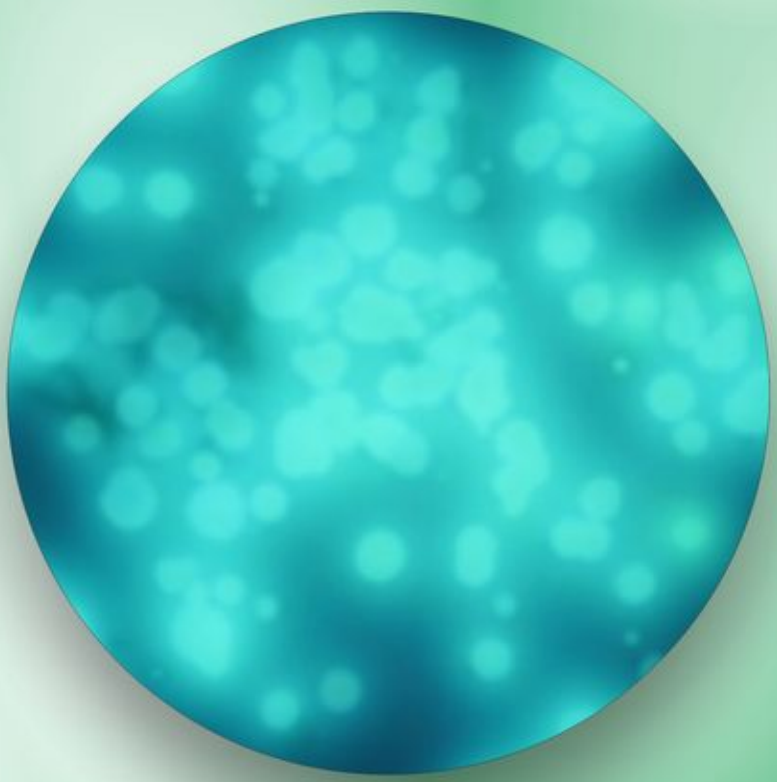
वार्षिक प्रतिवेदन

Annual Report

2007-08



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राष्ट्रीय मूँगफली अनुसंधान केंद्र

National Research Centre for Groundnut

(Indian Council of Agricultural Research)

Post Box No; 05, Ivnagar Road,
Junagadh- 362001, Gujarat, India

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PREFACE

The National Research Centre for Groundnut (NRCG) was established in 1979 to conduct basic and strategic research for enhancing groundnut production in India. Since its inception nearly thirty years ago, the Centre has grown bigger and has acquired high degree of scientific competence with the establishment of excellent research facilities. A number of farmer friendly technologies have been developed by this Centre for the benefit of the groundnut farmers of this country. This annual report summarizes the major activities of the Centre during 2007-08 and highlights the Centre's research thrust and technologies developed in different fronts.

During the year 2007-08, a number of fresh crosses were effected and selections were made from segregating populations. One test entry (PBS 24030) was notified and released for commercial cultivation in *kharif* season in Zone I in the name of Girnar 2. Based on the performance of advanced breeding cultures, PBS 24004 (Virginia bunch), PBS 12160 (Spanish bunch) and JUN 27 (Virginia bunch) in IVT I and IVT II of AICRP-G, two lines PBS 12160 and JUN 27 were promoted to advanced varietal trials. Segregating materials of 34 crosses attempted for different breeding objectives were supplied to 10 AICRP-G centres for location specific selection and varietal development. Interspecific breeding lines NRCGCS 148, 268 and 281 were confirmed as large seeded early Spanish groundnut and would be promoted to LSVT trial under AICRP-G. Thirty new advanced breeding lines (9 Spanish, 21 Virginia) possessing large pod/seed and/or pod yield superiority were developed. Molecular diversity in the accessions of *Arachis duranensis* and *A. glabrata* were determined. Genetic transformation program using the defensin gene construct was initiated. Some genotypes and varieties of groundnut were reported to be moderately resistant to jassids and thrips. Out of 102 genotypes evaluated against early leaf spots (ELS), late leaf spots (LLS), rust and stem rot diseases, seven genotypes showed resistance to ELS, LLS and rust and thirteen genotypes showed promising resistance against stem rot disease. Isolates of *Trichoderma*, NRCG-T 12 (*T. virens*) and T 31 (*T. koningii*) significantly reduced collar rot and stem rot incidence. A consortium of groundnut rhizobia and PGPR was developed for enhancing yield. Potassium and Sulphur-efficient genotypes of groundnut were identified. The maize + groundnut intercropping was reported to be beneficial and ICGV 86590 and TKG 19A were most suited groundnut varieties. A process was developed for the production of enzyme protease by microbial utilization of de-oiled groundnut cake through solid substrate fermentation.

The scientists of NRCG continued their publications in national and international journals. A number of scientists visited abroad and few young scientists joined this institute.

I sincerely thank all the concerned for helping in the publication of this annual report.

Director

Contents

SUMMARY

- One test entry (PBS 24030) developed under the project was notified and released for commercial cultivation in *kharif* season in Zone I in the name of Girnar 2.
- Thirty-six fresh crosses were attempted in *kharif* 2007 to incorporate resistance/tolerance of different biotic and abiotic stresses into the superior agronomic background. These crosses included a set of 30 crosses affected in a modified TTC design to investigate role of inter-allelic interactions in the inheritance of WUE traits.
- A total of 74 new advanced-breeding lines were developed during the season.
- Based on the performance of advanced breeding cultures, PBS 24004 (Virginia bunch), PBS 12160 (Spanish bunch) and JUN 27 (Virginia bunch) IVT I and IVT II of AICRP-G, two lines PBS 12160 and JUN 27 were promoted to advanced varietal trials.
- Of the forty selections derived from a single cross pod yields of the top five selections ranged only from 1001 to 1155 kg/ha in *kharif* season, as the season received excessive rains. However, in summer the pod and kernel yields of these 40 cultures ranged from 2263 - 3438 kg/ha and 1419 - 2329 kg/ha.
- F1 generations of different crosses attempted in *kharif* 2006 were raised in *kharif* 2007 and true hybrids were identified.
- A total of 281 single plant selections were made in different filial generations (F 2 to F 6) in the crosses attempted in the previous years for incorporating resistance to different biotic and abiotic stresses.
- In *kharif* 2007 a total of 409 advanced breeding lines developed under the project were maintained.
- Nucleus seed of two varieties Girnar 1 and Girnar 2 was produced.
- Segregating materials of 34 crosses attempted for different breeding objectives were supplied to 10 AICRP-G centres for location specific selection and varietal development.
- Seed treatment with 0.0035% Imidacloprid + 2 sprays of 0.008% Imidacloprid at 30 & 45 DAE was effective against jassids and thrips followed by 2 sprays with 0.04% monocrotophos (36 SL) at 30 & 45 DAE compared to control and other treatments.
- Out of 31 genotypes screened for resistance against jassids, genotypes such as NRCG CS-101, 102, and 220 were found moderately resistant (recording < 3 mean no. of jassids/ 5 sweeps).
- Out of 57 released varieties (SB) screened, varieties AK 159, ALR 2, CO 3 and GG 5 were found moderately resistant to jassids recording < 5 mean no. of jassids/ mt row
- Out of 51 released varieties (VB) screened, in case of jassids, varieties Chitra, CSMG 84-1, GG 13, M 522, MH 2 and MH 4 were found moderately resistant recording < 8 mean no. of jassids/ mt row. In case of thrips MA 16, MH 4, T 64, TG 41 and TMV 3 were found moderately resistant recording < 3 mean no. of thrips/ mt row
- In Integrated Insect Pest Management (IPM) experiment, groundnut + castor and groundnut + Bt cotton intercropping system reduced the jassids population. Groundnut + castor and groundnut + Hybrid cotton reduced the thrips population. Intercropping with red gram gave highest CBR (1: 3.99) followed by castor (1: 3.46) compared to sole groundnut and other intercrops.
- Among various biopesticides tested for their efficacy against sucking pests of groundnut, monocrotophos was found to be the best treatment for the control of both thrips and leafhoppers followed by *V. lecanii*, neem oil, econeem, *B. bassiana* and *M. anisopliae* in that order for thrips and *V. lecanii*, *B. bassiana*, *M. anisopliae*, econeem and neem oil in that order for leafhoppers.

- The comparative data of field screening from 2003 to 2007 revealed that 28 genotypes recorded below 5% incidence showing promising resistance to PBND.
- Out of 102 genotypes evaluated against early leaf spots (ELS), late leaf spots (LLS), rust and stem rot diseases, seven genotypes showed resistance to ELS, LLS and rust i.e. NRCG CS nos.' CS 293, CS 347, CS 266, CS 346, CS 303, CS 284 and CS 348. Thirteen genotypes shower promising resistance against stem rot disease viz., CS 267, CS 272, CS 280, CS 285, CS 292, CS 293, CS 294, CS 300, CS 310, CS 320, CS 323 and CS 347.
- The comparative data of field screening from 2003 to 2007 revealed that 9 genotypes viz. CS 144, CS 156, CS 158, CS 159, CS 160, CS 168, CS 196, CS 222 and PBS 25001 possessed multiple disease resistance.
- Out of six isolates of *Trichoderma*, NRCG-T 12 (*T. virens*) and T 31 (*T. koningii*) significantly reduced collar rot and stem rot incidence under concrete block conditions
- Application of castor cake enriched with *Trichoderma* as well as castor cake alone significantly reduced pod rot incidence. There was significant reduction in the disease severity of late leaf spot (LLS) by soil application of enriched *Trichoderma* plus foliar spray of culture filtrate of *V. lecanii* at 50 % dilution.
- Application of a consortium of phosphate solubilising microorganisms and groundnut rhizobia as seed treatment resulted in augmentation in growth and yield (19%) of summer groundnut.
- During the *kharif* season, application of a consortium of PGPR and groundnut rhizobia as seed treatment resulted in a yield enhancement of 21%.
- Groundnut inoculated with AM fungi resulted in remarkable increase in root volume, root biomass and pod yield.
- RAPD analysis of important fluorescent pseudomonad strains resulted in detectable polymorphisms among the strains.
- P, B and Zn are important nutrients for proper pod filling in groundnut and their application is essential for maintaining the proper seed and pod size for the production of export quality produce of large-seeded genotypes.
- 103 genotypes were Field screened and K and S-efficient genotypes identified:
- K-efficient: SP 250 A, LGN 2, Tirupati 3, Kadiri 3, UF 70-103, TG 64, M 13, NRCG 6155, ICGS 76, JSP 19, ALR 2, CSMG 84-1
- S-efficient: CSMG 84-1, Tirupati 3, LGN 2, ALR 2, ICG 88448, R 9251
- The groundnut cultivars responded upto 0.5 ppm Mo.
- The high Zn containing cultivars identified are CO 1, CO 2, Gangapuri, UF 70-103, GG 5 and ICGV 86590 which also contained high Fe in their kernel.
- The field experiments in NEH identified TKG 19A, GG 20, ICGS 76, CSMG 84-1, ICGV 86590 and M 13 as high yielding cultivars and NRCG 1308, 7206, 7471, FeESG 10-1, and FeESG 10-3 and ICGV 88448 as high yielding nutrient efficient groundnut genotypes with more than 1500 kg ha-1 pod yield and more than 1000 kg ha-1 seed yield.
- The maize + groundnut intercropping showed highest yield and ICGV 86590 and TKG 19A were most suited groundnut varieties.
- In large seeded groundnut the cultivars, M 13, TPG 41, CSMG 84-1, ICGS 76 performed well in NEH.
- Application of P, Ca and B and organic fertilizers are most critical for growing large-seeded groundnut with required yield and quality.
- Evaluation of different cropping systems in the permanent experiment on nutrient dynamics revealed that the highest total system productivity in terms of groundnut equivalent yield was recorded in groundnut-wheat-green gram cropping system with the application of FYM 5 (t/ha) + 50% RDF to groundnut and wheat both.

- The soil organic carbon built was also maximum in groundnut-wheat-green gram cropping system and the highest was recorded in the FYM 5 (t/ha) + 50% RDF management, which was found to be the most sustainable system.
- Application of organics, 'FYM (15t/ha) + Biofertilizers (*Rhizobium* and PSB) + Biopesticides (*Trichoderma* and castor cake) + Gypsum + rock phosphate' recorded the highest groundnut pod yield, 12.4 per cent higher over RDF.
- The highest total soil N (%) in groundnut was recovered with the application of 'FYM(15t/ha) + Biofertilizer + Biopesticide + Gypsum + rock phosphate' organic treatment.
- Long term field studies conducted during 2002 to 2008 on use of saline water in groundnut based cropping system in saline soil established that saline water of 2-3 dS/m can be used as supplemental irrigation in *kharif* groundnut, yielding up to about 1000 kg/ha (ECe 2.1 dS/m) whereas by using saline water of 4 dS/m, about 3500 kg/ha of wheat (ECe 7.3 dS/m), 1700 kg of mustard (ECe 5.2 dS/m) and 4200 kg/ha of rabi bajra can be obtained in rotation with *kharif* groundnut. However, use of saline water for irrigation in groundnut – groundnut rotation was found not to be an economical proposition.
- Prolonged use of irrigation water of high salinity decreased the nitrogen (protein) and oil content of groundnut kernel and mustard seed.
- Root zone soil salinity and soil pH also increased as a result of long-term use of saline water.
- Threshold salinity values for economical cultivation of different genotypes of groundnut and associated crops in rotation were determined
- Molecular diversity in the accessions of *Arachis* duranensis and A. glabrata were determined
- Parental lines used in the crossing programmes as well as in the development of the recombinant inbred lines were surveyed for the SSR marker polymorphism
- Genetic transformation program using the defensin gene construct was initiated
- For maximum blanching of groundnut, oven drying of kernels at high temperatures (150°C for 10 minutes) or longer durations (30 minutes at 110°C) is recommended
- The oil content of 126 genotypes of the core germplasm collection was in the range of 40.6 to 50.8% with a mean of 45.4% while the protein content was in the range of 18.2 to 29.8% with a mean of 25.1%
- Kernels of freshly harvested groundnut pods do contain small amounts (1-3 mg/100g) of vitamin C
- Kernels samples of cultivars GAUG 10, JL 24, Jawan, GG 5 were found to contain low allergen levels while those of cultivars GG 20, TG 26, GG 7 B 95 and M 13 were having high levels. Allergen levels in the kernels of 19 released cultivars were analysed and found in the range of 0.931 to 1.586 in terms of OD450
- The protease production potential of some proteolytic fungi was evaluated on de-oiled groundnut cake. The fungus *Aspergillus nidulans* MTCC 831 showed maximum protease production during solid substrate fermentation (SSF) (17.09 IU/g of de-oiled groundnut cake after 72 hours of fermentation). The presence of Cu was found to enhance the activity of the enzyme. The enzyme was found to be tolerant to high salt concentrations.
- Out of 92 advanced breeding lines and cultivars evaluated under artificially inoculated sick plot conditions for resistance to *A. flavus* invasion and aflatoxin contamination during 2005-2007, twenty were found promising.
- Among different intercropping systems, the population of *A. flavus* was significantly low in pearl millet intercropping system both during *kharif* 2007 and summer 2008.

- The results of long-term crop rotations revealed that garlic and onion crop rotation had significantly reduced the soil population of *A. flavus* and aflatoxin contamination in the subsequent groundnut crop.
- A total of 417 isolates of *Aspergillus* spp. (mostly *A. flavus* and *A. ochraceus*) have been accessioned in the Repository of Isolates of *Aspergillus* at NRCG and are being maintained as single spore cultures on agar slants as well as under long term storage as lyophilized culture. Fifty cultures from different groups and geographical locations were submitted to NBAIM, Mau.
- The fresh leaves of *Azadirachta indica* and *Annona squamosa* dried in shade and applied @ 500g/10 kg pods was found very effective in reducing post harvest *A. flavus* infection and aflatoxin contamination.
- Thirty new advanced breeding lines (9 Spanish, 21 Virginia) possessing large pod/seed and/or pod yield superiority were developed.
- 10th International Confectionery Groundnut Varietal Trial (X ICGVT) with 15 genotypes was taken up along with a local check (TPG 41). All the genotypes had significantly higher pod yield over the check, while eight recorded significantly higher seed size, the highest being 77.7 g/100 kernels in ICGV 00440.
- Genotypes ICGV 90208, ICGV 90210 and ICGV 97079 recorded zero seed infection and colonization by *A. flavus* (isolate AF 111) under laboratory screening, while PBS 29078, ICGV 90308, ICGV 91099, ICGV 99102, ICGV 00441 and ICGV 00446 had less than 10% seed infection.
- Interspecific breeding lines NRCG CS 252, 253, 254, 256, 259, 261, 268, 280, 285, 321, 335 and 360 showed promise under initial varietal trial and would be confirmed under advanced varietal trial.
- Two Interspecific breeding lines NRCG CS 148 and 83 were selected for higher pod yield and would be promoted to AICRP-G testing.
- Interspecific breeding lines NRCGCS 148, 268 and 281 were confirmed as large seeded early Spanish groundnut and would be promoted to LSVT trial under AICRP-G.
- Eighteen wild *Arachis* accessions were tested *in vitro* as salinity tolerant.

PROJECT 01: BREEDING AND GENETIC STUDIES ON BIOTIC AND ABIOTIC STRESSES IN GROUNDNUT

(CHUNI LAL, A. L. RATHNAKUMAR, K. HARIPRASANNA, VINOD KUMAR, T. V. PRASAD, P. C. NAUTIYAL AND A. L. SINGH)

Hybridization

During *kharif* 2007, 36 crosses were attempted for imparting resistance to different biotic stresses and to study inheritance of morpho-physiological traits associated with high water-use-efficiency/drought tolerance. Out of the total 6765 hand pollinations made, about 20% resulted in the recovery of probable hybrid pods at the time of harvest (Table 1).

Table 1. Hybridization success achieved in *kharif* 2007

Stress factors	No. of crosses attempted	Buds pollinated	Probable hybrid pods harvested	Crossing success (%)
Biotic stresses	6	1126	251	22.29
Abiotic stresses	30	5639	1139	20.20
Total	36	6765	1390	20.55

Selections and generation advancements

A total of 45 F_1s and 15 F_2s developed during last year were raised and true hybrids were identified based on the hybrid vigour in F1 and non-segregation observed in F2 generations. A total of 281 single plant selections could be made in different filial generations (F 3 to F 6) in the crosses attempted in the previous years for incorporating resistance to different biotic and abiotic stresses. A total of 74 non-segregating new advanced breeding cultures were identified in F7 generations.

Multiplication and maintenance of advanced breeding lines

During *kharif* 2007, a total of 409 advanced breeding lines (Table 2) developed under the project were raised for maintenance. These lines included 48 advanced breeding lines developed for high water use efficiency, and 51 mutants of variety Girnar 1.

Evaluation of advanced breeding lines developed for different breeding objectives

Comparative studies on seasonal effects on selections under summer conditions

Forty advanced breeding lines derived from the cross of Chico x R 33-1 and its reciprocal were grown along with parental lines in a RBD with 3 replications during summer 2007. Observations were recorded on shelling percent, 100-kernel weight (HKW), sound mature kernels (SMK), fodder yield , harvest index (HI), pod yields (PY), kernel yield (KY), specific leaf area (SLA), SPAD chlorophyll meter reading (SCMR), days to flower initiation (FI) and days to 50% of the plants to flower on plot basis (F50).

Genotypic differences were observed for all the traits implying, thereby, presence of considerable genetic variability for these traits among the genotypes studied. Besides, variance

due to replication was significant for SMK and SCMR. When the improvement of the advanced breeding lines over the parents was examined based on the per se performance, the advanced lines were found to be statistically significant with the respective best parent for all the traits studied. A good number of transgressive segregants, which outperformed the best parental lines, could be identified.

Table 2. Maintenance and multiplication of advanced cultures (Total 409)

Purpose	Multiplications		Maintenance	
	Spanish	Virginia	Spanish	Virginia
Disease resistance	6	16	18	11
Insect resistance	-	-	5	6
Aflatoxin resistance	-	-	12	2
Yielding ability	3	1	33	18
Earliness	2	-	16	31
Drought/Cold tolerance	1	6	10	5
Fresh seed dormancy	5	17	34	22
Seed viability	-	-	8	2
Mutant for shelling %	-	-	50(SB& B/VR)	
Water use efficiency	-	-	48(SB& VB/VR)	
Others			21(SB& VB/VR)	

Eight advanced lines recorded significantly higher pod and kernel yields over the best parental lines, besides two lines SE 32 and SE 38 recorded significantly higher kernel yields. Pod and kernel yields of these selected genotypes ranged from 2263 - 3438 kg/ha and 1419 - 2329 kg/ha as against the best yields obtained in their parental lines 1448 kg/ha and 609 kg/ha, respectively. Interestingly, except two genotypes, all these high yielding genotypes have recorded significantly high SCMR. As high SCMR is known to contribute to enhanced water-use efficiency of a groundnut-genotype, the high yielding genotypes in this case are likely to possess high water-use efficiency also. Of the eight genotypes recording high pod and kernel yields, four genotypes took significantly lesser number of days to initiate flowering compared to the parental line Chico, which has widely been used as donor parent for early maturity. Days taken by a genotype from sowing to first flower to bloom, is one of the component traits of early maturity. Thus, genotypes recording high yield coupled with early flower initiation observed in the study were likely to mature early also.

Comparative studies on seasonal effects on selections under *kharif* conditions

The same set of 40 genotypes along with parental lines Chico and R 33-1 were evaluated during *kharif* 2007 to find out high yielding-early maturing genotypes suitable for *kharif* situations. Observations on component traits of early maturity and WUE were recorded. Five selections (SE Nos. 8, 38, 6, 4 and 37) gave significantly higher yields over the best parent. Pod yields of these

five selections ranged from 1001 to 1155 kg/ha. For kernel yield, besides these five selections, two other selections (SE 31 and SE 32) were also found to be superior over the parents.

Groundnut varietal blends as an insurance against drought

Eight water-use-efficient (WUE) lines, two each performing well (top ten) under irrigated, IS (Jun 7, Jun 8); early-season drought, ESD (Jun 39, Jun 40); mid-season drought, ESD (Jun 37, Jun 46) and late-season drought, LSD (Jun 27, Jun 38) situations were selected from earlier exercise of screening 48 WUE breeding lines under irrigated and simulated drought (early-, mid- and end-of-season) situations at NRCG, Junagadh during rain-free season (summer). During summer 2006 seeds of these selected genotypes were mixed in 1:1 ratio in all possible combinations to produce 28 bi-blends. These bi-blends along with 8 component lines (uni-blends) were evaluated in a split plot design with drought pattern as main plot treatment and 36 treatments (8 uni-blends and 28 bi-blends) as sub-plot treatment. Under each drought pattern these entries were sown in a RBD with 2 replications and in 2-rows each of 3 m length. Observations on surrogate traits of WUE (SLA and SCMR) were recorded in each drought treatment and its counterpart under irrigated conditions before releasing the crop of drought stress. Post harvest observations were recorded on pod yield. This experiment was repeated in summer 2007.

Mixing ability analysis: Analysis of variance revealed that variance due to year and treatments were highly significant under all the situations of water availability. Variance due to treatment was further divided into variance due to general and specific mixing abilities, and in both the cases significant variation was observed. Variation due to interaction of specific mixing ability and year was significant under irrigated and early-season drought situations.

General mixing ability effects: Jun 7 and Jun 40 were observed to be mixing well under all the situations of water availability. In addition Jun 37 and Jun 38 could mix well under mid-season drought and irrigated situations, respectively.

Specific mixing ability effects: Specific mixing ability effects were found to be significant in 7, 12, and 7 and 10 bi-blends under irrigated, early-season, mid-season and end-of season drought situations. These bi-blends would be helpful in containing the harmful effects of non-availability of moisture (moisture-stress) at the respective stages.

Station trials for yield evaluation

Advanced breeding lines developed under the project for different biotic and abiotic stresses were evaluated in replicated trials in RBD in two rows, plot size each of 3 m length, in preliminary yield evaluation trial for one year and in four rows in advanced yield evaluation trial for two years. Three checks, GG 2 (Local check, LC), SB XI (Zonal check, ZC) and JL 24 (National check, NC) were used for comparison in Spanish group and four checks, namely GG 20, Kaushal, M 335 and Somnath were used in Virginia group. Observations on phenological traits (days to flower initiation, DFI and 50 % of plants to flower, DF50), WUE (SCMR and SLA) and yield and yield components (pod yield, kernel yield, shelling percentage, 100-kernel weight and sound mature kernels) were recorded.

During *kharif* 2007 also, there remained flood like situations like *kharif* 2006, particularly during reproductive phase, more so at peg and pod formation stage, continuously for over one month. It resulted in submerged conditions. Considerable proportion of plants was found with no pods at harvest. The remaining plants had mostly 1-2 pods per plant. It resulted in very poor yields.

Preliminary yield evaluation trial of breeding lines of Spanish groundnut

Sixteen advanced breeding lines were evaluated along with three checks during *kharif* 2007. Observations were recorded on phenological, WUE and yield traits. Days to flower initiation to 50% flowering varied from 25 – 30 and 27 – 33, respectively. Lowest SCMT recorded was 15 while the highest value recorded for this trait was 35. Lowest SLA was recorded in PBS 14060, which was significantly superior over the best check SB XI. Other significantly superior genotypes for this trait were PBS 11084 and PBS 16039 and PBS 19017. The Pod yields ranged from 395 to 1015 kg/ha. The only test entry PBS 16066, gave significantly superior pod yield, though it was only 1015 kg/ha, but the genotype recorded poor shelling outturn. The highest shelling outturn was observed in PBS 14060 (53%). Highest HKW and HSM recorded in PBS 14060 also resulted in high kernel yield of this genotype. The proportion of SMK of any test entry did not differ significantly from the best check.

Advanced yield evaluation trial of breeding lines of Spanish groundnut

Single year of evaluation

Thirty-nine advanced breeding lines were tested in *kharif* 2007 under this trial. The mutant of Girnar 1, PBS 30114, was the earliest to initiate flowering (23days), where as in 11 entries 50% of the plants initiated flowering in days which were significantly lesser than the best check variety. Similarly, significantly superior genotypes for other traits were also found. Two genotypes, PBS 16035 and PBS 16038, gave significantly superior pod and kernel yields over the best check SB XI.

Two years of evaluation

A set of fifteen advanced breeding lines was tested in *kharif* 2005 and 2007. Statistical analysis of pooled data over two seasons revealed that significant superior genotypes over the best check for a trait were found for HI (PBS 12018), HKW (PBS 16021, PBS 16020, PBS 30112, PBS 11046 and PBS 12018), SLA (PBS 11015) and SCMR (PBS 30012 and PBS 11015). For pod and kernel yields, and SP no test entries performed significantly superior over the best check varieties. However, there were ten advanced breeding lines, which were numerically superior in yield over the best check. Four genotypes gave more than 10% yield over the best check variety, the highest being in PBS 16021 (25.5%) followed by PBS 16020 (21.16%), PBS 12163 (17.14%) and PBS 30016 (15.6%) (Table 3). It is pertinent to mention that the genotypes PBS 16021 and PBS 16020, giving higher yields, also recorded tolerant reaction to PBND at Raichur, a hot spot location for this disease, during rabi-summer 2005-06 and *kharif* 2006. Similarly, PBS 15011, giving lowest SLA and highest SCMR, a combination of traits desirable from the point of view of high WUE of a genotype, also recorded reaction of tolerance to stem rot.

Table 3. Promising advanced lines based on two years evaluation

Trait	Range	Mean	Promising genotype (s)
PY/ha	1084-1684	1373	PBS 16021, 16020
KY/ha	614-1007	814	PBS 16021, 16020
HI	23-36	30	PBS 12018
HKW	18-30	24	PBS 16021, 16020, 30112, 11046, 12018, 16006
SLA	227-272	250	PBS 15011
SCMR	26-36	30	PBS 15011, 11046

Preliminary yield evaluation trial of breeding lines of Virginia groundnut

Thirteen advanced breeding lines of Virginia groundnut were evaluated in preliminary yield trial along with four check varieties. PBS 24100 recorded 24 and 25 days to initiate flowering and 50% flowering on plot basis, respectively which were significantly the least days recorded for these traits over the best check. Three genotypes, PBS 24090, PBS 24092 and PBS 26009 recorded significantly low SLA over the best check variety for this trait (Table 4). For rest of the traits studied, the genotypes were at par with the check varieties. For pod and kernel yields only two genotypes PBS 24090 and PBS 24091 recorded numerically better yields over the best check variety GG 20. These genotypes respectively gave 19 and 8, and 17 and 8% higher pod and kernel yields over GG 20.

Table 4. Promising Virginia cultures

Trait	Range	Mean	Promising genotypes
DFI	24-29	26	PBS 24100
DF50	25-32	29	PBS 24100
SLA	142-195	158	PBS 24090, PBS 24092, PBS 26009
PY/ha	478-1309	891	PBS 24090
KY/ha	269-904	593	PBS 24090

Advanced yield evaluation trial of breeding cultures of Virginia groundnut

Twenty two advanced breeding cultures of Virginia groundnut were evaluated along with four check varieties in *kharif* 2007. PBS 30162 and PBS 21046 were found to be most early in flowering as it took only 24 days to initiate flowering and 27 days for 50% of its plants to flower. SPAD readings averaged for 27 over all the test entries and checks with a range of 21 to 35, the highest being recorded in PBS 22042. No test entry performed statistically superior over the respective best checks for the traits studied. Very poor yields were recoded in this trial. The highest pod yield was recorded in GG 20.

Seed enhancement

Seed enhancement of advanced breeding cultures

Seed of five advanced breeding cultures (PBS 30073, PBS 30051, PBS 24004, PBS 30044 and PBS 30086) was enhanced to meet targets for supplying seed for AICRP-G trials.

Nucleus Seed Production of NRCG Groundnut varieties

Nucleus seed of Girnar 1 and Girnar 2 is being maintained. In *kharif* 2007, 16 and 78 kg nucleus seed of Girnar 1 and Girnar 2, respectively was produced. A total of 2500 single plants of Girnar 2 were harvested separately, for maintenance breeding. In addition to this programme 60 kg pods of Girnar 2 were supplied from Durgapura to SFCI, Central Farm, Jetsar for breeder seed production programme.

Status of advanced breeding cultures in AICRP-G Trials

Three advanced cultures JUG 27, PBS 12160 and PBS 24004 were evaluated in IVT I in *kharif* 2006 and IVT II in *kharif* 2007 of drought, Spanish and Virginia trials. At all India varietal level of evaluation, the test entry PBS 24004 did not perform better, and hence was dropped. The test entry JUG 27 has given encouraging performance over two years under mid- and end-of-season drought situations. And hence was promoted to advanced drought tolerance varietal trials (ADVTT). The test entry PBS 12160 has given highest yields in Zone IV over two years, and hence has been promoted to AVT. One variety PBS 24030 (Girnar 2) was identified for notification. It was notified in the name of Girnar 2. Two more advanced lines, PBS 30044 and PBS 30073 were tested in IVT I in *kharif* 2007.

