

वार्षिक प्रतिवेदन

ANNUAL REPORT
2011-12



मूँगफली अनुसंधान निदेशालय

पो. बो. नं. 5, जूनागढ - 362 001, गुजरात, भारत

Directorate of Groundnut Research

P. B. No. 5, Junagadh - 362 001, Gujarat, India

वार्षिक प्रतिवेदन

ANNUAL REPORT

2011-12

मूँगफली अनुसंधान निदेशालय
Directorate of Groundnut Research
(Indian Council of Agricultural Research)
P. B. No. 5, Ivnagar Road, Junagadh, Gujarat, India

Citation:

**Annual Report 2011-12, Directorate of Groundnut Research,
Junagadh-362001, Gujarat, India**

Editors:

**Dr. R. Dey
Dr. G. P. Mishra
Dr. J. B. Misra**

Technical assistance:

Dr. M. V. Gedia

Cover illustration:

**Groundnut crop in farmer's field
Polythene mulch technology for groundnut
A rich-harvest of groundnut**

Published by:

**Director
Directorate of Groundnut Research
P.O. Box 5, Ivnagar Road,
Junagadh-362001, Gujarat, India**

Printed at:

**Radhika Printers, Ahmedabad
Cell: 90999 11136, 90992 58738**

P r e f a c e

The year 2011-12 has been an outstanding year for Indian agriculture. The rainfall has been plentiful and the country reaped a bountiful harvest with a record total foodgrains production of 257.44 million tons. Although the area under groundnut shrunk to a record low of 4.19 million ha with a production of 5.62 million tons the average productivity was relatively high 1341 kg ha⁻¹ compared to those of previous three years. The export of groundnuts from India during April-November, 2011 increased to 452070 tons from 239110 tons during the same period previous year recording an impressive growth rate of 89.06%. In value terms the export of groundnuts recorded an exciting growth of 154.64% reaching a level of ₹3000.70 crores during April-November, 2011 from ₹1178.39 crores during previous year.

Quite like 2010-11, the rainfall in Junagadh was excessive in 2011-12 too and as a result several field experiments were ruined. This however, could not deter the scientists from pursuing their other experiments.

For the first time at this research institution, a workshop of the stakeholders in groundnut was organized at this directorate on 15th December 2011 to identify the areas of research to address the need of farmers, traders, exporters and above all the consumers.

In this year one genotype 'RG 510' was identified at the AICRP-G workshop held at MPUA&T, Udaipur and was subsequently notified for release by Govt. of India. In addition, two genotypes 'ICGV 00350' and 'HNG 123' identified earlier were also notified for release. During this year a total of 20184 q breeder seed comprising 61 varieties was produced.

Utilization of the grants was to the tune of ₹399.93 lakhs under head 'Plan' and ₹713.40 lakhs under the head 'Non-Plan' for DGR and ₹941.58 lakhs for AICRP-G, nearly cent per cent utilization. In addition, the funds received through the externally funded projects were also utilized effectively.

All the scientists and a few other officials have contributed the material for compilation of this report. Dr. R. Dey and Dr. G.P. Mishra took upon their shoulders the responsibility of compiling, editing and overseeing the printing. I place on record my sincere appreciation of the efforts made by Dr. Dey and Dr. Mishra.

I compliment the scientists of DGR as well as those of AICRP-G on their accomplishments described in this report and feel extremely happy in presenting this Annual Report of DGR for year 2011-12. I shall be grateful to receive comments from the readers on the content and style of presentation.

J. B. Misra
Director

CONTENTS

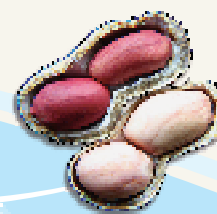
	Page
Executive Summary	I to VIII
Project 01: Breeding and genetic studies on tolerance of biotic and abiotic stresses in groundnut	01
Project 02: Integrated pest management (IPM) in groundnut based production system	15
Project 03: Physiological studies on environmental stresses in groundnut	22
Project 04: Microorganisms in relation to soil health and plant nutrition in groundnut	28
Project 05: Management of mineral nutrition and associated stresses in groundnut	34
Project 06 : Development of sustainable packages of practices for groundnut based cropping systems	45
Project 07: Management of existing and emerging problems of soil and water salinity for groundnut production	54
Project 08: Management of germplasm of cultivated groundnut (<i>A. hypogaea</i> L.) and its wild relatives	57
Project 09: Biotechnological approaches to the characterisation and genetic enhancement of groundnut	60
Project 10: Assessment and enhancement of quality in groundnut and its value added products	65
Project 11: Biotransformation of groundnut by-products into useful products	67
Project 12: Prevention and management of mycotoxin contamination in groundnut	69
Project 13: Impact assessment of improved groundnut production technologies: sustainable livelihood analysis	70
Project 14: Breeding for large-seeded and confectionery groundnut	73
Project 15: Utilization of wild <i>Arachis</i> gene pools for groundnut improvement	79
Project 16: Economic analysis of production, processing and utilization of groundnut in major groundnut growing states of India	86
Project 17: Breeding for improved fodder quality traits in groundnut	93
Project 18: Development of statistical models for evaluation of field trials on groundnut crop and determination of scenarios in area, production and yield	94
All India Coordinated Research Project on Groundnut	96
Achievements of externally funded projects	103
Publications	117
Human resource	127
Meetings	132
General information	134
Finance and Accounts	136

Executive Summary

CROP IMPROVEMENT

Summer 2011:

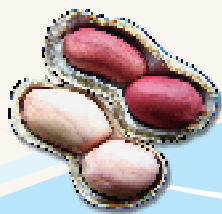
- Of the seven early-maturing Virginia lines evaluated, six were identified as high-yielding too.
- Under high-input conditions with a high-dose of phosphorus, three genotypes viz., NRCGs 10078, 7085 and 10107 were identified as P-responsive while under low-input conditions with low-phosphorus, NRCG 15049 was identified as P-responsive.
- From the ten cross combinations generated during *khariif* 2010 as many as 138 single plant progenies were selected for further generation advancement.
- In Spanish group trial, PBS 19022 line was identified as the best line for pod yield (20.5 g plant⁻¹), harvest index (36.7), hundred-kernel weight (64 g), seed count in 100 g (163), sound mature kernel (78%) and sugar content (12%).
- Seeds of six promising interspecific genotypes (CS 268, CS 281, CS 401, CS 253, CS 287 and CS 264) were multiplied and 35 kg pods genotypes⁻¹ were supplied to AICRP-G centres for evaluation.
- Out of eight advanced breeding lines evaluated for colonization by *A. flavus* on pod and kernels, two genotypes i.e. PBS 22065 and PBS 22067 did not support any infection.
- Upon phenotyping, wide variations were observed among 188 RILs of a mapping population for the traits related to early maturity, seed and pod yield, and water-use efficiency.
- Among the mutants of TAG 24 evaluated in sick plot, the observed incidence of stem rot was none in six families; <10% in four families; <20% in 26 families and <30% in three families. Among the individual genotypes, 21.6% incidence was seen in an inter-specific hybrid derivative VG 0107, 26.5% in advanced breeding line PBS 14060 and 27.3% in another advanced breeding line PBS 14064- these three genotypes were identified as the promising ones.
- Among the 66 Spanish mini-core accessions screened in sick plot for their reaction to *S. rolfisii*, NRCG 10107 recorded the maximum disease incidence (72.4%). Even under this disease pressure, the incidence of disease was below 20% in four accessions viz. NRCGs 14380 (13.8%), 14405 (16.7%), 14409 (17.4%) and 14383 (18.5%). Four other accessions which showed diseases incidence below 30% were: NRCGs' 14472, 14474, 14414, and 14424.
- Twenty-eight genotypes (12 released varieties, 7 accessions of ICRISAT mini-core collection and 9 accessions of subset of NRCG working collection) which exhibited low $\Delta^{13}\text{C}$ values (≈ 18.0) were studied for yield and its components. The pod yield plant⁻¹ under irrigated conditions was in the range of 3 g (NRCG 666) to 20.5 g plant⁻¹ (ICGV 86590) while under water deficit stress it was from 1.6 g (NRCG 12138) to 8.9 g plant⁻¹ (ICGV 86590).



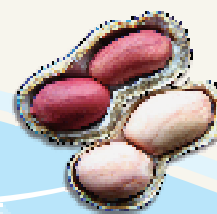
- Among the genotypes identified to be promising the reduction in pod yield due to moisture deficit stress was in the range of 25.7% to 56.6%. The causes of loss of yield appeared to be a reduction in number of pods per plant and 100-seed mass.
- Twelve accessions comprising four each of Virginia bunch and Spanish types and two each of Virginia runner and Valencia types were assessed for SCMR and specific leaf nitrogen content at 60, 80 and 100 DAS. The mean SCMR showed a decreasing trend while the mean specific leaf nitrogen content exhibited increasing trend over the three growth stages studied viz 60, 80 and 100 DAS.
- The correlation coefficients for the values of SCMR recorded at three different stages of crop growth indicated the relationship was direct and significant between the growth stages. While for nitrogen content, significant and direct correlation was observed only between the values for 60 DAS and 80 DAS and for the values of other growth stages, though inverse, the relationship was non-significant.
- The true assessment of nitrogen content in the fodder can be made only at the time of harvest and there was no significant relationship between SCMR and specific leaf nitrogen content.

Kharif 2011:

- Emanating from different breeding programmes 182 advanced breeding lines were maintained.
- For incorporating resistance/tolerance of different abiotic stresses or nutrient-use efficiency into the superior agronomic backgrounds 20 fresh crosses were attempted.
- One preliminary yield evaluation trial and one advanced evaluation trial for each of Spanish and Virginia advanced breeding lines were conducted.
- Ten crosses were made to develop varieties resistant/tolerant to diseases, pests and invasion by aflatoxin producing fungus with 18.6% to 55.5% hybridization success rate. Top three crosses in which maximum success rate for hybridization is found were ICGV 00350 x R 8808 (55.5%), ICGV 00350 x J 11 (53.1%) and TG 37 A x CS 19 (49.7%).
- Six mapping populations (in different filial generations), which were developed for resistance to stem rot or multiple diseases, were raised.
- Seeds of five elite advanced breeding lines viz.: PBS 22059, PBS 22066, PBS 22067, PBS 22062 and PBS 22063 were multiplied to obtain sufficient quantity of seeds for multi-location testing under AICRP-G.
- The breeding material (F_4 to F_6) of eight different crosses of three segregating generations was supplied to eight hot spot centres of AICRP-G to effect location specific selections for resistance/tolerance of different biotic stresses.



