of moisture deficit stress on partitioning of assimilates.

Screening of Valencia accessions for table purpose

From 2000 Valencia accessions available based on minimal passport data, 200 accessions were short-listed on the basis of country of origin. These accessions belonged to 15 different countries. These accessions were screened visually at the time of harvest for pod yield and pod features. On the basis of high yield, 51 accessions were short-listed and evaluated in a replicated

randomised block design for sixteen agronomic and yield traits during summer 2011. Mean days to maturity of the accessions was 109. Pod yield ranged from 5.7 g (NRCG 14329) to 13.6 g plant^{-1} (14163). Hundred Seed Mass ranged from 29.5g (NRCG 14451) to 52.0 g (NRCG 14432). Shelling out-turn ranged from 50.4% (NRCG 14188) to 73.8% (NRCG 14163). While in *kharif*, the yield levels of these 50 accessions were low due to incessant high rainfall received at peak flowering and pod formation stages and hence the true genetic potential of these accessions could not be assessed. Hence, this experiment will be repeated in *kharif* 2012.

Screening of germplasm for tolerance of *S. rolfsii*

Sixty-six Spanish mini core accessions were screened in a sick plot for resistance and tolerance of *S. rolfsii*. The maximum incidence of disease (72.4%) was recorded in accession NRCG 10107. Under this disease pressure, four accessions viz.: NRCG 14380 (13.8%), NRCG 14405 (16.7%), NRCG 14409 (17.4%) and NRCG 14383 (18.5%) recorded below 20% incidence of stem rot. In four other accessions, NRCGs 14472, 14474, 14414, and 14424, the incidence of disease was <30% which indicated their potential for use in crop improvement programme.

Table 1. Mean SCMR in irrigated and moisture deficit stress conditions

Parameter	10 DAIS		20 DAIS		30 DAIS	
	Irrn.	Str.	Irrn.	Str.	Irrn.	Str.
Mean SCMR	37.7	40.5	40.2	40.8	38.9	38.6
Range	28-45	39-45	35-46	34-48	27-45	34-46
CV (%)	4.6	5.0	6.0	9.4	6.2	10.5
CD (p=0.05)	3.6	4.1	4.9	5.2	4.9	6.1

Irrn.= Irrigated; Str.= Moisture deficit stress; DAIS= Days after imposing stress

Table 2. Mean SLA (g cm^{-2}) in irrigated and moisture deficit stress conditions

Parameter	10 DAIS		20 DAIS		30 DAIS	
	Irrn.	Str.	Irrn.	Str.	Irrn.	Str.
Mean SLA	190.7	166.1	175.9	176.9	172.5	167.6
Range	146-240	140-187	149-214	141-205	151-197	149-183
CV (%)	8.8	7.5	10.2	8.6	8.9	9.2

CD (p=0.05)	34.7	12.3	49.7	15.2	42.1	15.6

Irrn.= Irrigated; Str.= Moisture deficit stress; DAIS= Days after imposing stress

Table 3. Yield of promising genotypes under moisture deficit stress and irrigated conditions

Genotype	Pod yield (g plant^{-1})	
	Irrigated	Stress
ICGV 86590	20.5	8.9 (56.6%)
GG 2	17.3	8.5 (50.9%)
ICGV 87846	16.4	9.5 (48.2%)
DRG 12	14.3	7.1 (50.3%)
Kadiri 3	13.3	8.3 (37.6%)
GAUG 10	12.5	9.0 (29.1%)
M 197	10.5	7.8 (25.7%)
CD (p=0.05)	6.9	3.0

VII. Year: 2010-11

1. Field maintenance of wild *Arachis* germplasm

In field gene bank, 106 accessions belonging to 6 different sections *viz. Arachis* (66 accessions), *Caulorhizae* (1 accession), *Erectoides* (7 accessions), *Heteranthae* (7 accessions), *Procumbentes* (accessions 10), and *Rhizomatosae* (39 accessions) were maintained. The seeds and cuttings of these species were supplied to different indenters.

2. Acquisition, distribution and utilization of germplasm accessions

For use in various ongoing crop improvement programmes, 1398 germplasm accessions including wild relatives of groundnut, were supplied to 36 indenters for identification of promising lines for WUE, diseases and nematode tolerance, large seeded types and subsequent use in ongoing crossing programmes. The recipients included the scientists of DGR (1059 accessions), State Agricultural Universities (239 accessions) and AICRP-G centres (100 accessions). Three new accessions were acquired.

3. Multiplication and conservation of germplasm accessions

a) Voucher samples

In *kharif*-2010, 284 accessions (60 HYB, 40 HYR, 145 VUL, and 39 FST) were sown for multiplication. As poor yields were realized due to excessive rains, the seeds could not be sent for conservation in NBPGR, New Delhi.

b) Mini-core collection

Out of 184 accessions comprising the mini core collection, 75 accessions (6 HYB, 11 HYR, 30 VUL, and 28 FST) were multiplied in *kharif* 2010.

c) DUS reference varieties

Thirty DUS reference varieties (7 HYB, 8 HYR, 13 VUL, and 2 FST) were multiplied in *kharif* season for augment their seeds.

d) General accessions

A set of 159 accessions received from NBPGR was multiplied in *kharif* season.

e) Released varieties

A set of 173 released varieties (48 HYB, 26 HYR, 95 VUL, and 4 FST) was multiplied in *kharif* season for distribution and conservation.

e) Variability garden

A set of 45 morphologically unique accessions (15 HYB, 2 HYR, 10 VUL, and 18 FST), identified from the working collection, was multiplied for distribution and conservation.

f) Sub-set of NRCG working collection

In *kharif*, 167 accessions (37 HYB, 9 HYR, 72 VUL, and 49 FST), representing a subset of NRCG working collection, were multiplied. Of these, 86 accessions were deposited with NBPGR for conservation.

h) Repatriated accessions

A set of 185 accessions (HYB: 36; HYR: 28; VUL: 87; FST: 34) repatriated from ICRISAT was multiplied in *kharif* season. Due to poor yields, the quantities of seeds required for depositing with NGB could not be obtained. Hence, these accessions will be further multiplied in ensuing *kharif*.

i) Composite collection for water use efficiency

A total of 196 diverse germplasm accessions and advanced breeding lines developed through NFBSRA project were multiplied in *kharif*.

g) ICRISAT germplasm

For multiplication, a total of 91 (26 HYB, 5 HYR, 24 VUL, and 36 FST) accessions were sown in *kharif* 2010.