Supply of segregating material to AICRP-G Centres

Detailed information on the available crosses in F4 to F6 generations harvested in *kharif* 2007 was sent to all the AICRP-G centres along with the Material Transfer Performa. A request from ten centres for different crosses was received along with MTA. The requested seed was supplied to Shrigaon/Ratnagiri, Chintamani, Junagadh, Hanumangarh, Durgapura, Rahuri, Akola, Udaipur, Latur and Almora centers.

PROJECT 02: INTEGRATED PEST MANAGEMENT (IPM) IN GROUNDNUT BASED PRODUCTION SYSTEM

(T.V. PRASAD AND VINOD KUMAR)

Subproject 1: Integrated insects and non-insect pest management in Complex, Diverse and Risk-Prone (CDR) groundnut based production system

(T. V. Prasad)

Effectiveness of Imidacloprid against sucking pests of groundnut

An field trial was conducted during summer 2007 to test efficacy of insecticide (0.008% Imidacloprid : 17.8 SL) for the management of sucking pests of groundnut with the following treatments - T1: Seed treatment with 0.0035% Imidacloprid (70% WS); T2: T1 + 1 spray at 30 DAE; T3: T1 + 2 sprays at 30 DAE & 45 DAE; T4: 1 spray at 30 DAE; T5: 2 sprays at 30 & 45 DAE ; T6: 2 sprays with 0.04% monocrotophos (36 SL) at 30 & 45 DAE and T7: Untreated control. The results indicated that mean number of jassids and thrips were minimum in the treatment T3 followed by T6, compared to control and other treatments. Screening of segregating, stabilized lines and released cultivars of groundnut for resistance against major insect pests of groundnut

Out of 24 released varieties (SB) screened for sucking pests such as jassids and thrips, none was free from jassids and thrips infestation. In case of jassids, varieties such as Jawan, TG 26, and VRI 2 were found moderately resistant recording < 2 mean no. of jassids/ mt row and in case of thrips, varieties J 11, ALR 2, BSR 1, TMV 2, JL 220, GG 2, R 9251, Jawan and ICGS 31 were found moderately resistant recording < 2 mean no. of thrips/ mt row. Out of 31 genotypes screened for resistance against jassids under field conditions during *kharif* 2007, NRCG-CS 101, 102, and 220 were found moderately resistant (recording < 3 mean no. of jassids/ 5 sweeps) and NRCG-CS 214, 251, 266, 280, 289 and 301 were found susceptible (recording >7 mean no. of jassids/ 5 sweeps) compared to other genotypes tested. In case of and thrips, none of the genotype was found to be free from thrips infestation.

Out of 57 released varieties (SB) screened for sucking pests and defoliators, none of the varieties was free from thrips infestation. In case of jassids, varieties AK 159, ALR 2, CO 3 and GG 5 were found moderately resistant recording < 5 mean no. of jassids/ mt row and varieties R 8808, ICGS 37, TG 17 and TKG 19A were found susceptible recording > 11 mean no. of thrips/ mt row. Out of 51 released varieties (VB) screened for sucking pests, in case of jassids, varieties Chitra, CSMG-84-1, GG 13, M 522, MH 2 and MH 4 were found moderately resistant recording < 8 mean no. of jassids/ mt row and varieties LGN 2 and M 145, were susceptible recording > 15 mean no. of jassids/ mt row. In case of thrips MA 16, MH 4, T 64, TG 41 and TMV 3 were found moderately resistant recording < 3 mean no. of thrips/ mt row

Correlation studies between oviposition and adult emergence of *Careydon serratus* on groundnut pods

Laboratory experiments were conducted to study the effect of egg density on weight loss and adult emergence of *C. serratus* on groundnut pods (one, two and three seeded). Out of the three types of pods, the highest number of grubs' survived and the maximum number of adults emerged from three seeded pods, followed by two and one seeded pods. The number of adults emerged increased with increase in number of eggs per pod and also with increase in number of seeds per pod. Results indicated that only a maximum of 2.5, 4.2 and 4.8 adults could survive and emerge out of pods with one, two and three seeds, respectively. In all the cases the number of exit holes were positively correlated to the adults emerged. The per cent weight loss was highest with 10 eggs per pod and increased with the increase in the number of immature stages and adult emerged on all the three types of pods. There was significant positive correlation between per cent weight loss and egg density, no. of grubs, adult emergence and no. of exit holes in all the cases. However, egg density had no significant effect on the growth parameters (length, width and weight) of the adults that emerged from pods irrespective of the number of eggs ranging from 1 to 10 per pod.

Studies on the Life-table of *Caryedon serratus* Olivier (Coleoptera: Bruchidae)

Life-table of *C. serratus*, reared on groundnut in the laboratory at 25, 30 and 35 °C has been constructed. Life-table was constructed using the data on survival, fecundity and life span. At 25°*C* the innate capacity of increase (rm), finite rate of increase (lambda) and the mean time for completing a generation (T) were 0.0348 , 1.0357 and 147.75 days, respectively (Table 1).

Table 1. Growth parameters of *C. serratus* on groundnut at 25, 30 and 35 °C

Population growth parameters	Calculated values		
	25 °C	30 °C	35 °C
Net reproductive rate (Ro)	170.04	135.56	61.45
Mean length of generation (Tc)	147.75	105.51	63.27
Innate capacity for increase in number (rc)	0.0348	0.0465	0.0651
Corrected 'rm'	0.0351	0.0472	0.0662
Corrected generation time (T)	146.33	104.01	62.21
Finite rate of increase in number (λ)	1.0357	1.0483	1.0684
Weekly multiplication of population (λ7)	1.2785	1.3915	1.5895
Doubling time (Log 2/ Log λ)	19.75	14.69	10. 47
Hypothetical F2 females (Ro2)	28912.75	18377.42	3775.53

The net reproductive rate was highest at 25 °C (R0) of 170.04 indicated that on an average, a female of insect could produce 170.04 female off springs during its life span indicating that the insect can assume status of potential pest at this temperature. The mean length of generation (T), was 147.75, 105.51 and 63.27 at 25, 30 and 35 °C, respectively. Innate capacity for increase and finite rate of increase (λ) were 0.0472 and 0.0662 females/ female/day and 1.0483 and 1.0684-females/ female/day at 30 and 35 °C, respectively. Moreover, on reaching the stable age distribution, the population of *C. serratus*, at the various stages of egg, larva, pupa and adult,

accounted for 43.94, 54.92, 1.06 and 0.06, respectively at 25 °C and 29.61 and 42.68, 63.55 and 54.42, 6.05 and 2.44 and 0.78 and 0.43%, respectively at 30 and 35 °C.

Integrated Pest Management in groundnut based inter cropping system

An experiment on Integrated Insect Pest Management (IPM) in groundnut based inter cropping system was taken up during *kharif* 2007. The groundnut variety GG 20 was sown in plot size of 6 x 5 m^2 at 45 cm gap between rows. Ten treatments were used. The inter crops viz., sunflower (local), castor (GAUCH 4), pigeon pea (BDN 2), soybean (local), green gram (K 851) , cluster bean (local), Bt cotton (MRC 6301), desi cotton (Deviraj) and Hy. Cotton (G Cot 10) were used in the ratio of 3:1 with three replications.

The results indicated that groundnut + castor and groundnut + Bt cotton intercropping system reduced the jassids population while groundnut + cluster bean and groundnut + greengram intercropping system increased the jassids population at 90 DAS. Groundnut + castor and groundnut + hybrid cotton intercropping system reduced the thrips population while groundnut + soybean and groundnut + red gram increased the thrips population at 30 DAS.

Based on the cost of cultivation and the yields of groundnut and the inter crop, the CBR was worked out. Intercropping with red gram gave highest CBR (1: 3.99) followed by castor (1: 3.46). The yield economics showed that intercrop with pigeon pea gave the highest income of Rs. 60,303/ha followed by castor (Rs. 51,160/ha) compared to sole groundnut (Rs. 26,997/ha) and other intercrops (Table 2).

Table 2. Effect of groundnut based intercropping system on the yield and yield economics

Treatment	Yield (kg/ha)		Returns (Rs)		Gross Returns	Cost of cultivation	C:B ratio
	G'nut	Intercrop	G'nut	Intercrop			
Groundnut + Castor	643.7	1524.7	16092.6	35067.9	51160.4	14800	3.46
Groundnut + Soybean	645.1	600.9	16126.5	7210.4	23336.9	13800	1.69
Groundnut + Bt-cotton	813.9	376.8	20348.7	10550.1	30898.9	14800	2.09
Groundnut + Green gram	675.2	167.2	16879.6	4011.8	20891.5	13400	1.56
Groundnut + Red gram	470.0	2697.4	11750.0	48553.3	60303.3	15100	3.99
Groundnut + Cluster bean	834.2	222.0	20854.9	1997.8	22852.7	13400	1.71
Groundnut + Hy. Cotton	681.5	423.0	17037.0	11843.0	28880.0	14800	1.95
Groundnut + Sunflower	750.6	14.8	18765.4	222.2	18987.6	13800	1.38
Groundnut + Desi cotton	839.0	374.2	20975.3	10477.5	31452.8	13800	2.28
Groundnut alone	1079.9	0	26996.9	0.0	26996.9	13000	2.08
S.Em.±	61.8						
C.D. (at 5%)	183.6						
C.V. (%)	14.4						

Effect of bio-pesticides against sucking insect pests of groundnut

Various bio-pesticides were tested for their efficacy against sucking pests of groundnut. The thrips population varied from a minimum of 4.8 thrips / 5 sweeps/ mt. row in monocrotophos treatment to a maximum of 7.9 thrips / 5 sweeps / mt. row in neem oil treatment, as against 12.7 thrips/ 5 sweeps/ mt. row in control. The minimum and maximum leafhopper population was

recorded as 8.3 and 14 leafhoppers / 5 sweeps/ mt. row in monocrotophos and Metarhizium anisopliae treatments, respectively as against 20.5 leafhoppers / 5 sweeps/ mt. row in control. Thus monocrotophos was found to be the best treatment for the control of both thrips and leafhoppers followed by *Verticillium lecanii*, neem oil, econeem, *Beauveria bassiana* and *M. anisopliae* in that order for thrips and *V. lecanii*, *B. bassiana*, *M. anisopliae*, econeem and neem oil in that order for leafhoppers. The results indicated that maximum yield of 1391 kg/ha was recorded in *B. bassiana* treatment as against 1027.4 kg /ha in control. All the bio-pesticides were equally effective and superior to the control in producing higher pod yield of groundnut.

Effect of new synthetic insecticides against sucking insect pests of groundnut

Seed treatment with Imidacloprid (0.0035%) + 2 sprays of 0.008% Imidacloprid (30 & 45 DAG) was found superior in reducing jassids and thrips population compared to control and other treatments. Seed treatment with Imidacloprid (0.0035%) + 2 sprays of 0.008% Imidacloprid (30 & 45 DAG) recorded highest yield of groundnut (1761 kg/ ha) followed by 2 sprays of Thiamethoxam at 30 & 45 DAG (1753 kg/ha), compared to control (1273 kg/ha) and other treatments.

Development of efficient trap against sucking pests of groundnut

Four different types of traps were evaluated against sucking pests of groundnut with castor oil as trapping material. Out of the four traps tested, yellow tray trap was found efficient in trapping maximum no. of jassids (231.6 mean no. of jassids/week) compared to other traps. Whereas, in case of aphids and thrips, there was no significant difference in the trapping efficiency of different traps tested.

Monitoring of the major insect pests of groundnut

In the monitoring programme of the major insect pests of groundnut, pests such as *Helicoverpa armigera, Spodoptera litura* and *Aproaerema modicella* were monitored using pheromone traps. Aphids like *Aphis craccivora*, and *Hysteroneura setariae* were monitored using cylindrical sticky trap. The jassids and thrips were monitored using the sweep net in monthly sown crops. Maximum population of jassids was reported during February and October (94.8 and 79.75 mean no. of jassids/5 sweeps/ mt. row, respectively). Maximum population of aphids was recorded during January, February and December. Leaf miner and *Helicoverpa* moth catches were very meagre, where as the highest population of pests was recorded for *Spodoptera litura* moths, in the month of March (125.8 male moths/trap/week respectively).

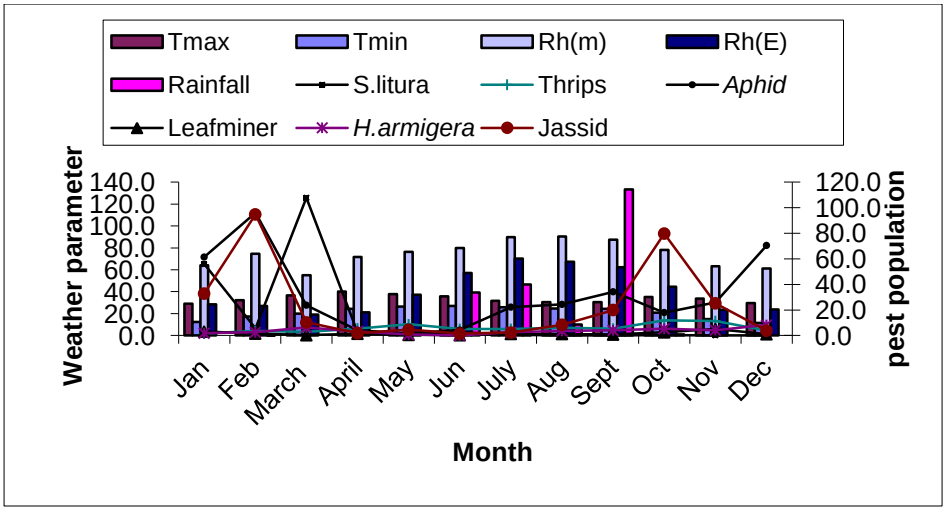


Fig 1. Monitoring of the major insect pests of groundnut (2007)

Subproject 02: Integrated management of major diseases (ELS, LLS, rust, collar rot, stem rot, PBND) of groundnut
(Vinod Kumar)

Disease resistance

Screening under field conditions

A total of 27 genotypes were evaluated against PBND and soil borne diseases vis-à-vis yield of groundnut during summer 2007 under field conditions. The results indicated that the incidence of PBND ranged from 0.0-12.0 %. Zero percent incidence of PBND was observed in most of the genotypes. The incidences of soil borne diseases were negligible in summer experimental trial.

The comparative data of field screening from 2003 to 2007 revealed that 28 genotypes viz. ALR 2, CODE 5-3, CODE 7, NRCG-CS nos' 19, 25, 86, 88,160, 164, 168, 186, 202, 251, ICGV 86590, JAL 05, OG 52-1, PBS 11026, PBS 11037, PBS 11042, PBS 11068, PBS 12160, PBS 12169, PBS 19012, PBS 30016, PBS 30158, TIR 16, TIR 42 and UF 70-103 recorded below 5% incidence showing promising resistance to PBND.

A total of 102 genotypes (second year screening) along with susceptible checks (GG 20) were evaluated against early leaf spots (ELS), late leaf spots (LLS), rust and stem rot diseases under field conditions during the rainy season of 2007. Seven genotypes which showed resistance to ELS, LLS and rust were NRCG CS nos.' CS 293, CS 347, CS 266, CS 346, CS 303, CS 284 and CS 348. Thirteen genotypes shower promising resistance against stem rot disease viz., CS 267, CS 272, CS 280, CS 285, CS 292, CS 293, CS 294, CS 300, CS 310, CS 320, CS 323 and CS 347.

The result of screening of 102 genotypes is presented in Table 3a. Seven genotypes which showed resistance to ELS, LLS and rust were NRCG CS nos.' CS 293, CS 347, CS 266, CS 346, CS 303, CS 284 and CS 348. Thirteen genotypes showed promising resistance against stem rot disease viz., CS 267, CS 272, CS 280, CS 285, CS 292, CS 293, CS 294, CS 300, CS 310, CS 320, CS 323 and CS 347 (Table 3b).

During *kharif* 2007, a total of 103 genotypes, which had shown multiple disease resistance from 2003-2006 against various diseases, were also screened under field conditions (Table 4a). Eleven genotypes showed 0 % collar rot incidence as against the highest 38.33 % in CS 239 and

12.68% in GG 20 (susceptible check). Four genotypes showed 0% stem rot incidence and 12 genotypes showed <5% as against highest 66.54% in PBS 30159 and 22.58% in GG 20 (susceptible check). Five genotypes were moderately resistant to early leaf spots as against the highest grade 7.67. One genotype recorded resistant reaction (2.17 grade) and four were moderately resistant (<3.5 grade) to late leaf spots as against the highest grade 6.17. Eight genotypes were resistant (<3.0 grade) against rust as against the highest grade 6.0. The genotypes, CS 131, CS 63, CS 73, CS 74, CS 158, CS 185, CS 222, PBS 30051, PBS 29010 and PBS 25001 showed multiple disease resistance during *kharif* 2007. The comparative data of field screening from 2003 to 2007 revealed that 9 genotypes viz. CS 144, CS 156, CS 158, CS 159, CS 160, CS 168, CS 196, CS 222 and PBS 25001 possessed multiple disease resistance (Table 4b).

Screening under in- vitro conditions (dry seed resistance)

A total of thirty advanced breeding lines along with susceptible (GG 2) and resistanct check (J 11) were screened for resistance against *A. niger* under laboratory condition adopting dry seed resistance technique. Out of these lines two viz. CS 168 and CS 25 showed moderate level of resistance recording below 30% seed colonization as against 100% in some genotypes and 83.3% in GG 2.

A total of 47 advanced breeding lines along with susceptible (GG 2) and resistanct check (J 11) were screened for resistance against *A. niger* (collar rot) under laboratory condition adopting dry seed resistance technique. Out of these 11 genotypes viz. CS 134, CS 264, CS 301, CS 306, CS 308, CS 319, CS 325, CS 329, CS 332, CS 344 and CS 353 showed resistant reaction against *A. niger* recording ≤10% seed colonization as against 32.85 % in GG 2.

Evaluation of isolates of *Trichoderma* spp. for bio-control efficacy against collar rot and stem rot pathogens under concrete block conditions

The promising isolates of *Trichoderma* spp. under in-vitro conditions were further evaluated under concrete block conditions during summer 2007 for the bio-control potential against the collar rot (*A. niger*) and stem rot (*S. rolfsii*) pathogens. Both the pathogens and the isolates of *Trichoderma* spp. were mixed in the top 5 cm soil @ 1x 106 CFU/ g soil. The cultivar used in the experiment was GG 2. Out of the six isolates viz. NRCG T-03, NRCG T-06, NRCG T-11, NRCG T-12, NRCG T-13 and NRCG T-31, the isolates NRCG-T 12 (*T. virens*) and T 31 (*T. koningii*) significantly reduced collar rot and stem rot incidence.

Antagonistic activity of 41 new isolates of *Trichoderma* spp. were first studied under in-vitro conditions (bangle method) against collar rot (*A. niger*) and stem rot (*S. rolfsii*) pathogens. Out of the promising isolates of *Trichoderma* spp. tested under in vitro conditions, six isolates viz. NRCG T-03, NRCG T-06, NRCG T-11, NRCG T-12, NRCG T-13 and NRCG T-31 were further tested under concrete block conditions against both collar rot and stem rot. Both the pathogens and *Trichoderma* spp. were mixed in the top 5 cm soil @ 1x106 CFU/ g soil. The cultivar used in the experiment was GG 2. The results showed that the isolates NRCG T-12 and T-31 both significantly reduced collar rot and stem rot incidence.

Study of cultural characteristics of newly isolated pathogen from groundnut leaves

The cultural characteristics of a newly isolated pathogen from groundnut leaves were studied. The colony growth on PDA was faster than MEA at all the temperatures and humidity

levels tested, however, the fungus failed to grow at 36 °C. The best condition for growth in laboratory was found to be at 25°*C*. The other cultural characteristics such as pycnidial production, appearance of colony, pigmentation, sectoring, etc. were also studied. The pathogen was identified as *Phoma arachidis*.

Biological control of major fungal foliar and soil borne diseases under field conditions

A field experiment was conducted during *kharif* 2007 to see the effect of soil application of enriched *Trichoderma* harzianum (Isolate T-170) and foliar application of culture filtrate of *Verticillium lecanii,* and *Trichoderma* on soil borne and foliar fungal diseases of groundnut.

The results revealed that the application of castor cake enriched with *Trichoderma* as well as castor cake alone significantly reduced pod rot incidence. There was significant reduction in the disease severity of late leaf spot (LLS) by soil application of enriched *Trichoderma* plus foliar spray of culture filtrate of *V. lecanii* at 50 % dilution on the first appearance of the leaf spots followed by two sprays at 15 days interval. Foliar spray of spore suspension of *Trichoderma* along with soil application could significantly reduce LLS disease.

Integrated Disease Management

A field trial in RBD with 3 replications and 10 treatments was conducted during *kharif* 2007. The disease incidences of aflaroot, collar rot and stem rot were low (<5%). Pod rot incidence ranged between 13.33-18.67%. The maximum disease intensity of ELS, LLS and rust were 7.33, 8.56 and 8.67 respectively in control on a 1-9 scale. The least LLS and rust was recorded with soil application of castor cake enriched *Trichoderma* (Isolate T-170) (@ 50kg/ ha *Trichoderma* multiplied in sorghum grain medium mixed with 100 kg castor cake/ ha) + Foliar spray of 5% turmeric powder which was statistically at par with foliar application of chlorothalonil (0.1%) in controlling LLS and rust. However, the highest pod yield was recorded in the treatment of soil application of castor cake enriched *Trichoderma* + foliar application of chlorothalonil which may be attributed to the plant growth promoting activities of *Trichoderma* spp.

Management of soil borne disease through organic amendment

A field trial in RBD with 3 replications and 9 treatments with susceptible cultivar GG 20, was conducted during *kharif* 2007 to study the effect of soil application of fresh leaves of karanj (*Pongamia pinnata*), banyan, *Calotropis procera* @500 kg/ha, and castor cake (500kg/ha), cotton seed cake (500kg/ha), gypsum (500kg/ha) and lime @ 100 kg/ha in furrow at the time of sowing for the management of stem rot and collar rot diseases. However, due to water logging in the field in early phase of crop growth and the pathogens being aerobic in nature the disease development for soil borne pathogens were <5%. The maximum disease incidence of collar rot, stem rot and pod rot observed were 2.15, 3.24 and 19.33 percent, respectively. The differences among the treatments with respect to pod rot were statistically non-significant.

Effect of foliar application of plant and animal products on disease intensity of major foliar fungal disease

A field experiment in RBD was conducted during *kharif* 2007 to see the effect of foliar application of some plant products like aqueous extract of turmeric, garlic, and leaf extract of neem, *Calotropis procera*, and neem seed kernel extract as well as some animal products like cow

urine, cow dung, cow milk and curd and their combinations on severity of major foliar fungal diseases. For comparison of efficacy foliar application of fungicide, chlorothalonil (0.1%) was kept as a standard treatment. The results showed that there was significant reduction in the intensity of late leaf spots (LLS) by foliar application of panchgavya (a combination of cow urine, cow dung, cow milk, curd and butter prepared in laboratory), and neem seed kernel extract (NSKE) which were statistically at par with foliar application of chlorothalonil. However reduction in severity of ELS and rust were statistically non-significant. Significantly higher pod yield was realized with the treatment of NSKE, which was statistically at par with foliar application of chlorothalonil.

Table 3a. Promising genotypes against ELS, LLS and rust under field conditions during *kharif* 2007 (Second year screening)

Sr. No.	Genotypes	Disease intensity (1-9) scale		
		ELS	LLS	Rust
	CS 293	2.67	1.67	1.67
	CS 347	2.83	1.67	1.50
	CS 266	2.83	1.67	2.67
	CS 346	3.00	1.67	1.67
	CS 303	3.33	2.00	1.67
	CS 284	3.67	1.83	2.50
	CS 348	3.83	2.00	2.17
	CS 325	-	-	1.67
	CS 280	-	-	2.50
	CS 329	-	-	2.50
	CS 169	-	-	2.67
	CS 283	-	-	3.00
	GG 20*	8.17	5.83	7.00

*Susceptible check; No. of genotypes screened: 103

Table 3b. Promising genotypes against stem rot under field conditions during *kharif* 2007 (Second year screening)

Sr. No.	Genotypes	Stem rot (% incidence)
	CS 267	3.57
	CS 272	7.03
	CS 280	9.98
	CS 285	7.49
	CS 292	8.82
	CS 293	6.82
	CS 294	9.52
	CS 300	6.25
	CS 310	6.46
	CS 320	6.20
	CS 323	4.17
	CS 347	2.50
	GG 20*	17.42
	CS 281	46.32

*Susceptible check; No. of genotypes screened: 103

Table 4a. Genotypes showing promising resistance under field conditions during *kharif* 2007 (among the genotypes that were screened during 2003-2006)

Sr No.	Disease	Genotypes	Remarks
1	Collar rot	CS 104, CS 131, CS 143, CS 151, CS 158, CS 187, CS 63, CS 72, PBS 12169, PBS 30051, PBS 30159	11 genotypes showed 0 % DI as against the highest 38.33 % in CS 239 and 12.68% in GG 20 (susceptible check).
2	Stem rot	CS 131, CS 141, CS 99, PBS 30053 (zero %) CS 72, CS 239, CS 90, CS 185, CS 200, CS 127, CS 198, PBS 30051, CS 104, CS 63, PBS 11070, PBS 29060 (< 5%)	4 genotypes showed 0% DI and 12 genotypes showed <5% as against highest 66.545 in PBS 30159 and 22.58% in GG 20 (susceptible check)
3.	Early leaf spots (ELS)	PBS 25001, CS 105, CS 160 CS 222, PBS 29060 (<5.83)	5 genotypes were moderately resistant as against the highest grade 7.67
4.	Late leaf spots (LLS)	PBS 25001 (2.17 grade) CS 35, CS 73, PBS 29017 CS 159 (<3.5 grade)	One genotype resistant and four genotypes were moderately resistant as against the highest grade 6.17
5.	Rust	CS 223, CS 73, PBS 25001 CS 185, CS 35, OG 52-1, PBS 29010, PBS 30051 (<3.0 grade)	Eight genotypes were resistant as against the highest grade 6.0
6.	Multiple disease	CS 131, CS 63, CS 73, CS 74, CS 158, CS 185, CS 222, PBS 30051, PBS 29010, PBS 25001	Multiple disease resistance during *Kharif* 2007

Total no. of genotypes screened = 103

Table 4b. Genotypes showing resistance over the years (2003-2007)

Sr No.	Genotypes*			
1	CS 19	CS 137	CS 185	CS 73
2	CS 25	CS 144	CS 192	CS 74
3	CS 35	CS 156	CS 196	CS 85
4	CS 36	CS 158	CS 222	PBS 25001
5	CS 72	CS 159	CS 223	PBS 25001
6	CS 79	CS 160	CS 257	PBS 29010
7	CS 131	CS 168	CS 63	PBS 30051

* Multiple disease resistant genotypes are in bold

PROJECT 03: PHYSIOLOGICAL STUDIES ON ENVIRONMENTAL STRESSES IN GROUNDNUT

(P. C. NAUTIYAL, J. B. MISRA AND RADHAKRISHNAN, T.)

Sugars as osmoprotectants

Osmoprotectants such as sugars and proline have important role to play under various environmental stresses such as drought, heat and cold, and soil salinity. Studies were conducted during summer season and changes in the concentration of sucrose and reducing sugars were evaluated under normal and water-deficit conditions (Table 1). Under water-deficit the concentration of sucrose decreased almost in all the cultivars, whereas reducing sugars increased. Thus genetic variability in the concentration of sugars indicated that accumulation of reducing sugars may be the trait associated with drought tolerance and could be useful in identification of molecular basis.

Table 1. Concentration of sucrose and reducing sugars in the leaves of the nine groundnut cultivars under normal and water-deficit stress conditions and after relief

Cultivars	Sucrose (%)			Reducing sugar (%)		
	Control	Stress	After relief	Control	Stress	After relief
ICGS 44	0.70	0.57	0.62	0.22	0.23	0.24
GG 7	0.66	0.58	0.62	0.20	0.23	0.25
TAG 24	0.64	0.60	0.59	0.17	0.22	0.23
Girnar 1	0.70	0.47	0.53	0.22	0.27	0.24
Gangapuri,	0.57	0.57	0.57	0.21	0.29	0.23
ICGV 86031	0.69	0.59	0.69	0.17	0.26	0.25
GG 2	0.62	0.46	0.55	0.21	0.22	0.25
TG 32	0.68	0.57	0.67	0.17	0.30	0.27
JL 24	0.62	0.53	0.55	0.18	0.23	0.22
C.D. (at 5%)	Before and after stress = 0.039 Treatment = 0.039 Cultivar =0.087			Before and after stress = 0.020 Treatment = 0.020 Cultivar = 0.039		

Stomatal density in relation to WUE

Ten high WUE lines were tested for the stomatal density on abaxial and adaxial surfaces of the leaf. In general, stomatal density on the upper and lower surfaces was in 1:1 ratio, but for some exceptional cases. For example, in ICR 3 stomatal density was higher on the upper surface than on the lower surface (Table 2). This genotype was also found to be the most water use efficient in the FPRE on farm trials and preferred by the farmers for cultivation in rain-dependent system. Therefore, it is presumed that the stomatal density may indicate about the WUE of a genotype and large number of germplasm accessions or segregation populations may be studied for this trait to access their WUE in addition to SLA.

Table 2. Stomatal density in the abaxial and adaxial surfaces in twelve groundnut genotypes

Genotypes	Abaxial (stomata/mm^2)	Adaxial (stomata/mm^2)	Mean
ICR 3	569	457	513
JBDR 64	313	351	332
ICGV 87846	260	324	292
JAL 42	313	303	308
JBDR 7	276	324	300
ICR 4	244	281	263
ICGV 02266	367	356	362
TIR 17	415	335	375
JUG 45	452	346	399
JUG 16	362	271	317
GG 20	441	394	418

Formulation of germplasm group for morphological, physiological and molecular characterization for drought tolerance

To increase the crop productivity in rain-dependent system, a better understanding of physiological traits associated with drought tolerance is required. Therefore, germplasm accessions were screened for the morphological, phenological, physiological and molecular traits associated with drought tolerance. The germplasm accessions included core collection made by NRCG (number 186), core collection made by ICRISAT (number 188), accessions selected based on variations in canopy architecture (number 50) and high WUE lines (number 184). Genetic variability was recorded in morphological features such as leaf glossiness, hairiness and dimensions. Phenological characteristics such as days to flower initiation, day to 50% flowering and reproductive efficiency also varied significantly. Wide genetic variability was also noticed in traits such as specific leaf area (SLA, cm2 g-1), SPAD chlorophyll meter reading (SCMR), stomatal density on the upper and lower surfaces (mm2), leaf desiccation tolerance (% water loss), leaf relative water content (RWC), leaf water potential, pod yield and harvest index (HI %) and root characteristics, i.e. root: shoot ratio, root biomass and root length, etc. The Mean and Range of the parameters studied are mentioned in Table 3.