- Eleven crosses were attempted to incorporate the trait of large-seed along with high yield and other confectionery traits for which 2438 buds were pollinated and 476 probable hybrid pods were harvested.
- In the yield evaluation trial for Virginia group, pod yield of two entries i.e. PBS 29148 and PBS 29152 (8.3 g and 8.0 g plant⁻¹, respectively) was found to be superior to that of the check (M 13). These entries were also superior for other traits like hundred kernel weight, sound mature kernels, hundred sound mature kernels, kernel- length and kernel-width.
- Out of eighty-eight advanced breeding lines developed for resistance/tolerance to biotic stress, 38 were of Spanish type and 50 of Virginia type. The material is being maintained and multiplied for further screening at respective hot spots for resistance/tolerance of biotic stresses.
- Seventeen new advanced breeding lines were developed from F₆ and F₇ generations, among which 15 lines belonged to Virginia group and 2 lines to Spanish group.
- So far, 67 advanced breeding lines for large-seed size coupled with other confectionery traits have been developed and are being maintained. Among the 16 lines evaluated, 13 were identified for kernel quality traits but none of these lines were superior to the check variety (M13) in the yield.
- In preliminary yield evaluation trials, one Spanish (PBS 14078), and five Virginia (PBS 24106, PBS 24114, PBS 24116, PBS 24130 and PBS 25033) lines were found promising. In advanced yield evaluation trials, one Spanish (PBS 16044), and five Virginia (PBS 25015, PBS 25017, PBS 25049, PBS 25051 and PBS 25053) lines were found promising.
- Amongst the Spanish types, the yield of variety TG 37A was the highest a variety that is already popular in Saurashtra region and is fast replacing the variety GG 2.
- Segregating materials generated from six crosses (using the parents having confectionery traits) were sent to four AICRP-G centers for site specific selection.
- Spanish bunch genotypes (37) and 4 checks (GG 7, TAG 24, TG 26 and TG 37A) were evaluated and pod yield of test genotypes did not differ significantly from that of the best check (GG 7). Genotype CS 396 was found promising for high pod yield, SHT, HKM, SMK and SCMR.
- PBS 29146 was significantly superior in respect of hundred kernel weight (53 g), sound mature kernel (93%), hundred sound mature kernel (65 g), and kernel length (17 mm) and width (9.2 mm). PBS 19024 was identified for high protein content (28.2%) and total biomass production. Another line PBS 19018 was identified for high sugar content (10.5%).
- For the varieties Girnar 2 and Girnar 3 a total of 231 kg nucleus seed was produced.

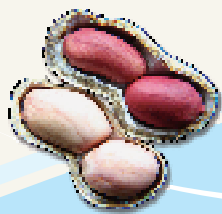


- Progenies of five crosses and 12 back crosses were evaluated for resistance to PBND, stem-rot and foliar diseases. 384 single plant selections were made from 22 (F_4 and BC_2) populations.
- One-hundred wild *Arachis* accessions belonging to six different sections viz.: *Arachis* (54), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (7), *Procumbentes* (6) and *Rhizomatosae* (40) were maintained in the field gene bank and 9024 accessions under working collection were conserved in the medium term cold storage module.
- Including wild relatives of groundnut, 2670 germplasm accessions were supplied to 41 indenters for use in the crop improvement programme. These germplasm accessions were supplied to the scientists of DGR (817), State Agricultural Universities (1786) and AICRP-G centres (50) to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and to use in crossing programmes. Fourteen accessions (4 released varieties and 10 amphidiploids) were newly acquired.
- In summer 189 diverse germplasm accessions and in *kharif* 1211 accessions were multiplied.
- Among 308 RILS ('GG 20 x CS 19') evaluated in summer and *kharif* 2011 (for incidence of stem rot and PBND), for stem rot as many as 155 genotypes were found to be resistant and 68 susceptible whereas for PBND, 197 were resistant and 35 susceptible.
- The transgenic event carrying the *Rs-AFP2* genes were confirmed and the transgenic events carrying the *mtlD* gene were characterised for their physiological responses to imposed salt and water stress. The expression of the CP genes of PBNV and NC gene of TSV in the transgenics were assayed by real time PCR.
- Along with susceptible check KRG 1, as many as 115 breeding lines identified earlier for being resistant to PBND, were subjected to molecular marker analysis using 20 SSRs.
- The Plant Germplasm Registration Committee (PGRC, NBPGR) approved the registration of four lines which are resistant or tolerant to rust, ELS, LLS, stem rot and PBND.

CROPPRODUCTION

Summer 2011:

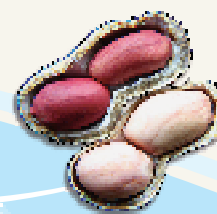
- The pod and haulm yields of groundnut increased significantly with one or the other treatment i.e. with application of polythene mulch –11.3% in pod and 20.5% in haulm ; application of hydrogel @ 2.5 kg ha⁻¹ – 6.0% in pod and 10.7% in haulm; and application of FYM @ 2 t ha⁻¹ –20.1% in pod and 12.4% in haulm; integrated application of organic manures, inorganic fertilizers and biofertilizers –10.2% in pod and 8.6% in haulm over those of RDF for inorganic fertilizers.



- The combined application of ammonium sulphate:SSP:MOP (40:60:60 kg) and Fe:Zn:B (10:2:1 kg) ha⁻¹ resulted in significantly higher pod and haulm yields over the other 13 treatments and was at par with treatment containing micronutrients and 25:50:0 kg recommended N:P:K + 5 t FYM + 500 kg gypsum ha⁻¹.
- Application of sulphur significantly improved the pod yield irrespective of its source (gypsum, cosavet and SSP) and levels (20, 40 and 60 kg S ha⁻¹).
- Application of 37.5 kg N, 70 kg P₂O₅ and 30 kg K₂O ha⁻¹ was found effective in improving summer groundnut yield as well as soil fertility over RDF (25:50:0 kg N:P:K ha⁻¹).
- Application of irrigation water either at 6-day intervals through drip and 15-day intervals with check basin method resulted in saving of 15.4% and 26.0% water over 4-day intervals through drip and 15-day intervals under check basin respectively.
- Application of potassium @ 30 kg K₂O ha⁻¹ exhibited an ameliorative effect on the imposed water salinity

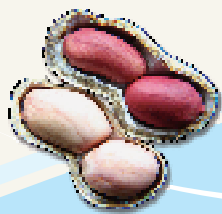
Kharif 2011:

- The pod yield of groundnut increased significantly with one or the other treatment i.e. with application of 75% N:P:K through drip —13.2%; under polythene mulch—43.1%; with the application of Hydrogel @ 1.5 kg ha⁻¹ —17.6%.
- Among the various combinations of different sources of nutrients the highest pod yield (1506 kg ha⁻¹ pod yield) was obtained with the combination of 40: 60: 60 kg ha⁻¹ (Urea: DAP: MOP) + 250 Kg ha⁻¹ gypsum + 10:2:1 (Fe: Zn: B).
- Application of 75% of the recommended doses of NPK through drip significantly enhanced the pod and haulm yields by 16.8 and 15.1%, respectively over that of 50% NPK through drip. Thus, there was a savings of 25% in the requirement of NPK fertilizers.
- Saline water (0.5 to 6 dS m⁻¹) was used for irrigation in groundnut–cowpea rotation for one year. It was concluded that 2-3 dS m⁻¹ salinity of water was the threshold salinity for economic yield of groundnut but the yield was highest with normal water (0.5 dS m⁻¹).
- In comparison to 13 other combinations, the combined application of '60 kg N, 100 kg P₂O₅, 125 kg K₂O, 200 kg Ca, 50 kg S, 60 kg Mg, 5 kg Zn and 2 kg B ha⁻¹' resulted in highest pod and haulm yields and also the highest soil N:P:K status after harvest.
- Among the eight Spanish cultivars, with the use of poor quality (saline) water for irrigation, the pod and haulm yields of TPG 41 (1128 kg ha⁻¹) and R 2001-3 (2413 kg ha⁻¹) were significantly higher than those of the other cultivars.
- Application of 25 kg N, 60 kg P₂O₅ and 30 kg K₂O ha⁻¹ significantly improved the productivity over the RDF (i.e. 12.5: 40: 0; N: P: K kg ha⁻¹).



CROPPROTECTION

- Among the nine intercrops, the smallest jassid population (4.5 five-sweeps⁻¹) was recorded in 'groundnut + bajra' while the smallest thrips population (3.6 five-sweeps⁻¹) was recorded in 'groundnut + soybean'.
- In *kharif*, the seed-treatment with imidacloprid @ 5.0 g kg⁻¹ not only lowered the incidences of jassid and thrips but also resulted in giving the highest pod yield (2612 kg ha⁻¹). In *rabi* season too, this treatment lowered the incidences of these pests and resulted in good yield (1788 kg ha⁻¹). Amongst the seven insecticides evaluated, the lowest jassid (3.2 five-sweeps⁻¹) and thrips (1.5 five-sweeps⁻¹) populations were recorded with the application of acetamiprid 20SP.
- The sprays of 0.01% thiomethoxam 25WG at 30 and 45 days after germination were found to be the most effective in controlling jassids (1.9 five-sweeps⁻¹) and thrips (4.3 five-sweeps⁻¹) populations. The highest pod yield (1995 kg ha⁻¹) was recorded with two sprays (30 and 45 DAG) of 0.05% acetamiprid 20SP.
- During storage the lowest pod damage (7.6%) by bruchid beetle was recorded in groundnut genotype T 28 while the lowest loss of weight (8%) was recorded in BG 3.
- In *kharif*, the lowest severity of foliar diseases (ELS, LLS, rust and *Alternaria* leaf blight) was observed with two sprays (45 and 60 DAS) of difenoconazole @ 0.025%, which was followed by two sprays of tebuconazole @ 0.375%.
- In Saurashtra, during summer, the severity of *Alternaria* disease observed in farmers' field was up to 20%. In *kharif*, occurrences of foliar diseases viz., early leaf spot, late leaf spot and rust were to the extent of 40-60%, 40-70% and 60-80%, respectively in the farmers' field surveyed.
- Amongst the genotypes screened for resistance to stem rot, CS 402 was found the best in summer while CS 409 was found the best in *kharif*. For collar rot, three genotypes (CS 421, CS 426 and CS 428) were identified to be tolerant in summer while nine genotypes (CS 422, CS 364, CS 427, CS 386, CS 377, CS 432, CS 433, CS 421, and CS 431) were identified to be tolerant in *kharif*. In summer, application of arbuscular mycorrhizal fungi in seed-furrows brought down the incidence of stem rot from 80.5% (untreated plots) to 29.4% (treated plots).
- Occurrence of several plant parasitic nematodes viz; *Helicotylenchus* spp., *Tylenchorhynchus* spp., *Pratylenchus* spp., *Rotylenchulus reniformis*, *Meloidogyne arenaria* and *Xiphinema* spp. was detected in groundnut fields in Rajkot district (Gujarat).
- In the long-term crop rotation experiment with maize, sorghum, groundnut, fallow land, soil population of *A. flavus* decreased after harvest of the summer crops. Soil population of *A. flavus* was lower at the time of harvest than that at the time of sowing. In summer produce, the seed infection by *A. flavus* was 6.7% and aflatoxin load was 8.9 ppb (µg kg⁻¹ kernel). Whereas, in *kharif* produce, the seed infection was 2.5, 6.7, 2.5, and 8.3% in groundnut crop grown in maize,



sorghum, fallow, and groundnut rotation plots, respectively with the corresponding values of 0.2, 2.6, 3.3 and 3.0 ppb for aflatoxin load.