4. Morpho-physiological characterization of mini-core germplasm

a) Characterisation of new accessions

A total of forty-one new accessions (21 HYB, 3 HYR, 5 VUL, 3 FST, and 9 unidentified) were evaluated and characterised in *kharif* 2010. Due to excessive rainfall during the critical stages of crop growth, only eight qualitative and 12 quantitative traits could be characterised. Pod yield in these accessions ranged from 2.0 g (NRCG 13311) to 11.2 g (NRCG 13307); Shelling turnover ranged from 47.9 (NRCG 743) to 72.2% (NRCG 13313). Hundred seed mass ranged from 16.0 g (NRCG 13192) to 48.6 g (NRCG 13000).

b) Characterisation of exotic collection

Forty exotic collections have been evaluated and characterised in *kharif* 2010 only eight qualitative and 12quantitative traits could be characterised

Among the 40 accessions studied, the pod yield was low (1.7 g/plant) in NRCG 17239 to 9.9 g/plant in NRCG 17242. Hundred seed mass ranged from 18.2 g (NRCG 17211) to 44.8 g (NRCG 17241). Shelling turnover ranged from 44.4 (NRCG 17211) to 73.8% (NRCG 17230).

c) Characterisation of large seeded accessions

Twenty-eight large seeded Virginia accessions (HYB: 18; HYR: 10) were evaluated and characterised for 12 pod and seed traits. The check varieties used were M 13 (HYR) and GG 20 (HYB).

The hundred seed mass ranged from 27.4 g (NRCG 12560) to 48.7 g (NRCG 4775). Pod yield of these accessions ranged from 2.2 g (NRCG 13085) to 11.8 g (NRCG 685) per plant. Shelling turn-over in the accessions ranged from 52.5 (NRCG 12447) to 72.3% (NRCG 13085).

4) Studies on flowering behaviour and yield of large-seeded germplasm accessions

For two consecutive summer seasons (2009 and 2010), 28 large seeded accessions (13 Spanish bunch and 15 Valencia) were evaluated in field for their yield traits in a randomized block design with two replications at two locations– DGR, Junagadh and ARS, Shirgaon. The flowering behaviour was studied in both 2009 and 2010 seasons at DGR Junagadh and only in 2010 season at ARS, Shirgaon. The varieties TKG 19A and GG 7 were used as check.

a) Results of analysis of two-year data generated at DGR, Junagadh

The total number of flowers produced in each of the 30 accessions at four different stages at ten-day intervals beginning at 45 DAS and culminating at 75 DAS (coinciding with flower initiation and peak flowering stages, respectively) were recorded besides recording observations on five yield traits (number of mature pods, pod yield, 100-seed mass, shelling outturn, and days to maturity). The ANOVA conducted by using data pooled over years indicated that:

- Among the yield traits, the year-to-year and the genotypic variations were significant only for number of mature pods and days to maturity while the variations for pod yield were non-significant and only genotypic variations were significant for 100-seed mass and shelling outturn.
- In case of flower production at the four different growth stages of growth, the year-to-year variation was not significant at 45 DAS while both year-to-year and genotypic variations were significant at all the other three stages.

The values of mean, range, critical difference and co-efficient of variation calculated by using pooled data for the yield traits are given in Table 1.

Table 1. Mean, range, critical difference (CD) and co-efficient of variation (CV) for the yield traits at DGR Junagah

Trait	Mean	Range	CD (p=0.05)	CV (%)
Mature pods (no. per plant)	12.3	4.3-18.8	6.8	33.1

Pod yield (g/plant)	12.9	5.4-16.9	6.4	35.9
Hundred seed mass (g)	45.4	38.0-55.2	6.2	7.8
Shelling outturn (%)	69.8	56.8-75.6	6.8	13.3
Maturity (no. of days)	114.3	110.5-119.8	5.15	2.2

b) **Results of analysis of one year data of two locations** (DGR, Junagadh and ARS, Shirgaon)

In summer 2010, the observations were recorded on flower production (at four stages of crop growth) and five yield traits for 28 germplasm accessions along with two check varieties, TPG 41 and GG 7.

The analysis of pooled data indicated that:

- For flower production, variations due to locations as well as genotypes were significant at all the four stages of crop growth
- Among the yield traits, days to maturity, number of mature pods and hundred seed mass exhibited significant variations due to genotype whereas the variations in pod yield were significant only due to location. The variations in shelling outturn due to location or genotype were, however, non-significant.

c) Comparison of expression of traits at DGR, Junagadh and ARS Shirgaon

The values of mean (pooled), range, critical difference and co-efficient of variation for yield traits in the two locations are provided in **Table 2.**

Table 2. Comparison of values of mean (pooled), range, citical difference, and co-efficient of variation for yield traits

Trait	Mean		Range		CD (p=0.05)	CV (%)
	Junagadh	Shirgaon	Junagadh	Shirgaon		
Mature pods (no./plant)	13.0	9.1	4.8-16.8	6.3-12.7	2.2	23.1
Pod yield (g/plant)	13.6	10.3	4.1-19.4	6.6-14.6		
Hundred seed mass (g)	44.6	54.7	39.0-53.0	41.3-68.4	5.6	4.6
Shelling outturn (%)	69.3	70.9	40.9-75.6	58.4-76.4	3.9	5.6
Days to maturity	112	106	108-119	96-119	6.7	2.5

Thus the values of days to maturity, pod yield and number of pods/plant for 30 genotypes grown at Junagadh were higher than the corresponding values pertaining to Shirgaon. While the values of hundred seed mass and also shelling outturn, were higher for Shirgaon than those for Junagadh.

It was found that the seed filling was rapid in Ratnagiri, which resulted in the high seed mass, but the number of pods and yield/plant were found to be slightly lower at Ratnagiri when compared with the values observed under Junagadh conditions. Temperature seemed to play a role in rapid seed filling at Ratnagiri (Table 3) which was about 25-30◦C throughout the crop growth.

Table 3. Weather-data for crop-period in *rabi*-summer 2009-10

Month	Temperature (˚C)				Relative Humidity (%)			
	Junagadh		Shirgaon		Junagadh		Shirgaon	
	Min.	Max.	Min.	Max.	Morning	Evening	Morning	Evening
January	13	31	24	33	59	23	61	49
February	15	32	23	32	63	19	76	60
March	22	38	26	33	62	16	83	68
April	24	41	29	33	74	19	78	68
May	26	41	30	35	76	29	73	64

5. Evaluation of genotypes with low $\Delta^{13}C$, for yield and physiological traits under moisture-deficit conditions

A total of 28 genotypes comprising 12 released varieties, 7 from ICRISAT mini-core collection and 9 accessions of subset of NRCG working collection and identified for exhibiting low $\Delta^{13}C$ values (around 18.0) were studied for yield and its components and physiological traits (SLA and SCMR) under moisture-deficit conditions in summer 2010.