Analysis of late embryogenesis abundant proteins (LEAs)

Field trials and laboratory experiments were conducted with seed dormant and non-dormant groundnut genotypes to understand precocious germination, post-harvest dormancy and protein profile during seed desiccation and germination. Externally applied ABA inhibited germination, while ethrel promoted germination, however the magnitude of effect of ethrel application varied in dormant and non-dormant types. Protein profile also varied due to application of ethrel, whereas little or no difference was observed between protein profiles of ABA treated and non-treated seeds at 24 h of germination (Fig. 1). In addition, a comparison of protein profiles of seed dormant and non-dormant types before harvest, at final-harvest and

during different hours of curing showed variation in interplay of protein bands of both low and high molecular weights.

Table 3. Range of the morphological and physiological parameters recorded in various core collections and germplasm accessions

A. Morphological		**Range**	**Mean**
Days to flower initiation	ICRISAT core	24 – 38	29
	NRCG core	24 – 37	27
Days to 50% flowering	ICRISAT core	30 – 42	33
	NRCG core	28 - 40	31
Leaf hairiness	ICRISAT core	7 Present 177 Absent	
	NRCG core	Not recorded	
Glossiness	ICRISAT core	179 P 5 A	
	NRCG core	165 P 2 A	
B. Specific leaf area (cm^2g^{-1})			
	ICRISAT core	119 – 377	207
	NRCG core	120 – 321	188
	High WUE lines	115 – 260	169
C. SPAD Chlorophyll Meter Reading			
	ICRISAT core	23 – 46	34
	NRCG core	28 -40	33
D. Leaf stomatal density (mm^2)			
Upper surface	NRCG core	255 - 588	393
Lower surface		21 – 547	369
E. Leaf desiccation tolerance			
Percentage water loss	NRCG core & high WUE lines	18 – 57	38
F. Pod yield ($g\ m^{-2}$)			
	NRCG core & high WUE lines	2 – 203	103
G. Harvest index			
	NRCG core & high WUE lines	0.0 – 0.72	0.36
H. Leaflet length (cm)			
Upper leaflet	NRCG core & high WUE lines	3.1 – 7.2	5.2
Lower leaflet	NRCG core & high WUE lines	2.9 – 6.1	4.5
I. Leaflet width (cm)			
Upper leaflet	NRCG core & high WUE lines	1.3 – 3.3	2.3
Lower leaflet	NRCG core & high WUE lines	1.1 – 2.6	1.9

The seed during curing or desiccation remained physiologically active. It could be possible that the LEA proteins appearing during desiccation may help the seed in prolonging its viability and vigour, however such proteins disappear during germination. In conclusion, nature of seed dormancy and role of ABA both in dormancy and expression of LEA proteins may lead to some improvement in quality and vigour of seed for drought tolerance.

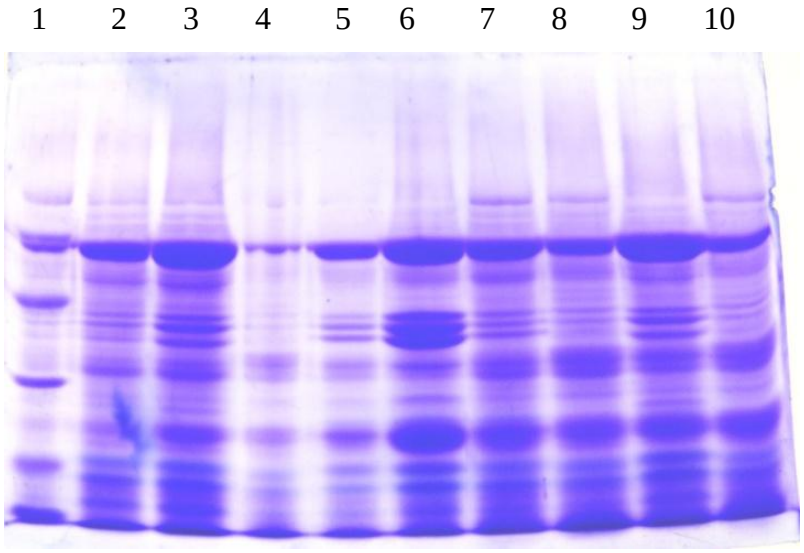


Figure 1. SDS-PAGE protein profile (KDa) of GAUG 10, ICGS 76, and GG 2 at 24 hours of germination, seeds treated with distilled water (control), ABA and ethrel (Lane 1: medium range molecular weight marker; lane 2: GAUG 10, control; lane 3: GAUG 10, ABA ; lane 4: GAUG 10, ethrel; lane 5: ICGS 76, control; lane 6: ICGS 76, ABA; lane 7: ICGS 76, ethrel ; lane 8: GG 2, control, lane 9: GG 2, ABA , lane 10: GG 2, ethrel.

Evaluation of wild *Arachis* species for abiotic stresses: II. Chlorophyll fluorescence (Fv/Fm), PS II & carbon isotope discrimination (13C/12C)

It was of interest to investigate the genetic variability among wild *Arachis* species and their accessions for tolerance to thermal stress and leaf water relations. A wide variation was observed in leaf morphological characters such as colour, shape, hairiness, length and width, and thickness (SLA) (Nautiyal et al. 2008). Present investigation is in continuation to our previous study to explore the variability in chlorophyll fluorescence and carbon isotope discrimination (13C/12C) among 68 wild *Arachis* species and their accessions. Observations on, photosynthetically active radiations (PAR), leaf temperature, steady state fluorescence yield (Fs), light adapted fluorescence maximum (Fm`), quantum efficiency of PS II (ΦPS II R) and electron transport rate (ETR) were recorded and mean values for three days and three different times are presented (Table 4). Wide genetic variation in the parameters recorded showed that high temperature tolerant lines must be efficient in their Photo system II and chlorophyll fluorescence (Fv/Fm). Genetic variability was also found in carbon isotope discrimination (13C/12C) in the leaf samples of these species analysed by the Crop Science Division, UAS, Bangalore. The observations need to be integrated with the molecular

analysis of the leaf DNA samples for identification of the molecular markers associated with drought or WUE and high or low temperature tolerance.

Table 4. Range and mean of chlorophyll fluorescence and PS II parameters, recorded in 68 wild *Arachis* species and their accessions.

Parameters	Range		Mean
	Maximum	Minimum	
Incident photosynthetically active radiation (PAR, $\mu molm^{-2}s^{-1}$)	1140	553	910
Temperature (TEMP, OC)	39	17	34
Steady state fluorescence yield (Fs)	45	14	25
Light adapted Fluorescence Maximum (Fm')	51	19	30
Photosystem II (PSII)	130	0.05	2
Electron transport rate (ETR)	144	13	69
Fluorescence origin (Fo)	222	118	157
Fluorescence Maximum (Fm)	1179	381	809
Light adapted variable fluorescence(Fv)	1013	257	654
Maximum quantum efficiency of PSII photochemistry (Fv/Fm)	0.86	0.67	0.80
Photochemical quenching co- efficient (qP)	-0.01	-0.12	-0.05
Non - Photochemical quenching co- efficient (qNP)	1.44	1.11	1.21
Alternative definition of non photo- chemical quenching (NPQ)	52.02	12.2	27.56

Influence of water-deficit on root distribution in different soil layers

Although root architecture has been shown to play an important role in crop performance, particularly under drought conditions, no information is available on the genetic control of root traits in groundnut, a crop largely grown in rainfed areas with low rainfall. In our study, a panel of 10 cultivars was evaluated under control and water-deficit conditions in root-study blocks to study the influence of water-deficit on root architecture. Significant genetic variability was detected for all the root traits that were investigated and analysis of the two years data showed that the cultivars maintained almost the same ranking under control and water-deficit stress. In conclusion, under stress conditions root growth was hampered both in terms of root: shoot ratio, and number of roots in different soil layers. The root volume length ratio, and root, shoot ratio also changed significantly under the water-deficit (Fig. 2). In many crop plants genetic variations are reported for drought, salt, acid soil resistance, or nutrient acquisition. Genetic variability obtained in our experiments need to be utilized in breeding programmes for improving drought tolerance in groundnut. Leaf RWC, water potential and chlorophyll fluorescence parameters was recorded at the peak stress period and after relief of stress to verify the drought tolerance nature of individual genotype with the root characteristics.

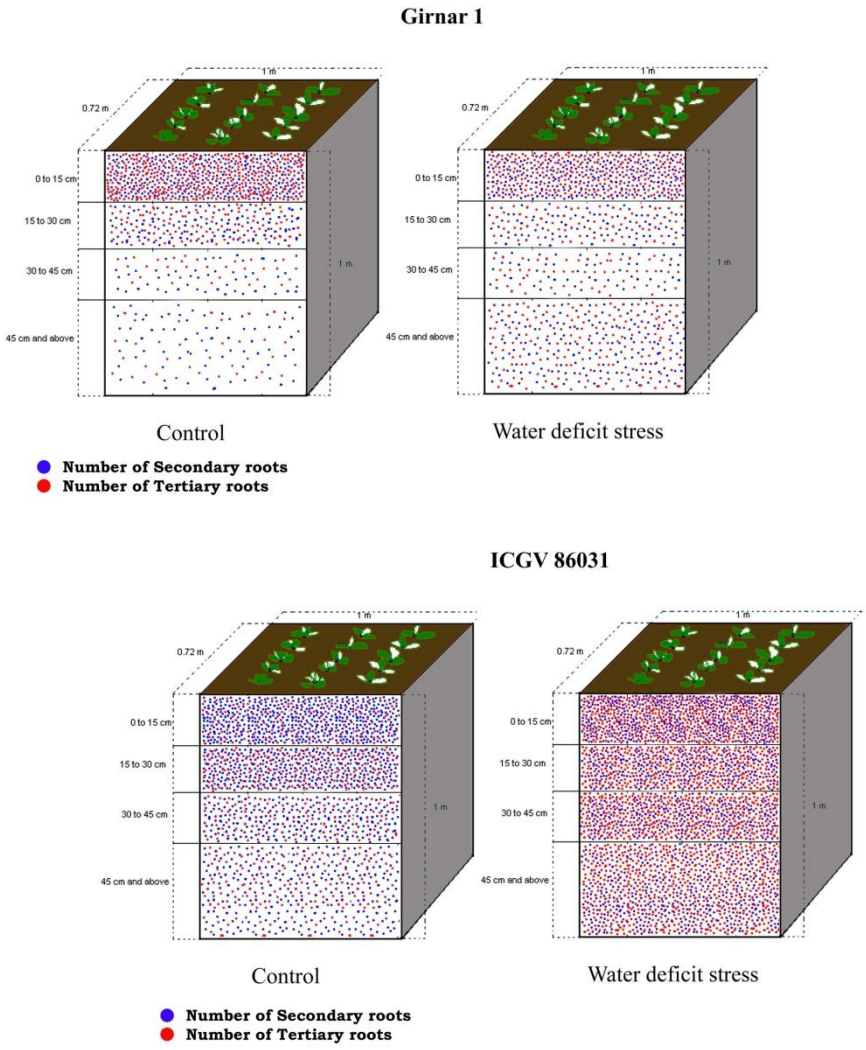


Figure 2. Distribution of roots in different soil layers under normal (control) and water-deficit stress treatments in two groundnut cultivars.

PROJECT 04: MICROORGANISMS IN RELATION TO SOIL HEALTH AND PLANT NUTRITION IN GROUNDNUT

(K. K. PAL and R. DEY)

Plant Growth Promoting Rhizobacteria (PGPR)

Evaluation of consortia of microorganisms for enhancing the growth and yield of groundnut, cultivar GG2 during summer, 2007

Phosphate solubilizing microorganisms, groundnut-rhizobia and plant growth promoting rhizobacteria were tested within and pair-wise for compatibility. On the basis of compatibility tests, a total of seven combinations of consortia were identified. All the seven consortia were tested in pot and field trials.

A number of combinations of compatible and competent strains of PGPR (*Pseudomonas aureofaciens* BHU1 and *Pseudomonas fluorescens* biovar V S1(6); consortium D) , PSB (*Pseudomonas sp*. BM8; *Bacillus polymyxa* H5; consortium E), and rhizobia (NRCG4 and NC92; consortium F) were identified and tested under field conditions. The individual member of each consortium has already been proved as good inoculants for groundnut. Inoculation of the different combinations of consortia during summer, 2007 resulted in better nodulation and shoot biomass production. In general, inoculation of consortia gave better growth response in comparison to un-inoculated control (Table 1). Best consortium was the combination of PSB (*Pseudomonas sp*. BM8 and *Bacillus polymyxa* H5) and rhizobia (NRCG4 and NC92), which resulted in 19.5% higher pod yield. This consortium also resulted in maximum haulm yield, nodulation, shoot and root biomass. The inoculation of consortium of PSB, PGPR and rhizobia also gave significantly higher pod yield.

Evaluation of consortia of microorganisms under potted conditions during summer, 2007

The different consortia used for field studies were also evaluated under potted conditions. All the different consortia of PGPR, PSB and rhizobia resulted in better nodulation and root growth. There was enhancement in pod yield also as a result of inoculation. Maximum yield was obtained with the inoculation of PSB (*Pseudomonas sp*.ACC 10 + B. megaterium) and rhizobia (TAL 1000 + NRCG 22).

Population dynamics of individual microorganisms in the consortia

The population dynamics of individual members of the consortia were also determined using intrinsic antibiotic resistance patterns which indicated that majority of the members of the consortia gave sizeable population. The population of the microorganisms in the rhizosphere soil ranged from 0.02 X 106 to 34.0 X 106 cfu/g during the crop duration. The population, in general, increased rapidly (2–19 times) from 30 DAS to 60 DAS and thereafter declined rapidly. Among the different microorganisms used in the different consortia, plant growth promoting *P. fluorescens* S1(6) and phosphate solubilizing *Bacillus polymyxa* H5 maintained considerably higher population even at the time of harvest. The phosphate solubilizing bacterium, *Bacillus megaterium*, could maintain a population of 34 X 106 to 10 X 106 cfu/g during the crop growth period. Similarly, *Pseudomonas sp*. ACC3 also maintained a sizeable

population. However, the population of *Pseudomonas sp*. C185 and *Pseudomonas sp*. ACC 10 declined rapidly after 30 DAS.

Groundnut rhizobia NRCG4 showed nodule occupancy ranging from 44% to 96% from 30 DAS to 90 DAS among the different consortia. The occupancy was maximum at 60 DAS and could maintain high level of occupancy even at 90 DAS. The consortia C and ABC supported maximum nodule occupancy. *Rhizobium* strains NC92, NRCG22 and TAL 1000 showed nodule occupancy ranging from 4-100% in different treatments from 30 DAS to 90 DAS. The nodule occupancy continued to increase from 30 DAS to 90 DAS in the different treatments. Among the different consortia, consortium EF was the best to support the maximum nodule occupancy of NRCG22 and TAL1000.

Evaluation of consortia of microorganisms for enhancing the growth and yield of groundnut, cultivar GG 2, during *kharif* 2007

A number of combinations of compatible and competent strains of PGPR (*Pseudomonas aureofaciens*BHU1 and *Pseudomonas fluorescens* biovar V S1(6); consortium D), PSB (*Pseudomonas sp.* BM8; *Bacillus polymyxa* H5; consortium E), and rhizobia (NRCG4 and NC92; consortium F) were tested to evaluate the efficiency of the consortia in enhancing the growth, yield and nutrient uptake in groundnut. Inoculation with different consortia comprising combinations of PGPR, PSB and rhizobia resulted in better root and shoot growth and plant biomass, better nodulation and nodule mass as compared to un-inoculated control. The best consortium was the combination of PGPR and rhizobia, which resulted in maximum pod yield (21%). The consortium of PGPR, PSB and rhizobia yielded at par with that of control (Table 2).

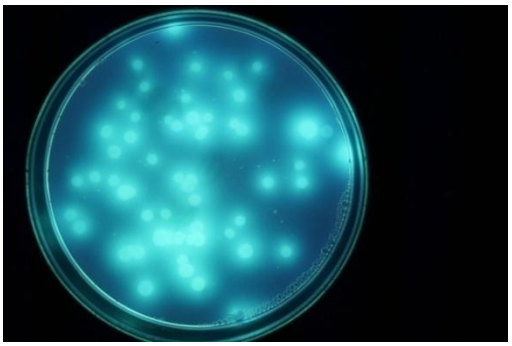
Evaluation of consortia of microorganisms under potted conditions during *kharif* 2007

The different consortia used for field studies were also evaluated under potted conditions. All the different consortia of PGPR, PSB and rhizobia resulted in better nodulation and root growth. There was enhancement in pod yield also as a result of inoculation. However, maximum yield was obtained with the inoculation of PSB (*Pseudomonas sp*. ACC 10 + *B. megaterium*) and rhizobia (TAL1000 + NRCG 22). The population dynamics of individual member of the consortia were also determined using intrinsic antibiotic resistance patterns which indicated that majority of the members of the consortia gave sizeable population densities.

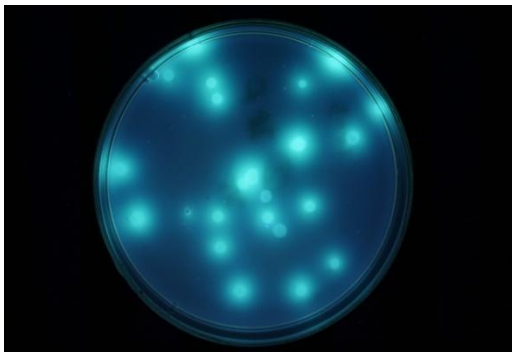
Studying the role of groundnut genotypes on the rhizodeposition and microbial population

Two parental lines of groundnut, i.e. GG 2 and ICGV 86031 and six progenies of the cross between these two parental lines were taken up to study the role of groundnut genotypes on rhizo-deposition and microbial population in groundnut rhizosphere. Among these progenies, three viz. JUG 22, JUG 24 and GUJ 48 were higher yielding and rest three progenies JUG 43, JUG 46 and JUG 47 were lower yielding as compared to the parental lines. It was hypothesized that through breeding process it is possible to enhance the population of both beneficial and deleterious microorganisms in the rhizosphere vis-à-vis yield enhancement or reduction of yield coupled with nutrient uptake. Evaluation of population dynamics of

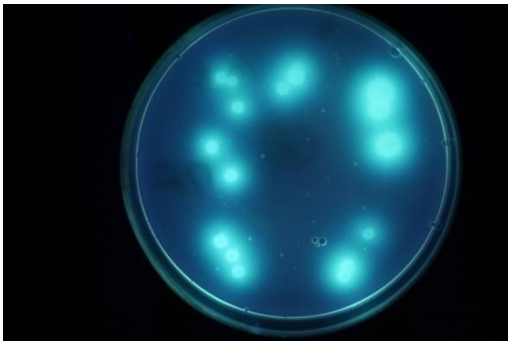
different representative groups of microorganisms at an interval of 7 days beginning 7 DAE in the rhizosphere of varieties and advanced breeding lines indicated that the population of cyanogenic fluorescent pseudomonads increased in lines, which produced significantly less yield than parental lines GG 2 and ICGV 86031. The population of cyanogenic fluorescent pseudomonads enhanced appreciably over the period of time (Fig. 1). A replicated trial during *kharif* 2007 indicated that in lines wherein yield was more, cyanogenic fluorescent pseudomonad population was maintained at low level as compared to low yielding lines where cyanogenic fluorescent pseudomonads increased several times (Table 3). Though increase of fluoresecent pseudomonads vis-à-vis cyanogenic strains was not linear always in low as well as high yielding lines, there was definite indication that in low and high yielding lines population of deleterious cyanogenic strains increased and decreased, respectively, as compared to parental lines. Increase in the population of cyanogenic fluorescent pseudomonads might only be one of the factors for low yield but needs more detailed investigation and validation.



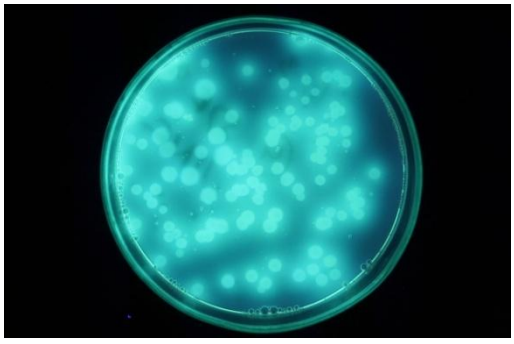
JUG 22



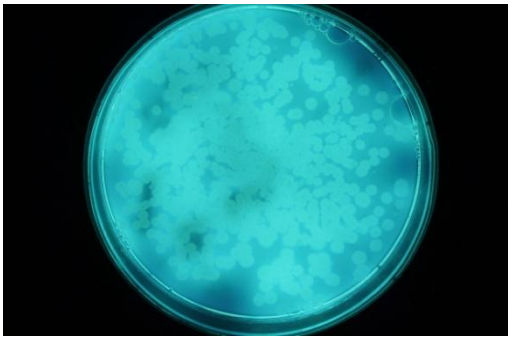
GG 2



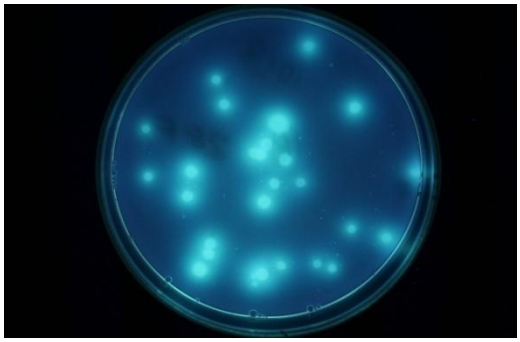
JUG 47



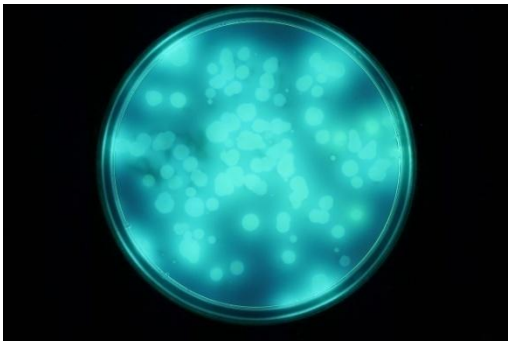
JUG 24



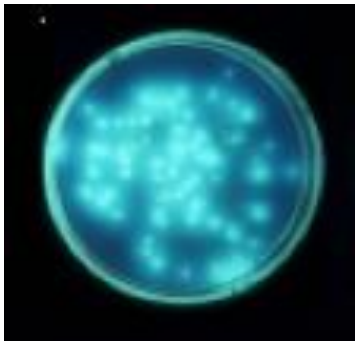
JUG 48



JUG 46



JUG 43



ICGV 86031

Fig 1. Population of fluorescent pseudomonads in the rhizosphere of different genotypes of groundnut as determined on S1 Gold medium

Evaluation of VAM fungi on the growth and yield of groundnut under potted conditions

A pot trial was conducted during the *kharif* season of 2007 to study the inoculation effects of AM fungi on groundnut growth and yield. Four AM fungi viz., *Glomus etunicatum, Glomus fasciculatum, Glomus mosseae,* and *Gigaspora scutellospora* were used in pot studies. Inoculation of different AM fungi (1500-2000 chlamydospores/100 g of soil) had significantly better effects on groundnut growth in terms of shoot and root biomass; nodule number and mass; and pod yield of groundnut, cultivar GG 2, as compared to un-inoculated control (Table 4). There was remarkable increase in root volume and root biomass in AM fungi inoculated treatments and in some cases, the root volume increased nearly two folds (inoculation with *Glomus mosseae*). Studies on VAM root colonization indicated that there was significant root colonization and formation of arbuscules and vesicles (Fig. 2) upon inoculation of the AM fungi as compared to un-inoculated control. However, there was infection at very low level in the un-inoculated control also, indicating the presence of native population of AM fungi in groundnut-cultivated soil.

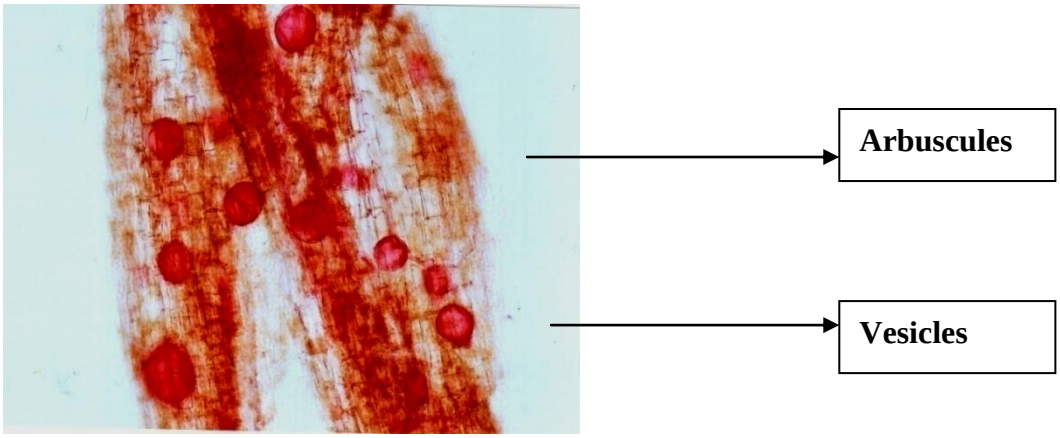


Fig 2. Colonization of groundnut root by Glomus mosseae

Studying different liquid formulations of groundnut rhizobia

A groundnut *Rhizobium* culture, NRCG 22, was selected to study the shelf life of the culture under room temperature and in refrigerated condition using different liquid formulations. Yeast Mannitol Broth (YMB) was used as a standard medium along with G1, G2, G4, G5 and G6 + PVP. These formulations contained chemicals like PVP, etc. which supposedly enhance

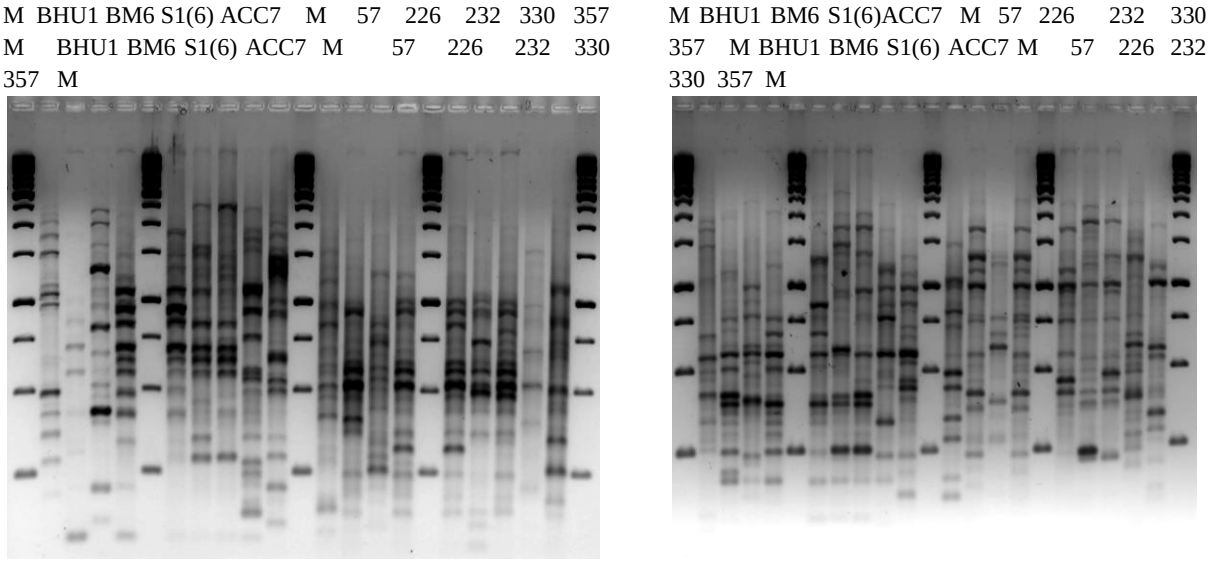
the shelf life of the liquid formulations. The population of the *Rhizobium* culture was monitored at frequent intervals (weekly upto one month and thereafter at monthly intervals). The colony count dropped from 109 cfu/ml at two weeks to almost negligible at two months when kept at room temperature. The viability was much better under refrigerated conditions with a minimum of 103 cfu/ml after three months. However, under both the conditions, the standard medium YMB proved to be the best supporting 109 cfu/ml after three months of storage under refrigerated conditions.

16S rDNA-RFLP analyses of some important PGPR and rhizobial strains

To differentiate the related isolates of groundnut rhizobia and fluorescent pseudomonads and also to study the polymorphisms, RFLP of 16S rDNA was performed. Four fluorescent pseudomonad isolates viz. *Pseudomonas fluorescens* ACC7, *Pseudomonas fluorescens* biovar III BM6, *Pseudomonas fluorescens* biovar V S(1)6 and *Pseudomonas aureofaciens* BHU1 were taken. Similarly, 16S rDNA of rhizobial isolates viz. IGR 40, TAL 1000, NC 92, NRCG 4, NRCG 12, FN 1, FN 2, and BNX 2 were taken. Double digestion of 1486 bp 16S rDNA with *RsaI* and *HhaI* resulted in four distinct restricted fragments of approximately 375, 270, 140 and 85 bp in case of ACC7 and BM6. In case of BHU1 and S1(6), double digestion of amplified 16S rDNA resulted in four distinct bands of 315, 270, 145 and 90 bp. In case of rhizobial strains, however, analysis indicated that RFLP patterns of 16S rDNA of TAL1000 and NC92 were similar whereas all other strains were different.

RAPD analysis of important fluorescent pseudomonad strains for polymorphisms and fingerprinting

Fluorescent pseudomonad isolates BM 6, ACC 7, S1(6) and BHU 1 were analysed for RAPD using OPERON RAPD Kit A (10 mer oligonucleotide primers). Use of OPA1, OPA2, OPA3 and OPA4 resulted in detectable polymorphisms among the strains (Fig. 3).