BASIC SCIENCES

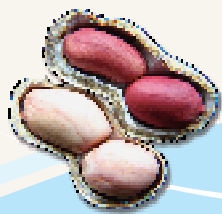
- Among six varieties evaluated, TAG 24 and ICGS 44 were identified to be the most drought-tolerant in summer season and were characterized by having high membrane stability during water-deficit stress. Variety TAG 24 showed a good capacity of recovering from stress while the damage due to photo-inhibitory action was the minimum in ICGS 44.
- Production of reactive oxygen species (ROS) and lipid peroxidation was more when water deficit stress was imposed at flowering and pod development stages than the other stages. Varieties, SG 99 and DRG 1 showed high ROS production as well as lipid peroxidation under water deficit stress. Under water-deficit stress, the decrease in membrane stability index and RWC was comparatively less in Virginia runner genotypes.
- Phosphorus, potassium, boron and zinc were found to be vital for proper pod-filling and obtaining proper seed size. Nickel and cobalt enhanced nodulation and pod yield even if applied at very low levels of 0.05 and 0.10 kg ha⁻¹, respectively. The seed dressing with molybdenum exerted a synergistic effect with Ca, K and P in groundnut. Among 171 cultivars evaluated, 10 high-Fe density and 17 high-Zn density cultivars were identified. Foliar application of ZnSO₄ enhanced the Zn content of groundnut seeds.
- Four groundnut cultivars (GG 7, GG 20, ICGS 76 and CSMG 84-1) were found high yielding and this region was found conducive for cultivation of large-seeded cultivars (BAU 13, GG 20, CSMG 84-1 and ICGS 76). In Nagaland, either only organic or 50% organic + 50% NPK was best for pod yield compared to other combinations evaluated. In Mizoram, maximum pod yield was obtained with a combination of P₅₀ + K₅₀ + Lime_{2.5 (tha⁻¹)} + boron + molybdate in bold-seeded groundnut variety ICGS 76 and application of foliar spray of Chemiebore (2 kg ha⁻¹) was found to be superior to soil application. Intercropping of groundnut with maize, rice, sesamum and mung was feasible in this region.
- Thirty-one popular varieties were analyzed for oil content which was in the range of 46.7% (CSMG 84-1) to 52.9% (GG 20) with a mean of 50.5%. The stability index (O/L) of these varieties was in the range of 0.94 (13ICGV 91114) to 2.73 (BAU). The varieties GG 20, TKG 19A and Mallika were identified for having high oil (>52%) and high O/L (>2) ratio.
- Contents of glucose, sucrose, and RFO's in Spanish group of DGR mini-core germplasm were in the range of 10 to 210 mg 100g⁻¹, 4.87 to 14.57 g 100g⁻¹ and 0.09 to 4.88 g 100g⁻¹, respectively. The content of RFO's (flatus sugars) in the germplasm lines was not linked with any other biochemical parameter studied; hence new varieties can be developed with low RFO's without much difficulty. Tolerance to drought stress has a negative impact on quality of groundnut genotypes.



- Application of AM fungi, *Glomus mosseae*, resulted in increase in yield by 13%. Inoculation with the newly isolated strains of groundnut rhizobia RH11, RH17 and RH20, enhanced the pod yield of cultivar TG 37A and the strain RH11 was adjudged to be the best.
- Application of DAPG-producing fluorescent pseudomonads enhanced pod yield by 13%.
- Among various carriers and methods evaluated for delivery of microbes, charcoal was found to be the best carrier with an enhancement in pod yield by 16%.
- For the production of proteases by microbial action on de-oiled groundnut cake eight proteolytic bacterial cultures were evaluated. Presence of Ni, Cu and Fe in the assay medium enhanced the activity of the protease produced by *Brevibacillus halotolerans* P6 and *Bacillus subtilis* subsp. *subtilis* SP8-14. Presence of Ni at 1.5 mM concentration, enhanced the activity of the enzyme produced by P6 up to 22 times and at 0.5 mM concentration enhanced the activity of enzyme produced by SP8-14 by 15 times.

SOCIALSCIENCES

- In the opinion of the farmers, during summer there was 20% yield advantage with TG 37A over GG 2, due to better germination and formation of a larger number of pods per plant. Compared to GG 2, the plants of TG 37A suffered much lower incidence of diseases and pests. With TG 37 A, there was an increment of 9.6% in the gross returns and 7.4% increment in the net returns. The survey also indicated that only 7% of the farmers replaced their seed every year, while 10% replaced it in the third year and 83% in the fourth year.
- Polynomial regression models of 2nd order were validated to study the trends in area, production and productivity of groundnut of 16 states of India besides analysing the trends in area of a few other crops grown in major groundnut growing states. The analysis indicated that the gain in area under cotton was the main factor behind the loss of area under groundnut in some of the major groundnut growing regions in Gujarat, Tamil Nadu, Andhra Pradesh and Madhya Pradesh while the trends in area of cotton did not have any bearing on the trend in area of groundnut crop in Karnataka, Rajasthan and Maharashtra.
- Survey conducted in Gujarat and Andhra Pradesh indicated that the extent of mechanization in groundnut is relatively high in Junagadh (Gujarat) than in Anantpur (Andhra Pradesh). Yet in both the states, considerable scope exists to enhance mechanisation to enable the farmers complete the operations in time.
- Another survey indicated that the average size of the farms growing organic groundnut was 3.3 ha whereas it was 3.8 ha for the conventional farms. A relatively large number of effective workers were there in the families of farmers opting for organic cultivation which corroborated to the fact that organic cultivation is more labour intensive in groundnut. Among the factors that motivated the farmers to adopt organic cultivation were the improvement in soil quality and avoidance of hazards of inorganic cultivation rather than higher monetary benefits.



PROJECT 01: BREEDING FOR TOLERANCE OF BIOTIC AND ABIOTIC STRESSES IN GROUNDNUT

(CHUNI LAL, A. L. RATHNAKUMAR, NARENDRA KUMAR, AJAY B.C., A. L. SINGH, K. S. JADON AND HARISH G.)

Sub-project 01: Breeding for tolerance of abiotic stresses in groundnut

(CHUNILAL, AJAY B.C. AND A.L. SINGH)

Hybridization

During *kharif* 2011, twenty crosses were attempted for incorporating traits like tolerance of different abiotic stresses, nutrient use-efficiency and yield attributes. On an average the success rate was 28% (Table 1).

Table 1. Cross-wise pollinations attempted, hybrid pods harvested (*kharif* 2011)

Cross	Trait of interest	Buds pollinated (no.)	F ₁ pods harvested (no.)	Crossing success (%)
Girnar 2 x Girnar 3	Fresh seed dormancy	270	97	35.9
Girnar 2 x Girnar 1	Drought tolerance	244	93	38.1
Girnar 2 x PBS 14081	High yield and pod number	222	69	31.1
PBS 14081 x TMV 2 NLM	Drought tolerance (high SCMR)	234	58	24.8
PBS 14081 x PBS 15031	High HI	256	75	29.3
Girnar 3 x NRCG 14425	Uniform maturity	229	73	31.9
PBS 14081 x NRCG 14405	High shelling	214	73	34.1
PBS 21087 x CS 1	Drought tolerance (low SLA)	228	51	22.4
PBS 16038 x CS 1	Drought tolerance (low SLA)	272	60	22.1
JAL 24 x ICR 3	Drought tolerance	309	92	29.8
Girnar 3 x FDRS 10	Nutrient use-efficiency	265	93	35.1
TG 37 A x FDRS10	Nutrient use-efficiency	212	105	49.5
GPBD 4 x FDRS10	Nutrient use-efficiency	78	10	12.8
GG 20 x FDRS10	Nutrient use-efficiency	68	14	20.6
TPG 41 x FDRS10	Nutrient use-efficiency	171	34	19.9
Girnar 3 x NRCG 7320	Nutrient use-efficiency	179	50	27.9
TG 37 A x NRCG 7320	Nutrient use-efficiency	123	46	37.4
GPBD 4 x NRCG 7320	Nutrient use-efficiency	82	15	18.3
GG 20 x NRCG 7320	Nutrient use-efficiency	59	16	27.1
TPG 41 x NRCG 7320	Nutrient use-efficiency	234	38	16.2
	Total	3949	1162	29.4



Selection and generation advancement in F₂ and onwards

Although the rains continued up to November in *kharif* 2011, which affected the yields adversely, yet selections were made in different generations and the selected segregating materials were advanced to the next respective generations. Thirteen new advanced breeding lines – eight in F₇ and five in F₈ filial generations – were identified.

Maintenance breeding

One hundred and eighty-two advanced breeding lines developed for different breeding objectives were maintained in *kharif* 2011 for their further utilization in the groundnut improvement programmes.

Station yield evaluation trials

In these trials, observations were recorded on days to flower initiation (DF_i, d), days to 50% flowering on plot basis (DF₅₀, d), SPAD chlorophyll meter reading (SCMR), specific leaf area (SLA, cm² g⁻¹), days to maturity (DM, d), pod yield (PY, kg ha⁻¹), kernel yield (KY, kg ha⁻¹), 100-kernel weight (HKW, g), weight of hundred sound mature kernels (HSMK, g), sound mature kernels (SMK, %), shelling out-turn (SOT, %). The performance of advanced breeding lines evaluated in different trials is discussed trial-wise below.

Preliminary yield evaluation trial of breeding lines of Spanish groundnut

Twenty-seven Spanish advanced breeding lines along with three check varieties (GG 2, GG 7 and TG 37A) were evaluated in an RBD trial with three replications, for yield and its components, besides surrogates of water-use efficiency (SLA and SCMR). The plot size was of five rows each of 5 m length. The row-to-row spacing was 45 cm and plant-to-plant spacing within a row was 10 cm. ANOVA indicated highly significant differences due to genotypes for all the traits studied. Among the check varieties, the highest SCMR, the lowest SLA, the highest pod yield and SMK were observed in TG 37A. For early initiation of flowering, KY, HKW, HSMK and SOT, the check variety GG 7 was found to be the best. Among the test entries, significantly higher SCMR was observed in PBS 11085, PBS 14078 and PBS 15027. Significantly higher pod yield was recorded in advanced breeding line PBS 14078 only. Significantly higher HKW and HSMK were observed in four lines viz., PBS 11085, PBS 11092, PBS 15023 and PBS 15027. Besides, significantly superior HSMK was recorded in the line PBS 14080 also. For rest of the traits, none of the test entries was found superior to the respective best check variety (Table 2).