The genotypes were grown in a randomised block design with two replications. For imposing moisture-deficit stress, the irrigation was withheld for 30 days from 40 DAS to 70 DAS. The soil-moisture content at 15 cm depth was 15.0, 13.5 and 6.2% at 10, 20 and 30 days after imposing stress (DAST), respectively while corresponding values at 30 cm depth were 17.0, 14.2 and 11.1% respectively. These values were indicative of the extent of moisture deficit stress to which the genotypes were subjected. The soil temperature at 15 cm depth was 32.0, 38.7 and 44.1°C at 10, 20 and 30 DAST, respectively.

The ANOVA indicated the significant differences due to genotypes for all the traits studied. The range of per plant pod yield was 4 g (TMV 10) to 34 g (BG 2) for the released varieties and from as low as 1 g (NRCG 404) to as high as 15 g (NRCG 14395) for the germplasm accessions. The varieties giving high pod yield under moisture deficit stress were ICGV 86590 (22g), Kadiri-3 and M 197 (21 g), and DRG 12 (20 g). Among the germplasm accessions only NRCG 14390 gave above 11g pod yield per plant.

Thus the main cause for the low yields of germplasm accessions appeared to be reduction in both the number of pods per plant and 100-seed mass and thereby indicating an adverse affect of moisture deficit stress on partitioning of assimilates. While among the released varieties, the number of pods and hence the yields were much less affected.

The SLA and SCMR were measured 10, 20 and 30 days after imposing the moisture deficit stress in the 28 genotypes. The values of SLA in all the five high-yielding varieties at 20 DAST were much higher than those at 10 DAST and the values decreased subsequently and were them lowest at 30 DAST.

The increase in the SLA 20 DAST could be attributed mainly to increase in leaf area while reduction in SLA observed at 30 DAST could be attributed mainly to increase in leaf weight and reduction in leaf area (Figure 1).

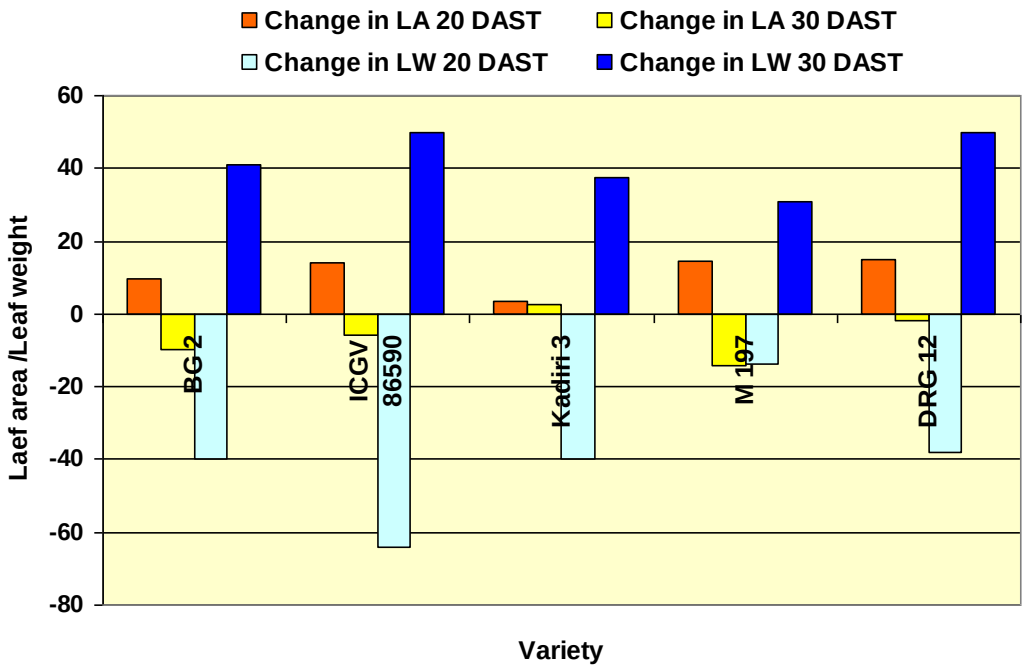


Figure 1. Changes in leaf area and weight (%) under moisture-deficit stress

The largest increase in SLA (from 206.3 to 293.3 cm^2g^{-1}) was in DRG 12 at 20 DAST while the largest reduction in SLA at 30 DAST was in BG 2 (from 186.7 to 157.2 cm^2g^{-1}). Interestingly, the variety Kadiri 3 maintained its leaf area and showed the least reduction at 30 DAST at the same time it regained its leaf weight at 30 DAST almost as much as it lost after 20 days of stress. It was also observed that the SCMR increased gradually during the period of stress in all the varieties (Figure 2).

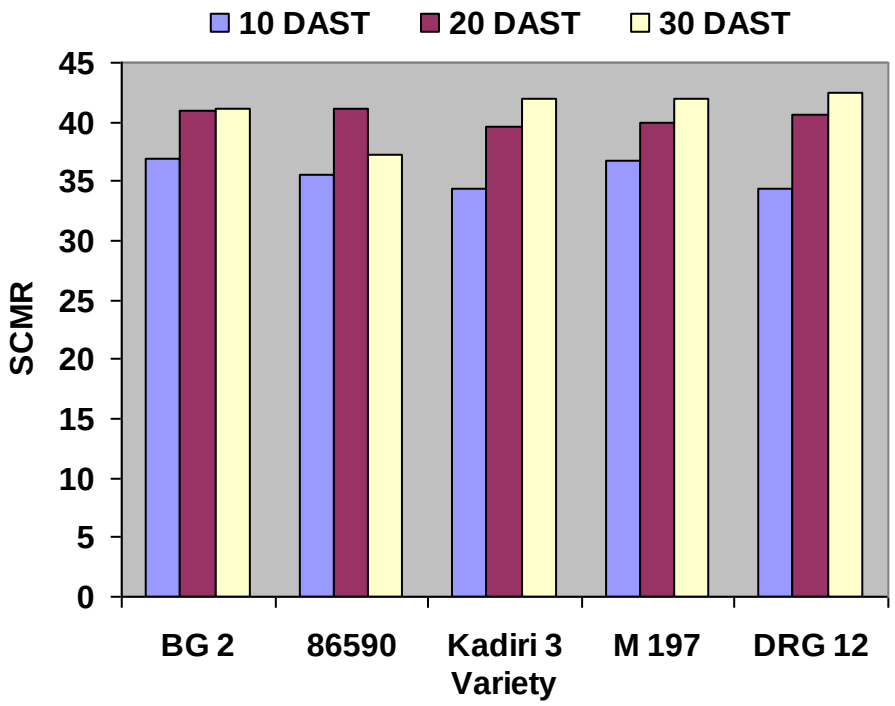


Figure 2. Changes in SCMR under water-deficit

6. Screening of Spanish mini-core collection for fresh-seed dormancy

Out of 67 Spanish accessions evaluated, four accessions which exhibited fresh-seed dormancy over two seasons were registered as novel 'genetic stock' with the NBPGR. Out of four accessions registered, two possessed fresh seed dormancy for as long a period as 60 days- these are NRCG 14350 (INGR 10034) and NRCG 14409 (INGR 10035). Another two accessions possessed fresh-seed dormancy for relatively a short period of 40 days and these are NRCG 14326 (INGR 10032) and NRCG 14336 (INGR 10033).