Left: first 9 lanes OPA1; remaining 9 lanes OPA2; Right: first 9 lanes OPA1; remaining 9 lanes OPA2

Fig 3. RAPD profiles of important fluorescent pseudomonads generated using Operon RAPD primer kit A

Table 1. Effect of consortia of PGPR, PSB and rhizobia on the growth and yield of groundnut, cultivar GG 2, during summer 2007

Treatments	Pod yield (kg/ha)	Haulm yield (kg/ha)	Nodule number at 45 DAS
Con D	2135	4500	27.2
Con E	2270	4405	35.2
Con F	2027	4415	48.7
Con DE	2027	4587	32.7
Con DF	2360	4467	54.0
Con EF	2507	4970	68.5
Con DEF	2227	4395	40.2
Control	2097	4240	21.2

Table 2. Effect of consortia of PGPR, PSB and rhizobia on the growth and yield of groundnut, cultivar GG 2, during *kharif* 2007

Treatments	Pod yield (kg/ha)	Haulm yield (kg/ha)	Nodule number at 45 DAS
Con D	1232	3932	36.0
Con E	1227	3680	41.0
Con F	1210	3897	57.0
Con DE	1255	3730	33.0
Con DF	1365	4030	64.0
Con EF	1207	4000	52.0
Con DEF	1292	4070	53.0
Control	1119	3532	28.0

Table 3. Population densities (X 105 CFU / g soil) of pseudomonads in the rhizosphere of different genotypes of groundnut at 28 DAE

Genotypes	Fluorescent pseudomonads	Non-fluorescent pseudomonads
JUG 22	0.70	0.15
JUG 24	8.50	2.50
JUG 48	2.25	1.20
JUG 43	2.15	1.30
JUG 46	5.20	0.20
JUG 47	2.60	2.85
GG 2	1.15	0.80
ICGV 86031	2.55	2.40

Table 4. Effect of inoculation of mycorrhizal fungi on the growth and yield of groundnut, cultivar GG 2, under potted conditions

Trt.	PY (g/p)	SL (cm/p)	RL (cm/p)	NDW (mg/p)	RV (cc/p)	Root Col. (%)	Arb.(%)	Ves. (%)
Control	2.33	24.4	36.5	53.7	5.7	12	4	2
G. etunicatum	3.20	29.0	55.4	65.0	8.3	62	44	22
G. fasciculatum	3.37	28.9	51.3	70.0	8.8	64	42	20
G. mosseae	3.34	29.6	52.2	75.0	10.7	60	46	18
G. scutellospora	3.21	29.0	53.7	85.0	5.7	54	40	24

PY= pod yield; SL= shoot length; RL= root length; NDW= nodule dry weight; RV= root volume; Arb= Arbuscules; Ves= Vesicles

PROJECT 05: MANAGEMENT OF MINERAL NUTRITION AND ASSOCIATED STRESSES IN GROUNDNUT

(A. L. SINGH)

Subproject 1: Mineral nutrient requirements and related disorders in groundnut (A. L. Singh and R. S. Jat)

P and micronutrient (Zn +B) nutrition in various seed-sizes of groundnuts

The effect of P and micronutrients, especially Zn and B, on the pod nutrition of various seeds size of groundnut was studied in a field experiment taking 40 groundnut genotypes varying in pod structure and sizes (Length 1.64-4.7 cm, width 0.74-1.68 cm) and seed sizes (Length 0.5-1.8 cm, width 0.3-0.97 cm). The genotypes were grown without and with P50 and Zn + B (each element at 1 kg ha-1) and the observations revealed that:

The P and Zn + B increased pod yield by increasing the length and width of the pod and seed in groundnut.

The large seed-sized groundnut requires more P and showed high P in their seed and shell than the small sized genotypes. Boron and Zn increases their contents in seed and shell with more pronounced effect in large seeded one. The large seeded groundnut genotypes face B and Zn-deficiency, as their Zn requirement is not met properly. The study revealed that P, B and Zn are important nutrients for proper pod filling in groundnut and their application is essential for maintaining the proper seed and pod size for the production of export quality produce of large-seeded genotypes.

Screening for K and S-efficient genotypes

Field screening to identify K and S-efficient groundnut genotypes was attended by growing 103 genotypes under unfertilized and fertilized conditions (control, 50 kg k/ha and 20 kg S/ha treatments) and based on the relative performance and nutrient contents the nutrient efficient and inefficient groundnut genotypes were identified.

K-efficient: SP 250 A, LGN 2, Tirupati 3, Kadiri 3, UF 70-103, TG 64, M13, NRCG 6155, ICGS 76, JSP 19, ALR 2, CSMG 84-1,

S-efficient: CSMG 84-1, Tirupati 3, LGN 2, SP 250 A, ALR 2, ICG88448, R 9251,

K-inefficient: MH 2, MH1, RS 138, Tirupati 2, GAUG 10.

S-inefficient: MH 2, Tirupati 2, Karad 4-1 NRCG 7472, Chico

Studies on the various levels of Mo in groundnut

The micro-plot studies in four groundnut cultivars (GG 2, JL 24, ICGS 76 and GG 20) revealed significant increase in yield by increasing the Mo doses upto 0.5 kg ha-1 in all the cultivars, however, the responses were more pronounced in GG 7, ICGS 76 and GG 20. The Mo above 0.5 kg ha-1 was not beneficial. Among the various mode of application soil application was better than seed dressing.

Seed treatment with micronutrients

Micro-plot studies using seed treatment of various micronutrients (copper sulphate, manganese sulphate, iron sulphate, zinc sulphate and sodium molybdate) in commonly grown

cultivars GG 2, GG 7, ICGS 76 and GG 20 revealed that, as seed treatment, all the cultivars responded to these micronutrients and increased yield significantly. Though, in general, there was maximum response of zinc followed by iron, interestingly all the cultivars showed good response of Mo, Mn and Fe with slight variations. Application of Zn showed maximum yield in ICGS 76 and GG 20 cultivars, however, maximum yield in GG 2 was due to Fe and in GG 7 it was due to Mo.

Screening Core germplasm for fertilizer response and high nutrient density

One hundred and ninety four core germplasm lines were grown under unfertilized and fertiliszed conditions to study the fertilizer response and micronutrient density in kernels for three years and the study revealed that: During last *kharif* season, due to flood like situation resulting in plant mortality, the plant survival and average pod and haulm yields (with 24 and 19 plants, 18 and 15g pods and 183 and 148g haulm yields in control and fertilized plots respectively) was more in control than the fertilized plot. The genotypes, NRCG 12065, NRCG 11711, NRCG 12049, NRCG 11551, NRCG 2538 and NRCG 11656 performed well with more than 500 kg/ha pod yield and appeared to be tolerant to water saturation for about 40-45 days.

The genotypes having high nutrient density in their kernel during regular season were:

High Fe: NRCG 12291, 12148, 11088 12880, 11236 (above 100 ppm)

High Mn: NRCG 11126, 12291, 3533, 10820, 12321 (above 40 ppm)

High Zn: NRCG, 11868, 3648, 12321, 1086, 11925 (above 50 ppm)

High Cu: NRCG 12746, 9966, 10820, 11088, 11276 (above 14 ppm)

Screening groundnut cultivars for high Zn content in seed

The seeds of 80 groundnut cultivars were analyzed for Zn, as well as Fe, Mn, Cu, Ca and P and sorted based on their Zn concentrations in seed and categorized as low (< 30 mg kg^{-1}), medium (31-50 mg kg^{-1}) and high (>51 mg kg^{-1} Zn) zinc density genotypes. Some of the high Zn containing cultivars were CO 1, CO 2, Gangapuri, UF 70-103, GG 5 and ICGV 86590 which also contained high Fe in their Kernel.

Yield targeting in groundnut

Field experiments on the yield target, based on the soil analysis and nutrient requirement, were conducted using two groundnut cultivars where a pod yield of 4.5-5 t/ha could be achieved during summer season and 3.5 t/ha during *kharif* season. Altering the soil physical condition by adding sand and the broad bed furrow increased aeration and 15-20 % yield enhancement was obtained during rainy season, but was not beneficial during summer season.

Screening, maintenance and multiplication of nutrient-efficient and inefficient lines

A total of 110 nutrient-efficient and in-efficient groundnut genotypes were grown for maintaining the seed stocks of these genotypes for various purposes and also for testing in NEH region.

Subproject 2: Management of soil acidity and related problems of groundnut

Screening of groundnut genotypes for Al-toxicity tolerance

In sand culture

Thirty five groundnut genotypes were screened for their tolerance of Al-toxicity (1000 µM of Al as $AlCl_3$) in pots where Al-toxicity symptoms on roots and subsequently on plant growth were noticed 25-30 days after sowing, causing reduction in growth and yields. Based on these symptoms and relative performance, the genotypes NRCG 816, 1169, 11657, 2906, 3823, 7105 and 7185 showed comparatively more tolerance to Al-toxicity than others.

Field Screening in Acid soils

The 96 core collection of germplasm lines were tested in the Acid soils of NEH region at Tripura, Mizorum, Barapani and Nagaland both under fertilized and unfertilized conditions. Some of the promising lines identified showing tolerance to Al-toxicity were: NRCG 11551, NRCG 2538, NRCG 11656

Experiment on organic farming

The various organic farming approaches when tested in NEH region, always showed their superiority over inorganic ones. The FYM (@ 10 t/ha) alone was the best for highly eroded soils of NEH region and helped in alleviating Al-toxicity. The traditional farmers' practice of Bun farming method was also much towards nature. The other promising organic sources identified were Pig slurry, Vermi-compost (5 t/ha), poultry manure and green leaf of Gliricidia and subabul.

In Manipur, among the organic treatments, vermicompost @2t/ha produced the highest pod yield (2142 kg/ha) and was at par with application of oil cake @1t/ha but significantly higher than other organic treatments. In Mizorum, the biofertilizers containing PSM + PGPR increased 25 % kernel yield, whereas the VAM alone increased 58 % kernel yield. The Neem cake (500 kg/ha), Pig slurry (10 t/ha), vermi-compost (5 t/ha) and poultry manure could increase 75, 85, 127 and 116% kernel yield, respectively as against 133 % increase due to FYM application. The hedge row crop of *Tefrosia microphylla*, *Crotalaria microphylla*, *Plemangia* and *Glirricidia* grown on the bunds and incorporated as organic manuring in groundnut and rice showed excellent response in Nagaland.

Nutrient management in Bold Seeded Groundnut

To identify key nutrients for large-seeded groundnuts and find out the ameliorative measures for NEH region, experiments on nutrient management were conducted in large-seeded groundnut with various combinations of organic and inorganic nutrients. The field studies have shown that, in acid soils of NEH combination of organic with inorganic sources was better than the use of inorganic fertilizers only. Application of P, Ca and B and organic fertilizers are most critical for growing large-seeded groundnut with required yield and quality. Highest pod yield was recorded with N40 + P50 + K100 + Lime (2.5 t/ha) + 1 kg/ha B. Addition of FYM brought down the soil acidity and Al-toxicity and hence was most essential for growing confectionary groundnuts. Thus, it is essential to fertilize the large-seeded groundnut with essential elements.

The NEH has a lot of potential area for growing confectionery groundnut as groundnut expresses its full potential in the region where water is not a limiting factor.

Subproject 3: Development of sustainable production technologies for north-eastern India (A. L. Singh, N. P. Singh, S. Biswas, K. A. Pathak, R. Bhagawati, M. Singh, P. H. Bhatt and L. S. Rathor)

Evaluation of recently released cultivars and nutrient efficient lines

Thirty two groundnut genotypes comprising of recently released cultivars and nutrient efficient lines were evaluated in NEH region and the suitable ones identified were:

Mizorum: TKG 19A, GG 20, ICGS 76, ICGV 88448, CSMG 84-1, ICGV 86590

Tripura: M 13,TAG 24, NRCG 7599, NRCG 6450, NRCG 6155

Arunachal Pradesh: GG 7, TKG 19A NRCG 1308, and 7599

Nagaland: ICGS 76, CSMG 84-1, GG 7, FeESG 8 and 10 and CS lines

It was observed that a few early varieties doing well in NEH are best fit in the cropping system. The high yielding groundnut genotypes were also tolerant of Al-toxicity, resistant to ELS, LLS and rust diseases and hence can be grown in NEH region.

Identification of suitable groundnut varieties for various intercropping systems

Field experiment with three intercropping systems (Rice + Groundnut, Maize + Groundnut and Green gram + Groundnut) and four varieties of groundnut (ICGS 76, TKG 19A, JL 24 and ICGV 86590) demonstrated highest groundnut yield in maize + groundnut intercropping and the varieties ICGV 86590 and TKG 19A were most suited.

Screening groundnut genotypes for foliar diseases

A total of 198 groundnut genotypes comprising of germplasms and nutrient efficient lines were used in this study during *kharif* crop season in Tripura. The seeds were sown in row system of plantation at the middle of May. The natural occurrences of leaf spot diseases were scored in 1-9 point scale on 30, 60 and 90 days after sowing (DAS). Randomly plucked infected leaves were examined under microscope to distinguish the differential appearance of early (*C. arachidicola*) and late (*P. personata*) leaf spot diseases. The data of last observation were computed to evaluate the genotypic effect of host on disease occurrence.

Groundnut crop was affected by leaf spot [early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Phaeoisariopsis personata*)] diseases during *kharif* crop season at ICAR research farm in Tripura. Of the diseases, early leaf spot was the major disease under natural infection. The differential studies of the two major leaf spot diseases, early leaf spot (*C. arachidicola*) and late leaf spot (*P. personata*), revealed that all the spots on 30DAS and 60DAS were of early leaf spot disease and on 90 DAS, while examined 7598 spots, 94.79% spots were due to the effect of *C. arachidicola* and 5.21% spots were of *P. personata*. As regards the varietal influence on the leaf spot disease incidence, it was found that none of the genotypes was immune to the disease. Most of the spots developed on groundnut leaves were of early leaf spot disease, which appeared on 30 days after sowing (DAS) and increased sharply in between 60 and 90 DAS (Fig. 1). Further, there was no significant difference on its

occurrence among the genotypes at initial stage of infection i.e. on 30 DAS and the differences started on 60 DAS onwards that became clearly visible on 90 DAS. The severity of other important foliar disease, such as, rust (P. arachidis) was very less and did not vary significantly among the genotypes. The low rust incidence in the groundnut cultivars might be attributed with the antagonistic effect of leaf spot disease.

Of the 198 germplasms, only 7 genotypes, viz., NRCG 813, NRCG 935, NRCG 945, NRCG 992, NRCG 996, NRCG 1001 and NRCG 11734, were found as resistant to leaf spot diseases with disease rating score range 2 - <3. In addition, 12 genotypes were found moderately resistant (score range 3 - < 5), 33 genotypes were moderately susceptible (5 - < 7) and 146 genotypes were susceptible (7 – 9).

Evaluation of core germplasms for their performance in acid soils of NEH region

Leaf spot:

In all, 96 core collection of groundnut germplasms were evaluated for their disease reaction under natural conditions of Tripura. All the genotypes were affected by leaf spot disease during *Kharif* crop. However, leaf spot disease incidence was comparatively low in NRCG 3198, NRCG 1086, NRCG 11942, NRCG 11927, NRCG 12256, NRCG 12393, NRCG 12264, NRCG 12297, NRCG 12968, NRCG 12255, NRCG 13393, NRCG 12869, NRCG 12299 and NRCG 11985 when studied both under fertilized and unfertilised conditions.

Rust: The NRCG accessions 12299, 12319, 12255, 12256, 11236 and 12996 showed resistance to rust incidence under field conditions.

Stem rot: The NRCG accessions 10969, 10541, 12879, 12630, 11194, 11346, 12256, 12255, 12523, and 11450 were highly prone to stem rot attack.

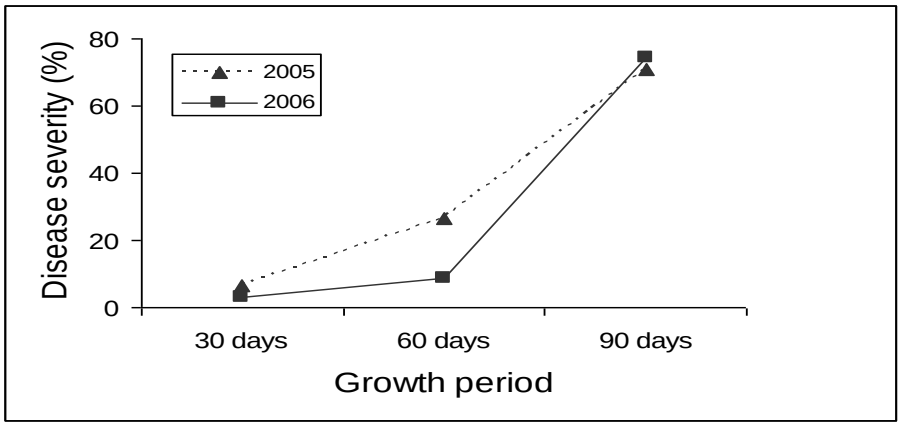


Fig. 1. Development of leaf spot diseases in advanced breeding lines of groundnut during different growth periods and years in *kharif* season of Tripura

Table 1. Influence of advanced breeding lines of groundnut on the incidence of leaf spot diseases during *kharif* crop season in Tripura

Reaction*	Genotypes
Immune (rating 1)	Nil
Resistant (rating 2 - <3)	NRCG 813, NRCG 935, NRCG 945, NRCG 992, NRCG 996, NRCG 1001, NRCG 11734
Moderately resistant (rating 3 - <5)	NRCG 1006, NRCG 1021, NRCG 1026, NRCG 1045, NRCG 1056, NRCG 1057, NRCG 1260, NRCG 4607, NRCG 12355, NRCG 12358, NRCG 12438, NRCG 12457
Moderately susceptible (rating 5 - < 7)	ICGV 8844, NRCG 162, NRCG 1048, NRCG 1062, NRCG 1403, NRCG 1440, NRCG 4513, NRCG 4589, NRCG 4594, NRCG 4636, NRCG 4654, NRCG 4680, NRCG 4706, NRCG 6234, NRCG 6473, NRCG 6491, NRCG 6989, NRCG 10327, NRCG 11954, NRCG 11959, NRCG 12311, NRCG 12483, NRCG 12503, NRCG 12554, NRCG 12648, NRCG 12652, NRCG 12701, NRCG 12799, NRCG 12800, NRCG 12803, NRCG 12819, NRCG 12922, PBS 13
Susceptible (rating 7- 9)	146 genotypes

* Disease rating score 1 = 0%, 2 - < 3 = 1-5%, 3- <5 = 6-20%, 5 - < 7 = 21- 40% and 7- 9 = 41-100% incidences.

Evaluation of confectionery groundnut genotypes in NEH region

Eight large seeded groundnut cultivars i.e. ICGV 86590, GG 20, ICGS 76, GG 7, TKG 19 A, CSMG 84-1, TPG 41 and M 13 were evaluated for their yield potential in NEH region under high management conditions (FYM 10 t/ha + PSM + PGPR and all fertilizers) in Mizorum, Tripura and Nagaland. After evaluating the confectionery groundnut genotypes, under high management conditions in fields in NEH, M 13, TPG 41, ICGS 76 and CSMG 84-1 were found suitable for Mizorum, Tripura and Nagaland and ICGS 76 and CSMG 84-1 for Manipur and any one of these could be used.

PROJECT 06: DEVELOPMENT OF SUSTAINABLE PACKAGES OF PRACTICES FOR GROUNDNUT BASED CROPPING SYSTEMS

(R.S. JAT, H.N. MEENA, I.K. GIRDHAR, K.K. PAL and P.C. NAUTIYAL)

Permanent experiment on nutrient dynamics in groundnut based cropping system

A long term experiment was initiated in 1998 with five popular groundnut based cropping system in the region viz., sole groundnut, two intercropping systems (groundnut+pearl millet and groundnut+pigeon pea) and two sequential cropping systems (groundnut–wheat and groundnut–wheat–green gram) under different combinations of organic and inorganic fertilizer regimes. The field experiments are being conducted to assess the (i) evaluation of different groundnut based cropping systems and, (ii) long term effects of nutrient management on soil nutrient content and productivity of groundnut based cropping systems.

Groundnut was established at 30 cm row to row and 10 cm plant-to-plant spacing at the onset of monsoon. In groundnut+pearl millet intercropping system, groundnut and pearl millet was planted in alternate rows at 30 cm spacing. While, in groundnut+pigeon pea intercropping system, three rows of groundnut was planted alternately with one row of pigeon pea. In groundnut-wheat rotation, wheat was grown at 30 cm row to row and 7.5 cm plant-to-plant spacing in the post rainy rabi season and in groundnut-wheat-green gram rotation, green gram was grown as green manuring crop after wheat in summer season. Cultivation practices for all crops were as per recommended practices, except nutrient management. Nutrients were applied as per treatment; 100% recommend dose of fertilizers (RDF) and 50% RDF+5 t farm yard manure (FYM) per hectare to groundnut; 100% RDF, 50% RDF and 50% RDF+5 t (FYM) per hectare to wheat; 100% RDF and 50% RDF to each of pigeon pea and pearl millet crop. Green gram was raised as green manure crop without any fertilizers. The economic yield was calculated on net plot area basis and then converted to kg/hectare. Evaluation of different cropping systems revealed that the highest total system productivity (TSP) in terms of groundnut equivalent yield (GEY) was recorded in groundnut-wheat-green gram cropping system. The nutrient management practices showed that groundnut with FYM+50% RDF accrued the highest total system productivity in terms of GEY.

Whereas, the highest TSP in terms of GEY of 3123 kg/ha was found in G (FYM+50%) – Wheat (FYM+50%) - Green gram cropping system. The groundnut, pearl millet and pigeon pea recorded highest yields with 100% RDF to groundnut and the component crops both. In case of wheat, the highest grain yield of wheat was recorded in the groundnut-wheat-green gram system followed by groundnut-wheat system. Among different fertility levels, the highest wheat yield was found with G (FYM+50%)-Wheat(FYM+50%)-Green gram in the groundnut-wheat-green gram system. The soil fertility report showed that the organic carbon build-up (t/ha) was maximum in groundnut–wheat–green gram cropping system and the highest was recorded in the G (FYM+50%) - Wheat (FYM+50%) – Green gram management system which found to be most sustainable system.

Fig.1. Total system productivity of different cropping systems

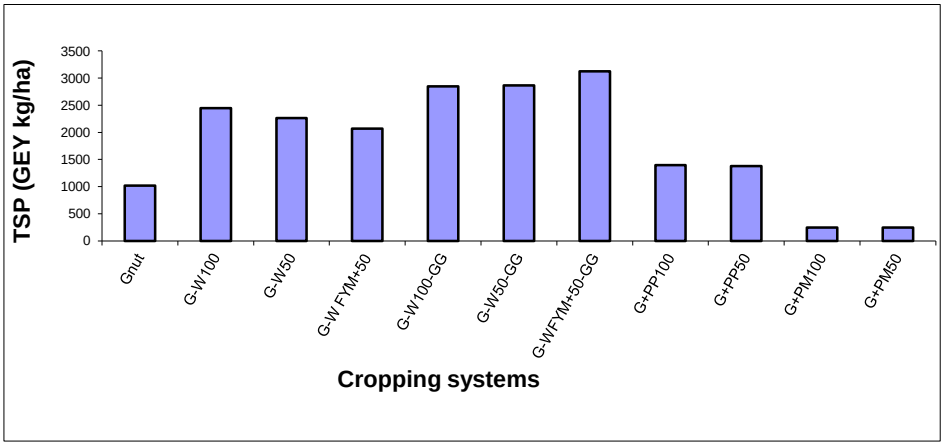
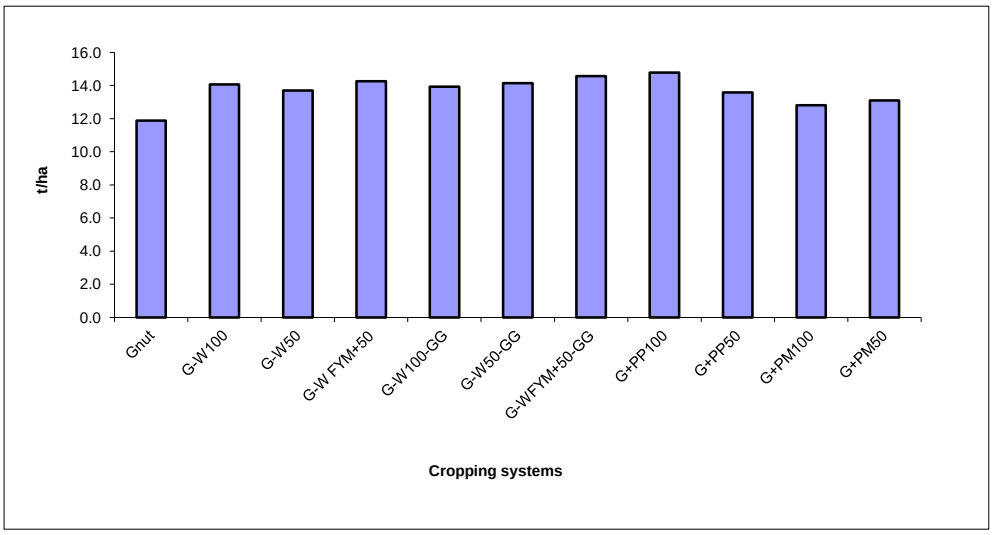


Fig.2. Effect of cropping systems on soil organic carbon stock



Development of packages for organic groundnut production

The experiment was initiated in the summer season to find out the best organic groundnut production practice. The treatment consisted of five organic practices; T1- farm yard manure (FYM) (15 t/ha), T2- T1+Biofertilizer (*Rhizobium* and PSB), T3- T2+Biopesticide (*Trichoderma* and castor cake), T4- 50% FYM+50% RDF, T5- recommended practice (RDF), T6- Control and T7- T3+Gypsum+ rock phosphate (RP). The crop was taken under irrigated condition with no water stress at any stage. The seeds were treated with biofertilizers followed by biopesticides as per treatment and sown after drying. Other treatments were applied as basal at the time of sowing. The results showed that the productivity of summer groundnut increased significantly higher over RDF. The highest groundnut pod yield (2078 kg/ha) was recorded with 'FYM (15 t/ha) + Biofertilizer + Biopesticide + Gypsum + RP' which was 12.4 per cent higher over RDF, followed by 'FYM (15t/ha) + Biofertilizer' (7.9%). The soil total N analysis showed the similar trend i.e. the highest total % N was recovered with the application of 'FYM (15t/ha) + Biofertilizer + Biopesticide + Gypsum + RP' treatment.

Table 1. Effect of different organic and inorganic nutrients on groundnut pod yield

Treatment	Pod yield (kg/ha)
T1-FYM (15 t/ha)	1747
T2- T1+Biofertilizers	1926
T3- T2+Biopesticides	1847
T4- FYM (50%) + RDF (50%)	1790
T5- RDF	1848
T6- Control	1737
T7- T3+Gypsum+Rock phosphate	2078
C.D (5%)	82
C.V. (%)	9.1

PROJECT 07: MANAGEMENT OF EXISTING AND EMERGING PROBLEMS OF SOIL AND WATER SALINITY FOR GROUNDNUT PRODUCTION

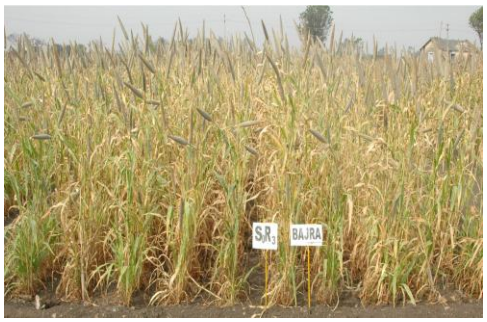
(I. K. GIRDHAR, R. S. JAT, P. C. NAUTIYAL AND K. K. PAL)

Use of saline water in groundnut based cropping system

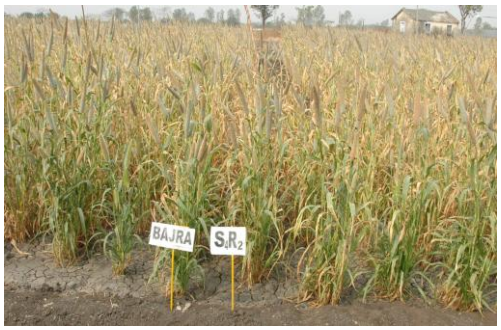
Generally, farmers in the Saurashtra region of Gujarat are taking single crop of groundnut and summer/winter season are being kept fallow due to non-availability of good quality of irrigation water. If we use saline water by taking two crops in a year, the total production and productivity of the crop can be increased by efficiently utilizing available rainfall. With this objective in mind, the field experiment on utilization of saline water in different crop rotation was started in 2002 and continues up to 2008. After the harvest of mustard crop, different released varieties of groundnut crop were taken in *kharif* 2007 in the saline soil using saline water irrigation. Among the different tested released varieties in the saline environment, GG 20 and ICGS 76 yielded maximum under the Virginia group and TG 26, TAG 24 and ICGS 37 gave the maximum yield under the Spanish group. It was found that the varieties under the Virginia group showed more tolerance to salinity than Spanish group.

After the harvest of groundnut in *kharif* 2007, rabi bajra crop was evaluated in different salinised plot using saline water irrigation. The different levels of salinity of irrigation water used in bajra crop was 0.5, 2, 4 and 6 dS/m which resulted in the build up of root zone soil salinity in different treated plots. Soil salinity at harvest in these treated plots were 1.0, 2.5, 5.0 and 7.5 dS/m, respectively.

Decrease in grain yield of bajra with an increase in soil salinity from 1.0 to 5.0 dS/m was found to be non-significant (Fig. 1) and at 7.5 dS/m salinity, the grain yield of bajra was significantly lower in comparison to control (Soil salinity – 1.0 dS/m). An increase in soil pH as a result of increased soil and water salinity further deteriorated the soil health particularly at high soil pH and high soil salinity. After the harvest of rabi bajra in March 2008, different varieties of groundnut in varying soil and water salinity was taken in *kharif* 2008. The performance of these varieties at different saline environment is shown in Fig. 2.