Table 2. Performance of selected advanced Spanish breeding lines for SCMR, SLA, and yield in preliminary yield evaluation trial (*kharif*2011)

Genotypes	Traits									
	DF ₁	DF ₅₀	SCMR	SLA	PY	KY	HKW	HSMK	SMK	SOT
<i>Test entry</i>										
PBS 11085	25	28	33*	199	778	435	30*	38*	35	56
PBS 11092	26	28	30	195	1211	783	32*	43*	41	65
PBS 14078	29	33	32*	197	1310*	747	26	34	31	57
PBS 14080	26	29	28	192	744	419	28	38*	44	56
PBS 15023	25	28	31	180	749	472	35*	43*	52	63
PBS 15027	28	33	32*	182	1220	797	30*	41*	43	65
<i>Check</i>										
GG 2	25	27	28	205	420	258	18	23	33	62
GG 7	25	27	27	237	1028	658	27	34	47	64
TG 37 A	26	30	28	186	1049	617	23	33	48	58
CV (%)	8	4	7	10	17	18	7	7	17	4
CD (5%)	3	2	4	30	229	147	3	3	10	4

Advanced yield evaluation trial of breeding lines of Spanish groundnut

Twelve advanced breeding lines of Spanish type along with three check varieties (GG 2, GG 7 and TG 37A) were evaluated in *kharif* 2011 in an RBD design with three replications, for yield traits, besides surrogates of water-use efficiency (SLA and SCMR). The plot size was five rows each of 5 m length. The row-to-row spacing was 45 cm and plant-to-plant spacing within a row was 10 cm. ANOVA indicated highly significant differences due to genotypes. For the traits SCMR, PY, KY, HKW and SMK, the check variety TG 37A was found to be the best. The lowest SLA and the highest SOT were recorded in GG 2, whereas for DF₁, DF₅₀ and SMK, GG 7 was adjudged to be the best check variety. When compared with the best check variety for a given trait, the test entry PBS 16044 performed significantly superior for the traits namely, SCMR, SLA, PY, KY, HKW, HSMK and SMK. The test entry PBS 14068 performed significantly superior for KY, HKW and SMK, and PBS 15032 for SMK. Significant and superior performance of the line PBS 16039 was observed for the traits SCMR, SLA and HSMK. SE 8 was found significantly superior for HKW and HSMK. For DF₁, DF₅₀ and SOT none of the entries outperformed the respective best check variety for these traits (Table 3).



Table 3. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield in advanced yield evaluation trial (*kharif*2011)

Genotypes	Traits									
	DF _i	DF ₅₀	SCMR	SLA	PY	KY	HKW	HSMK	SMK	SOT
<i>Test entry</i>										
PBS 14068	26	29	32	178	1211	840*	34*	45*	29	69
PBS 15032	23	26	31	205	920	604	26	36*	22	66
PBS 16039	25	29	34*	161*	937	540	28	37*	24	58
PBS 16044	27	30	36*	173*	1343*	877*	31*	41*	43*	65
SE 8	26	29	30	175	987	645	34*	46*	39	65
<i>Check</i>										
GG 2	25	28	25	197	295	197	17	23	21	67
GG 7	25	28	25	219	659	423	24	31	32	64
TG 37A	26	29	30	200	1022	628	26	33	27	61
CV (%)	5	6	8	7	15	15	7	5	21	4
CD (5%)	2	3	4	24	200	124	3	3	9	4

Preliminary yield evaluation trial of breeding lines of Virginia groundnut

Sixty-four advanced breeding lines of Virginia bunch groundnut along with two check varieties (GG 20 and Somnath) were evaluated for yield and surrogates of water-use efficiency (SLA and SCMR) in an RBD with three replications. The plot size was five rows each of 5 m length. The plants were raised at 10 cm distance from plant-to-plant within a row and rows were distanced at 60 cm from each other. ANOVA indicated highly significant differences due to genotypes for all the traits. The check variety Somnath was adjudged to be the best check for DF_i, PY, KY, HKW and HSMK. For other traits (DF₅₀, SCMR, SLA, SMK and SOT) GG 20 was the best check variety of the two checks used for this trial. When advanced breeding lines were compared with the best check variety, five lines PBS 24106, PBS 2021, PBS 24116, PBS 24130 and PBS 25033 were found to have given significantly superior pod as well as kernel yields. In addition, in four entries (PBS 24112, PBS 24113, PBS 24119 and PBS 24129) significant kernel yields were registered. For other traits no test entry was found to perform significantly better over the respective best check for a trait (Table 4).



Table 4. Performance of selected advanced Virginia breeding lines in preliminary yield evaluation trial (*kharif*2011)

Genotypes	Traits									
	DF _i	DF ₅₀	SCMR	SLA	PY	KY	HKW	HSMK	SMK	SOT
<i>Test entry</i>										
PBS 24106	30	36	34	173	1915*	1357*	33	40	48	65
PBS 24112	29	33	32	185	1887	1398*	37	51	36	69
PBS 24113	28	31	33	179	1871	1379*	34	49	36	69
PBS 24114	30	34	30	182	2021*	1468*	39	49	44	68
PBS 24116	27	31	33	173	1955*	1436*	35	47	28	68
PBS 24119	30	34	33	185	1824	1326*	33	42	36	67
PBS 24129	30	33	32	180	1766	1341*	29	38	42	71
PBS 24130	29	33	33	180	1921*	1458*	31	39	41	71
PBS 25033	30	34	31	138	2007*	1476*	33	42	50	69
<i>Check</i>										
GG 20	28	31	38	162	1220	893	41	54	63	73
Somnath	23	35	31	189	1575	1078	44	55	45	68
CV (%)	8	4	6	9	19	19	8	7	18	3
CD (5%)	4	2	3	27	336	227	4	5	12	3

Advanced yield evaluation *trial* of breeding lines of Virginia groundnut

Twenty-two groundnut genotypes comprising of twenty advanced breeding lines of Virginia bunch groundnut and two check varieties (GG 20 and Somnath) were evaluated for their performance under rainfed conditions in *kharif*2011. All the twenty two genotypes were grown in an RBD with three replications. The plot size was five rows each of 5 m length. Seeds were sown to maintain a plant-to-plant distance of 10 cm within a row and rows were spaced at 60 cm from each other. Highly significant differences due to genotypes were found for all the traits studied, as indicated by the ANOVA. GG 20 was found to be the best check variety for DF_i, DF₅₀, SCMR, SLA, SMK and SOT. The test entries PBS 25091 and PBS 24093 were found to be significant and superior over this check variety for the traits SLA and SOT, respectively. For the remaining five traits (PY, KY, HKW and HSMK), the variety Somnath was found to be the best check. Four test entries namely, PBS 25015, PBS 25017, PBS 25051 and PBS 25053 registered significantly superior PY as well as KY, and one test entry PBS 25049 yielded significantly better PY over this check variety. The test entries PBS 25093 and PBS 24093 registered significantly superior HKW and HSMK over the best check variety (Table 5).



Table 5. Performance of selected advanced Virginia breeding lines in advanced yield evaluation trial (*kharif* 2011)

Genotypes	Traits									
	DF ₁	DF ₅₀	SCMR	SLA	PY	KY	HKW	HSMK	SMK	SOT
<i>Test entry</i>										
PBS 25089	28	35	32	176	778	532	29	37	31	68
PBS 25090	29	33	36	145	1062	750	36	45	46	71
PBS 25091	27	32	28	139*	1083	762	36	44	36	70
PBS 25093	27	32	32	157	870	609	44*	57*	50	70
PBS 21085	29	34	34	171	928	625	30	39	21	67
PBS 21091	31	37	30	199	840	588	30	39	40	70
PBS 21095	27	31	36	171	1263	733	39	46	26	58
PBS 21096	28	32	35	143	861	614	33	44	22	71
PBS 24093	26	29	36	155	1207	881	45*	55*	45	73*
PBS 25015	30	34	36	185	1393*	980*	37	49	37	70
PBS 25017	30	34	37	170	1412*	989*	37	50	44	70
PBS 25047	31	36	37	167	967	661	27	37	24	68
PBS 25049	29	35	37	163	1451*	958	29	40	25	66
PBS 25051	31	34	31	187	1417*	987*	33	41	38	70
PBS 25053	30	35	35	174	1515*	1030*	31	42	37	68
PBS 26025	30	34	35	168	881	611	33	44	29	69
PBS 29100	29	33	37	176	1326	911	37	48	45	69
<i>Check</i>										
GG 20	26	28	39	162	1077	783	40	52	44	73
Somnath	27	30	37	162	1191	799	41	54	36	67
CV (%)	5	4	15	8	19	19	6	5	23	2
CD (5%)	2	2	8	23	285	195	3	4	13	2

Drought-screening nursery

Hundred and twenty-five advanced breeding lines were evaluated along with 3 check varieties (ICGS 76, ICGS 44, Girnar 1) in *kharif* 2011; however, due to excessive rainfall the genotypic differences for drought tolerance could not be ascertained.

Phenotyping of a mapping population (188 RILs) derived from a cross TAG 24 x TMV2 NLM for surrogates of water-use efficiency under irrigated and drought situations

A mapping population comprising of 188 RILs derived from the cross TAG 24 x TMV2 NLM and developed for the traits of water-use efficiency, were sown in a split-plot design with two irrigation treatments (irrigated and drought) as main plot and 190 genotypes



(188 RILs and the two parental lines) as sub-plots in summer 2011. The plot size was 2-rows each of 3 m length. Soil moisture content was recorded on every alternate day and both before and after irrigation, at 0-5 and 5-10 cm depths. The soil temperature was recorded daily at 8, 12 and 16 h at 5 and 10 cm soil depths. Observations on different traits were recorded by following standard procedures (SLA was recorded without floating the sample leaves in water as SLA 1 and after floating same leaves in water for 3 h as SLA 2). Mid-season drought was imposed by withholding irrigation from 50th to 78th day after sowing. As the seed was not sufficient for all the test entries resulting in poor plant stand in some cases, the data on only 90 genotypes was statistically analyzed. The ANOVA revealed that irrigation-treatments had significant influence on pod and kernel yields and the ratio of kernel width (KW, mm) to Kernel length (KL, mm). Though significant genotypic differences were observed for these traits, the interactions between genotypes and the irrigation treatments were not significant. Except for WSD, highly significant genotypic differences were observed for all the traits studied. Interactions between irrigation and genotypes were highly significant for SP, HiP, HKW, HSMK, KL, KW and oil content.

Evaluation of early maturing advanced breeding Virginia groundnut lines under summer conditions

Seven advanced breeding sister lines - derived from a cross of Chico and Robout 33-1, early maturing Spanish and Virginia germplasm lines, respectively - were evaluated in a trial with three replications in summer 2011 along with early-maturing Virginia check variety Somnath. ANOVA revealed that except for DF_1 , DF_{50} , WSD and SCMR, the genotypic differences were highly significant for all other traits studied. Except SE 6, all the lines matured (103 to 107 d) significantly earlier than Somnath (112 d). These lines also gave significantly higher pod (2935 to 3712 kg ha⁻¹) as well as kernel (2010 to 2618 kg ha⁻¹) yields. Higher kernel yields of these genotypes were corroborated by their high and significantly superior SOT, which ranged from 68 to 71%. The SMK of four genotypes viz., SE 23, SE 34, SE 35 and SE 38 was higher than that of the check variety. The oil content (50.0%) of only one genotype (SE 6) was significantly higher than that of the check variety (48.6%). The yield of this genotype, however, was poor. The protein content of all the genotypes was significantly higher (25.4 to 27.8%) than that of Somnath (22.7%). The moisture content of seeds was in the range of 7 to 7.3%. Amongst the test entries, SE 23, SE 32, SE 34, SE 37 and SE 38 had significantly lower moisture content compared to Somnath (Table 6).