IV. Assessment of kernel infection and colonization

Twenty two accessions, belonging to NRCG subset of working collections, were screened *in vitro* for seed infection and colonization by the highly virulent strain of *A. flavus* **(AF-111)**. Out of these, six accessions showed infection and colonization below 2.33% and 3.33%, respectively while among others genotypes the infection was as high as 100% and colonization up to 56.67% (Table3).

Table 3. Assessment of infection and colonization in groundnut genotypes identified for *in vitro* tolerance of *A. flavus*

Genotype	Infection (%)	Colonization (%)
NRCG 12431	6.67	0.00
NRCG 12591	23.33	3.33
NRCG 12671	23.33	0.00
NRCG 12732	13.33	0.00
NRCG 12899	26.67	3.33
NRCG 12968	13.33	0.00

IV. Screening of mini-core collections DGR and ICRISAT **for major pests and diseases at hot spots**

The mini-core collections of DGR and ICRISAT were screened for PBND at Raichur during summer 2010. The incidence of PBND was high (50.3%) in the susceptible variety GG 11 while one NRCG (NRCG 14625) and two ICRISAT (ICG 171 and ICG 85) mini core accessions were identified for showing very low (<10%) incidence.

Five accessions of NRCG mini core, NRCGs 14710 (10.1), 13603 (12.2), 13129 (12.8), 1030 (14.6) and 9225 (15.4); and six accessions of ICRISAT mini-core, ICGs' 17625 (11.1), 11687 (12.2), 9911 and 14105 (12.5), 12370 (13.9) and 4729 (17.8%) recorded low (<20%) incidence.

VIII. Year 2009-10

1. Field maintenance of Wild *Arachis* germplasm

81 accessions under 6 sections *viz Arachis* (28), *Caulorhizae* (1), *Erectoides* (6), *Heteranthae* (1), *Procumbentes* (8) and *Rhizomatosae* (37) were maintained in the field gene bank. The seeds and cuttings of these species were supplied to different indenters.

2. Acquisition, distribution and utilization of germplasm accessions

14 released varieties; 7 identified for release and two wild accessions were acquired from 7 AICRP-G centres for medium term conservation.

A total of 1656 germplasm accessions including wild relatives of groundnut were supplied to 36 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of DGR (333), State Agricultural Universities (1268), ICAR Institutes (30) and others (25) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in crossing programmes.

Promising accessions were identified for two WUE traits, $\Delta^{13}C$ and $\Delta^{18}O$ (NRCG 11915- 17.4, 22.5; NRCG 12568- 17.9, 21.1; NRCG 12965-18.7, 21.1; NRCG 12274- 18.3, 23.3; NRCG 12326-19.2, 21.1, respectively) by UAS Bangalore. Of which three accessions have been used as parents (NRCG 11915, NRCG 12326 and NRCG 12568) in hybridisation programme to develop mapping populations (RILs) and for further identification markers of the above trait.

3. Multiplication and conservation of germplasm accessions

h) Voucher samples

A total of 284 (HYB: 60; HYR: 40; VUL: 145; FST: 39) accessions have been sown in kharif 2009 for multiplication and depositing with NBPGR, New Delhi for conservation. Sufficient (>200g seeds) could be obtained only in 33 accessions
and were deposited.

i) Mini-core collection

Seventy-five (HYB: 06; HYR: 11; VUL: 30; FST: 28) accessions were multiplied (out of 184 accessions) in kharif 2009 of which 31 accessions have been deposited with NBPGR for long-term conservation.

j) DUS reference varieties

Thirty DUS reference varieties (HYB: 07; HYR: 08; VUL: 13; FST: 02) were
multiplied in kharif season for enhancing sufficient quantity of seeds.

k) General accessions

A set of 197 accessions (HYB: 72; HYR: 29; VUL: 42; FST: 54) received from ICRISAT was multiplied in *kharif* season. Of which 132 accessions in which sufficient quantity of seeds have been multiplied were deposited with NBPGR.

e) Released varieties

A set of 158 released varieties (HYB: 39; HYR: 23; VUL: 92; FST: 04) was multiplied in kharif season for distribution and conservation.

l) Variability museum

A set of 45 accessions (HYB: 15; HYR: 02; VUL: 10; FST: 18), which are morphologically unique and identified from among the working collections, were multiplied for distribution and conservation.

m) High oil collection

A set of 19 accessions (HYB: 06; HYR: 01; VUL: 03; FST: 09) having high oil (>50%) content were multiplied and conserved.

n) Sub-set of NRCG working collection

A total of 167 accessions (HYB: 37; HYR: 9; VUL: 72; FST: 49) of a subset of NRCG working collection were multiplied in *kharif*. Of which 86 accessions have been deposited with NBPGR for conservation.

h) Repatriated accessions

A set of 156 accessions repatriated from ICRISAT was multiplied in *kharif* season. Sufficient quantity of seeds could not be multiplied for depositing with NGB. Hence, these accessions will be multiplied in ensuing *kharif*.

4. Morpho-physiological characterization of mini-core germplasm

I. Morphological characterisation in *kharif* season, 2009

a) Characterisation of subset of NRCG working collection

A set of 167 accessions (HYB: 37; HYR: 9; VUL: 72; FST: 49) of a subset of NRCG working collection have been evaluated and characterised in *kharif* 2009 for 19 qualitative and 27 quantitative traits.

Two accessions, NRCGs' 10259 and 11157 exhibited earliness (105 d). The range observed for this trait was 105-138 days; shelling turnover ranged from 44.7 (NRCG 12299) to 69.5% (NRCG 11700). Hundred seed mass was as small as 16.0 g (NRCG 12698) to as high as 52.8 g (NRCG 5405). Pod yield per plant ranged from 1.2 g (NRCG 10969) to 10.2 g (NRCG 12591). Number of pods/plant ranged from 1 (NRCG 12299) to 17.3 (NRCG 11511).