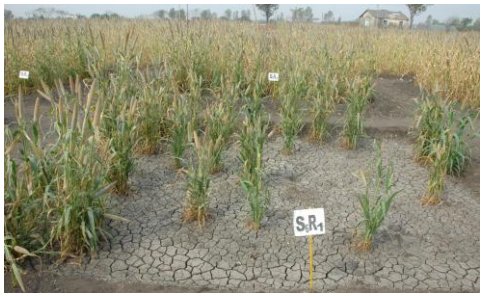


Water Salinity = 0.5 dS/m Soil Salinity = 1.0 dS/m



Water Salinity = 2 dS/m Soil Salinity = 2.5 dS/m

Water Salinity = 4 dS/m Soil Salinity = 5.0 dS/m



Water Salinity = 6 dS/m Soil Salinity = 7.5 dS/m

Fig.1: Effect of soil and water salinity on the performance of rabi bajra crop

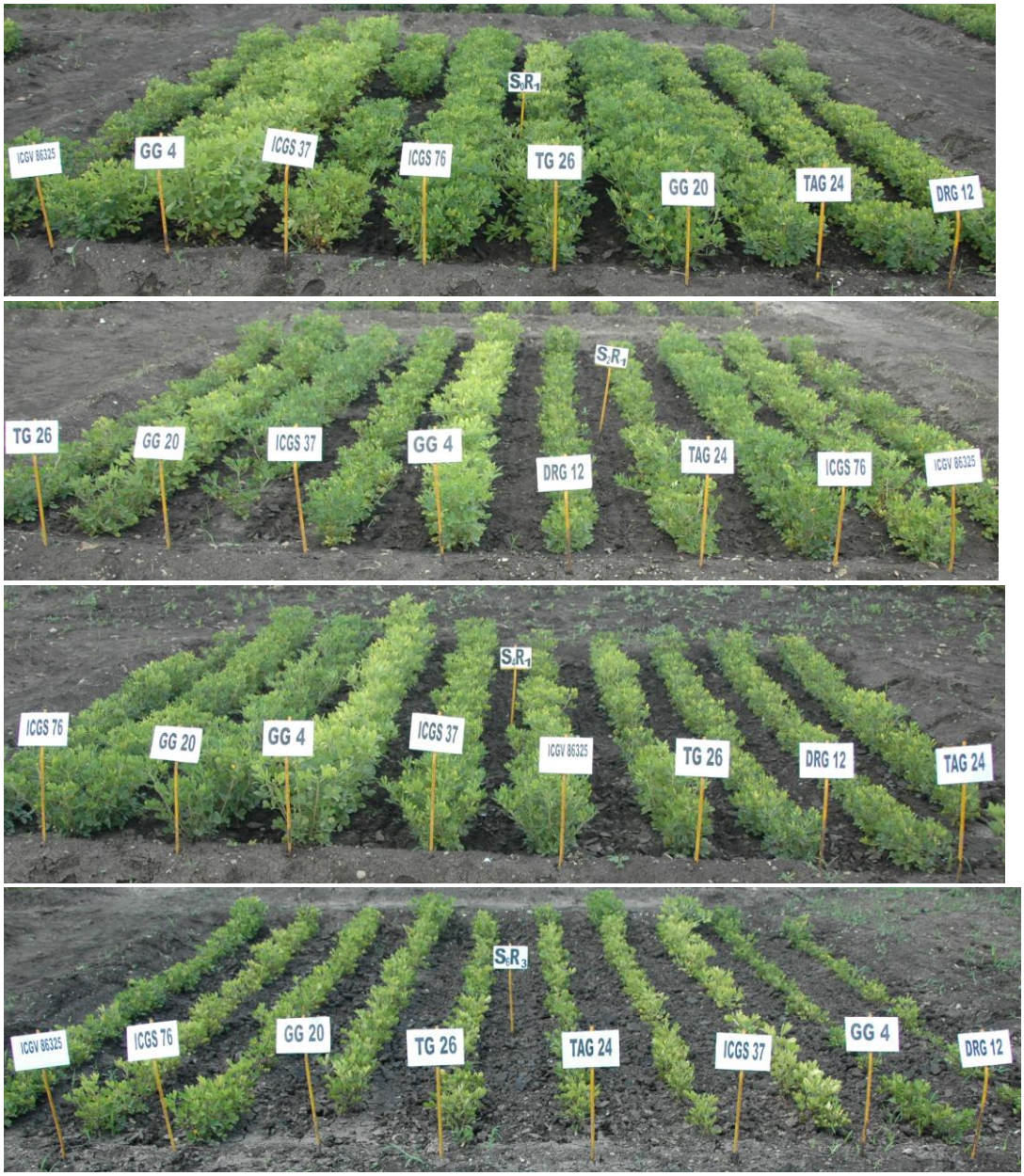


Fig. 2: Performance of different varieties of groundnut at varying salinity levels

PROJECT 08: MANAGEMENT OF GERMPLASM OF CULTIVATED GROUNDNUT (*Arachis* hypogaea L.) AND ITS WILD RELATIVES

(A.L. RATHNAKUMAR, S.K. BERA, HARIPRASANNA, K., T.V. PRASAD, VINOD KUMAR AND SUMANTH KUMAR)

Acquisition of new germplasm accessions

Thirty-two released varieties from Oilseeds Research Station, Tindivanam, Regional Research Station, Vridhachalam, Agricultural Research Station, Chinthamani, and Rajasthan College of Agriculture, Udaipur and eight farmers' varieties collected at Bhuj region of Gujarat were added to the crop inventory. Twenty-seven accessions of wild *Arachis* species were also obtained from National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Hyderabad.

Supply of germplasm accession to indenters

Three hundred and ninety two germplasm accessions including wild relatives of groundnut were supplied to 29 indenters for use in the crop improvement programme. These germplasm were supplied to the scientists of NRCG (218), State Agricultural Universities (127), other ICAR Institutes (30), AICRPG centres (13) and others (04).

Multiplication of groundnut germplasm

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

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.

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 one hundred and thirty eight (26 VUL; 23 FST; 59 HYB; 30 HYR) new germplasm accessions obtained from ICRISAT were multiplied.

A set of 211 germplasm accessions (VUL 37; FST 22; HYB 80; HYR 72) was multiplied in *kharif* season for depositing in NGB. These germplasm were identified for repatriation under ICAR-ICRISAT collaborative project. Due to heavy rainfall in *kharif* season, sufficient quantity of seeds could not be obtained in all the accessions. However, a total of 135 accessions having sufficient seeds in each of the above germplasm were deposited with NGB for long-term conservation.

For Medium Term storage at NRCG:

Fifty-seven exotic lines, 45 morphologically distinct accessions, 120 released varieties, 30 reference varieties identified under DUS project and 10 accessions of Bambara groundnut were multiplied and the seeds were conserved in the medium term cold storage module at NRCG.

Characterization of germplasm

Characterization for morphological and yield traits

One hundred and ninety eight accessions of ICRISAT and 114 working collections of NRCG were sown for characterization for 11 qualitative and 27 quantitative traits. In addition, 32 large seeded accessions and 17 accessions having high pod yield were also sown for characterization. However, due to high rainfall, the yield and its related traits were severely affected. The promising germplasm identified during *kharif* season are provided below:

S. No	Traits	Promising ICRISAT germplasm	Promising NRCG germplasm
1	High pod yield (>10 g/plant)	NRCGs' 14162	NRCGs 13587, 14803, 14815, 14817
2	High shelling (68 - 72%)	NRCGs' 14236, 14263, 14282, 14306, 14249, 14280, 14284,	NRCGs' 671, 3026, 14748, 14791, 14792, 14750
3	Large seed weight (>45 g/100 seed)	NRCGs'14132, 14148, 14193, 14194, 14195, 14197, 14224	NRCGs, 9785, 14809, 14812, 13489, 13901

Evaluation for Δ 13C, 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 (13C) during photosynthesis. The same physiological parameter determines water use efficiency also and hence Δ 13C has been widely used as a potential surrogate for WUE. The relationship between Δ13C 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 Δ13C 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 Δ13C. Some of the promising accessions having low Δ13C are as follows:

S. No.	Habit Group and promising accessions	Δ13C	Days to maturity
1	FST		
	NRCG 11924	18.255	124
2	HYB		
	NRCG 404	18.696	132
	NRCG 8963	18.701	132
	NRCG 11865	18.727	126
	NRCG 12138	18.745	130
	NRCG 119422	18.922	130
3	HYR		
	NRCG 666	18.651	120
	NRCG 17	18.770	130
	NRCG 12393	18.851	130

Genetic diversity in rabi/summer groundnut varieties

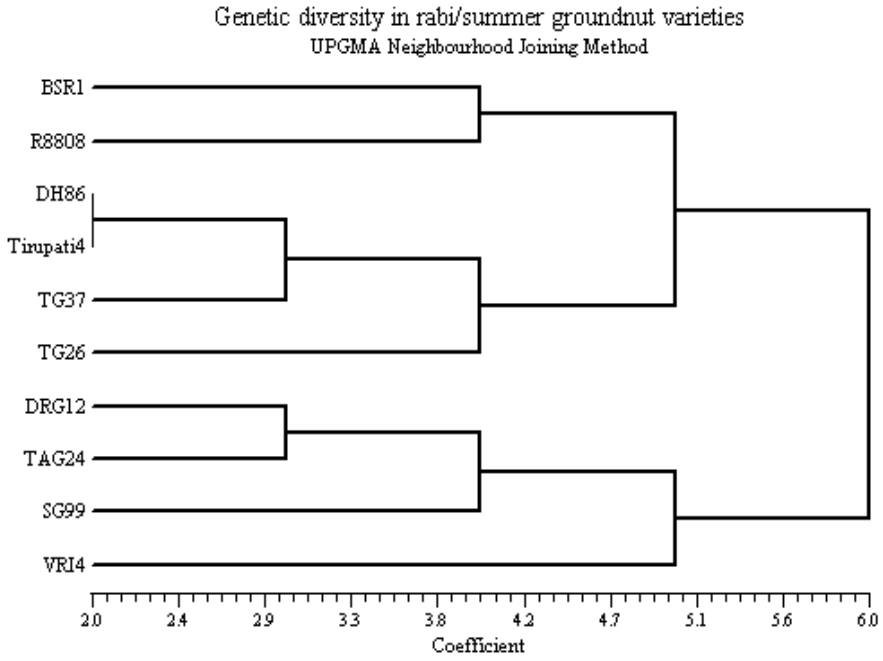
Groundnut, which was mainly grown in the rainy season (*kharif*) in India, faced a sea change from 1970-71 and is also being grown in winter (rabi) and summer in Andhra Pradesh, Tamil Nadu and Karnataka where it exhibited a higher yield potential than in *kharif*. Since then, the area under rabi and summer groundnut has increased and spread to Gujarat and Maharastra and reached up to 1.5 million ha in India as on today.

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), Tirupati 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:

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)	SG 99, TAG 24, R 8808
5	Days to maturity (100 – 105 days)	SG 99, TAG 24, R 8808

The same data was 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.



Screening of mini-core germplasm at hot spots

At hot spot centers for major pests and diseases under AICRP-G, 351 mini-core germplasm (ICRISAT and NRCG) were screened. The following germplasm were found to be promising for target pests which can be utilized in the resistant breeding programme

Centre	Hot spot for	Disease/insect pressure	Promising germplasm accessions
Kadiri	Peanut Stem Necrosis Disease (PSND)	0.12-23.14%	NCAc 515 (0.2%)
Raichur	Peanut Bud Necrosis Disease (PBND)	4.0-72.0%	NRCG 6696 (5.2%) NRCG 13129 (7.1%) NRCG 13078 (7.7%) NRCG 9238 (8.8%) NRCG 13177 (9.8%)
Junagadh	Collar rot	0.0-35.0%	NRCGs 4206, 9740, 1079, 11604, 13011, 13010, 4236, 11611, 13024, 13076, 13051

Field gene bank of wild *Arachis* species

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

PROJECT 09: BIOTECHNOLOGICAL APPROACHES TO THE CHARACTERISATION AND GENETIC ENHANCEMENT OF GROUNDNUT

(RADHAKRISHNAN T., A.L. RATHNAKUMAR, CHUNI LAL, S.K. BERA, VINOD KUMAR, HARIPRASANNA AND T.V. PRASAD)

Studies on molecular diversity and genetic transformation

Analysis of different accessions of *Arachis* duranensis for their molecular diversity and identification of duplicates.

The following accessions of A. duranensis were studied by SSR and AFLP:

Sl No	Species	Accession No.
	A. duranensis	12043
	A. duranensis	11804
	A. duranensis	12038
	A. duranensis	11802
	A. duranensis	11797
	A. duranensis	11806
	A. duranensis	11805
	A. duranensis	11792
	A. duranensis	11782
	A. duranensis	11803
	A. duranensis	11791
	A. duranensis	12025
	A. duranensis	14831
	A. duranensis	12021
	A. duranensis	11801
	A. duranensis	12045

Twenty gels with 33 primers were analysed and limited differences between some accessions were worked out. Repetition of the experiment for further confirmation and analysis of the data are in progress. AFLP of these accessions is also in progress (2 primers completed). RAPD with OPA 20 had shown distinct differences between accessions and further studies with more primers are in progress. Analysis of different accessions of *Arachis* glabrata for their molecular diversity and identification of duplicates.

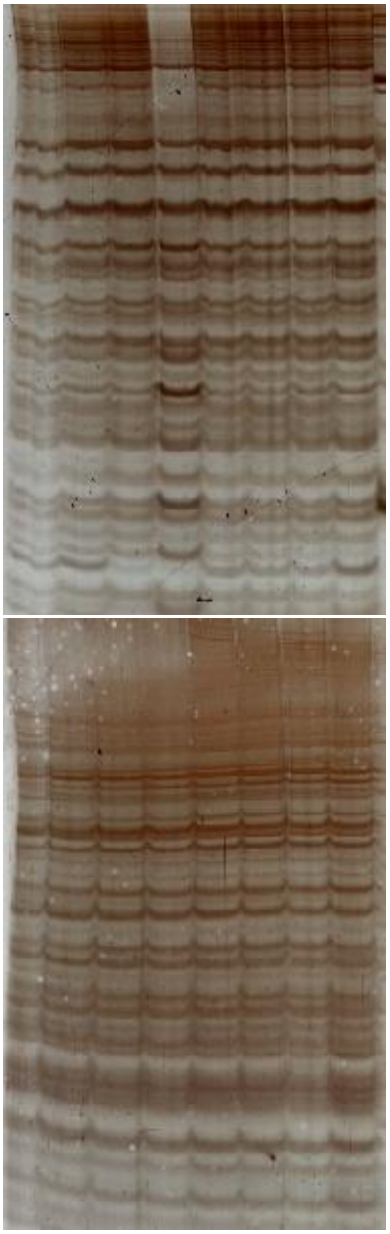
The following 23 accessions of A. glabrata were analysed using AFLP (6 primers):

NRCG	SPECIES	11838	A. glabrata	11837	A. glabrata
11826	A. glabrata	12036	A. glabrata	11833	A. glabrata
11817	A. glabrata	11831	A. glabrata	11839	A. glabrata
11841	A. glabrata	11840	A. glabrata	12033	A. glabrata
11823	A. glabrata	11818	A. glabrata	11815	A. glabrata
11832	A. glabrata	11828	A. glabrata	11821	A. glabrata
11834	A. glabrata	11824	A. glabrata	11813	A. glabrata
11830	A. glabrata	11846	A. glabrata	11835	A. glabrata

Limited amount of polymorphism was observed between these accessions. The scoring of the gels and their grouping is in progress

Analysis of foliar disease resistant parental lines for marker polymorphism

The foliar disease resistant/susceptible parents (GG 20, CS 19, GPBD 4, TG 26, Dh 8, TAG 24, ICGV 86560) were analysed using 14 AFLP and the primers tested could not reveal polymorphism in these genotypes. Hence, more SSR markers may be tested on these genotypes.



AFLP amplification using P19 and P60 primers

Characterisation of released cultivars for fingerprinting

Genomic DNA of the following cultivars were isolated and purified. The pre selective amplification was completed and selective amplification using the selected set of primers is in progress.

TPG 41	JL 220
TG 37A	CO 3
TG 26	R 8808
KADIRI 6	OG 52-1
VRI 4	BRS 1
ALR 2	TIRIPATI 4
ALR 3	GG 21
GG 5	LNG 2
GG 6	R 9251
GG 7	CSMG 884
VG 9521	HNG 10
AK 159	GG 15
DRG 1	M 522

Genotyping of the parents of the mapping population

The genotypes TAG 24, TMV2 NLM, Chico, CSMG 84-1, ICG (FDRS) 10 and JL 24 were analysed using 76 SSR primers of which 74 produced amplicons. Twenty one primers (28.4%) were polymorphic. The PM series primers were more efficient and the number of alleles ranged from 1 to 6. The study using additional primers is in progress.

Table showing the extent of polymorphism

PRIMER	Poly / Mono	No.of alleles
1 IDT	MONO.	
3 IDT	MONO.	
5 IDT	MONO.	
7 IDT	POLY.	2
9 IDT	MONO.	
11 IDT	MONO.	
13 IDT	MONO.	
15 IDT	MONO.	
17 IDT	MONO.	
19 IDT	MONO.	
21 IDT	MONO.	
23 IDT	MONO.	
25 IDT	MONO.	
27 IDT	MONO.	
29 IDT	MONO.	
31 IDT	MONO.	

33 IDT	MONO.	
35 IDT	MONO.	
37 IDT	MONO.	
39 IDT	MONO.	
41 IDT	MONO.	
43 IDT	MONO.	
45 IDT	MONO.	
47 IDT	MONO.	
49 IDT	MONO.	
51 IDT	MONO.	
53 IDT	POLY.	3
55 IDT	MONO.	
57 IDT	MONO.	
59 IDT	MONO.	
61 IDT	MONO.	
63 IDT	MONO.	
65 IDT	MONO.	
67 IDT	POLY.	2
69 IDT	MONO.	
71 IDT	MONO.	
73 IDT	MONO.	
75 IDT	MONO.	1
77IDT	MONO.	
79 IDT	MONO.	
81 IDT	MONO.	
83 IDT	MONO.	
85 IDT	MONO.	
87 IDT	MONO.	
89 IDT	POLY.	3
97 IDT	POLY.	2
99 IDT	MONO.	1
93 IDT	POLY.	3
95 IDT	MONO.	1
105 IDT	MONO.	1
113 IDT	POLY.	3
121 IDT	POLY.	2
127 IDT	POLY.	2
137 IDT	MONO.	
141 IDT	POLY.	2
143 IDT	MONO.	
1 PM 3	POLY.	3
3 PM 15	MONO.	
5 PM 32	NR.	
7 PM 35	MONO.	
9 PM 36	POLY.	3
11 PM 42	POLY.	3
13 PM 45	POLY.	2
15 PM 50	POLY.	3
17 PM 53	NR	
19 PM 65	POLY.	2
21 PM 137	POLY.	3
23 PM 145	MONO.	1
25 PM 183	MONO.	
27 PM 188	POLY.	2
29 PM 200	MONO.	
31 PM 201	POLY.	2
33 PM 204	POLY.	3
35 PM 210	MONO.	
37 PM 238	POLY.	6

Genetic transformation

In genetic transformation using the gene Cry F, 339 multiple shoots were induced after co-culture and 115 were transferred to rooting medium with selection pressure and 4 shoots produced roots. The putative transgenics already produced by using the gene constructs cry 1 F and the coat protein genes of PSNV have been tested using the dipstick. Of the 150 plants tested for confirmation no positive could be identified. More than 360 plans are in culture and DNA from 50 plants were isolated for PCR confirmation

Defensin Gene construct

A gene construct with the defensin gene was obtained from the University of Hyderabad. Transformation work using this gene construct has already been initiated using this gene. A total of 1255 multiple shoots were regenerated after co-cultivation and 530 shoots were transferred for rooting under selection pressure. Of these 25 shoots produced shoots and the selected plants are now being confirmed by molecular methods.

PROJECT 10: ASSESSMENT AND ENHANCEMENT OF QUALITY IN GROUNDNUT AND ITS VALUE ADDED PRODUCTS

(J. B. MISRA, DEVIDAYAL AND R.S. JAT)

Sub-project 1: Assessment of quality in germplasm collection, breeding material and produce of other experiments (subproject leader: J.B. Misra)

Development of protocols for studying blanching qualities of groundnut varieties

Experiments conducted with four genotypes (*kharif* 2005 produce) viz. G 11, M 13, BAU 13 and B 95, revealed that increasing oven drying temperature from 110°C to 150°C or time from 10 minutes to 30 minutes resulted in an increase in extent of blanching. At high temperatures, however, discoloration of kernels was observed. The genotypes differed in their extent of blanching. The differences, however, were most conspicuous when the oven drying was done at 110°C or 120°C for 10 minutes. At high temperatures or longer durations the differences tended to narrow down and even disappear as the blanching in all genotypes approached completion (100%).

Chemical composition of groundnut cultivars:

Parameter	Oil (%)	Protein (%)
No. of cultivars	54	71
Minimum	41.3 (DRG 12)	16.7 (R M 335)
Maximum	51.9 (ICGV 86031)	30.7 (SG 84)
Mean	47.7	22.8

Kernel samples of groundnut cultivars grown in *kharif* ’06 were analyzed for their oil and protein contents. The values for range and mean are given in the above table. The cultivars DRG 12 and TMV 2 and were identified as low oil (42% or less) varieties while the varieties SG 84 and TKG 19A were identified as the high protein (28% or more) cultivars. Tirupati 2 was identified as a low oil (43.8%) and high protein (27.8%) cultivar.

Evaluation of core germplasm collection for quality attributes:

Kernel samples of the core germplasm collection comprising 126 genotypes, was analyzed for its oil and protein contents. The oil content was in the range of 40.6 to 50.8% with a mean of 45.4% while the protein content was in the range of 18.2 to 29.8% with a mean of 25.1%. The frequency distribution curves for oil and protein contents indicated a normal distribution about the mean for both the parameters. The correlation coefficient between the values of oil and protein content was − 0.209.

Vitamin C content of groundnut kernels:

Preliminary investigation indicated the kernels of freshly harvested pods do contain small amounts (1-3 mg/100g) of vitamin C. During pod filling, the developing kernels however,

contain appreciable amounts of vitamin C, which gradually decreases with increasing maturity of pods.

Allergen content of groundnut varieties:

Using ELISA technique, the allergen content of 19 released varieties was determined. The kernels of cultivars differed in their allergen content under assay conditions in the range of 0.931 to 1.586 in terms of OD450. Kernels samples of cultivars GAUG 10, JL 24, Jawan, GG 5 were found to contain low allergen levels while those of cultivars GG 20, TG 26, GG 7 B 95 and M 13 were having high levels.

Service rendered to other sections: The particulars of the service rendered are tabulated below:

Name of section	**Number of samples**		
	Oil	**Nitrogen**	**Fatty acid**
Plant Breeding	504		
Agronomy	227		
Plant Physiology	309		
Soil science	067	145	058
Entomology	057	042	
Cytogenetics	020		
AICRIP's Centres	394		
Total	1578	187	58

Sub-project 2: Studies on organic farming of groundnut (subproject leader: Devi Dayal; associates: R.S. Jat, K.K. Pal and J.B. Misra)

A field experiment was conducted in summer-2007 with groundnut and sesame crops to assess the effect of different components of organic farming. Seven different combinations of organic and inorganic treatments were applied as given below:

T-1	FYM (15 t)
T-2	FYM (15 t) + biofertilizers
T-3	FYM (15 t) + biofertilizers + biopesticides
T-4	FYM (50%) + RDF (50%)
T-5	RDF (100%)
T-6	Control (no application)
T-7	FYM (15t) + biofertilizers + biopesticides + gypsum + rock phosphate

The results for groundnut crop indicated that highest haulm yield, pod yield and harvest index were obtained with T7 (FYM 15 t/ha + biofertilizers + biopesticide + gypsum + RP) followed by T4 (50 % FYM + 50 % RDF).However, thenumber of mature pods per plant was highest in T4. In sesame, the highest straw yield, grain yield and harvest index were obtained in T4 (50 % FYM + 50 % RDF) followed by T2 (FYM 15 t/ha + biofertilizers) but the number of capsules per plant were highest with T7.

PROJECT 11: BIOTRANSFORMATION OF GROUNDNUT BYPRODUCTS INTO USEFUL PRODUCTS

(R. DEY, K. K. PAL AND J. B. MISRA)

Shelf life of amylase enzyme

Studies on shelf life of amylase extracted from Bacillus amyloliquefaciens indicated that when stored at 4oC, about 50% activity was lost after a period of two months.

Isolation of lipolytic microorganisms

Isolation of lipolytic microorganisms was done from soil and naturally decomposing oil cakes of groundnut by enrichment techniques. A total of seven bacterial and two lipolytic fungal isolates were obtained in CeNAN tributyrin base agar plate. Five out of the seven bacterial isolates were bacilli and two were pseudomonads.

Evaluation of protease production potential of some proteolytic fungi on de-oiled groundnut cake

The protease production potential of *Aspergillus nidulans* MTCC 831, *Beauveria bassiana* 1186, *Rhizopus microsporus* var. oligosporus MTCC 556 and *Aspergillus awamori* MTCC 548 was studied on de-oiled groundnut cake. Screening of these fungi on Skimmed Milk Agar plates (SMA) showed that the hydrolysis zone of casein varied from 45 mm to 83 mm after 72 hours of incubation, the maximum hydrolysis zone being produced by *Rhizopus microsporus* var. oligosporus MTCC 556. Solid substrate fermentation of de-oiled groundnut cake was carried out to study the protease production potential of the fungal cultures. It was observed that different types of proteases (acid, neutral and alkaline) were produced by different fungi.

Based on the activity, *Aspergillus nidulans* MTCC 831 was selected and purified enzyme obtained from de-oiled groundnut cake using this fungal culture was studied in details. The activity of the neutral protease gradually increased from 25oC (Figure 1) and reached a maximum at 50 °C (280.26 IU/mg protein). The neutral proteases showed maximum activity at pH 7 at which it showed enzymatic activity of 282.14 IU/mg of protein (Figure 2).

Effect of cations

The effect of cations on neutral protease produced from de-oiled groundnut cake by utilizing A. nidulans MTCC 831 was studied. The cations were Ca2+, Mg2+, Al3+, Co2+, Fe3+, Cu2+, Hg2+, Mn2+ and Na+. In majority of the cases, with the exception of Na and Cu, the activity of the purified neutral protease started declining beyond 2.5 mM concentration. In case of Hg, the activity reduced drastically at 2.5 mM. Cu was found to enhance the activity of the neutral protease significantly. Nearly four time's increase of the activity was noticed with the addition of 2.5 mM of CuCl2 in the buffer (Figure 3). The activity remained stable up to 12.5 mM and thereafter it started reducing though not below what was obtained without the addition of Cu ion. Addition of Cu at 50 mM drastically reduced the activity and after that enzyme was denatured. Addition of NaCl in the buffering system also improved the activity

of neutral protease and an increase in activity was noticed up to 900 mM of NaCl (Table 1). However, the enzyme remained active up to 2.6 M. This indicated the level of salt that can be tolerated by the enzyme.

Stability of purified protease

The stability of the enzyme was studied at 50oC for a duration at which the enzyme remained active without losing its activity. Results revealed that at 50ºC the activity of neutral protease was stable up to 300 minutes (Figure 4) and the activity decreased thereafter.

Shelf life of enzyme

Purified protease obtained from de-oiled groundnut cake by solid-state fermentation employing *Aspergillus nidulans* MTCC 831 was evaluated for shelf life at 7 days interval up to 91 days, after harvest of the enzyme (Figure 5). The results indicated that the enzyme was stable and maintained its activity of about 280 IU/mg protein through out the study period.

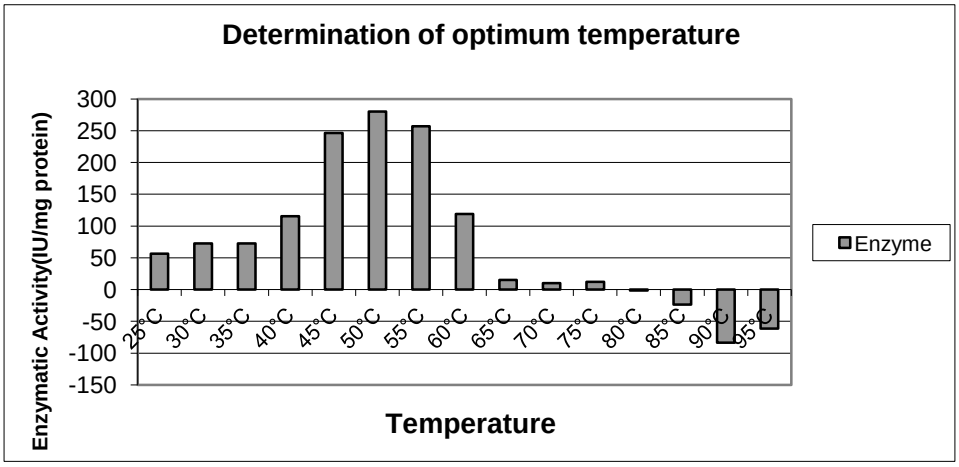


Fig 1. Determination of optimum temperature for maximum activity of purified neutral protease obtained from *Aspergillus nidulans* MTCC 831

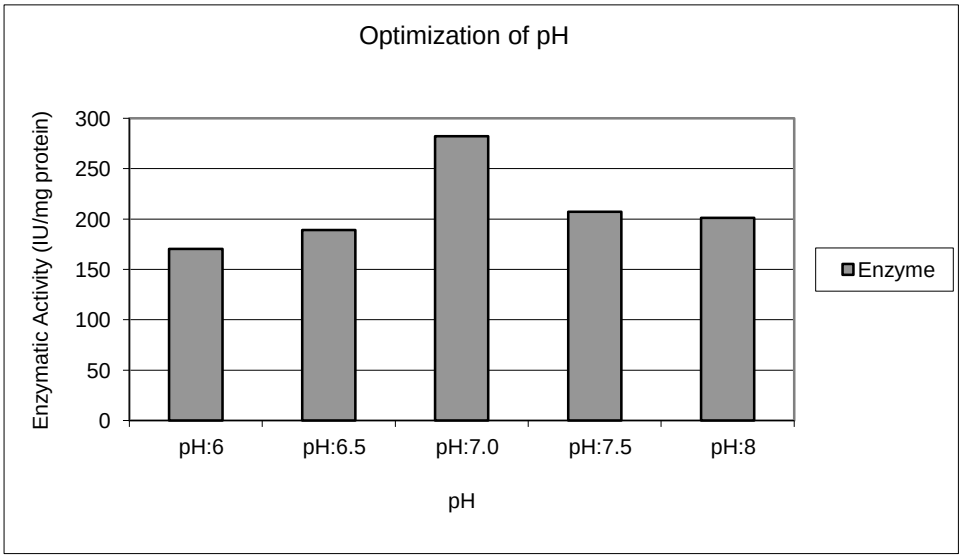


Fig 2. Determination of optimum pH for maximum activity of purified neutral protease from *Aspergillus nidulans* MTCC 831

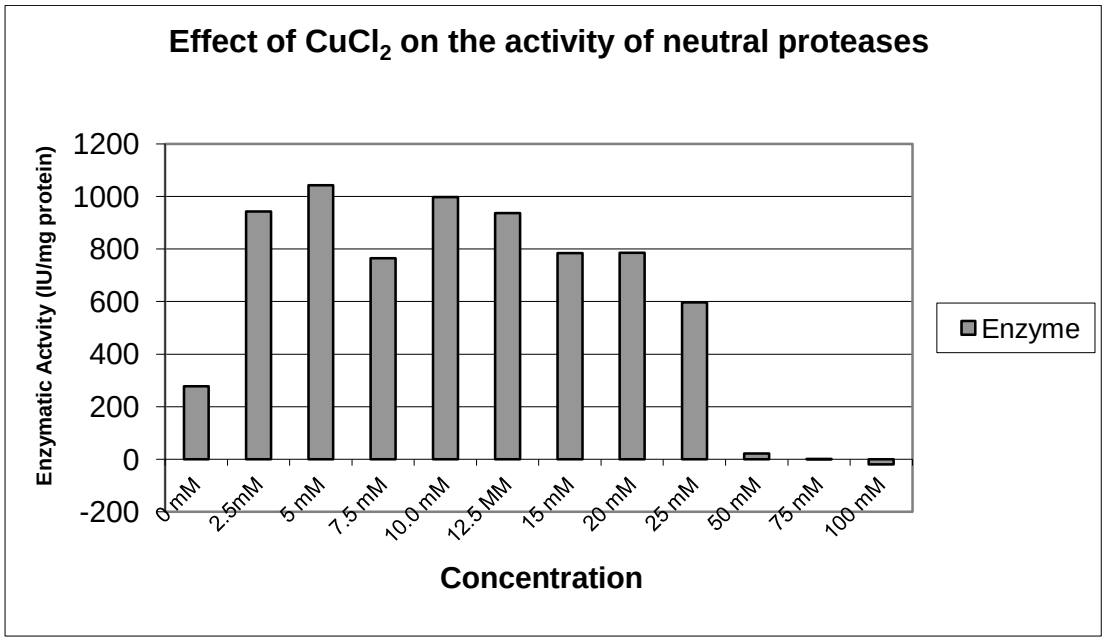


Fig 3. Effect of $CuCl_2$ on the activity of neutral proteases obtained from *Aspergillus nidulans* MTCC 831 at pH:7.0 and 50 °C