Table 6. Performance of early-maturing Virginia groundnut genotypes in summer 2011

	Genotypes									
Traits	SE 6	SE 23	SE 32	SE 34	SE 35	SE 37	SE 38	Somnath	CD (5%)	CV (%)
DF _i	47	45	44	44	45	45	44	43	NS	4
DF ₅₀	55	55	54	54	54	53	54	52	NS	3
PY	1546	3082*	2935*	3371*	3712*	3504*	3290*	2354	386	7
KY	756	2045*	2010*	2331*	2618*	2420*	2267*	1403	293	9
DM	114	103*	106*	106*	106*	107*	105*	112	4	2
SCMR	35	34	34	35	35	35	34	36	NS	5
SLA	169	187	173	170	201	172	178	157	19	6
WSD	27	22	22	21	26	20	23	24	NS	20
HKW	56	32	28	27	28	25	29	58	4	6
HSMK	75	48	40	42	42	41	39	77	6	7
SMK	36	45*	40	48*	48*	42	51*	33	11	15
SOT	49	66*	68*	69*	71*	69*	69*	60	4	4
Oil (%)	50.0*	49.0	47.0	47.4	47.6	47.4	47.5	48.6	1.1	1.3
Protein (%)	25.4*	26.4*	27.3*	27.8*	27.7*	27.1*	27.2*	22.7	1.1	2.3
Moisture (%)	7.3	7.0*	7.0*	7.0*	7.1*	7.0*	7.0*	7.1	0.1	0.8

Raising of F₁ generation and selection of true hybrids

Identification of true hybrid plants in the ten crosses attempted in *kharif* 2010 for different breeding objectives was done in summer 2011. In total 748 kernels were obtained from 654 pods harvested as the probable hybrid pods in *kharif* 2010, and these kernels were sown cross-wise in summer 2011. At the time of harvest, true hybrid plants were identified cross-wise. At the time of harvest identification of true hybrid plants was done based on the dominant and discernible trait of the donor parent (male parent) and/or hybrid vigour of the F₁ plant. In all the crosses only 29 plants were identified as the true hybrid plants.

Raising of advanced breeding lines and DGR-varieties

Seeds of 10 advanced breeding lines (PBS 16035, PBS 16038, PBS 16039, PBS 16040, SE 28, PBS 15031, PBS 11056, SE 25, PBS 30086 and JUN 27) were enhanced to meet the seed requirement for the AICRP-G trials. Nucleus seed production of Girnar 2 and Girnar 3 varieties was taken up under polythene mulch, and 121 and 110 kg seed pods of Girnar 2 and Girnar 3, respectively were harvested, and made available for seed project (Figure 1).





'Girnar 2'



'Girnar 3'



'PBS 16040'



'PBS 16038'



'SE 25'



'PBS 15031'

Figure 1. Nucleus seed production of DGR varieties

Screening of genotypes for phosphorus uptake during summer 2011

Fifteen genotypes were screened for phosphorus uptake with two treatments having recommended dose of Nitrogen (50 kg ha^{-1}), Phosphorus (50 kg ha^{-1}) and Potassium (60 kg ha^{-1}) (T1) and second treatment (T2) had double the recommended dose of Phosphorus (100 kg ha^{-1}) and recommended dose of Nitrogen and Potassium. The Phosphorus content in shoot and kernels were estimated by Vanadomolybdate method using 1 g of fine powdered plant samples. Genotypes NRCG 15049 and TG 37A recorded high kernel yield when phosphorus application was increased and they accumulated same amount of phosphorus in shoots under both the treatments (0.10% and 0.11%, respectively) (Table 7). Genotype NRCG 12299 recorded high shoot-P concentration under both the treatments.



Table 7. Performance of genotypes for yield, shoot-P and kernel-P (summer 2011)

Genotypes	PY (g plant ⁻¹)		Shoot-P (%)		Kernel-P (%)	
	T1	T2	T1	T2	T1	T2
Girnar 3	22.2	22.3	0.10	0.16	0.40	0.36
NRCG 5007	7.2	14.1	0.14	0.15	0.46	0.38
NRCG 7085	23.3	11.9	0.15	0.12	0.44	0.60
NRCG 7320	20.1	12.1	0.12	0.14	0.38	0.34
NRCG 10078	18.6	14.8	0.11	0.14	0.38	0.50
NRCG 10107	8.6	12.4	0.12	0.14	0.38	0.76
NRCG 10126	27.5	12.7	0.08	0.14	0.50	0.32
NRCG 10374	25.2	14.7	0.12	0.16	0.40	0.36
NRCG 12299	6.8	5.7	0.24	0.19	0.40	0.38
NRCG 12998	15.1	9.3	0.12	0.14	0.36	0.34
NRCG 13182	23.0	15.3	0.12	0.15	0.58	0.64
NRCG 15049	20.7	23.3	0.10	0.10	0.70	0.38
TG 37A	23.7	25.7	0.11	0.11	0.38	0.44
TPG 41	15.8	17.1	0.13	0.13	0.34	0.38
Mean	18.4	15.1	0.13	0.14	0.47	0.51

PY = Pod yield; Shoot-P% = Phosphorus content in shoots; Kernel-P% = Phosphorus content in kernels

Screening of genotypes for phosphorus uptake during *kharif* 2011

Fourteen genotypes were screened for their ability to uptake phosphorus under phosphorus deficit condition. Experiment was conducted with two treatments having recommended dose of Nitrogen (50 kg ha⁻¹), Phosphorus (50 kg ha⁻¹) and Potassium (60 kg ha⁻¹) (T1) and second treatment (T2) had recommended dose of Nitrogen and Potassium without Phosphorus application (T2). The phosphorus content in shoot and kernels were estimated by Vanadomolybdate method using 1g of fine powdered plant samples.

Analysis of variance indicated significant genotypic differences for all traits namely, plant height, branches per plant, pods per plant, pod yield, shoot phosphorus content and kernel phosphorus contents. Interaction between genotype x phosphorus stress was significant for phosphorus accumulation in shoot and kernels. Yield levels during *kharif* were very low due to excessive rains at the time of crop growth and pod formation. Hence, genotype x phosphorus stress interaction was not significant for yield.

Genotype Girnar 3 recorded high yield and accumulated same amount of phosphorus in kernels under both the phosphorus levels. Genotypes Girnar 3, NRCG 10374 and NRCG 13182 maintained their yield and phosphorus content in kernels under both



phosphorus levels. NRCG 12299 accumulated more phosphorus in kernels under stress and also maintained its yield level. NRCG 10078 maintained its phosphorus levels in kernels by translocating from shoot under stress (Table 8).

Table 8. Performance of genotypes for yield, shoot-P and kernel-P (*kharif* 2011)

Genotypes	PY (g plant ⁻¹)		Shoot-P (%)		Kernel-P (%)	
	T1	T2	T1	T2	T1	T2
Girnar 3	4.3	4.0	0.18	0.16	0.39	0.39
NRCG 5007	4.4	2.5	0.15	0.14	0.41	0.38
NRCG 7085	1.2	1.4	0.15	0.16	0.55	0.41
NRCG 7320	0.8	0.6	0.16	0.16	0.42	0.40
NRCG 10078	5.1	3.1	0.25	0.15	0.41	0.42
NRCG 10107	3.1	2.5	0.13	0.13	0.48	0.43
NRCG 10126	1.2	0.8	0.17	0.20	0.43	0.41
NRCG 10374	1.7	1.9	0.19	0.16	0.46	0.48
NRCG 12299	1.2	1.6	0.22	0.18	0.39	0.43
NRCG 12998	0.5	0.2	0.16	0.15	0.50	0.43
NRCG 13182	3.3	3.3	0.16	0.16	0.45	0.46
NRCG 15049	1.9	1.3	0.14	0.17	0.40	0.43
TG 37A	4.8	3.8	0.13	0.13	0.46	0.43
TPG 41	5.4	2.5	0.14	0.12	0.36	0.36
Mean	2.7	2.0	0.17	0.15	0.44	0.42
CD (%)	2.7	1.9	0.02	0.04	0.03	0.04

PY = Pod yield; Shoot-P(%) = Phosphorus content in shoots; Kernel-P(%) = Phosphorus content in kernels

Sub-project02: Breeding for tolerance of biotic stresses in groundnut

(A. L. RATHNAKUMAR, NARENDRA KUMAR, K. S. JADON AND HARISH G.)

Crosses effected

Ten crosses were effected in *kharif* 2011 to develop varieties resistant/tolerant to diseases (collar rot, stem rot, PBNB), thrips, and *Aspergillus flavus* (for low aflatoxin contamination). The number of harvested cross-pods varied from 41 to 122 and the success rate of hybridization was 18.6% to 55.5%. The crosses 'ICGV 00350 x R 8808' (55.5%), 'ICGV 00350 x J 11' (53.1%) and 'TG 37 A x CS 19' (49.7%) recorded relatively a high success rate. The highest number of probable F₁ pods were recorded in three crosses i.e. 160 in 'ICGV 00350 x J 11', 122 in 'ICGV 00350 x R 8808', and 100 in 'Dh 86 x Girnar 1'.



Raising of F_1 's.

- **Summer 2011:** Three crosses (CS 158 x CS 19, TG 37A x SGL 4233 and GG 7 x SGL 4233) made earlier for developing genotypes tolerant to collar rot and stem rot were raised in summer 2011 to identify true F_1 's and a total of 90 true hybrid plants were identified.
- **Kharif 2011:** Seven crosses were raised in *kharif* 2011 for identifying the true F_1 's in respect of collar rot and stem rot, PBNB and foliar diseases. A total of 132 true F_1 plants were identified in the seven crosses i.e. 33 in 'GG 20 x ICGV 87846', 32 in 'GG 20 x CS 19', 16 in 'GG 20 x JSP 19', 4 in 'ICGV 00350 x ICGS 44', 23 in 'ICGV 00351 x ICGS 44', 28 in 'TMV Gn 13 x VG 9816' and 6 in 'GBPD 4 x VG 9816'.

Advancement of different filial generations

The breeding materials generated earlier were advanced to next filial generation in *kharif* 2011 and thus the progenies of 70 crosses were advanced to next filial generations. Of these, seven crosses were rejected due to poor performance and large proportion of poor recombinants. Amongst the segregating generations, 36 crosses in early generations (up to F_4) and 34 crosses in advanced generations were advanced. Twenty-three new genotypes (12 Spanish and 11 Virginia) were selected at F_6 and onwards.

Development of mapping populations:

- **Kharif 2011:** Six mapping populations developed for resistance to one or more diseases were raised in different filial generations in *kharif* 2011. Of these, three populations in F_3 were meant for stem rot and another three in F_4 generation for rust, LLS and PBNB.