The low yield observed in most of the germplasm accessions may be due to the incessant heavy rains (550 mm in July 2009) received during peak flowering to pod formation stages.

b) Characterisation of new accessions

A total of forty-two new accessions (HYB: 21; HYR: 3; VUL: 5; FST: 3; UNK: 10) have been evaluated and characterised in *kharif* 2009 for 19 qualitative and 27 quantitative traits. Of these, four accessions failed to germinate. Pod yield in these accessions ranged from 2.2 g (NRCG 11984) to 15.0 g (NRCG 13317); Shelling outturn ranged from 40.0 (NRCG 13487) to 76.6% (NRCG 13491). Hundred seed mass ranged from 22 g (NRCG 13313) to 52.8 g (NRCG 17148). Number of mature pods ranged from 2.3 (NRCG 13500) to 14.8 (NRCG 13308).

c) Characterisation of exotic collection

Forty exotic collections have been evaluated and characterised in kharif 2009 for 19 qualitative and 27 quantitative traits.

Among the 40 accessions studied, the yield and number of pods were low (1.3 g/plant with a single pod) in EC416393 to 9.0 g/plant in EC4 14465 with 5 pods/plant. Hundred seed mass ranged from 26.4 g (EC416434) to 54.2 g (EC 416454). Shelling turnover ranged from 57.3 (EC 416509) to 69.2% (EC416428).

d) Characterisation of large seeded accessions

Twenty-eight large seeded Virginia accessions (HYB: 18; HYR: 10) were evaluated and characterised for 15 pod and seed traits.

The hundred seed mass ranged from 38.0 g (NRCG 12499) to 70.8 g (NRCG 4917). Twenty accessions exhibited more than 60 g/100 kernels. Pod yield of these accessions ranged from 1.9 g (NRCG 5195) to 19.8 g (NRCG 12806) per plant. Shelling turn-over in the accessions which had >60g/100 kernels, ranged from 66

(NRCG 9045) to 68.3% (NRCG 4917)

e) Assessment of morphological diversity in Spanish bunch accessions of mini-core collection in summer 2009

Sixty-seven Spanish bunch mini-core germplasm accessions were evaluated for 19 qualitative and 27 quantitative traits over two years in summer 2009 to identify diverse and promising accessions for yield and its related traits. Wide variability existed for all the qualitative and quantitative traits studied.

Diversity analysis performed through Ward's minimum variance method indicated the presence of appreciable diversity for the important yield related traits studied. The principal component analysis indicated that the first three vectors cumulatively explained 73.2% of the observed variation.

The characters contributed for diversity in the 1st vector were days to flowering (first -0.24; fifty- 0.29;and seventy five- 0.25 percent flowering), days to maturity (0.58), hundred pod (0.68) and hundred seed (0.79) weights, pod length (0.81), pod width (0.84), seed length (0.81) and seed width (0.46). In 2nd vector, days to flowering (first :0.60; fifty: 0.70; and seventy five: .65 percent flowering) and days to maturity (0.28) contributed more towards the diversity. Thus, it is clear that the accessions studied exhibited more diversity for flowering duration and maturity in addition to pod and seed traits (**Table 1**) when compared to the other accessions.

Table 1. Mean performance of diverse germplasm accessions (Pooled over two seasons)

NRCGs	DTG	DIF	DFF	NMP	PYP	SHE%	HSW	DTM
14329	15	35	39	13	12	58	40	117
14351	14	33	37	20	15	65	34	108
14407	15	29	34	17	11	69	41	118
14409	15	35	37	13	8	67	34	115
14422	14	34	39	11	7	70	40	115
14434	14	34	39	11	7	64	39	110
14437	14	35	39	15	10	70	41	117
14461	14	33	38	14	11	70	41	120
14465	14	35	39	13	8	65	39	117
14474	14	33	39	13	11	66	37	115
14482	14	34	41	15	12	57	36	117
14485	14	32	37	14	12	72	39	115

DTG=Days to germination; DIF=Days to initial flowering; DFF=Days to fifty percent flowering; NMP=Number of mature pods; PYP= pod yield per plant (g); shelling (%); HSW=Hundred seed weight (g); DTM=Days to maturity

f) Flowering behaviour in large seeded accessions

Thirty Spanish bunch and Valencia large seeded accessions were evaluated for their flowering behaviour. Based on number of flowers produced on weekly basis, the accessions were classified as low, medium and high flower producers in each category. In each of these categories, there were wide variations for number of flowers and duration of flower production. In low flower

producers of *fastigiata* and *vulgaris* accessions the flowering was with a single peak while in medium flowering *fastigiata* and *vulgaris* accessions, the flowering peaks were erratic and bimodal. While in high flower producers, the flowering was gradual and unimodal in some genotypes and erratic in some other. The data was compared with seed mass recorded by these accessions both at Junagadh and Ratnagiri. It was observed that among the accessions which produced less number of flowers at a given point, there was a rapid filling of kernel which has been reflected through increase in the seed mass. However, the number of pods and yield/plant appear to be slightly lower at Ratnagiri when compared with the values observed under Junagadh conditions (Table 2). Temperature seemed to play a role in rapid seed filling at Ratnagiri.

Table 2. Comparison of maturity, pod yield and seed mass at DGR, Junagadh and Ratnagiri

Accessions	**DGR**			**Ratnagiri**			**Gain in HASM**
	DTM	**HSM**	**PY**	**DTM**	**HSM**	**PY**	
3648	112	45.0	9.4	111	54.6	12.3	+10
10910	112	38.0	8.5	**101**	50.4	11.2	+12
11183	111	51.6	12.3	108	55.3	10.4	+3
11044	112	54.0	12.9	109	55.7	10.8	+2
12383	115	54.4	13.5	111	59.9	11.4	+5
LSD (0.05)	2.9	4.8	2.2	3.8	2.7	1.9	-

II. Evaluation of different germplasm for $\Delta^{13}C$, a surrogate trait for Water Use Efficiency (WUE)

a) Sub-set of working collection

With a view to understand the genetic variations for surrogate trait of WUE in a sub-set of working collection, leaf samples were collected in two replicates as per standard procedure and analysed for $\Delta^{13}C$ using mass spectrometry available at UAS, Bangalore. The range observed for $\Delta^{13}C$ was 18.25 (NRCG 11924) to 21.971 (NRCG 12639) with very low variability (coefficient of variability was 3.37%). The modal value was 20.61. Among the 49 FST germplasm accessions studied, only one accession recorded low value for $\Delta^{13}C$ (**Table 3a**). Some of the promising accessions having low $\Delta^{13}C$ are as follows:

Table 3a. Promising accessions for low $\Delta^{13}C$ in a subset of working collection

S. No	**Habit Group and promising accessions**	**$\Delta^{13}C$**	**Days to maturity**
1	FST		
	NRCG 11924	18.25	124
2	HYB		
	NRCG 404	18.69	132
	NRCG 8963	18.70	132
	NRCG 11865	18.72	126
	NRCG 12138	18.74	130
	NRCG 119422	18.92	130
3	HYR		
	NRCG 666	18.65	120

	NRCG 17	18.77	130
	NRCG 12393	18.85	130

b) Mini-core collection

The genetic variation for $\Delta^{13}C$ was analysed in mini-core collection comprising 184 accessions. Out of the 184 accessions, one accession could not be analysed. The range observed for this trait was 10.86 (NRCG 14442) to 23.49 (NRCG 14461). The co-efficient of variability observed for this trait was 10%. Six accessions (**Table 1b**), two of Virginia bunch and four of Virginia runner recorded low $\Delta^{13}C$ values. The modal value in this collection was 19.65.