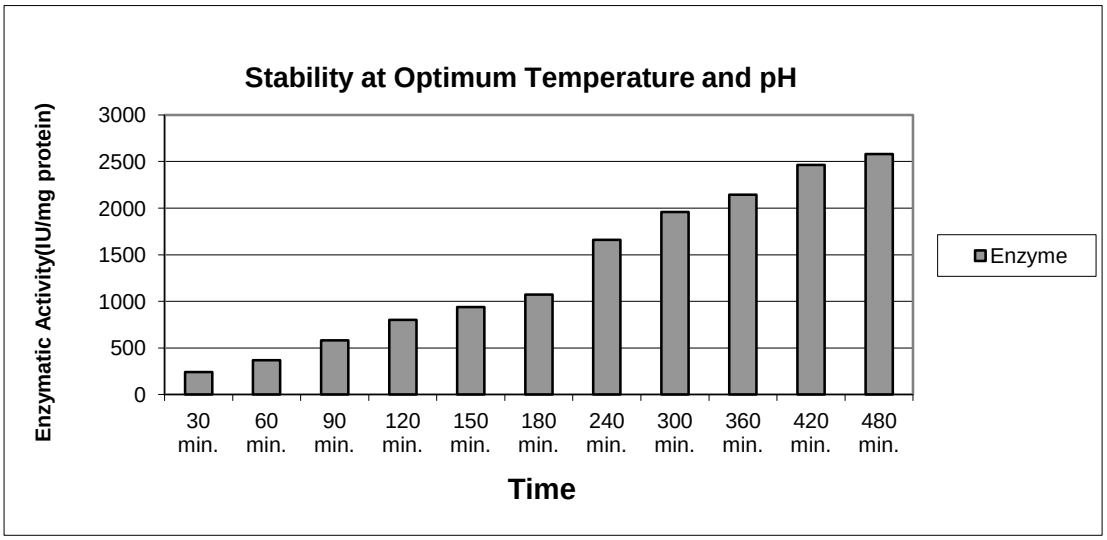


Fig 4. Thermostability of purified neutral protease obtained from *Aspergillus nidulans* MTCC 831

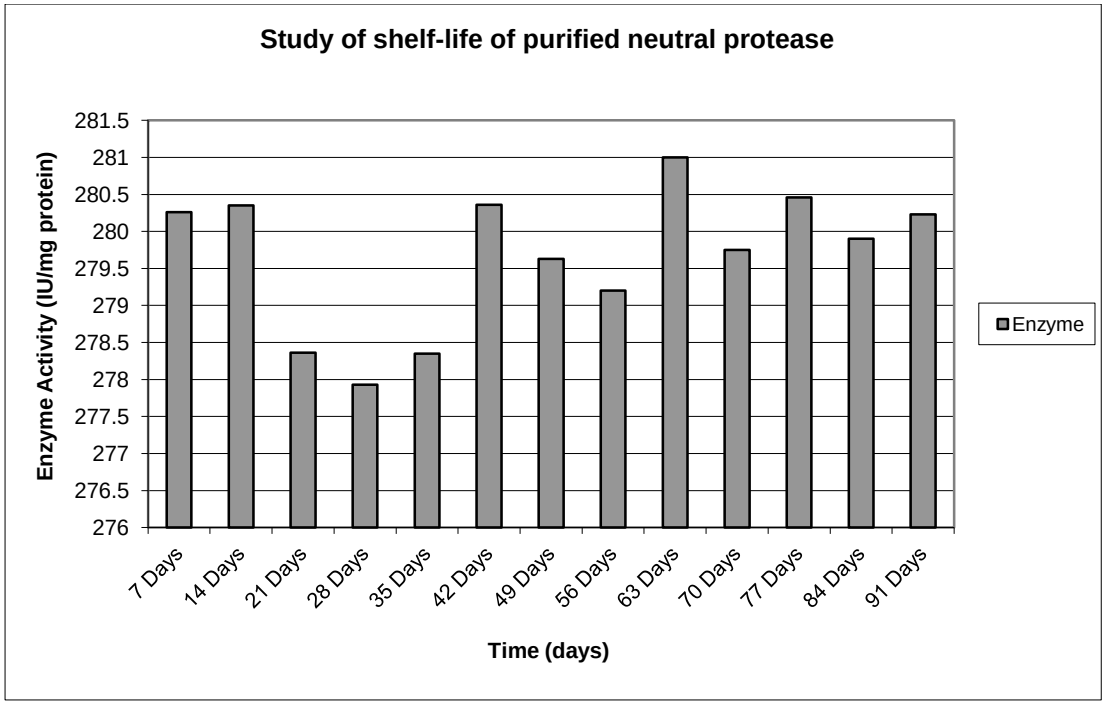


Fig 5. Studying the shelf-life of purified neutral protease obtained from *Aspergillus nidulans* MTCC 831

Table 1. Effect of NaCl on the activity of neutral protease obtained and purified from *Aspergillus nidulans* MTCC 831 at pH7.0 and 50 °C

NaCl concentration (mM)	Activity (IU/mg protein)	NaCl concentration (mM)	Activity (IU/mg protein)
100	183.43	525.0	251.78
102.5	188.25	550.0	251.33
105.0	180.18	575.0	251.56
107.5	192.31	600.0	233.39
110.0	189.12	700.0	181.65
112.5	184.45	800.0	175.23
115.0	195.69	900.0	160.70
120.0	220.09	1000.0	150.42
125.0	217.34	1100.0	131.49
150.0	225.48	1200.0	136.70
175.0	221.80	1300.0	120.12
200.0	231.09	1400.0	111.79
225.0	210.40	1500.0	104.23
250.0	209.11	1600.0	63.75
275.0	213.12	1700.0	97.54
300.0	199.43	1800.0	106.01
325.0	200.38	1900.0	90.50
350.0	262.92	2000.0	72.98

375.0	186.17	2100.0	85.27
400.0	184.35	2200.0	91.40
425.0	252.13	2300.0	82.09
450.0	260.97	2400.0	103.11
475.0	270.04	2500.0	79.68
500.0	258.04	2600.0	50.47

PROJECT 12: PREVENTION AND MANAGEMENT OF MYCOTOXIN CONTAMINATION IN GROUNDNUT

(VINOD KUMAR)

Evaluation of released cultivars and advanced breeding lines for resistance to aflatoxin contamination

A total of fifty-nine advanced breeding lines of NRCG and the cultivars showing promising testa level resistance against *A. flavus* in laboratory conditions, including susceptible (GG 20) and resistant check (J 11) were evaluated in augmented block design in sick plot under artificially inoculated conditions for resistance to *A. flavus* infection during 2007. The soil was inoculated thrice with the most virulent isolate of *A. flavus*, AF 111 at sowing, flowering and at 90 days of crop growth. Observation was recorded on incidence of aflaroot. The pod samples were taken and analysed for seed infection of *A. flavus* and levels of aflatoxin contamination. The population of *A. flavus* was monitored in the sick plots. The minimum and maximum population of *A. flavus* at sowing was 9.67 x 103 and 18.00 x 103 cfu/g soil respectively. At pod development stages the minimum and maximum population of *A. flavus* were 20-25.33 x 103 and 32-34.00 x 103 cfu/g soil, respectively. The seed infection level varied between 10-14.5%. The extent of aflatoxin contamination ranged from 0.12-297.41 µg kg^{-1}. Thirteen genotypes viz. NRCG CS 44, 70, 80, 74 78 and 129; TAG 24, ICGS 86309, Karad 4-11, ICGS 1, PBS 29077, TAG 41, and ICGS 86326 showed promising resistance to *A. flavus* infection in *kharif* 2007.

A close perusal of the data on screening of genotypes for tolerance/resistance against *A. flavus* infection in augmented block design under artificially inoculated sick plot conditions from 2005 to 2007 revealed that twenty genotypes viz. ALR 2, B 95, BAU 13, ICGS 1, K 134, NRCG CS nos.'- 36, 38, 41, 47, 69, 76, 77, 215, 272, 273, 312, 350 and RHRG 12, TAG 24, and TAG 26 showed low to moderate level of resistance to *A. flavus* infection and subsequent aflatoxin contamination over the years

Effect of long-term crop rotation and cropping system on soil population of *Aspergillus flavus* and pre-harvest aflatoxin contamination

Effect of cropping system

This experiment was initiated during summer 2007. The soil and pod samples were taken from the ongoing long-term trial of Agronomy Section on cropping system. Five different groundnut based cropping systems viz., Groundnut-Groundnut, Groundnut-Wheat, Groundnut-Wheat-Green gram, Groundnut-Pigeon pea and Groundnut-Pearl millet, with different combination of recommended dosages of fertilizers and the FYM was being studied. The results so far revealed that the population levels were higher in *kharif* than in summer. The population levels were significantly lower in pearl millet intercropping system both during *kharif* 2007 and summer 2008. Some kind of association/affinity was apparent with regard to soil population of *A. flavus* and the type of crops grown in the field. For example, during summer when soil sample was taken at the same time from wheat and groundnut plots, groundnut plots recorded significantly higher population of *A. flavus* than wheat. The seed infection and colonization were 0.0-5.53 % and 5.57-21.13%, respectively during *kharif*

2007, and 26.65-26.67% and 8.8-14.33%, respectively during summer 2008. No significant differences were observed among the treatments with regard to seed infection and colonization by *A. flavus* during *kharif* 2007 and summer 2008. The level of aflatoxin contamination in pods was found low during summer 2008 (<3 µg kg-1).

Effect of long-term crop rotation

A long-term experiment on groundnut-garlic and groundnut-onion rotation to see the effect on population of *A. flavus* and aflatoxin contamination was initiated in *kharif* 2005. The soil population count of *A. flavus* was estimated in the samples taken just after sowing and two weeks before harvest (pod development stage). The experiment was laid out in a factorial randomised block design with two cultivars, one susceptible (GG 2) and another resistant cultivar (J 11) in main plot and four rotations in subplots viz. Groundnut-Garlic-Groundnut, Groundnut-Onion-Groundnut, Groundnut-Groundnut, and Groundnut-Fallow-Groundnut. The plot size was 6.3 x 8 m^2 and the number of replication was three. At harvest, pods were collected randomly from three spots in each plot. Seed infection and colonization by *A. flavus* was recorded after seed plating onto moistened filter paper in sterilized 9 cm diameter Petri dishes were incubated at 28±1 °C for 7 days. The level of aflatoxin contamination in kernel was assayed through indirect competitive ELISA.

The results showed that both the garlic and onion crop rotation had reduced the soil population of *A. flavus* and aflatoxin contamination level significantly in the subsequent groundnut crops in *kharif* 2007. Population in summer was significantly lower than the *kharif* in all the years. During summer 2008 population varied from 2.23 to 8.34x103 cfu/g soils. The lowest population was 2.81x103 and 2.23x103 cfu/g soil observed in the plots where groundnut-garlic and groundnut-onion rotation was followed as against the highest population 8.34x103 cfu/g in groundnut-groundnut rotation.

Characterization of isolates of *Aspergillus flavus*

Characterization of isolates for aflatoxigenicity

Among 417 isolates of *A. flavus* accessioned in the 'Repository of Isolates of *Aspergillus* at NRCG', 116 isolates were non-aflatoxigenic, 223 isolates were weakly toxigenic, 39 isolates each were moderately and highly toxigenic constituting 27.8%, 53.4%, 9.35% and 9.35%, respectively of the total isolates. Among the six different morphological groups identified earlier, Group A of *A. flavus* contained maximum number of toxigenic isolates.

Sclerotial production vis-à-vis toxigenicity of isolates of *A. flavus*

All the 327 isolates of *Aspergillus flavus* at NRCG Accession were characterized for sclerotia producing ability vis-à-vis toxigenicity. The plates were inoculated for growth and sporulation for 15 days at room temperature. The isolates were categorized for the production of sclerotia as well as sclerotial number and size. Sclerotial size was measured with the help of ocular and stage micrometer. Ten sclerotia of each isolate were measured. The isolates produced sclerotia of varying size ranging from 697 to 1549 µm (Table 2). The isolates were classified into sclerotia producers and non-sclerotia producers. Among the sclerotia producers, based on the abundance of sclerotia produced, was scored visually into poor,

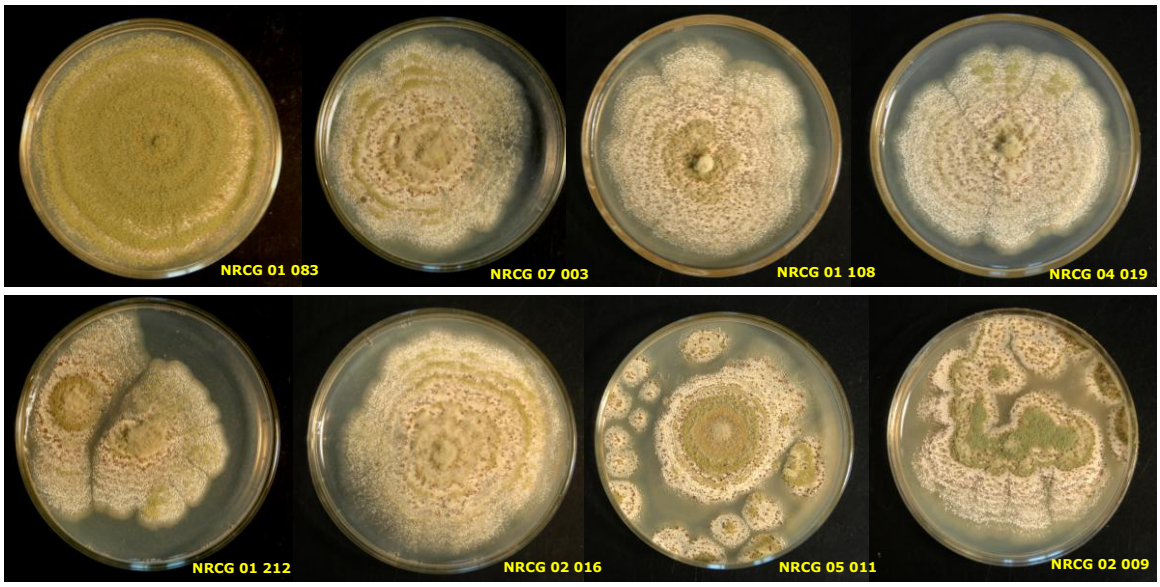
moderate and high categories. Fifty-four isolates produced abundant sclerotia (more than 50 sclerotia/plate) while under moderate, low and non-sclerotial types were 47, 69 and 157, respectively (Table 1). A positive correlation was found between sclerotial production and the aflatoxigenicity of the isolates.

Table 1. Variation in production of sclerotia among different isolates of *Aspergillus flavus*

Number of Sclerotia	Group	Grade	No of isolates
0	Absent	-	157
1-20	Poor	+	69
20-50	Moderate	++	47
Above 50	High	+++	54

Table 2. Variation in size of sclerotia among different isolates of *Aspergillus flavus*

Group	Size	No. of Isolates
Large	1000 to 1500 µm	24
Medium	850 to 1000 µm	39
Small	587 to 839µm	97



Variation in size and number of sclerotia produced in different isolates of *Aspergillus flavus*

Studies on pre-harvest antagonists

Thermo-tolerance studies of the isolates of *Trichoderma spp.*

The thermo-tolerance of the 41 new isolates of *Trichoderma spp*. was studied under in-vitro conditions. The results revealed that majority of the isolates could grow well in the range of 25-30 ºC, however, the four isolates viz. NRCG T 07, 11, 14 and 29 could grow well even at 35-37 ºC.

Field studies with organic carrier enriched with isolates of *Trichoderma spp.*

Field studies were conducted with the isolates of *Trichoderma*, which were found highly antagonistic under in-vitro assay. For this, three carriers viz. powdered castor (*Ricinus communis*) cake, neem (*Azadirachta indica*) cake and FYM were inoculated with combinations of four isolates namely, NRCG T12, NRCG T16, NRCG T32 and NRCG T34 multiplied in sorghum grain medium @2.5 kg in 50 kg organic carrier. After mixing, it was kept in shade for about ten days before applying to the soil in furrow. The results revealed that either neem or castor cake enriched with the isolate NRCG T12 effectively reduced *A. flavus* population and aflatoxin contamination.

Evaluation of different drying and storage conditions for reducing post harvest aflatoxin contamination

Summer produce of cultivar GG 2 was dried by different methods and stored under different conditions. Drying techniques were windrow drying (W, sun-dried in the field), windrow shade drying (WS, pods in one windrow covered by haulms of plants from adjacent windrows), inverted windrow drying in small heaps (WI), NRCG Method of drying (on bamboo tripod), and conventional drying (Farmers' Method).

After field drying for five days, the pods were brought to laboratory and were stored in polyethylene bags and ordinary gunny bag with or without desiccants (CaCl2, 10 g kg-1 pods) and were stored for six months. In each treatment, 10 kg pods was stored. Initial moisture was estimated prior to pod storage. Seed infection and aflatoxin contamination were recorded at an interval of one month. The temperature and humidity were recorded at the time of harvesting, threshing (stripping of pods, on 5th day), at the time of storage and at an interval of one month before each sampling. At the interval of one month 200 pods was taken out from each treatment and observations were recorded for percentage kernels infection by *A. flavus* and aflatoxin B1.

The results revealed that lowest infestation of bruchids (*C. serratus*) in pod (1%) and kernel (0%) was in the windrow method of drying, stored in polyethylene bags with $CaCl_2$ as against the highest 17 and 28%, respectively. However, lowest seed infection and colonization of *A. flavus* was found in windrow shade method of drying coupled with storage of pods in polythene bags with $CaCl_2$.

Figure: Different methods of drying

Effect of botanicals and bio-control agents on post-harvest aflatoxin contamination

For this study, pods of two cultivars *viz*. GG 2 and GG 20 were stored in the month of June after harvesting of summer crop, sun dried on terrace for 5 days and then used for storage in ordinary gunny bags/farmers' method. Ten kg pods of these varieties were stored for each. The treatments were: fresh (shade dried) leaves of Neem (*Azadirachta indica*), Custard apple (*Annona squamosa*), Karanj (*Pongamia pinnata*), milkweed (*Calotropis procera*), and *Bacillus thuringiensis* (commercial formulation) along with control. At intervals of one month 200 pods were taken out from each treatment and observations were recorded on percent pod and kernel infection by storage pests, *Caryedon serratus*, percent kernels infection by *A. flavus*, and AFB1 content.

For every 10 kg groundnut pods, half a kg shade dried leaves were applied. Shade dried leaves of each botanical were hand crushed and the coarse powdered leaves were thoroughly mixed with 10 kg of groundnut pods and stored in sterile cotton bags. Thirty gram of commercial formulation of *Bacillus thuringiensis* was used for 10 kg pods mixed thoroughly.

The results revealed that after six months of storage the lowest pod and kernels infestation by *C. serratus* was in the treatment of neem and *Annona squamosa* leaves. The highest pod and kernels infestation of *C. serratus* was in control (29 and 35%) followed by in *Calotropis procera* (22 and 14% respectively). The kernels infection by *A. flavus* was zero percent in neem leaves and custard apple leaves. The highest percent infection by *A. flavus* was in *Calotropis procera* (0.66%). The lowest AFB1 content was 4.38 ppb in *Azadirachta*

indica and highest AFB1 content was 12.390 ppb in *Calotropis procera*. In control, AFB1 content was 31.26 ppb.

Effect of different storage methods on storage pest infestation and aflatoxin contamination

This study was initiated during summer 2007. The pods of the cultivar GG 2 were taken from summer groundnut trials: one from field inoculated with *A. flavus* and other from un-inoculated plot. Just after harvesting, pods were sun dried on terrace for a week and then was used for storage studies experiment as per the treatment details. In each storage structure of 20 kg capacity, 15 kg pods were filled. The treatments were 1. Bamboo basket with layer of cowdung and yellow soil+ inoculated pods, 2. Bamboo basket with layer of cowdung and yellow soil + uninoculated pods, 3. Bamboo basket + inoculated pods, 4. Bamboo basket + uninoculated pods, 5. Fertilizer bag + inoculated pods, 6. Fertilizer bag + uninoculated pods, 7. Polyethylene bag (100 microns) + inoculated pods, 8. Cotton cloth bag + uninoculated pods, 9. Ordinary Gunny bag + inoculated pods, 10. Ordinary Gunny bag + uninoculated pods, 11. Air tight Metallic bins + inoculated pods, and 12. Air tight metallic bins + uninoculated pods.

At intervals of one month 200 pods were taken out from each treatment and observations were recorded on percent pod and kernel infection by storage pests Caryedon serratus, percentage kernels infection by *A. flavus*, and AFB1. The results revealed that after six months of storage the lowest pod and kernels infestation by *C. serratus* (5%) was in fertilizer bag and the highest pod and kernels infestation by *C. serratus* was in bamboo basket storage (49%). The highest per cent infection (7%) by *A. flavus* was in gunny bag and lowest in polythene lined fertilizer bags. The aflatoxin contamination level was highest (35.47 ppb) in the airtight metallic bins. Significant differences were observed among treatments with regard to aflatoxin contamination. Based on the data, it was concluded that the polythene lined fertilizer bags are efficient in maintaining low levels of aflatoxin content in stored pods provided initial moisture level had been brought to less than 10%.

PROJECT 13 : SOCIO-ECONOMIC STUDIES OF FARMERS DEPENDENT ON GROUNDNUT BASED LIVELIHOOD SYSTEMS

(G. D. SATISH KUMAR)

Socio-economic status (SES)

The results of the survey showed that the average age of farmers was 43 years and the average direct experience with the groundnut crop was 18 years. The farmers had enough functional literacy. Majority of the sampled farmers possessed reading and writing skills (52%), 13% of the farmers were educated up to primary school, 4% up to high school and 2% of the farmers were educated beyond high school. Sixty percent of the surveyed farmers were maintaining joint family system with up to five members in the family. The farmer had well built *pacca* houses; almost 83% possessed the *pacca* residential houses. The mode of conveyance possessed by the majority of the farmers was motorcycle and bicycle. The farmers possessed the household items such as TV (83%), refrigerator (48%), mobile (26%), landline telephone (61%) and flourmills (96%).

This indicated that the socio-economic status of the farmers of this region was quite good compared to the farmers of other parts of the country. Significant differences were not observed between the villages with respect to the socio-economic status of farmers.

Cropping System

The average farm holding was 4 ha. More than 85% of total cultivated area was grown as mono crop under rainfed conditions and double cropping of groundnut-wheat, groundnut-Onion, groundnut-cumin and pearl millet-summer groundnut was also observed. Intercropping with castor, pigeon pea, sesame and pearl millet was practiced. In mono cropping of groundnut, farmers grow groundnut year after year in same field. In irrigated areas groundnut-wheat or groundnut-fallow-groundnut (summer) is common rotation.

Farmers were growing GG 2, GG 20, GAUG 10, TG 37A and local varieties such as Samudri, Shedubar, Tata Sumo, Punjab 1, etc., of groundnut, BDN 2 of pigeon pea, GCH 4, 5 of castor, Gujarat Til 1 of sesame and MH 167 of pearl millet. The sources of irrigation were mainly wells (80%) and river (for 10% of farmers).

Farm mechanization Index

The farmers of the region possessed the necessary farm implements for groundnut cultivation. Only 4% of sampled farmers possessed the farm tractors, 63% farmers possessed electric/oil engines for pumping water from the wells, 83% of the farmers possessed groundnut threshers, 87% had the required plant protection equipment such as sprayer. The farmers possessed bullock carts, seed drills (hand operated and mechanical), ploughs, hoes, harrow and multi-purpose iron tool bars. The farm mechanization index indicated that the farmers had sufficient mechanization on their farms and the threshers & seed drills were very popular.

Social participation and Extension participation

The social participation data indicated that 22% of the respondents were associated with cooperative societies as members and participated in its activities regularly. Another 39% were associated with non-government organization such as BKS and participated in its activities regularly.

The data on extension participation indicated that less no. of farmers participated in extension meetings, discussions with extension workers, and observed the demonstration plots of neighbouring farmers. Sixty five percent of the sampled farmers had participated in Krishi melas and visited agricultural exhibitions, 65% of the farmers had even read extension publication/literature in local language, 87% of the farmers had either viewed TV programme/listened to radio for agricultural programmes. These results indicated that the farmers had medium social participation and low extension participation. The farmers were using the print media such as extension publications and mass media sources such as Radio and TV programmes for enriching their knowledge on agriculture related aspects.

Adoption of improved management practices and the adoption gaps
Adoption of improved management practices

Variety & agronomic practices

The package of practices which were important for realizing higher yields of groundnut were identified and farmers were asked whether they adopted it or not. The results indicated that 35% of the sampled farmers had sent their soil samples for soil testing, but only 11% of the farmers were following the soil test based fertilizer application in groundnut. Farmers used cultivator four times for soil preparation and 20% of the farmers practiced deep ploughing during summer season. The farmers (21%) had heard of new varieties of groundnut such as GG 5, GG 7.

Almost all the farmers were adopting seed treatment with chemical such as Carbendazim, DM 45 and Thiram. Farmers were not aware of the beneficial effects of application of *Rhizobium*. The farmers were using higher seed rate of even 170 kg/ha for sowing GG 20 variety mainly to withstand the germination problem. On an average 145 kg/ha seed was used. The spacing adopted by farmers ranged from 45-90 cm between rows and 10-30 cm between the plants. Majority of the farmers were using 90x10 spacing in groundnut. The sowing method ranged from manual sowing behind the plough, manually operated seed drill to mechanically operated seed drill. Majority of the farmers used manually operated seed drill for sowing. The spacing was regulated between the rows by these seed drills. Some of the farmers were practicing gap filling mainly with fodder crops such as maize and pulses (black gram and green gram, sometimes red gram). The idea behind this was to divert the pests and diseases and also to get some fodder for the livestock and dal for the household purpose.

More than half of the sampled farmers adopted the application of organic manures such as FYM during soil preparation. The average dosage was 1.5 t/ha every 2/3 years. Almost all the farmers were adopting the fertilizer application in groundnut. Most of the farmers were applying only DAP at higher doses during sowing. Majority of the farmers did not adopt the split application of fertilizer. Forty per cent of farmers reported one or the other kind of micronutrient deficiency in groundnut, but only 6.5% of them adopted control

measures such as application of biozyme and gypsum. Majority of the farmers had not adopted any control measure. Twenty per cent of farmers had reported yellowing in groundnut and the reasons perceived by farmers for this were heavy rainfall coupled with lack of proper drainage on their fields and Fe-S deficiency. The farmers were not adopting any control measure.

The farmers normally started their intercultural operations 15 days after sowing and continued till 50 days after sowing, for 2-7 times and these operations ended with peg formation. Almost 50% of the farmers possessed knowledge on the benefits of weedicides and they were adopting the same. Pendimethalin/STOMP was the most popular weedicide followed by basaline. Only 10% of the farmers were applying gypsum procured from GSFC @1-2t/ha at the time of land preparation. Some of the farmers were using the sprinkler system for irrigation, mainly to optimise the use of available water resources.

Plant protection

The important insect-pests causing damage to groundnut as observed by the farmers were sucking pests such as aphids, jassids & thrips, helicoverpa, termites, white fly and white grubs. The farmers adopted chemical control methods; spraying of insecticides such as Quinolphos, Endosulphan, Imidachlorpicrin, Monocrotophos, Acephate, Chlorpyriphos and Phosphomidone. The important diseases reported by the farmers were stem rot and collar rot, root rot, rust and leaf spots. The incidence of stem rot was up to 50% in some cases with GG 20 variety. The farmers opined that they needed a variety like GG 20 in terms of yield and should be resistant to stem rot and collar rot. The farmers adopted the control measures such as seed treatment, spraying of chlorothalanil and soil application of *Trichoderma* and castor cake.

Harvest and post-harvest management

Majority of the sampled farmers possessed the knowledge on the right time of harvesting and rightly specified the indications for harvesting the crop. Farmers practiced the sun drying in open fields and threshing was done by mechanical thresher of their own or hired. All the farmers practiced the collection of left over pods after harvesting the crop. It was observed that majority of the farmers mixed the left over pods with the main lot and only 10% of farmers kept the left over pods separately from the main lot. Majority of the farmers had no awareness of aflatoxin contamination in groundnut and only 4% of the farmers have little awareness of aflatoxin contamination. The farmers generally did not adopt any control measure for the aflatoxin management. It was observed that only 10% of the sampled farmers were adopting the practice of grading their produce mainly based on location of the plot.

The groundnuts were stored for 2-4 months in the form of pod, till the farmers realized better market prices. The pods were stored in gunny bags/heaps inside the house. The gunny bags were stacked in the house in a well-ventilated room. The farmers also stored the pods for seed purpose separately by keeping Celphos tablets in the gunny bags. The seed is replaced normally every 3-4 years. The important storage pests reported by the farmers were bruchid beetle, khapra beetle, fig moth, rice moth, meal moth and rats. The economic damage was mostly due to bruchid beetle and it was up to the extent of 25% in severe cases. Farmers generally placed celphos and phorate tablets.

Adoption gaps

The adoption gap was estimated by the following formula

$\sum ni/N \times 100$

Where,

ni = number of farmers who had not adopted the practice

N = number of farmers interviewed

Table 1. The gaps in adoption of improved practices by the farmers

Sl.no.	Improved practice	Adoption gap (%)
	Soil test based fertilizer application	90
	Seed rate & spacing	96
	Seed treatment with *Rhizobium*	95
	Seed treatment with PGPR	100
	Application of organic manures	40
	Application of gypsum	89
	Weed management (chemical)	30
	Supplementary irrigation	60
	Fertilizer management	45
	Micro nutrient management	96
	Management of insect-pests	45
	Management of diseases	42
	Post harvest management	45

Table 2. The impact of adoption of improved technology

Practice	**Score**		**P**
	Adopters	**Non-adopters**	
No. of farmers interviewed	56	40	-
Age	49.32	43.43	0.027
SES	51.39	50.45	0.712
Experience with groundnut crop	3.80	4.25	0.215
Extension participation	25.78	20.96	0.004**
Institutional contact	2.04	0.43	0.002**
Provision of supplemental irrigation	23.75	21.75	0.573
Improved variety	2.80	2.93	0.118
Agronomic practices	24.36	21.95	0.000**
Macro nutient management	5.29	5.13	0.267
Micro nutrient management	2.12	2.39	0.478
Insect-pest management	7.25	6.58	0.081
Disease managment	7.54	7.25	0.106
Post harvest management	10.11	8.68	0.007**
Groundnut pod yield	2057.50	1788.78	0.005**

** significant at 1 %

The impact of adoption of improved practices

The farmers were divided into adopters and non-adopters post data collection based on the total adoption scores. The results of 't' test (Table 2) of adoption scores indicated that there were non-significant differences between adopters and non-adopters with respect to nutrient management and plant protection measures. There were significant differences between the adopters and non-adopters with respect to adoption of agronomic practices such as time of sowing, spacing and seed rate and post harvest management of groundnut. This resulted in realization of higher yields by the adopters (Rs.2057 kg/ha) compared to non-adopters (1789 kg/ha).The extension participation and institutional contact had positive and significant influence on the adoption of improved technology. The SES and experience with groundnut were not significant with adoption of improved technology.