Multiplication and distribution of breeding materials to different AICRP-G centres:

Multiplication of breeding materials:

- **Summer, 2011:** Five Spanish advanced breeding lines were multiplied to obtain sufficient seed for conducting preliminary yield trials and another 33 Spanish advanced breeding lines were multiplied for screening against different biotic stresses at hot spots.
- **Kharif 2011:** Eighty-eight advanced generation breeding lines (38 Spanish and 50 Virginia) developed so far were maintained and multiplied to obtain seed required for screening against biotic stresses at hot spots.



Seeds of five elite advanced breeding lines (PBSs 22059, 22066, 22067, 22062 and 22063) were multiplied in *kharif* 2011 for producing seed required for testing in multi-locations testing under AICRP-G.

Distribution of breeding materials to different AICRP-G centres

The breeding material (F_4 to F_6) of eight different crosses of three segregating generations was supplied to eight hot-spot centres of AICRP-G for making location specific selections for response to different biotic stresses during *kharif* 2011.

Screening of advanced breeding lines for *in-vitro* seed colonization

- **Summer 2011:** Eight advanced breeding lines were evaluated for *in-vitro* colonization of pod and kernel by *Aspergillus flavus*. At both pod and kernel levels, two genotypes (PBS 22065 and PBS 22067) did not show any infection (Figure 1) in comparison with 3% infection seen in the resistant check J 11 and 20% in susceptible check GG 20.



PBS 22067



PBS 22074



PBS 22059



PBS 22064

Figure 1. Promising advanced breeding lines for low *in-vitro* seed colonisation by *A. flavus*



Screening of advanced breeding lines and mutants of TAG 24 for resistance or tolerance of *S. rolfii* under sick plot conditions

In a sick plot, 440 breeding lines (385 M₅ mutant families of TAG 24 and 55 advanced breeding lines including those of AICRP-G) were screened. The disease incidence was in the range of 0-86% among the mutants and 20-74% among the advanced breeding lines. Among the mutants of TAG 24, the observed incidence was none in six families, <10% in four families; <20% in 26 families and <30% in three families. Among the advanced breeding lines, none was free from stem rot. Among the individual genotypes 21.6% incidence was seen in an inter-specific hybrid derivative VG 0107, 26.5% in advanced breeding line PBS 14060 and 27.3% in another advanced breeding line PBS 14064- these three genotypes were identified as promising ones.



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

(THIRUMALAISAMY P. P., HARISH G., K. S. JADON,
PRASANNA H. AND NATARAJA M. V.)

Sub-project 01: Management of insect pests in groundnut based production system

Integrated Pest Management in groundnut based inter cropping system (*kharif*)

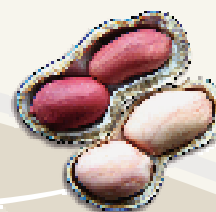
In an experiment conducted in *kharif* 2011 on groundnut (cv. GG 20) based intercropping with 10 treatments viz. 'groundnut + maize', 'groundnut + *jowar*', 'groundnut + *bajra*', 'groundnut + sesamum', 'groundnut + sunflower', 'groundnut + soybean', 'groundnut + cowpea', 'groundnut + black gram', 'groundnut + green gram' and sole groundnut, the lowest population (4.5 five-sweeps⁻¹) of jassids was recorded in the intercrop 'groundnut + *bajra*' compared to sole groundnut. 'Groundnut + soybean' supported a smaller population (3.6 five-sweeps⁻¹) of thrips and the values were at par with 'groundnut + *jowar*' (3.7 five-sweeps⁻¹), 'Groundnut + *bajra*' (3.7 five-sweeps⁻¹), 'groundnut + sesamum' (3.7 five-sweeps⁻¹) and 'groundnut + black gram' (3.8 five-sweeps⁻¹). The highest yield of groundnut was recorded in 'groundnut + green gram' (663 kg ha⁻¹) with a C:B ratio of 1:1.28. The observed differences in insect populations, however, were not statistically significant.

Effect of seed treatment with imidacloprid on sucking pests of groundnut in *kharif*

The insecticide imidacloprid was evaluated for its efficacy in management of pests of groundnut in *kharif* by using it for seed treatment. The insecticide used was imidacloprid @ 0.5 g kg⁻¹ seed; 1.0 g kg⁻¹ seed; 2.0 g kg⁻¹ seed; 3.0 g kg⁻¹ seed; 4.0 g kg⁻¹ seed; and 5.0 g kg⁻¹ seed. The standard check was two sprays of monocrotophos (0.04%) at 30 and 45 DAS while control crop was raised without any treatment. Seed treatment with imidacloprid @ 5.0 g kg⁻¹ seed was found the most effective in not only reducing the jassids (8.5 five-sweeps⁻¹) and also thrips (13.7 five-sweeps⁻¹) populations but also gave the highest yield (2612 kg ha⁻¹). The populations of jassids and thrips in the untreated plots were 11.3 five-sweeps⁻¹ and 7.2 five-sweeps⁻¹, respectively while the pod yield was 1911 kg ha⁻¹.

Evaluation of new chemicals on insect pests of groundnut

Efficacy of seven new insecticides for management of sucking pests of *kharif* groundnut was evaluated. The new insecticides rynaxypyr 20SC, flubendiamide 480SC, thiodicarb 80DF, novaluran 10EC, acetamiprid 20SP, thiomethoxam 25WG, imidacloprid 0.008%, and the standard checks monocrotophos 36SC and chlorpyrifos 20EC were sprayed at 30 and 45 DAS. The untreated plot was used as control. The lowest jassids (3.2 five-sweeps⁻¹) and thrips (1.5 five-sweeps⁻¹) populations were recorded in Acetamiprid



20SP. The highest pod yield of 2326 kg ha⁻¹, however, was recorded in thiometaxam 25WG while the yield of control plot was 1658 kg ha⁻¹.

Effect of seed treatment with imidacloprid (70% WS) on the infestation of sucking pests in summer groundnut (cv. GG 2)

The efficacy of treatment of seeds with imidacloprid for the management of sucking pests of groundnut in *rabi* was evaluated. The insecticide was applied @ 0.5 g kg⁻¹ seed, 1.0 g kg⁻¹ seed, 2.0 g kg⁻¹ seed, 3.0 g kg⁻¹ seed, 4.0 g kg⁻¹ seed, 5.0 g kg⁻¹ seed while the standard check monocrotophos 0.04% was applied as foliar spray at 30 and 45 DAS. The crop raised with untreated seeds without any spray was used as control. The seed treatment with imidacloprid @ 5.0 g kg⁻¹ seed was not only most effective in reducing the jassid (6.1 five-sweeps⁻¹) and also of thrips (10.8 five-sweeps⁻¹) populations but also resulted in the highest pod yield (1788 kg ha⁻¹) compared to an yield of 1239 kg ha⁻¹ obtained from the control plot.

Effect of spray of new insecticides on infestation of sucking pests of groundnut in *rabi*, cultivar GG 2

Among the four new insecticides evaluated, spray of thiomethoxam (0.01% at 30 and 45 DAG) was found to be the most effective in reducing the populations of jassids (1.9 five-sweeps⁻¹) and thrips (4.3 five-sweeps⁻¹). The highest yield of groundnut (1995 kg ha⁻¹), however, was obtained from the plots receiving two sprays (30 and 45 DAG) of acetamiprid (0.05%).

Among the four types of bags viz., lino-bag, fertilizer bag, gunny bag and super grain bag evaluated, the super grain bag was found to be the most effective in controlling the pod damage (< in 50%) during a storage period of four months (Figure 1).



Lino bag



Fertilizer bag



Gunny bag



Super grain bag

Figure 1. Different types of storage-bags used for storing groundnut pods to study their suitability for preventing damage by bruchid beetle



Screening of groundnut genotypes for the extent of damage caused by bruchid beetle during post-harvest storage

Among the 30 genotypes screened, T 28 suffered the least damage of kernels (7.6%) while BG 3 recorded the least loss of weight (0.8%) (Figure 2).

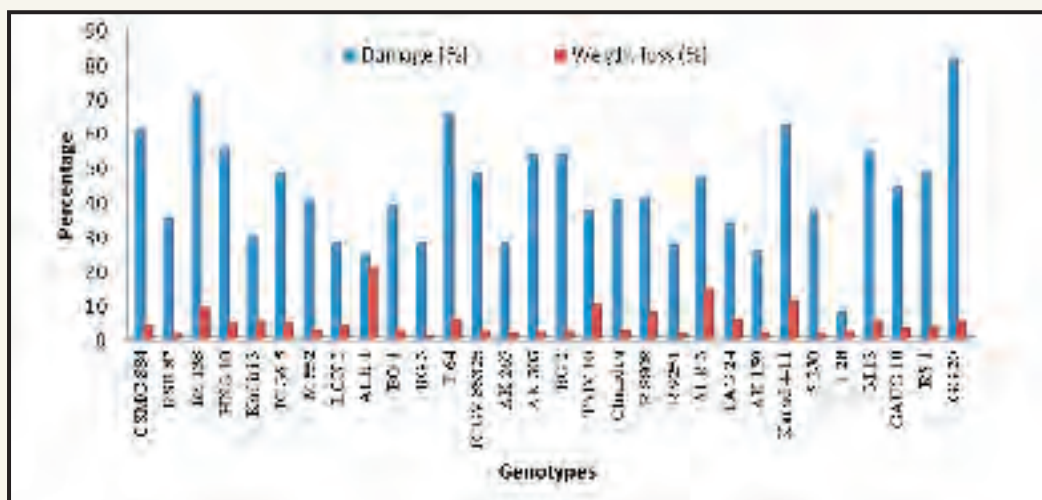


Figure 2. Kernel damage and weight-loss caused by bruchid beetle during post-harvest storage

Sub-project 02: Integrated management of major diseases (ELS, LLS, Rust, Collar rot, Stem rot, PBND) of groundnut

Survey of Saurashtra region for occurrence of major diseases of groundnut

Three districts of Saurashtra, viz. Junagadh, Rajkot and Jamnagar, were surveyed for occurrence of major diseases and also of *Alternaria* diseases (Table 1). During summer, the occurrence of *Alternaria* disease was observed in the farmers' fields, the severity of disease, however, was <20%. In Junagadh, in a few fields in Vadal and Vadalchowki, the incidence, however, was up to 60%. Occurrence of stem rot and PBND were also noticed in the farmers' fields. During *kharif*, the foliar diseases viz. early leaf spot, late leaf spot and rust were observed to the extent of 40-60%, 40-70% and 60-80%, respectively in the farmers' fields surveyed.

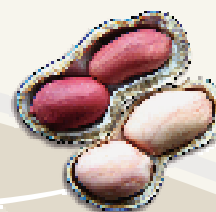


Table 1. Incidence of diseases in groundnut fields in the *Saurashtra* region

Disease	Summer	<i>Kharif</i>
	Disease severity (%)	
Early leaf spot	-	40 - 60
Late leaf spot	-	40 - 70
Rust	-	60 - 80
<i>Alternaria</i> leaf blight	20 - 60	<5
	Disease incidence (%)	
Stem rot	10 - 20	5 - 15
Collar rot	-	8 - 30
Afla-root	< 2	-
PBND	5 - 15	< 2

The effect of arbuscular mycorrhizal fungi on stem rot caused by *Sclerotium rolfsii*

In summer, the application of AM fungi in seed-furrow @100 g m⁻² (≈100 spores g⁻¹ soil) reduced the incidence of stem rot (29.4%) compared to control (80.5%) (Table 2). In *kharif*, the incidence of stem rot was only 26% in the plots treated with arbuscular mycorrhiza compared to 29.8% in control plots. The protracted and excessive rain fall (963 mm in 45 days) during crop season adversely affected the growth of both AM fungi and *Sclerotium rolfsii*.