Table 3b. Promising accessions for low **$\Delta^{13}C$ in mini-core collection**

S. No	Habit Group and promising accessions	$\Delta^{13}C$	Days to maturity
1	**HYB**		
	NRCG 14390	18.65	134
	NRCG 14395	18.87	130
2	**HYR**		
	NRCG 14342	16.02	132
	NRCG 14352	18.61	132
	NRCG 14357	18.77	135
	NRCG 14442	10.86	139

c) Released varieties

The genetic variation for $\Delta^{13}C$ was analysed in 122 released varieties. The lowest $\Delta^{13}C$ value was observed in GAUG 10 (10. 61) and the highest value was observed in AK 12-24 (21.64). The mode was 19.55 and the CV (%) recorded was very low (1%). Twelve varieties two of Spanish bunch, seven of Virginia bunch and three Virginia runner types recorded low $\Delta^{13}C$ values and were found promising.

Table 3c. Promising released varieties for low $\Delta^{13}C$

S.No	Habit Group and promising varieties	$\Delta^{13}C$	Days to maturity
1	**VUL**		
	ICGV 86590	18.86	110
	DRG 12	18.94	110
2	**HYB**		
	BG 2	18.61	124
	BG 3	18.56	123
	Kadiri 2	18.81	129
	Kadiri 3	18.80	123
	T 64	18.49	122
	TG 1	18.83	122
	TMV 10	18.51	120
3	**HYR**		
	DSG 1	18.59	124

	GAUG 10 M 197	16.60 18.50	123 124

In all the three group of materials studied, Spanish bunch types with low$\Delta^{13}C$ values were found to be very few or rare.

IX. Year: 2008-09

1. Field maintenance of Wild *Arachis* germplasm

81 accessions under 6 sections: *Arachis* (28), *Caulorhizae* (1), *Erectoides* (6), *Heteranthae* (1), *Procumbentes* (8) and *Rhizomatosae* (37) were maintained in the field gene bank. The seeds and cuttings of these species were supplied to different indenters.

2. Acquisition and distribution of germplasm accessions

21 released varieties were acquired from 9 centres. Eight farmers' varieties were also collected from Bhuj region of Gujarat state.

1039 germplasm accessions including wild relatives of groundnut were supplied to 28 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of NRCG (524), State Agricultural Universities (411), AICRPG centres (90) and others (14). These germplasm were supplied to identify promising lines for WUE, nematode tolerance, large seeded types and to use in crossing programmes.

3. Multiplication of germplasm accessions

o) Mini-core germplasm accessions

Although, about 14130 groundnut germplasm are available at ICRISAT, variability contained in these germplasm accessions has not been adequately utilized in the groundnut improvement programme. Most groundnut cultivars stand on a very narrow genetic base. This is due to lack of information on agronomic and other economic traits, which require extensive evaluation. Hence, the ICRISAT (184 accessions) and NRCG (167 accessions) have developed a sub-set called "mini-core" accessions, which represent the entire spectrum of variability, based on passport data and morphological descriptor traits. The habit group-wise split up of accessions in both the mini-cores are presented below

Table 1. Habit group-wise grouping of mini-core collections

ICRISAT mini-core		NRCG mini-core	
HYR	40	HYR	9
HYB	42	HYB	37
VUL	64	VUL	72
FST	38	FST	49
T OTAL	**184**		**167**

HYR= Virginia runner; HYB= Virginia bunch; VUL= Spanish bunch; FST= Valencia

Before these accessions are thoroughly evaluated for various economic or specific traits of interest, their multiplication in large scale is essential. Hence the germplasm of both the mini-core accessions were multiplied during kharif season. The regeneration in each of these accessions ranged from 30 g to 100 g.

p) Supply of new germplasm accessions to National Gene Bank

NRCG, being one of the National Active Germplasm Sites' (NAGS), the seeds of working collection are to be deposited in National Gene Bank (NGB), NBPGR, New Delhi for long term conservation. During *kharif* season Three hundred and ninety five germplasm accessions were multiplied.

A set of 236 germplasm accessions (VUL 69; FST 34; HYB 66; HYR 67) was multiplied in *kharif* season for depositing in NGB. These germlasm were identified for repatriation under ICAR-ICRISAT collaborative project.

q) For Medium Term storage at NRCG:

Fifty-four exotic lines, 45 morphologically distinct accessions, 154 released varieties, 30 reference varieties identified under DUS project and 30 large seeded accessions of groundnut were multiplied and the seeds were conserved in the medium term cold storage module at NRCG.

4. Morpho-physiological characterization of mini-core germplasm

a) Morphological variations in mini-core germplasm

351 accessions have been evaluated and characterised for two years at three locations namely, NRCG, Junagadh, MPKV Jalgaon and RRS Vridhachalam in Kharif season and 67 Spanish bunch accessions in summer as per details below.

Table 2. Variation for yield parameters in mini-core collections of NRCG and ICRISAT

Locations	Pod yield (g/plant)	Kernel yield (g/plant)	Kernel mass (g/100 kernel)	Shelling (%)
Vridhachalam	3 - 25	2 - 19	14 -111	52 -72
CV (%)	(48)	(50)	(17)	(20)
Jalgaon	4-21	3 -14	17-55	67
CV (%)	(28)	(30)	(23)	(5)

The results on genetic variation for qualitative traits indicated that for the market oriented traits like pod beak, pod constriction, shell thickness, pod reticulation and seed (kernel) traits like colour, shape and size there existed substantial variability indicating the usefulness of the germplasm studied in crop improvement programme.

An experiment was carried out to assess the extent of variability, to estimate the genetic coefficients of variation (Genotypic coefficient of variation, GCV; phenotypic coefficient of variation, (PCV), proportion of heritable variation (h^2) and to understand the extent of genetic diversity for 19 qualitative and 28 quantitative traits in 64 mini-core germplasm accessions of groundnut during summer season, 2008.