PROJECT 14: BREEDING FOR LARGE-SEEDED AND CONFECTIONERY TYPE GROUNDNUT

(HARIPRASANNA, K., RADHAKRISHNAN, T., CHUNI LAL, J. B. MISRA, AND VINOD KUMAR)

During the period under report groundnut germplasm accessions and advanced breeding lines obtained from different sources along with materials developed at the NRCG were evaluated in separate yield evaluation trials. Fresh crosses were effected for incorporating large seed size, and segregating generations of various crosses were advanced to next respective generation and selections were made based on phenotypic superiority. A brief report of activities undertaken is as follows:

Hybridization

During *kharif* 2007, 15 crosses were attempted involving large seeded and high yielding parental lines to incorporate large seed size coupled with high yield. In addition, a cross was attempted involving extremes of seed size for generating mapping population. A total of 3323 buds were pollinated and 447 probable hybrid pods were harvested with a success rate of 13.5% only, due to aberrant weather conditions.

Raising F_1s and identification of true hybrids

Twelve crosses were raised along with parents and 77 true hybrids were identified, and pods were harvested separately to raise single plant progenies in the subsequent *kharif* season.

Selection and generation advancement

True F_2s were selected from 23 crosses sown and 15 bulks were made for advancing. From the 30 crosses in F_3 generation 20 bulks were selected for advancing. Three crosses in F_4, 14 crosses in F5, 4 crosses (8 selections) in F_6 and 9 crosses (29 selections) in F_7 were sown for advancement and further selection. Total 51 new selections were made based on phenotypic expression (Table 1).

Thirty new advanced breeding lines (9 Spanish, 21 Virginia) possessing large pod/seed and/or pod yield superiority were isolated from the F_6 and F_7 generations sown. Segregating materials in F_4 – F_6 generations of 12 crosses were supplied to nine AICRP-G centres, based on their requirement, for location specific selection during ensuing *kharif* season and varietal development.

Table 1. Crosses advanced and selections made during the year

Generation	No. of crosses	Crosses/ Seln. sown	No. of bulks/Seln. made
F1	12	12	77 SPP
F2	23	23	15
F3	30	30	20
F4	3	3	3
F5	14	14	11
F6	4	8	4
F7	9	29	33

Multiplication and maintenance

Advanced breeding lines/germplasm lines obtained from ICRISAT were multiplied during summer 2007 for subsequent evaluation. Forty-eight advanced breeding lines were sown for multiplication and 43 lines were sown for maintenance during *kharif* 2007. Two advanced breeding lines (PBS 29077 and PBS 29078) were sown for mass multiplication for seed enhancement. PBS 29080 and ICGV 99101 were sown for maintenance. Sufficient quantity of seed was produced in PBS 29077 and PBS 29078 and both were proposed for IVT of Large Seeded Varietal Trial (LSVT) during *kharif* 2008 under AICRP-G network. Ten germplasm lines were sown for seed enhancement during summer 2008 for subsequent evaluation.

Station trials

Three different yield evaluation trials were conducted under this project. The performance was poor during *kharif* season because of incessant and heavy rainfall. In all the trials observations on flowering, days to maturity, pod and kernel yields, and related traits were recorded.

Preliminary yield trial

Sixty-nine genotypes including germplasm lines, advanced breeding lines from BARC and confectionery lines from ICRISAT were evaluated along with three checks (GG 20, M 13 and TKG 19A). The mean pod yield ranged from 336 to 2011 kg/ha with a mean of 1121 kg/ha, and kernel yield ranged from 204 to 1377 kg/ha with a mean of 739 kg/ha. The best check for pod and kernel yield was GG 20 and only one genotype had pod yield more than GG 20, and 32 genotypes had pod yield above the experimental mean. The 100-seed weight (HSW) ranged from 21.1 to 53.1 g and 100-mature seed weight ranged from 26 to 71.6 g. The best checks were M 13 (46.6 g) and TKG 19A (59.9 g), respectively. Only two (TG 42 and TG 40) had significantly high HSW, and three (TG 42, TG 40, NRCG 12157) had significantly high 100-mature seed weight. Shelling outturn ranged between 53.7 and 72.6% and wide variation was observed for SMK (12.5-57%).

The mean days to flower initiation varied from 20.5 to 29, and days to 50% flowering lied between 22.5 and 32. The pod yield per plant ranged from as low as 2.0 g to as high as 12.1 g. The mean performance for some selected lines is given in Table 2.

Large Seeded Yield Evaluation Trial

Twenty-seven advanced breeding lines along with three checks (GG 20, M 13 and TKG 19A) were evaluated in a RBD with 3 replications. Data were recorded for SCMR, flowering initiation, 50% flowering, plant stand, pod yield and related traits. The mean pod yield per plant ranged from 6.2 to 12.0 g/plant. The experimental average yield was 1467 kg/ha with a range from 1076 to 2094 kg/ha. The kernel yield ranged from 649 to 1381 kg/ha. Only one genotype (ICGV 97051) recorded numerically higher pod yield over the best check GG 20. The HSW ranged from 31 g (PBS 29086) to 64.5 g (PBS 29079A) while the highest value for the check varieties was 46.2 g (TKG 19A). Three (PBS 29079A, PBS 29079B and ICGV

91089) genotypes recorded significantly higher HSW over TKG 19A. The 100-mature seed weight ranged from 40.3 (PBS 29086) to 91.6 g (PBS 29079A), and four (PBS 29079A, PBS 29069, PBS 29079B and ICGV 91089) recorded significantly higher mature seed size than TKG 19A. The mean performance for some selected lines is given in Table 3.

The mean duration for flower initiation ranged between 22.3 to 27.3 days while for 50% flowering the mean duration was 25.3 to 30.3 days. The total days to maturity ranged from 112 to 121 days and none of the genotype matured earlier than TKG 19A, which matured in 112 days. The harvest index had a mean value of 27.3% ranging from 19.8 to 38.3% in different genotypes. None of the genotypes had significantly higher harvest index or shelling outturn or SMK from GG 20, the best check.

International Confectionery Groundnut Varietal Trial

X International Confectionery Groundnut Varietal Trial, supplied by ICRISAT, with 15 genotypes was taken up in a triple lattice design along with a local check (TPG 41) for the 2nd year, as performance was very poor during *kharif* 2006. The pod yield ranged from 849 to 2406 kg/ha with a mean of 1715 kg/ha. All the entries had significantly higher pod yield than TPG 41. The HSW ranged from 32.1 (TPG 41) to 48.3 g (ICGV 00451), and the 100-mature seed weight ranged from 52.7 (ICGV 99083) to 77.7 g (ICGV 00440). Eight cultures recorded significantly higher seed size than check. The shelling outturn ranged from 55.2 to 71.2% and all the genotypes had lower mean value than TPG 41. The SMK percentage showed wide variation (26 - 47.7%). Except one (ICGV 00441) all genotypes recorded significantly higher SMK than TPG 41. ICGV 00440 exhibited significantly higher harvest index (41%) compared to TPG 41. The genotypes matured between 106 and 120.7 days and all the cultures were significantly late compared to the check. The mean performance of some of the genotypes is given in Table 4.

Quality evaluation

Advanced trial

The produce of 27 advanced breeding lines evaluated along with three checks (GG 20, M 13 and TKG 19A) during *kharif* 2006 was subjected to quality analysis for pod characteristics and kernel size, shape, seed size uniformity, SMK, testa colour, etc. Majority of the genotypes had only small to medium bold pods with very less uniformity because of incessant rainfall during the season. Some of the genotypes that had uniform medium bold pods were PBS 29052, PBS 29073, PBS 29078, PBS 29080 and ICGV 89214. PBS 29079 A and PBS 29079 B had bold pods but with less uniformity. The HSM ranged from 34.4 to 56.4 g (PBS 29079B) and the genotypes PBS 29069, PBS 29078, PBS 29073 and PBS 29080 had HSM above 50 g while the best check (M 13) had only 44.5 g (Table 5). Majority of the lines had elongated-oval to oval seed shape with tapering to intermediate shape of the end. Kernels were highly shrivelled in majority of the genotypes because of poor growing season. Seed size uniformity was highly varying in PBS 29069, PBS 29079 A, PBS 29079 B, ICGV 89214, ICGV 90208, ICGV 90210, ICGV 90212, ICGV 91089 and ICGV 97061 along with all three checks. Pods were non-uniform and medium sized in most of the genotypes.

Among the 15 genotypes evaluated in the X ICGVT, majority of the genotypes had medium to medium-bold pods because of the poor growing conditions during *kharif* season and the kernels were highly shrivelled. The HSM of kernels ranged from 35.8 to 58.5 g. Majority of the genotypes had elongated to elongated oval seed shape, but with less seed size uniformity and tan or dark tan coloured testa.

Screening for seed coat tolerance of *A. flavus* infection

Selected advanced breeding lines from the yield evaluation trial were subjected to lab screening for seed coat tolerance of *A. flavus* (isolate AF 111) infection in collaboration with the Plant Pathology section. The seed colonization ranged from zero to 20%. Among the checks M 13 had zero seed colonization though had 23% seed infection. Genotypes ICGV 90208, ICGV 90210 and ICGV 97079 recorded zero seed infection and colonization, while PBS 29078, ICGV 90308, ICGV 91099, ICGV 99102, ICGV 00441 and ICGV 00446 had zero seed colonization and less than 10% seed infection. Some other genotypes that had zero seed colonization in spite of high seed infection are ICGV 97061, ICGV 00429, PBS 29073, ICGV 99083, ICGV 90212 and ICGV 97051. Genotypes that had high yield or seed size with low colonization are ICGV 89214, ICGV 97051, ICGV 90208, PBS 29073, ICGV 90173, PBS 29080, PBS 29078 and ICGV 91099. Other breeding lines, which recorded zero colonization, can act as source of *A. flavus* resistance in the breeding programmes.

Evaluation of Spanish type germplasm lines

During summer 2007, 19 Spanish type germplasm lines were evaluated along with a check, TKG 19A, for yield and seed size superiority in order to identify suitable donor parents for development of large-seeded varieties in the Spanish background to have early maturity. Observations were recorded for yield and related traits. Two germplasm lines, NRCG 7035 and NRCG 11696, recorded significantly higher pod yield over the check TKG 19A while 12 other lines had numerical superiority. For kernel yield also NRCG 7035 and NRCG 11696 exhibited numerical superiority over TKG 19A. NRCG 11909 recorded the highest 100-kernel weight (50g) which was significantly higher than that recorded in TKG 19A (38.7 g). Another line NRCG 12069 recorded numerically higher seed weight over the check. The high yielding genotypes had poor 100-kernel weight (30-31 g). Three accessions (NRCG 11669, 10751 and 7035) had significantly higher shelling outturn than the check, TKG 19A. The recovery of sound mature kernels varied very widely from 22% to 85%. Three accessions (NRCG 10751, 11869 and 11932) recorded above 70% mean value for the trait (Table 6). The accessions will be evaluated for one more season to ascertain the superiority.

Development of mapping population

The F_3 generation of three crosses (large x small type) was advanced to F_4 for the purpose of developing recombinant inbred lines for seed size. From each plant single pod was harvested to raise the next season crop and advance the generation. The F4 generation was sown to advance the generation to F_5 during the *kharif* season and single pods were harvested from each plant. Advancing the generation from F_5 to F_6 is being taken up during summer 2008.

All the pods from each plant will be harvested to raise the single plant progenies in the subsequent season and for maintenance.

Table 2. Mean performance of selected genotypes in the preliminary trial

Sr. No.	Genotype	Pod yield (kg/ha)	Kernel yield (kg/ha)	Shelling outturn (%)	100-seed weight (g)
1	TG 40	1515	945	62.4	71.6
2	TG 42	1472	932	63.5	70.0
3	NRCG 12157	797	506	63.2	68.1
4	TG 43	1673	1122	67.1	66.9
5	NRCG 12052	1092	733	67.1	65.7
6	NRCG 12131	1170	801	68.5	65.1
7	NRCG 9036	901	568	63.1	64.9
8	ICG 5344	1121	756	67.5	64.9
9	ICG 13350	1360	928	68.3	63.5
10	NRCG 12074	1505	970	64.4	63.5
11	NRCG 12132	1163	781	66.9	63.3
12	NRCG 12118	675	447	66.2	63.2
13	ICG 5684	1102	697	63.5	62.9
14	NRCG 12059	701	449	63.9	62.6
15	NRCG 988	1101	746	67.2	62.4
16	NRCG 12048	875	581	66.4	61.7
17	NRCG 12068	1247	850	68.0	61.3
18	NRCG 9038	892	597	66.8	60.9
19	NRCG 12069	1595	1114	69.9	60.1
20	NRCG 12133	1001	657	65.7	60.0
70	TKG 19 A	1681	1090	64.9	59.9
71	GG 20	1915	1290	67.8	50.0
72	M 13	1589	1074	67.6	57.9
	Mean	419	277	3.7	8.1
	C.D (5%)	1121	739	65.4	50.6

Table 3. Mean performance of selected genotypes in the advanced trial

Sr. No.	Genotype	Pod yield (kg/ha)	Kernel yield (kg/ha)	Days to maturity (days)	Shelling outturn (%)	100-seed weight (g)
1	ICGV 97051	2094	1354	118.3	64.5	58.6
2	PBS 29078	1839	1257	113.0	68.5	61.2
3	ICGV 97061	1756	1156	118.3	65.6	62.4
4	ICGV 89214	1727	1089	119.0	62.9	64.4
5	PBS 29073	1628	1106	114.7	67.9	60.4
6	ICGV 97049	1587	1007	117.7	63.2	58.2
7	ICGV 90208	1575	1071	117.0	68.0	62.2
8	ICGV 97040	1540	1009	118.0	65.3	59.3
9	PBS 29033	1524	1022	117.7	66.9	58.3
10	ICGV 91089	1514	1028	121.3	67.9	70.6

11	PBS 29080	1469	993	113.3	67.6	59.5
12	PBS 29067	1457	921	117.3	63.3	65.0
13	PBS 29079 B	1424	940	116.3	66.0	78.5
14	ICGV 90308	1360	945	118.3	69.2	63.7
15	ICGV 90173	1299	786	119.3	60.2	63.9
16	PBS 29069	1285	791	120.7	61.4	79.1
17	PBS 29035	1211	824	117.0	68.1	62.8
18	PBS 29082	1172	715	117.7	61.0	60.2
19	PBS 29079 A	1134	746	117.0	65.7	91.6
28	GG 20	1927	1381	116.3	71.6	51.1
29	M 13	1625	1079	118.7	66.4	56.5
30	TKG 19 A	1762	1157	112.0	65.5	57.8
	Mean	1467	958	117.3	65.0	61.0
	C.D (5%)	387	273	111.0	3.2	8.5

Table 4. Mean performance of selected genotypes in X ICGVT

Sr. No.	Genotype	Pod yield (kg/ha)	Kernel yield (kg/ha)	Days to maturity (days)	Shelling outturn (%)	100-seed weight (g)
1	ICGV 00440	2390	1623	116.3	68.0	77.7
2	ICGV 00451	1621	1085	118.7	66.5	77.5
3	ICGV 00456	1675	1158	117.0	69.0	71.5
4	ICGV 99102	1743	1111	118.3	63.7	65.9
5	ICGV 97079	2406	1639	120.7	68.1	64.7
6	ICGV 00429	1418	911	119.3	64.4	64.6
7	ICGV 00391	1738	1148	119.3	66.1	61.6
8	ICGV 99105	1666	1062	116.3	63.6	58.6
16	TPG 41	849	601	106.3	71.2	53.0
	Grand mean	1715	1114	117.8	65.1	61.3
	C.D (5%)	347	229	2.4	1.5	4.5

Table 5. Quality parameters of selected genotypes evaluated in advanced trial

Sr. No.	Genotype	100-seed weight (g)	Shape of kernel	Shape of end	SSU	Testa colour
1	PBS 29079 B	56.4	Elongated-oval	Intermediate	4	Light tan
2	PBS 29069	54.0	Elongated	Intermediate	5	Light tan
3	PBS 29078	53.3	Elongated	Intermediate	7	Salmon
4	PBS 29073	50.8	Elongated	Intermediate	6	Salmon
5	PBS 29080	50.7	Elongated-oval	Intermediate	6	Salmon
6	ICGV 90173	49.4	Elongated	Tapering	7	Tan
7	PBS 29067	49.0	Oval	Blunt	7	Tan
8	PBS 29082	49.0	Elongated-oval	Blunt	8	Tan
9	ICGV 89214	48.7	Oval	Intermediate	5	Light tan
10	PBS 29079 A	47.9	Elongated-oval	Intermediate	4	Light tan
11	ICGV 97051	46.7	Elongated	Tapering	7	Tan

12	ICGV 91099	46.6	Oval-round	Intermediate	7	Tan
28	GG 20	40.3	Oval	Intermediate	7	Tan
29	M 13	44.5	Elongated-oval	Tapering	5	Dark tan
30	TKG 19A	41.9	Elongated-oval	Intermediate	4	Tan

[SSU-Seed size uniformity: 10…1 (highly uniform to highly varying)]

Table 6. Mean performance of selected Spanish type germplasm lines

Sr. No.	Genotype	Pod yield (kg/ha)	Kernel yield (kg/ha)	Shelling outturn (%)	100-seed weight (g)	Sound mature kernels (%)
1	NRCG 7035	1975.8	1280.2	65.0	30.7	47.0
2	NRCG 11696	1715.9	1086.5	62.8	30.5	56.0
3	NRCG 11867	1362.4	795.9	57.0	32.5	60.5
4	NRCG 12069	1311.7	775.3	57.7	43.2	55.0
5	NRCG 11909	1296.8	795.9	61.3	50.0	49.0
6	NRCG 11869	1287.5	743.5	57.5	36.0	82.5
20	TKG 19 A	983.2	555.8	56.8	38.7	39.0
	C.D (5%)	726.5	475.0	6.6	5.6	29.1

PROJECT 15: MULTIPLICATION AND UTILIZATION OF WILD *Arachis* GENE POOLS FOR IMPROVEMENT OF GROUNDNUT

(S. K. BERA, P. C. NAUTIYAL, A. L. SINGH, RADHAKRISHNAN T., CHUNI LAL, T. V. PRASAD AND VINOD KUMAR)

Hybridization

BC3, BC2, BC1 and interspecific hybridization were made between desirable *Arachis* hypogaea and interspecific hybrids, BC1 and BC2 in field condition during rainy season (Table 1). Fourteen to twenty-nine percent probable cross-pods were harvested from 10 BC3 crosses entangling two elite cultivars and five interspecific BC2 progenies. Similarly, 26-38 percent cross-pods were harvested from 5 BC2 crosses between short duration cultivars, chico and five interspecific BC1 progenies. Five BC1 crosses involving cultivar, TAG 24 and five interspecific hybrids produced 13-36 percent cross-pods. Besides, GG 20 susceptible to stem rot was crossed with three resistant cultivars, OG 52-1, ICGV 86590 and germplasm, NRCG CS 19 in half diallele design and 9-36 percent cross-pods were harvested.

Table 1. Hybridization undertaken during rainy season

Cross combination	No. of pollination	No. of cross pod	Percent cross pod
BC3			
TKG19A////Chico /// GG 2 // J11 / A. kempfmarcadoi	283	42	15
TKG19A////Chico /// GG 2 // J11/ A correntina	321	54	17
TKG19A////Chico /// GG2 // J11 / A.duranensis	314	75	24
TKG19A////Chico /// GG2 // J11 / A. kretschmeri	311	70	23
TKG19A////Chico /// GG2 // J11 / A.stenosperma	350	78	22
OG 52-1////TAG 24 /// GG2 // J11 / A correntina	278	75	27
OG 52-1////TAG 24 /// GG 2 // J11 / A. duranensis	317	54	17
OG 52-1////TAG 24 /// GG2 // J11 / A. kretschmeri	274	79	29
OG 52-1////TAG 24 /// GG2 // J11 / A correntina	329	45	14
OG 52-1////TAG 24 /// GG2 // J11 / A. stenosperma	325	95	29
BC2			
Chico///GG2 // J11 / A. digoi (NRCG11781)	440	116	26
Chico///GG2 // J11 / A. batizocoi (NRCG12030)	477	163	34
Chico///GG2 // J11 / A. Monticola (NRCG11800)	400	105	26
Chico///GG2 // J11 / A. pusilla (ICG8131)	363	104	29
Chico///GG2 // J11/ A. kretschmeri (NRCG12029)	320	123	38
BC1			
TAG 24//J11 / NRCG14821	320	115	36
TAG 24//J11 / NRCG11781	309	41	13
TAG 24//J11 / NRCG12037	351	72	21
TAG 24//J11 / NRCG11800	483	128	27
TAG 24//J11 / NRCG11785	470	73	16
Intervarietal			
GG 20 x CS 19	406	44	11
GG 20 x ICGV 86590	319	36	11

GG 20 x OG 52-1	358	51	14
CS 19 x ICGV 86590	455	74	16
CS 19 x OG 52-1	392	35	9
ICGV 86590 x OG 52-1	357	127	36

Advancement of segregating lines

Segregating progenies comprising 79 single plant selections and 33 bulk selections (F4 to F7 generations) from 12 interspecific and four intervarietal crosses were sown in 3-10 lines of 3 meters bed for further selection and advancement during rainy season (Table 2). However, progenies were advanced to next generation without selection due to adverse climatic condition throughout the crop season in Junagadh.

Table 2. Advancement of segregating lines

Cross	No. of lines sown	
	Single plant	Bulk
J 11 x A. duranensis	32	23
(J 11 / A. duranensis)// GG 2	36	-
6x A. hypogaea x A. cardenasii	-	1
J 11 x A. corentina F2	-	1
J 11 x A oteroi F2	-	1
J 11 x A. diogoi F2	-	1
J 11 x A.helodis F2	-	1
J 11 x A kretschmeri F2	-	1
J 11 x A kretschmeri F3	11	1
J 11 x A. duranensis F3	-	1
J 11 x A.corentina F2	-	1
VRI 4 x A corentina.	-	1
White flower x Crinkle leaf		24
White testa x Crinkle leaf		16
Red testa x Crinkle leaf		7
ICGL 5 x Crinkle leaf		3
Total	79	83

Evaluation of advanced lines

Initial evaluation of advanced breeding lines

Advanced lines were evaluated for yield and other agronomic traits in augmented design during rainy season. One hundred and thirty five test genotypes with 4 checks (GG 20, JL 24, TKG 19A and TAG 24) were sown in 3 lines of 3 metres bed in 4 blocks. Observations on foliar diseases were recorded after 75 days of sowing and pod yield and its attributes were recorded at harvest. The Checks, GG 20 and TKG 19A recorded significantly higher pod yield per 10 plants than JL 24 and TAG 24 (Table 3). No block effect was observed while comparing test entries with best check (GG 20). NRCG CS 252 and 285 significantly out yielded than best check pod yield/10 plant (124g) though 12 genotypes registered numerically higher pod yield than GG 20 (Table 4). The shelling percentage, hundred kernel mass

(HKM), sound matured kernel (SMK) percentage and harvest index (HI) of these 2 genotypes were at par with GG 20.

Table 3. Response of Check varieties

Check	Pod wt. /10 pl (g)
GG 20	124**
JL 24	64
TKG 19A	105.75**
TAG 24	81
Mean	94
CD	16.84

Table 4. Pod wt/10 pl.(g) of promising lines

Genotype	Pod wt./10pl.	Kernel wt./10pl.	Shelling%	HKM (g)	SMK%	BY(g)	HI%
CS 252	188**	93	49	40	78	484	19
CS 253	147	77	52	33	88	398	19
CS 254	128	74	58	33	88	353	21
CS 256	148	74	50	38	85	430	17
CS 259	146	67	46	42	87	405	17
CS 261	128	60	47	49	90	317	19
CS 268	128	53	41	42	87	284	19
CS 280	126	64	51	32	83	360	18
CS 285	168**	86	51	44	84	509	17
CS 321	136	73	54	30	86	404	18
CS 335	127	72	57	33	88	325	22
CS 360	152	74	49	36	88	401	18
GG 20 (Best check)	124	69.5	56	40	81	433	16
CD	29.77						

The Initial evaluation trial consisting of 120 test genotypes, with checks, was repeated during summer season. Twenty genotypes recorded significantly higher pod yield than check. NRCG CS 247, 344, 345, 347, 360 and 362, out of 20 genotypes, recorded higher shelling out turn.

Advanced evaluation of breeding lines

Promising genotypes selected on the basis of 3 years performance under initial yield evaluation were confirmed under advanced yield trial. Thirty genotypes were evaluated along with checks under RBD with 3 replications during rainy season. Post harvest observations were recorded at harvest. None of the genotype out yielded the pod yield of the check, per plot, (1176.3kg). However, NRCG CS 83 and 148 performed at par GG 20 (check) and also showed higher shelling percent and hundred kernel mass (Table 5). The performance of genotypes was not been adjudged due to extended heavy rainfall in entire crop season at Junagadh and water stagnation in the experimental plots.

Table 5. Advanced yield trial of breeding lines

NRCGCS	Pod wt./plot* (g)	Shelling%	SMK%	HKM(g)
CS 148	1077.3	66	85	42
CS 83	1080.0	59	78	31
GG 20	1176.3	54	82	28
SE	129.8			
CD	270.0			

*Plot Size=12 squre meter

Evaluation of breeding lines for large kernel size

Selected genotypes with higher hundred kernel mass (HKM) were confirmed under large kernel size experiment during rainy season. Thirty genotypes with higher HKM were sown in RBD with two replications. Pod yield per plant, shelling percent, sound matured kernel were recoded along with hundred kernel mass. NRCG CS 148, 268, 281 and 285 though recorded higher HKM than best check (TKG 19A) failed to differ significantly. NRCGCS 268 and 281 confirmed significantly higher HKM than check over pooled analysis of *kharif* '06 and *kharif*'07 data, while NRCG CS 148 recorded slightly higher HKM (Table 6). Pod weight per plant, shelling percent and sound matured kernel percent of NRCG CS 268 and 281 were also higher than TKG 19A.

Table 6. Response of breeding lines with large kernel size

	Pod wt./pl. (g)		Shelling %		SMK %		HKM (g)	
Genotype	Kh 07	Pooled (06&07)	Kh 07	Pooled (06&07)	Kh 07	Pooled (06&07)	Kh 07	Pooled (06&07)
NRCG CS 148	8.4	12.6	71.4	69.7	89.3	76.7	58.0	59.1
NRCG CS 268	11.2	12.0	67.0	69.0	88.4	81.7	59.5	63.4**
NRCG CS 281	7.5	10.9	56.0	60.0	91.8	88.3	59.5	62.5**
B 95	6.5	13.4	64.8	53.5	85.3	84.9	50.5	46.2
BAU 13	4.0	10.7	58.7	57.9	85.0	82.9	39.5	43.0
TKG19A	6.6	17.9	53.8	63.7	84.3	75.8	52.5	51.4
SEm	0.9	2.6	1.6	4.1	2.9	4.8	3.8	3.7
CD	2.6*	ns	4.7*	11.7*	8.2*	NS	11.1*	10.7*
CV%	25.5	22.0	13.94	12.6	4.8	5.6	13.6	11.7

Scoring of breeding lines for multiple disease resistance

Genotypes showing resistance under natural field screening over 3 seasons at NRCG, Junagadh were scored further against Late leaf spot (LLS), rust, Peanut bud necrosis (PBND) and Stem rot at Raichur during rainy season of 2007. Each genotype was sown in 2 lines of 3 meters bed along with resistant and susceptible checks. Genotypes were scored in 1-9 scale for LLS and rust, while genotypes were scored by disease incidence for PBND and stem rot and expressed in percent (Table 7). NRCG CS Nos. 15, 19, 21, 60, 70, 74, 77, 83, 85, 86, 124, 127, 176, 180, 186, 195, 196, 212 and 222 recorded less than or equivalent to 5 and 4 scoring against LLS and Rust, respectively and less than 20 percent diseases pressure against

PBND and stem rot in *kharif* 2007 as well as pooled over 2006 and 2007 seasons. These 19 genotypes were confirmed as multiple disease resistant lines over locations (Junagadh and Raichur) and years (5 seasons) under natural field condition. These lines can be used in breeding programme. Besides, NRCG CS 83 recorded consistently very low PBND incidence over 3 seasons (*kharif* 06, summer'06 and *kharif*'07) at hot spot location (Raichur) and is resistant to PBND .

Table 7. Scoring of breeding lines for LLS, Rust, PBND and Stem rot

Entry	LLS (1-9 scale)		Rust (1-9 Scale)		PBND (%)		Stem rot (%)	
	2007	Max.	2007	Max.	2007	Mean	2007	Mean
CS-015	5	5	3	3	5	6.9	7.5	5.2
CS-019	4	4	4	4	10.7	9.5	10.7	11.6
CS-021	3	4	2	3	5	9.3	7.5	6.5
CS-060	4	4	2	4	8.7	11.5	8.7	9.1
CS-070	3	3	3	4	--	17.6	--	5.9
CS-074	3	4	2	2	12	16	12	12.7
CS-077	4	4	3	3	18.8	15.1	18.8	13.7
CS-083	5	5	3	3	3.8	3.6	10.3	10.3
CS-085	4	4	4	4	6.7	5.4	16.7	12.4
CS-086	5	5	3	3	18.2	14.7	9.1	8.3
CS-124	4	4	3	3	--	8.7	--	13
CS-127	5	5	3	4	16.7	12.5	6.7	5.5
CS-176	5	5	4	4	15.4	12.1	19.2	16.1
CS-180	4	4	2	2	18.8	12.4	2	2.5
CS-186	4	4	3	3	13	21.1	13	12.8
CS-195	4	4	4	4	20	16	3	3.9
CS-196	3	3	3	3	14.3	10	14.3	8.6
CS-212	3	5	2	4	15.4	18.6	11.5	12.3
CS-222	4	4	3	3	12.2	12.4	12.2	9.9
R-2001-1	3	4	3	4	8.3	5.6	13.9	9.8
R-2001-2	3	4	3	3	3	5.1	9.1	8.1
R-2001-3	3	3	3	3	6.1	4.7	6.1	6.4
GPBD-4	3	3	3	3	41.1	31.9	22.2	15.6
KRG-1	7	7	6	6	30	25	18.8	12.8
TMV-2	7	8	4	5	27.9	21.9	32.1	30.1

Induction of variability through chemical mutagenesis

GG 2 was treated with three chemical mutagens (Ethyl Methane Sulphonate, Colchicine and Cloramphenicol) during summer 2003. Desirable mutants were forwarded based on agronomic traits. A total of 109 selected lines were sown during rainy season for further advancement. However, mutants were harvested in bulk without selection due to adverse climatic condition resulting in poor yield. These mutants were sown in five lines of three-meter bed during summer season. The pod yield and shelling percent were recorded from160

mutants. Fourteen mutants showed promise in pod yield along with shelling percent when compared with GG 2 (Table 8). Significant changes in pod characters as well as plant types were observed in some of these lines.