Table 2. The effect of arbuscular mycorrhizal fungi on stem rot

Treatment	Initial plant population (no. block ⁻¹)		Diseased plants			
			(no. block ⁻¹)		(%)	
	Summer	<i>Kharif</i>	Summer	<i>Kharif</i>	Summer	<i>Kharif</i>
Arbuscular mycorrhiza +	34	34	10	9	29.4	26.0
<i>S. rolfsii</i>						
<i>S. rolfsii</i>	36	38	29	11	80.5	29.8
S. Em.±					2.6	1.5
CD (5%)					9.5	NS
CV (%)					32.5	36.5

Management of foliar diseases (ELS, LLS, rust and *Alternaria* leaf blight) by application of fungicides

During summer, among the six fungicides evaluated, the lowest disease severity of *Alternaria* leaf disease (2 in 1-9 scale) was recorded with two sprays (45 at 60 DAS) of difenoconazole @ 0.025%, which was followed by two sprays (45 at 60 DAS) of tebuconazole @ 0.375% (3 in 1-9 scale) while the severity was 5 in control (Table 3).



Table 3. Management of *Alternaria* leaf blight in groundnut using fungicides

Treatment	Initial plant population (no. plot ⁻¹)	Disease score (1-9 scale)	Pod yield (kg ha ⁻¹)
Mancozeb @ 0.2%	493	5	1816
Copper oxychloride @ 2%	534	4	2004
Hexaconazole @ 0.0075%	501	4	1903
Tebuconazole @ 0.375%	516	3	2137
Difenoconazole @ 0.025%	516	2	1990
Propiconazole @ 0.025%	551	4	2004
Control	487	5	2020
S.Em.±	0.11	0.20	0.07
CD (5%)	NS	0.58	NS
CV (%)	9.29	10.03	6.24

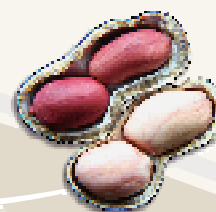
In *kharif*, on a 1-9 scale, the lowest scores of 1.0 for ELS, 1.3 for LLS and 1.5 for rust were recorded in the plots sprayed twice (45 and 60 DAS) with difenoconazole @ 0.025%, which was followed by two sprays (45 and 60 DAS) of tebuconazole @ 0.375% with disease scores of 2.3 for ELS, 3.3 for LLS and 2.3 for rust whereas, in control plots, the corresponding scores were 8.0, 8.5 and 7.5 for ELS, LLS and rust, respectively (Table 4).

Table 4. Management of early leaf spot, late leaf spot and rust in groundnut by use of fungicides

Treatment	Initial plant population (no. plot ⁻¹)	Disease score (1-9 scale)			Haulm yield (kg plot ⁻¹)
		ELS	LLS	Rust	
Mancozeb @ 0.2%	539	6.5	6.8	5.3	5.3
Copper oxychloride @ 2%	525	6.5	7.0	5.8	3.5
Hexaconazole @ 0.0075%	548	3.8	3.8	3.5	5.7
Tebuconazole @ 0.375%	549	2.3	3.3	2.3	8.9
Difenoconazole @ 0.025%	517	1.0	1.3	1.5	9.1
Propiconazole @ 0.025%	547	3.3	3.5	3.5	7.3
Control	551	8.0	8.5	7.5	4.6
S.Em.±	14.38	0.22	0.26	0.28	0.30
CD (5%)	NS	0.66	0.76	0.80	0.82
CV (%)	5.33	9.98	10.5	13.3	8.79

Effect of application of nutrients on incidence of stem rot

The application of nutrients as per recommended doses did not have any significant effect on the incidence of stem rot and foliar diseases in any of the growing seasons (summer or *kharif*).



Management of stem rot and afla-root diseases using bio-agents

Isolates of *Trichoderma* (T-170 and Dharwad), *Pesudomonas* (DGR and TNAU-Pf-1) and their combinations were used as seed treatment and for furrow application. Incidence of stem rot was in the range of 11.5 to 24.4% during summer and 32.3 to 52.3% during *kharif*. None of the bio-agents individually or in any combination had any significant influence on the incidence of stem rot.

Screening of genotypes for tolerance of stem rot (*Sclerotium rolfsii*)

Among 20 genotypes (including the check variety GG 2) evaluated in summer in concrete blocks, the lowest incidence of stem rot was observed in CS 402 (15%) while the highest was observed in GG 2 (54%). In *kharif*, the lowest incidence was observed in CS 409 (11%) and the highest in GG 2 (36%).

Screening of genotypes for tolerance of collar rot (*Aspergillus niger*)

Among 20 genotypes (including check variety GG 2) grown in summer in concrete blocks, the lowest incidence of collar rot was recorded in CS 421 (6%) which was followed by CS 426 (8%) and CS 428 (9%) while it was highest in the check variety GG 2 (53%). In *kharif*, the lowest incidence of 3% was observed in four genotypes viz., CS 422, CS 364, CS 427 and CS 386, followed by 8% in three genotypes viz., CS 377, CS 432, and CS 433; 9% in two genotypes viz., CS 421 and CS 431 compared to 18% in GG 2, the check variety. No incidence, however, was recorded in three genotypes viz., CS 424, CS 430 and CS 434.

Sub-project 03: Survey, damage functions and management strategies for plant parasitic nematodes in groundnut

Survey of plant parasitic nematodes associated with groundnut in Rajkot district of Gujarat

The groundnut growing areas in the Rajkot district of Gujarat was surveyed in both *rabi*-summer and *kharif* seasons. In each season 25 root and soil samples were drawn from the groundnut fields. Each sample (200 cc) was in turn drawn from a composite sample representing five locations in a field of one acre. The nematodes from the soil samples were extracted by Cobb's sieving and decanting technique and the endoparasitic nematodes were examined in fresh roots.

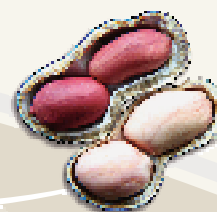
Community analysis of plant parasitic nematodes revealed that *Helicotylenchus* spp. was the most abundant (relative frequency = 32.1%) while *Xiphinema* spp. was the least (relative frequency = 7.1%). The prominence value was highest for *Helicotylenchus*



spp. (54.2) followed by *Pratylenchus* spp. (35.4), *Rotylenchulus reniformis* (26.6), *Tylenchorhynchus* spp. (21.0) and lowest for *Xiphinema* spp. (13.0) during *rabi*-summer. In *kharif*, the highest prominence value for *Helicotylenchus* spp. (52.7), which was followed by *Tylenchorhynchus* spp. (29.1), *Pratylenchus* spp. (21.2), *Rotylenchulus reniformis* (30.1), *Xiphinema* spp. (17.9) and *Meloidogyne arenaria* (1.6) (Table 5). Thus there was only a little difference in the pattern of distribution of plant parasitic nematodes during two growing seasons. The root-knot nematode, *M. arenaria*, however, was recorded only during *kharif* season with least prominence value.

Table 5. Community analysis of plant parasitic nematodes in Rajkot district of Gujarat

Nematode	Mean	Absolute frequency	Relative frequency	Absolute density	Relative density	Prominence value
Rabi-summer						
<i>Helicotylenchus</i> spp.	128	72	32.1	63.9	29.1	54.2
<i>Tylenchorhynchus</i> spp.	70	36	16.1	35.1	16.0	21.0
<i>Pratylenchus</i> spp.	102	48	21.4	51.0	23.3	35.4
<i>Rotylenchulus reniformis</i>	74	52	23.2	36.9	16.8	26.6
<i>Xiphinema</i> spp.	65	16	7.1	32.5	14.8	13.0
Kharif						
<i>Helicotylenchus</i> spp.	115	84	33.3	57.5	25.9	52.7
<i>Tylenchorhynchus</i> spp.	88	44	17.5	43.9	19.8	29.1
<i>Pratylenchus</i> spp.	75	32	12.7	37.5	16.9	21.2
<i>Rotylenchulus reniformis</i>	78	60	23.8	38.9	17.5	30.1
<i>Meloidogyne arenaria</i>	9	12	4.8	4.5	2.0	1.6
<i>Xiphinema</i> spp.	80	20	7.9	40.0	18.0	17.9



PROJECT 03: PHYSIOLOGICAL STUDIES ON ENVIRONMENTAL STRESSES IN GROUNDNUT

(A. L. SINGH, K. CHAKRABORTY, K. A. KALARIYA AND S. K. BISHI)

Effect of water deficit stress on photosynthesis and chlorophyll fluorescence in groundnut

In summer 2011, a field experiment was conducted with six Spanish groundnut cultivars *viz.* ICGS 44, TAG 24, SG 99, ICGV 86031, DRG 1 and AK 159 to study chlorophyll fluorescence parameters and net photosynthesis under water deficit (WD) condition between beginning bloom and beginning seed (WD I) and then beginning seed and beginning maturity (WD II), by withholding irrigation from 31 to 62 DAS and 62 to 87 DAS, respectively. The soil moisture content was 17% and 18% at 0-15 and 15-30 cm soil depths in well watered plots which decreased to 9% and 10% respectively during WD I. The soil moisture of the plot under water deficit treatment depleted by 45 and 44% with respect to well irrigated plot at 0-15 cm soil depth at WD I and WD II respectively and 68 and 50% at 15-30 cm depth at WD I and WD II, respectively. While the RWC of leaves decreased from 92% in control to 88% under water deficit condition. WD condition significantly increased F_o and NPQ but decreased the maximum quantum yield of PS II (F_v/F_m) from 0.81 in control to 0.77 under WD I condition which was resolved to 0.80 after 48 hours of withdrawal of stress (Figure 1). The rate of photosynthesis which was 29 and 36 $\mu\text{mol m}^{-2} \text{s}^{-1}$ in well irrigated plots decreased to 26 and 28 $\mu\text{mol m}^{-2} \text{s}^{-1}$ by WD condition with a reduction of 11.1 and 29.7 % (Figure 2) in Pn compared to control under WD I and WD II, respectively.