In the present study, the 64 accessions studied during summer 2008 have shown substantial diversity for the traits studied. They were grouped in to seven clusters with a differential intra and inter cluster distances. The number of accessions that were grouped in a single cluster also varied considerably from 7-13 accessions per cluster.

Among the 7 clusters, cluster V recorded a high variability for number of mature pods, pod yield and hundred seed weight. These traits are reported to be highly correlated with each other. The other clusters, which showed promise for number of mature pods and pod yield were cluster VI, cluster VII and cluster III.

Mean performances of germplasm studied, their variability, genetic coefficients of variation and habitability in respect of both qualitative and quantitative traits indicated that the following germplasm can be used as parents for improving specific traits in groundnut:

- For earliness, NRCG 14407
- For compact plant type, NRCG 14425
- For high root bio-mass, NRCG 14356
- For more secondary branches, NRCGs, 14377, 14470
- For high pod yield, NRCGs, 14365, 14368, 14433
- For yield related traits like number of mature pods, seed weight and shelling, NRCG 14433, 14365

a) Physiological evaluation of mini-core germplasm accessions for $\Delta^{13}C$, a surrogate trait for Water Use Efficiency (WUE)

Though estimates of Water Use Efficiency (WUE) can be obtained gravimetrically, screening of large populations, as those of germplasm would be difficult through this method. Understanding the genetic variability for water use efficiency especially to address drought stress has resulted in the discovery that plants discriminate against heavy isotope of carbon (**^{13}C)** during photosynthesis. The same physiological parameter determines water use efficiency also and hence **$\Delta\ ^{13}$C** has been widely used as a potential surrogate for WUE. The relationship between Δ^{13}C and WUE has been reported to be inverse.

With a view to understand the WUE of NRCG mini-core germplasm, leaf samples were collected in two replicates and analyzed using mass spectrometry available at UAS, Bangalore. The range observed for Δ^{13}C was 18.25 (NRCG 11924) to 21.971 (NRCG 12639) with very narrow range variability (coefficient of variability was 3.37%). The modal class was just 20.61. Among the 49 FST germplasm accessions studied, only one accession recorded low value for Δ^{13}C. Some of the promising accessions having low Δ^{13}C are as follows

Table 3. Promising accessions for **$\Delta\ ^{13}$C**

S.No	**Habit Group and promising accessions**	**$\Delta\ ^{13}$C**	**Days to maturity**
1	FST		
	NRCG 11924	18.25	124
2	HYB		
	NRCG 404	18.69	132
	NRCG 8963	18.70	132
	NRCG 11865	18.72	126
	NRCG 12138	18.74	130
	NRCG 119422	18.92	130
3	HYR		
	NRCG 666	18.65	120
	NRCG 17	18.77	130
	NRCG 12393	18.85	130

4. Screening of Spanish mini-core collection for fresh seed dormancy

An experiment was carried out to evaluate 64 diverse Spanish bunch germplasm accessions from the mini-core collection of NRCG (sub-species *fastigiata* var. *vulgaris*) along with two Spanish bunch non-dormant check varieties, JL 24 and GG 2 for fresh seed dormancy under laboratory conditions. The seeds were obtained from the crop raised in the field during summer 2008. The seeds were removed from pods immediately after harvest were placed on moist filter paper and incubated at 35±2°C and 65% relative humidity

Significant differences were observed among the genotypes for days taken for complete germination and percent germination. Both the check varieties exhibited 100% germination within 4 weeks. Seeds of four accessions, NRCG 14329, NRCG 14349, NRCG 14350 and

NRCG 14409 did not germinate even after 8 weeks of incubation indicating the presence of very strong fresh seed dormancy.

In another four accessions (NRCGs'14326, 14336, 14368, 14380) the germination continued to be very low (below 20%) even after eight weeks of incubation indicating the presence of greater degree of fresh dormancy in these genotypes.

The seeds of two accessions, NRCG 14474 and 14348 exhibited only up to 50% germination after 8 weeks of incubation indicating the presence of partial dormancy. These genotypes can be used a source of fresh seed dormancy in Spanish bunch breeding programmes.

5. Nodulation efficiency of mini-core germplasm collections

Nodulation efficiency of 195 germplasm accessions including released varieties as check were analysed at 70 DAS. On an average, 50 nodules/plant was observed even under the submerged conditions of last Kharif season.

The number of nodules/plant was as low as 3 (NRCG 14443) to 315 (GAUG 10). More than 100 nodules/plant was observed in 6 accessions namely NRCGs 14432, (184), 14374 (100), 14373 (102), 14495 (126), 14437 (154), 14459 (123). Among the released varieties, GAUG 10 (313) and M 13 (282) has recorded a maximum number of nodules/plant.

6. Morphological characterization of Rabi-summer groundnut varieties

In the past, the varieties released in India were mainly targeted for *kharif* situations. The varieties under cultivation during *rabi* and summer seasons were mostly bred for *kharif* but later adopted by farmers owing to the absence of specific varieties for *rabi* and summer cultivation. However, recently few varieties have been released exclusively for *rabi* and summer cultivation. Most of these varieties are Spanish types.

Hence, an experiment was conducted in summer season to characterize 10 groundnut varieties exclusively released for *rabi*/summer cultivation in various states. These varieties were BSR 1 and VRI 4 (Tamil Nadu), R 8808 (Karnataka), Dh 86 (Orissa, West Bengal), Tirupat 4 (Andhra Pradesh), TG 37 (Gujarat), TG 26 (Gujarat and southern Rajasthan), DRG 12 (peninsular states), TAG 24 (Maharashtra) and SG 99 (Punjab) were assembled and evaluated for 26 quantitative traits. For all the five important yield traits TAG 24 was found to be superior. The yield and its related traits as observed in top three varieties are provided below

Table 4. Trait specific released varieties identified

S.No	Trait	Varieties
1	Number of mature pods (12-15)	SG 99, TAG 24, TG 37 A
2	Hundred seed weight (45-50 g/100 seed)	SG 99, TAG 24, TG 37 A