Table 8. Yield parameters of mutants of GG 2

Genotype	Pod character	Pod Wt./10 pl.	Kernel wt./10 pl.	Shelling %
m-74		360	244	67.78
m-93		212	147	69.34
m 10	Smooth pod	210	136	64.76
m-9	Smooth pod	202	121	59.90
m-31		201	126	62.69
m-91		200	124	62.00
m-11/1	Smooth pod	192	142	73.96
m-11/2	Bold	191	93	48.69
m-7		190	100	52.63
m-88		184	120	65.22
m-94		183	126	68.85
m-13		181	105	58.01
m 52/1	Smooth pod	179	122	68.16
m-113		179	126	70.39
GG 2		177	123	69.49

Characterization of wild *Arachis* species against abiotic stresses

Characterization against drought related traits

Seed bearing and rhizomatous wild *Arachis* species were characterized against drought related parameters like Specific leaf area (SLA) and SPAD chlorophyll meter reading (SCMR) under field condition during rainy season. SLA ranged from 103.2 to 492.4 and SCMR ranged from 13.2-41.4 (Table 9) among 145 accessions evaluated. Seven genotypes registered significantly lower SLA than mean. Further, three accessions (NRCG 11811, 11831 and 12035) out of seven, recorded significantly higher chlorophyll content than mean. These three accessions would be confirmed further by in vitro screening.

Table 9. Wild accession with low (SLA) and high (SCMR)

NRCG No.	Species	Propagation	Δ13C	SLA(cm/g)	SCMR
11811	A. Stenophylla	Seed bearing	NA	103.5**	40.8**
11831	A. glabrata	Rhizomatous	21.840	121.7**	34.4**
11819	A. glabrata	Rhizomatous	19.606	122.6**	33.0
11816	A. glabrata	Rhizomatous	21.240	126.3**	28.9
11781	A. diogoi	Seed bearing	20.273	126.9**	26.1
12035	A. appresipilla	Seed bearing	22.493	127.6**	41.4**
11787	A. paraguariensis	Rhizomatous	NA	129.1**	24.4
Range				103.5-492.4	13.2-41.4
Mean				205.6	28.0
SE				36.37	2.55
CD				75.66	5.31

In vitro characterization against salinity related traits

Callus was induced from leaf of 31 wild *Arachis* sp. (Table 10) in MS medium supplemented with 2.5ml PIC/L and 1.5ml/L BAP. Callus of 31 wild accessions were screened in vitro under 50, 100, 150, 200 and 250mM NaCl concentration and allowed to grow for 4 weeks. Eighteen accessions showed comparatively good callus growth in 250mM salt concentration. However, NRCG 11832 looked very promising under 250mM salt concentration with green callus (Figure 1). Fresh callus weight, dry callus weight and chlorophyll content were recorded after 4 weeks. Promising accessions will be confirmed further for their salinity tolerance through biochemical parameters like proline accumulation and Na and K uptake.

Table 10. Tolerant wild *Arachis* sp. against salinity

S.No.	Accession No.	Callus growth (g) under 250mM/l NaCl (30 Days after culture)
1	NRCG 12019	4.745
2	NRCG 11824	2.908
3	NRCG 11793	5.910
4	NRCG 11815	2.872
5	NRCG 11832	7.728
6	NRCG 11846	2.710
7	NRCG11830	3.965
8	NRCG11831	6.428
9	NRCG11803	2.374
10	ICG 8189	7.064
11	ICG 8903	2.551
12	NRCG 11820	2.459
13	NRCG 11825	4.527
14	NRCG 11842	2.484
15	NRCG 11834	4.730
16	NRCG 11821	4.276
17	NRCG 12046	2.550
18	NRCG 11804	8.727

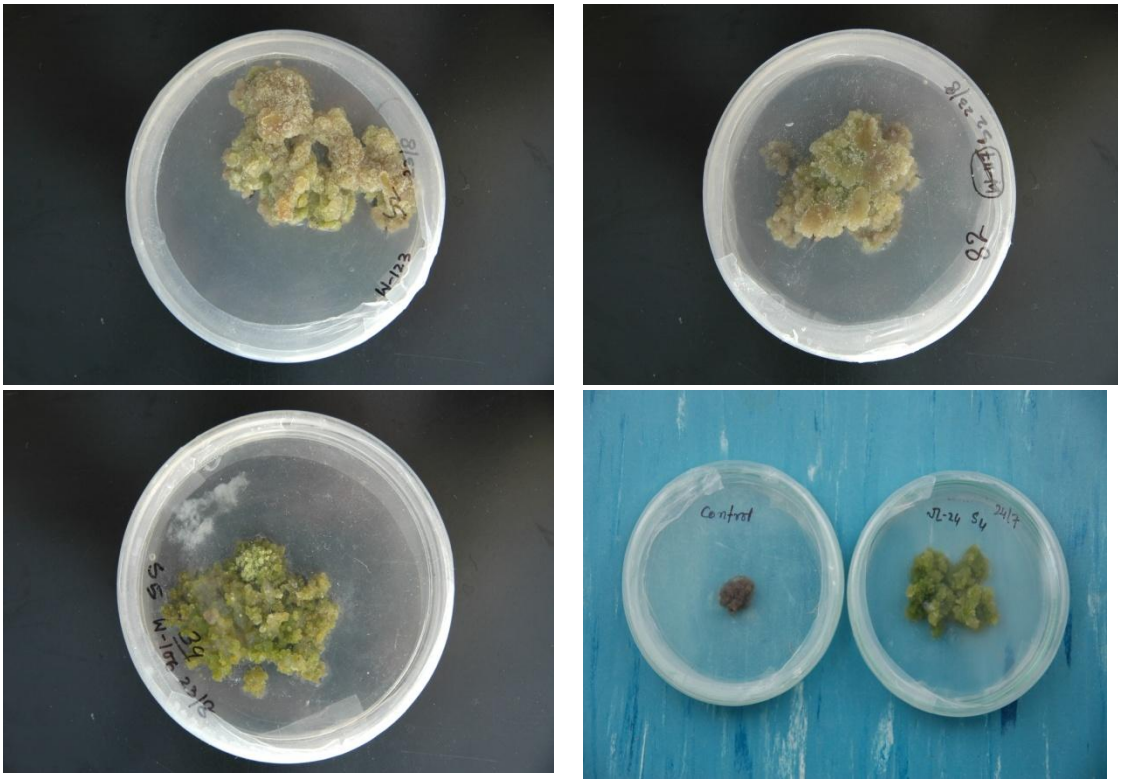


Figure 1. Tolerant cell lines of wild Aarchis accessions growing under 250mM/L of NaCl

EXTERNALLY FUNDED PROJECTS

ALL INDIA NETWORK PROJECT ON SOIL BIODIVERSITY-BIOFERTILIZERS (PI: K.K. PAL, CO-PI: R. DEY)
Funding agency: ICAR, New Delhi
Duration: 01.04.2007-31.03.2012
Total Fund: ₹ 23.00 lakh

EXPLORING BACTERIAL AND ARCHAEBACTERIAL DIVERSITY IN KUTCH ECO-REGION OF GUJARAT FOR AGRICULTURAL AND INDUSTRIAL APPLICATIONS
(PI: K.K. PAL, CO-PI: R. DEY)
Funding agency: ICAR, N Delhi through AMAAS project
Duration: 01.04.2007-31.03.2012
Total Fund: ₹ 38.10 lakh

PUBLICATIONS

Research Articles

- Bera SK and Bhatt DM (2007) In vitro Callogenesis and plant regeneration from anther culture in groundnut (*Arachis* hypogaea L.). J Plant Gent Resour. 20 (2):118-121.
- Chuni Lal, Rathnakumar AL, Hariprasanna K, Gor HK and Chikani BM (2007) ICGV 96399 and ICGV 97245: Early-maturing groundnut advanced breeding lines with high per-day-productivity under rainfed situations. International *Arachis* Newsletter No. 27:14
- Girdhar IK, Bhalodia PK, Misra JB and Girdhar V(2007) Use of saline water in groundnut – wheat rotation in calcareous black clay soils of Saurashtra region of Gujarat. J Oilseeds Res. 24(2): 255-262.
- Hariprasanna K, Chuni Lal, Radhakrishnan T, Gor HK and Chikani BM (2008) Analysis of Diallel Cross for Some Physical-Quality Traits in Peanut (*Arachis* hypogaea L.) Euphytica 160 (1): 49-57.
- Hariprasanna K, Chuni Lal and Radhakrishnan T (2008) Relationship between flowering duration and physical-quality traits as well as pod yield in groundnut (*Arachis* hypogaea). Indian Journal of Agricultural Sciences 78 (2):180-182.
- Kumar GDS and Devi Dayal (2007) Farmer's perceptions on groundnut based intercropping systems in Junagadh district of Gujarat. Indian Journal of Extension Education 43 (3-4): 37-40.
- Kumar GDS, Popat MN and Kanani PR (2008) Farmer's perceptions of quality of groundnut: vis-à-vis farmer's characteristics. Journal of International Agricultural and Extension Education 15 (1): 45-54.
- Lal C, Hariprasanna K, Rathnakumar AL, Basu MS, Chikani BM, Gor HK (2008) Genotypic differences for traits associated with water-use efficiency and yield in groundnut (*Arachis* hypogaea L.) under rainfed conditions. Tropic Agric. (Trinidad) 5: 185-192.
- Kumar V, Bagwan NB, Vyas UM and Singh D (2008) Dynamics of soil population of *Aspergillus flavus* Link and aflatoxin contamination in groundnut based production system in Gujarat. Indian Phytopathology 61(3): 343-347.
- Kumar V, Basu MS and Rajendran TP (2008). Mycotoxin research and mycoflora in some commercially important agricultural commodities. Crop Protection (UK) 27: 891-905.
- Nandagopal V, Prasad TV, Gedia MV, Anand Prakash and Rao J (2007) Life History, Distribution and Management of Caryedon serratus (Olivier): A Review. Journal of Applied Zoological Researches 18(2): 93-107.
- Nandagopal V, Prasad TV, Gedia MV and Chowdhury L (2007) Post Embryonic Observations on the Metamorphosis of Caryedon Serratus (Olivier) -The Major Storage Pest of Groundnut. Journal of Applied Zoological Researches 18(2): 133-136.
- Nautiyal PC, Rajgopal K, Zala PV, Pujari DS, Basu M, Dhadhal B and Nandre BM (2008) Evaluation of Wild *Arachis* species for abiotic stress tolerance: I Thermal stress and leaf water relations. Euphytica, 159:43-57.
- Prasad TV, Nandagopal V, Gedia MV, Koradia VG and Patel HV (2007) Effect of intercropping on the yield and yield parameters of groundnut (*Arachis* hypogaea). Indian Journal of Agricultural Sciences. 77 (8): 515 – 518.
- Prasad TV, Nandagopal V, Gedia MV, Koradia VG and Patel HV (2007) Effect of artificial defoliation during different crop growth stages on yield losses of Spanish

groundnut (*Arachis* hypogaea). Indian Journal of Agricultural Sciences. 77 (9): 574 – 578.

- Prasad TV, Nandagopal V, Gedia MV, Makwana AD and Patel HV (2007) Simulated defoliation during different crop growth stages to assess insect damage during and yield losses in Spanish groundnut, *Arachis* hypogaea L. Journal of Oilseeds Research 24(2): 283-285.
- Singh AL and Chaudhari V (2007) Macronutrient requirement of groundnut: Effects on uptake of macronutrients. Indian J Plant Physiology 12: 72-77.
- Singh AL, Hariprasanna K and Solanki RM (2008) Screening of Groundnut Genotypes for Tolerance of Salinity Stress. Australian Journal Crop Science 1(3): 69-77.
- Books and Book chapters
- Ghewande MP and Kumar V (2008) Oilseeds- Groundnut and Castor. In "Disease Management in Arid Land Crops" (S. Lodha, R. Mawar and B.S. Rathore, eds.), Scientific Publishers, Jodhpur (India), pp. 81-98.
- Kumar GDS (2007) Transfer of pest management technologies. In: Groundnut Entomology (Eds) Nandgopal, V. and Gunathilagaraj, K. Satish Serial Publishing House. pp 557-570.
- Singh AL, Chaudhari V and Basu MS (2007) Boron deficiency and its nutrition of groundnut in India. pp 149-162. In: Advances in Plant and Animal Boron Nutrition (F. Xu ed) Springer Publishers

Presentations in conferences/ symposia/ seminar/ other forum

- Basu MS, Desai S, Kumar V, Waliyar F, Nigam SN and Thakur RP (2008) Status of aflatoxin contamination and management in groundnut in India. In: Proceedings of the ACIAR Regional Workshop on "Minimizing aflatoxin risk in peanuts" held at ICRISAT Center, Patancheru, India (21-22 February 2007).
- Basu S, Mayes S , Stadler F, Sheshshayee MS, Christiansen JL, Adu-Dapaah H, Nautiyal PC, Karunaratne A, Ali SA (2008) Promoting indigenous crops as a tool for tackling climate change and food insecurity in semi-arid Africa, presented in International Conference in Climate change in the session: Climate change and challenges for the next decades", France.
- Chuni Lal and Singh AL (2007) Screening for high zinc density groundnut genotypes in India. In: Proceeding of Zinc Crops 2007 Conference for improving crop production and human health, Istanbul, Turkey 24-26th May 2007. Website: <http://www.zinc-crops.org/ZnCrops2007/page_session_1.htm> and <http://www.fertilizer.org/ifa/publicat/bap/2007_zinccrops_page_1.asp>
- Gedia MV, Vyas HJ, Acharya MF and Prasad TV (2008) Bio-intensive Management of Spodoptera litura (Fab.) (Lepidoptera : Noctuidae) on Castor (Ricinus communis L.). In Abstracts of First International Conference on "Agrochemicals Protecting Crop Health and Natural Environment" 8-11 January, 2008, IARI, New Delhi, 159 pp.
- Kumar GDS (2008) Farmers perceptions of quality and aflatoxin contamination of groundnut. Paper presented at State level post graduate paper presentation competition- 2008 for Agricultural Universities of Gujarat sponsored by GUJCOST, held at S.D. Agricultural University, Dantiwada.
- Nautiyal PC, Radhakrishanan T and Singh R (2008) Groundnut research on drought tolerance at NRCG: From breeding to farmer's field, Invited paper presented in National Symposium on advances in legume research, March 6 & 7, 2008, Department of Agricultural Botany Annamalai University, Annamalainagar, Tamil Nadu. (Abstract: Session III, Pp 91-92).

- Nautiyal PC, Radhakrishan T, Kulkarni G, Mehta R and Basu MS (2008) Eco-physiological interactions for drought and drought induced heat tolerance and associated molecular characteristics in bambara groundnut landraces. Resource Capture by Crop: Integrated Approaches, a 3 day conference at University of Nottingham, Sutton Bonington Campus, UK, 10-12 September, 2008.
- Prasad TV, Nandagopal V and Gedia MV (2007) Effect of egg density on weight loss and adult emergence of Caryedon serratus (Olivier) in groundnut kernels in Souvenir and Abstracts of National Conference on Applied Zoology and Sustainable Development, 13-14 July, 2007, Indian Institute of Chemical Technology (IICT), Tarnaka, Hyderabad, 27 pp.
- Prasad TV, Nandagopal V, Gedia MV and Savaliya SD (2008) Evaluation of some bio-pesticides against sucking pests of groundnut (*Arachis* hypogaea Lin.). In Abstracts of First International Conference on "Agrochemicals Protecting Crop Health and Natural Environment" 8-11 January 2008, IARI, New Delhi, 137 pp.
- Satish Kumar GD, Devi Dayal and Prasad TV (2007) Impact of farmer participatory assessment of integrated pest management in groundnut. In Souvenir and Abstracts of National Seminar on Appropriate Extension Strategies for Management of Rural Resources, 18 – 20 December, 2007, UAS Dharwad, Karnakata, 121-122 pp.
- Singh AL (2007) Prevention and correction of Zinc deficiency of groundnut in India. In: Proceeding of Zinc Crops 2007 Conference for improving crop production and human health, Istanbul, Turkey 24-26th May 2007. Website: <http://www.zinc-crops.org/ZnCrops2007/page_session_1.htm> and <http://www.fertilizer.org/ifa/publicat/bap/2007_zinccrops_page_1.asp>.
- Singh AL, Jat RS and Bhogal NS (2008) Scenario of micro and secondary nutrient deficiencies in oilseed crops and amelioration practices for increasing crop production. In: Extended summaries, National Seminar On "Micro and Secondary Nutrients for Balanced Fertilization and Food Security" March 11-12, 2008, Anand Agricultural University, Anand pp. 42-44. Invited Lead paper.
- Radhakrishnan T, Misra JB, Rathnakumar AL, Bera SK, Chuni Lal, Hariprasanna K and Muralidharan V (2008) Biotechnological approaches to improvement of groundnut crop: challenges and opportunities (lead paper) National Seminar on Advances in Legume Research, Annamalai University, Annamalai Nagar, Tamil Nadu 6-7 March 2008

Technical bulletins/ Popular articles/ Training manual published

- Misra JB, Dey R, Pal K K, Chauhan S, Girdhar V and Jain VK (2007) Mungphali Ke Kuch Abhinav Vyanjan, National Research Centre for Groundnut, Junagadh, Gujarat
- Singh R, Tabatia BM, Nautiyal PC, Basu MS and Zala PV (2007-08) Rain-dependent groundnut cultivation: Problems and Prospects (in Gujarati), Published in ISOPOM Farmers participatory Project on Increasing Groundnut Productivity under Rainfed Conditions. A NRCG Publication.
- Satish Kumar GD, Devi Dayal, Prasad TV and Jain VK (2007). Akikrit keet prabandhan (IPM) se bhadege mungphali ki phydhavaar (Hindi). Krishi Chayanika, 3: 21-22
- Kumar GDS, Radhakrishnan T, Gedia MV and Savaliya SD (2008) Mungphalinu Uthpadhan Vadharva matena Vygnanik Paddathiya (Gujarati). Extension Bulletin. pp13.

PARTICIPATION IN CONFERENCE/ WORKSHOP/ SEMINAR/ SYMPOSIA/ MEETINGS/ TRAINING PROGRAMMES

Vinod Kumar

- Annual *Kharif* Groundnut Workshop held at Dharwad from 17th -19th April, 2007.
- Six-monthly Review Meeting of the Mycotoxin Network Project at IIVR, Varanasi during 24th -25th August 2007
- Annual Rabi/ Summer Groundnut workshop held at ICAR Research Complex, Goa, during 17-18th September 2007.
- 3rd Annual Review Meeting of the Mycotoxin Network Project held on 28th January 2008 at NCIPM, New Delhi

TV Prasad

- Participated and presented poster titled "Evaluation of some bio-pesticides against sucking pests of groundnut (*Arachis* hypogaea Lin.)". In First International Conference on "Agrochemicals Protecting Crop Health and Natural Environment" 8-11 January, 2008, IARI, New Delhi
- Participated and presented poster titled "Population dynamics of leafhopper, Balclutha hortensis L. in relation to abiotic factors groundnut ecosystem during different seasons in Saurashtra region of Gujarat." In International Symposium on "Agrometeorology and Food Security" 18-21 February, 2008, CRIDA, Hyderabad, 209 pp.
- National Conference on "Applied Zoology and Sustainable Development", 13-14 July, 2007, Indian Institute of Chemical Technology (IICT), Tarnaka, Hyderabad.
- *Kharif* groundnut workshop, held at UAS, Dharwad during 17-19 April, 2007
- Rabi/Summer groundnut workshop held at ICAR Research Complex, Goa, during 17 -18 September, 2007.

Radhakrishnan T

- Training workshop on capacity building on intellectual property protection and technology licensing in agriculture, Kerala Agricultural University (Indo-US Agricultural knowledge initiative) 17-20 Feb 2008
- Group meeting of groundnut research workers held at ICAR Research complex for Goa, 17-18 Sep 2007
- Project workshop of ISOPOM funded projects on FPRE and Seed systems, at ICRISAT , 23-24 Jan 2008
- Radhakrishnan, T, Misra, JB, Rathnakumar, AL, Bera SK, Chuni Lal, Hariprasanna K and V. Muralidharan 2008 Biotechnological approaches to improvement of groundnut crop: challenges and opportunities (lead paper) National Seminar on Advances in Legume Research, Annamalai University, Annamalai Nagar, Tamil Nadu 6-7 March 2008

R Dey

- Training programme "Safe vegetable production" at AVRDC, ICRISAT from 1st to 7th October' 2007

RS Jat

- Annual workshop (*kharif* and rabi-summer) of All India Coordinated Research Project on Groundnut.
- As a member of the National Level Monitoring Team of ISOPOM visited Karnataka State and assessed the progress.

- National Seminar on "Developments in soil science" at University of Agriculture Sciences, Bangalore from 27-30 November, 2008 and presented paper on "Use of boron for quality produce of groundnut in sandy soils".
- International Conference on grain legumes: quality improvement, value addition and trade, at IIPR, kanpur from 14-16 February, 2009 and presented paper on "Effect of organics on the productivity and economics of Spanish bunch groundnut under irrigated conditions

GD Satish Kumar

- 21 days training programme on Development of web applications for knowledge dissemination in Agriculture during 4th-24th March, 2008 held at Division of Computer Applications, Indian Agricultural Statistics Research Institute, New Delhi

STAFF LIST (31.03.2008)

1.	Dr. V. Muralidharan Dr. M.S.Basu	Director (from 22.11.2007) Director (upto 31.10.2007)
2.	Dr.J.B.Misra	Pr. Scientist, (Biochemistry)
3.	Dr.I.K.Girdhar	Pr. Scientist, (Soil Science)
4.	Dr.P.C.Nautiyal	Pr. Scientist, (Pl Physiology)
5.	Dr.A.L.Singh	Pr. Scientist, (Pl Physiology)
6.	Dr.T.Radhakrishnan	Pr. Scientist (Plant Breeding)
7.	Dr.A.L.Rathnakumar	Sr. Scientist (Plant Breeding)
8.	Dr.S.K.Bera	Sr. Scientist (Gen & Cytog)
9.	Dr.Chuni Lal	Sr. Scientist (Plant Breeding)
10.	Dr.K.K.Pal	Sr. Scientist (Microbiology)
11.	Dr.Rinku Dey	Sr. Scientist (Microbiology)
12.	Dr.G.D.Satish Kumar	Scientist(Extension)
13.	Shri G.Govind Raj	Scientist(Economics)
14.	Dr.T.V.Prasad	Scientist(Entomology)
15.	Dr. Hariprassana	Scientist(Pl. Breeding)
16.	Dr.Vinod Kumar	Scientist (Pathology)
17.	Shri V.V.Sumanth Kumar	Scientist. (Computer Application)
18.	Dr.R.S.Jat	Scientist(Agronomy)
19.	Dr.H.N.Meena	Scientist (Agronomy)
20.	Dr.R.S.Tomar	Farm Superintendent (T-6)
21.	Sh.V.K.Sojitra	T-6
22.	Sh.H.B.Lalwani	T-6
23.	Sh.C.P.Singh	T-6
24.	Sh. D.M.Bhatt	T-6
25.	Dr.D.L.Parmar	T-6
26.	Sh.H.M.Hingrajia	T-6
27.	Sh.N.R.Ghetia	T-6
28.	Sh.P.V.Zala	T-6
29.	Sh.Ranvir Singh	T-6
30.	Dr.S.D.Savaliya	T-6
31.	Sh.V.G.Koradia	T-6
32.	Sh.P.K.Bhalodia	T-6
33.	Dr.H.K.Gor	T-6
34.	Dr.J.R.Dobaria	T-6
35.	Dr.M.V.Gedia	T-6
36.	Sh.P.R.Naik	T-6
37.	Mrs.Veena Girdhar	T-6
38.	Mrs. V.S.Chaudhari	T-5

39.	Sh.Virendra Singh	T-5
40.	Sh. B.M.Chikani	T-5
41.	Sh.D.R.Bhatt	T-5
42.	Sh.R.D.Padvi	T-5
43.	Sh.S.P.Singh	T-5
44.	Sh.H.V.Patel	T-5
45.	Sh.V.K.Jain	T-5
46.	Sh.Prabh Dayal	T-4
47.	Sh.C.B.Patel	T-4
48.	Sh.Sugad Singh	T-3
49.	Sh.J.G.Kalariya	T-4
50.	Sh.K.H.Koradia	T-4
51.	Sh.A.M.Vakhariya	T-4
52.	Sh.G.J.Solanki	T-3
53.	Sh.P.B.Garchar	T-3
54.	Sh.N.M.Safi	T-3
55.	Sh.G.G.Bhalani	T-2
56.	Sh.B.M.Solanki	T-2
57.	Sh. Pitabas Das	T-2
58.	Sh.Josef John	Administrative officer
59.	Shri J.B.Bhatt	AAO
60.	Sh.R.T.Thakar	Asst
61.	Mrs. Rosamma Joseph	PS
62.	Sh.Y.S.Kariya	PA
63.	Sh.L.V.Tilwani	PA
64.	Mrs.Santha Venugolan	Astt
65.	Mrs.M.N.Vaghasia	UDC
66.	Sh.R.D.Nagwadia	UDC
67.	Sh.M.B.Kher	Security Supervisor
68.	Sh. H.S.Mistry	LDC
69.	Sh.C.G.Makawan	LDC
70.	Sh.P.N.Solanki	LDC
71.	Sh. N.M.Pandya	SSG-IV
72.	Sh.D.M.Sachaniya	SSG-IV
73.	Sh.R.B.Chawada	SSG-III
74.	Sh.C.N.Jethwa	SSG-III
75.	Sh.B.K.Bariya	SSG-III
76.	Sh.R.V.Purohit	SSG-II
77.	Sh.M.B.Shaikh	SSG-II
78.	Sh.K.T.Kapadia	SSG-II
79.	Sh.J.G.Agrawat	SSG-II
80.	Sh.V.N.Kodiatar	SSG-II

81.	Sh.R.P.Sondarwa	SSG-I
82.	Sh.G.S.Mori	SSG-I
83.	Sh.V.M.Chawada	SSG-I
84.	Mrs.D.S.Sarvaiya	SSG-I
85.	Sh.A.D.Makwana	SSG-I
86.	Sh.N.G.Vadher	SSG-I
87.	Sh.P.M.Solanki	SSG-I
88.	Sh.B.J.Dabhi	SSG-I
89.	Sh.C.G.Moradia	SSG-I

FOR THE YEAR 2007-2008

2. Staff Strength

Category of staff	Sanctioned	Filled	General	SC	ST	OBC
Scientific	39+01RMP	20	13	01	01	05
Technical	40	38	21	03	05	07
Admn.	14	13	08	02	0	03
SSS	19	19	04	05	03	07
Total	112+1	90	46	11	09	22

Discipline and grade wide sanction scientific positions

Discipline	Scientist	Sr. Scientist	Pr. Scientist	Total
Plant Breeding	04	02	02	08
Genetics & Cytogenetics	01	01	0	02
Economics Botany	01	01	0	02
Agronomy	02	01	01	04
Soil Science : Pedology	01	0	0	01
Soil Science :Soil Chemistry fertility/Microbiology	0	01	0	01
Plant Pathology	02	02	0	04
Agril.Entomology	02	01	0	03
Microbiology (PS)	02	01	0	03
Plant Physiology	02	01	0	03
Biochemistry (PS)	01	01	0	02
Agril. Statistics	01	01	0	02
Computer Application	01	01	0	02
Agril.Extension	01	0	0	01
Agril. Economics	01	0	0	01
Total	22	14	3	39

Financial Up gradation :-

DPC Held on 30.04.2008 for Tech. Staff, benefit 11 Employees.

DPC Held on 25.10.2007/26.10.2007 for SSG-I to LDC Benefit 01 Employee.

IMC :-
Chairman:- Dr. V.Murlidharan, Director, NRCG, Junagadh.
Members:-
Dr.R.A.Sherasia, Director of Agril. (Gujarat), Krishi Bhavan, Sector,10-A, Gandhinagar.
Shri Thakosalaraman, IAS, Dept. of Agril. Chepauk, Chennai,600 005, Tamil Nadu.
Dr.N.C.Patel, Dean, Collage of Agril. Engineering & Tech. JAU, Junagadh.
Shri Vinubhai Makad, Progressive farmer, Mundra-Kutch-Bhuj.
Shri Haridasbhai Bhikhabhai Zala, Progressive Farmer, Vadhavi-Junagadh.
Sr.FAO, CAZRI, Jodhpur.
Dr. Radhakrishnan T. NRCG, Junagadh.
Dr.V.S.Bhatia, Pr. Scientist, Plant Physiology,NRC for soyabean,Indore.
Dr.D.Kumar, Project Coordinator, Plant breeding AICRP,CAZRI,Jodhpur.
Dr.C.Chatopadhyaya, Pr. Scientist, Plant Pathology, NRC-R&M, Bharatpur.
Dr.D.B.Kuchedia, Director Research ,Agril. Economics, JAU, Junagadh.

Retirement:-
1. Dr. M.S. Basu, Director,NRCG, Junagadh. 31.10.2007

Institute Joint Staff Council:-
Chairman:- Dr.M.S.Basu, Director,NRCG Junagadh-362 001,Gujarat.
Members: Staff side:
Shri D.R. Bhatt, Secretary-IJSC and Membe CJSC
Shri Y.S. Kariya, Member
Smt.M.N.Vaghasia, Member
Shri Sugad Singh, Member
Shri B.K. Baria, Member
Shri C.N. Jethwa, Member

Members:- Office side:
Dr. J.B. Misra, Pr. Scientist, Secretary, NRCG, Junagadh.
Dr. R. Day, Sr. Scientist, NRCG, Junagadh.
Dr. Chuni Lal, Sr. Scientist, NRCG, Junagadh.
Shri C.P.Singh, T-6
AO, NRCG, Junagadh

FINANCE AND ACCOUNTS

Expenditure Statement for the year 2007-08

NRCG Main Unit **Rs. In Lakhs**

Sr. No.	Budget Head	Non Plan			Plan		
		BE	RE	Expenditure	BE	RE	Expenditure
1	Establishment charges	195.10	208.00	207.42	0.00	0.00	0.00
2	Wages	15.00	17.60	18.90	0.00	0.00	0.00
3	Loans & Advances	3.00	5.00	2.78	0.00	0.00	0.00
4	Pensions	1.00	25.00	25.50	0.00	0.00	0.00
5	T.A.	4.50	5.00	4.62	15.00	13.00	12.80
6	Recurring Contingencies	13.78	30.65	27.54	126.00	57.00	81.10
7	Works	0.00	0.00	0.00	27.00	10.00	4.13
8	Equipments	16.62	16.62	16.62	55.00	97.00	83.55
9	Furniture	0.00	0.00	0.00	10.00	5.00	0.47
10	IT	0.00	0.00	0.00	0.00	0.00	0.00
11	Books	0.00	0.00	0.00	16.00	16.00	12.82
12	HRD	0.00	0.13	0.13	0.00	2.00	0.16
	Total	249.00	308.00	303.51	249.00	200.00	195.03

AICRP-G

Sr. No.	Budget Head	RE 2007-08	Expenditure
1	Pay and Allowances	339.50	339.26
2	TA	6.90	6.90
3	Contingency	27.60	27.6
4	Non Recurring contingencies	0.00	0
5	HRD	0.00	0.00
6	Need Based Research	6.00	2.49
7	Pay and Arrear (VI pay comm.)	0.00	0.00
8	TSP	0.00	0.00
	Total	380.00	376.25