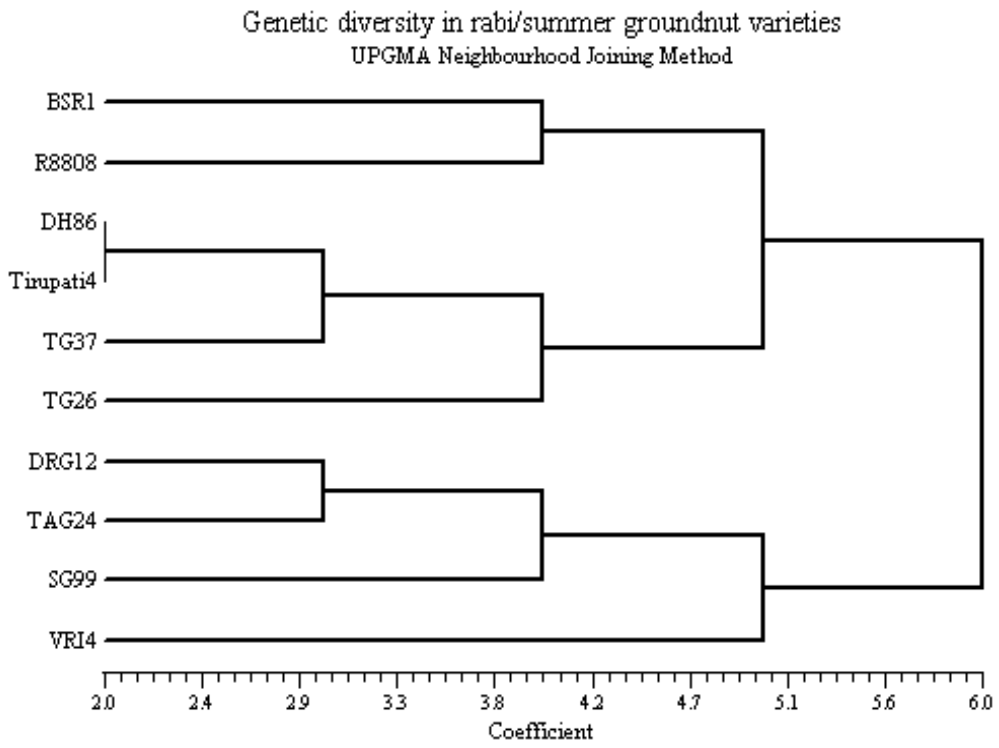
3	Pod yield/plant (`15 g/plant)	TAG 24, VRI 4, BSR 1
4	Shelling (%) (70% and above)	**Error! Not a valid link.**, R 8808
5	Days to maturity (100 - 105days)	**Error! Not a valid link.**, R 8808

The same data has been used to perform diversity analysis to assess the true genetic worth of the 10 *rabi*/summer groundnut varieties using NTSYSpc software (version 2.0). The similarity coefficients were calculated and by using this coefficient matrix, clustering was done by applying neighbour joining method, (Saitou and Nei, 1987).

The dendrogram revealed that the 10 varieties studied were grouped in to three distinct clusters indicating presence of adequate variability for the traits studied. The first cluster comprised of two (BSR 1, R 8808) ; the second (Dh 86, Tirupati 4, TG 37, TG 26) and third (DRG 12, TAG 24, SG 99, VRI 4) clusters comprised of four varieties each. Among the clusters, cluster number 3 is highly variable for the traits studied.

It is interesting to observe that in cluster number 1 and 2, the varieties grouped had one parent in common in their pedigree. For example, if we trace back the pedigrees of BSR 1 and R 8808 in cluster 1, it was observed that they have been derived from crosses involving R 33-1 as one of their parents.

Similarly, among Dh 86, Tirupati 4, TG 37 and TG 26, the mutant, TGE 2 or JL 24 and its mutant (BARCG 1) have been involved as one of the parents in their pedigrees. However, the varieties Dh 86 and Tirupati 4 were observed to be very closely related, although in their pedigree none of the parents involved were found common. In cluster number 3 also, the parents of none of the four varieties were common in their pedigree indicating the true genetic diversity present in these four varieties and can be exploited for traits of interest.



6. Screening of mini-core collections for major pests and diseases at hot spots

The mini-core collections of NRCG and ICRISAT were screened for PBND and PSND at Kadiri and Raichur centres during rabi-summer 2007-08. At Raichur five entries, ICGs' 76, 442, 1688, 9802 and 10185 recorded low level of PBND incidence (<5%) at harvest as against the susceptible genotype NRCG 135 which recorded 42.11% incidence.

At kadiri, the incidence of PBND was low (21%) in the susceptible genotype (NCAC 726). Two accessions, NCAC 2953 (1%) and NCAC 2838 (1.5%)recorded a very low level of incidence.

Same was true for the incidence of PSND also. The susceptible genotype (TINGO MARIA) recorded 23% incidence of PSND.

For both PBND and PSND, six accessions namely PI 52108, NCAC 399, 2953, 1333, MFOKAA and KU NO 235 recorded very low levels of incidence (<5%).

III. Screening of Spanish mini-core collection for fresh seed dormancy

Ten out of 67 accessions, which exhibited fresh seed dormancy during summer 2008, were evaluated in summer 2009 for further confirmation. It was observed that the ten genotypes which exhibited different patterns of fresh seed dormancy in summer 2008 have shown the same degree of dormancy in summer 2009 also.

Two accessions, NRCG 14350 and NRCG 14409 were found to possess a long period of fresh seed dormancy i.e more than 60 days and two accessions, NRCG 14326, NRCG 14336 with a fresh seed dormancy period of 40 days.

In addition in thirty large seeded accessions, the fresh seed dormancy was assessed. Fresh seed dormancy was absent in all the accessions except for NRCG 12731 (48-115 A). This accession, exhibited dormancy for more than a month.

IV. Nodulation efficiency of mini-core collection

Nodulation efficiency of 195 germplasm accessions including released varieties as checks were analysed at 70 DAS in *kharif* 2009. On an average, 50 nodules/plant was observed.

The number of nodules/plant was as low as 3 (NRCG 14443) to 315 (GAUG 10). More than 100 nodules/plant was observed in 6 accessions namely NRCGs 14432, (184), 14374 (100), 14373 (102), 14495 (126), 14437 (154), 14459 (123). Among the released varieties, GAUG 10 (313) and M 13 (282) had recorded maximum number of nodules/plant.

V. Screening of mini-core collections for major pests and diseases at hot spots

The mini-core collections of NRCG and ICRISAT were screened for PBND and PSND at Kadiri and Raichur centres during *kharif* and summer 2009. At Raichur, disease incidence of PBND was high (56.3%) in susceptible variety, GG 11 in summer. Three ICRISAT mini-core accessions, ICGs 5245 (4.35), 14105 (4.55), 11687 (6.52) recorded <10% PBND incidence while four NRCG accessions, 9225, 11511, 13603 and 14710 recorded <15% PBND incidence. In *kharif*, nine accessions (ICG 4543, 1415, 5745, 13787, 2106, CS 083, 107, 203, NRCG 11212) recorded <10% incidence in kharif as against 80% incidence in the susceptible genotype, ICG 4911. The resistant variety, ICGS 44 recorded 8.3% incidence of PBND.

At kadiri, the incidence of PBND was low (<10%) for both PBND and PSND in summer. Hence, valid conclusion could not be drawn.