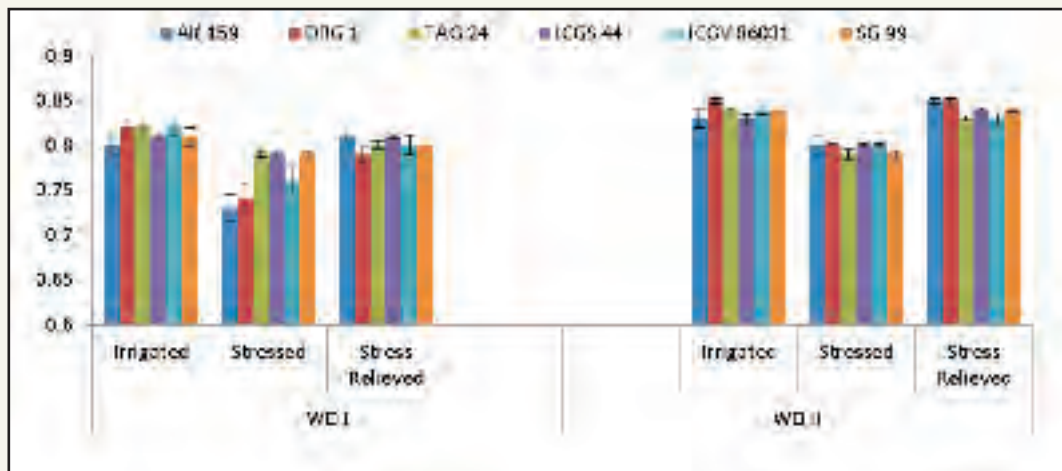


Figure 1. Maximum quantum yield of PS II (F_v/F_m) affected by water deficit condition



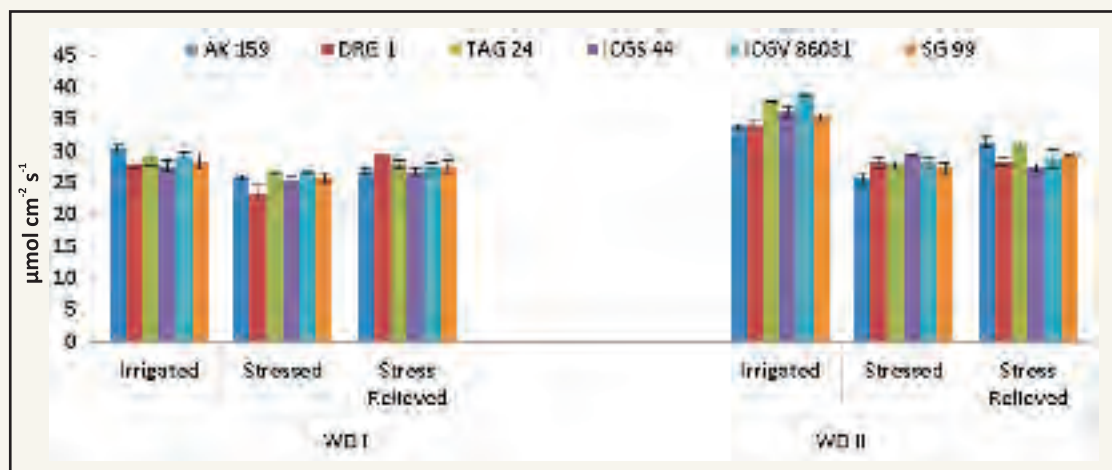


Figure 2. Net photosynthetic rate (Pn) affected by water deficit condition

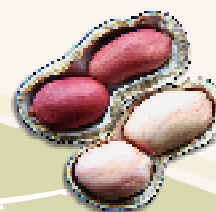
Effect of water deficit condition on oxidative stress and antioxidant enzyme activity in groundnut

Similar experiment was conducted with six Spanish groundnut cultivars during summer 2011 to study the oxidative stress tolerance character and antioxidant enzyme activity under water deficit (WS) condition during flowering (WS 1) and pod development stages (WS 2), by withholding irrigation from 31 to 62 DAS and 62 to 87 DAS, respectively.

Total chlorophyll content was reduced under WS 2 in all the genotypes ranging from 5.47% (ICGS 44) to 16.20% (DRG 1). But during WS 1 total chlorophyll content was increased in all the genotypes except SG 99. Membrane stability index (MSI) was reduced under both WS 1 and WS 2 and the reduction was highest in DRG 1 (22.10%) in WS 2 (Table 1).

Table 1. Effect of water deficit stress on RWC, MSI and total chlorophyll content
(figures represent percent decrease over the control)

Variety	RWC		MSI		Total Chlorophyll	
	WS1	WS2	WS1	WS2	WS1	WS2
SG 99	2.58	3.26	22.08	18.49	15.17	14.02
ICGS 44	0.68	5.54	8.01	9.36	-19.09	5.47
ICGV 86031	6.41	8.38	10.11	13.76	-14.16	14.62
TAG 24	3.33	2.91	3.89	10.90	-16.42	8.46
AK 159	3.97	8.35	4.14	18.47	-16.33	14.61
DRG 1	5.88	10.06	9.83	22.10	-8.77	16.20



Production of reactive oxygen species in terms of H_2O_2 and superoxide radical (SOR), and lipid peroxidation was more at both WS 1 and WS 2. SOR content was highest in ICGV 86031 ($16.9 \Delta A_{540} g^{-1} FW$) and DRG 1 ($18.56 \Delta A_{540} g^{-1} FW$) during WS 1 and WS 2, respectively. Similarly, H_2O_2 content in ICGV 86031 increased in both WS 1 ($1.55 \mu mol g^{-1} FW$) and WS II ($2.23 \mu mol g^{-1} FW$). Recovery data showed that ICGS 44 and TAG 24 have better stress recovery ability as these varieties showed least H_2O_2 production (1.52 and $1.55 \mu mol g^{-1} FW$, respectively) under stress recovery (Figure 3). Activity of the antioxidant enzymes viz. superoxide dismutase (SOD) was higher especially under WS 2 in ICGS 44 ($1.35 unit min^{-1} \mu g^{-1} protein$) and TAG 24 ($1.32 unit min^{-1} \mu g^{-1} protein$) (Figure 4). Similarly, the activity of other enzymes like catalase, peroxidase, glutathione reductase and ascorbate peroxidase showed increase under water deficit stress in all the genotypes. Under both WS 1 and WS 2 the genotype DRG 1 showed greater susceptibility towards stress compared to ICGS 44 and TAG 24; which could be attributed to the ability of the tolerant genotypes maintaining better RWC, higher antioxidant enzyme activity (SOD, CAT, GR, APX and POD) and sustaining much less membrane injury due to imposition of water deficit stress (Table 2). Variety TAG 24 showed better stress recovering capacity with high photosynthesis under control as well as WS condition whereas, data on chlorophyll fluorescence parameters showed that variety ICGS 44 was least affected to damage via photo-inhibitory action.

Table 2. Stress tolerance index value of groundnut genotypes and their categorization

Variety	WS 1	WS 2	Response to water deficit stress
SG 99	1.43	0.99	Tolerant
ICGS 44	1.77	0.95	Tolerant
ICGV 86031	0.37	0.26	Susceptible
TAG 24	0.98	0.61	Tolerant
AK 159	0.81	0.34	Susceptible
DRG 1	0.68	0.40	Susceptible



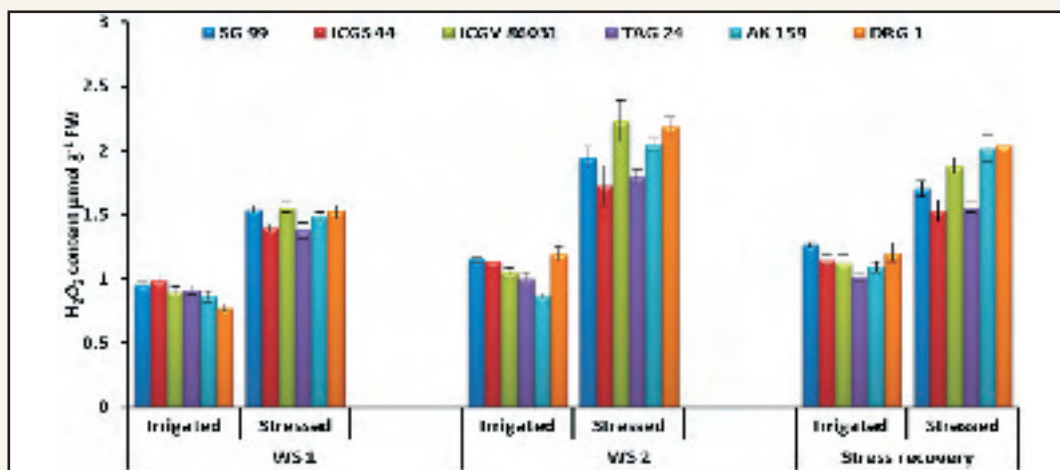


Figure 3. Effect of water deficit stress on H₂O₂ production

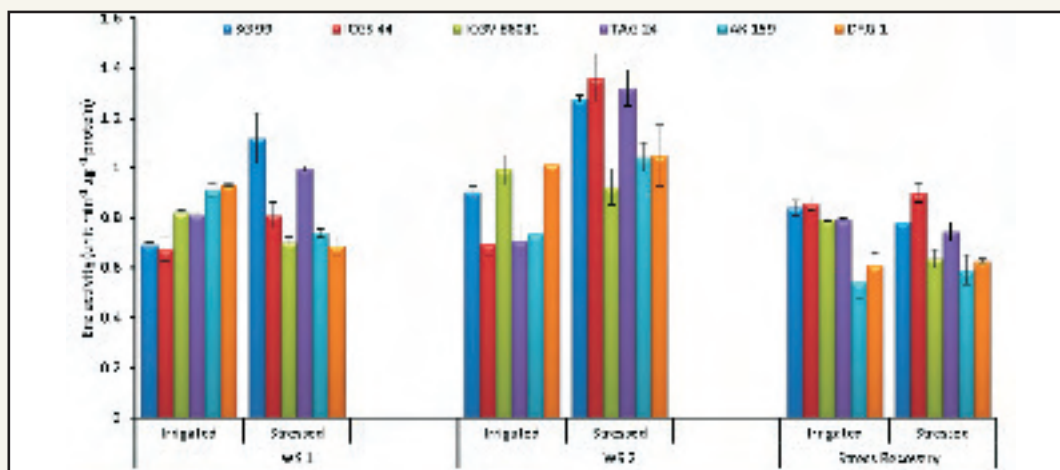
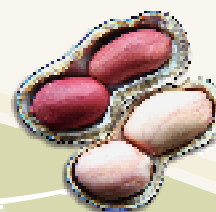


Figure 4. Effect of water deficit stress on superoxide dismutase (SOD) activity

Screening of groundnut genotypes for water deficit stress tolerance in field condition

In *kharif* 2011, an experiment was conducted with 20 varieties of Virginia and 26 varieties of Spanish group under protected and rain-fed condition. Out of 26 Spanish bunch cultivars the highest pod yield (167 g m⁻²) was recorded in ICGS 44 whereas the lowest pod yield (49 g m⁻²) was recorded in TMV 2 under protective irrigation. Under rain-fed condition the highest pod yield (148 g m⁻²) was recorded in ICGS 44 whereas the lowest pod yield (28 g m⁻²) was recorded in TMV 2. The highest harvest (HI) index was recorded in cultivar TAG 24 (0.42) whereas lowest HI was recorded in TMV 2 (0.16) under protective irrigation. Under rain-fed condition the highest HI (0.43) was recorded in TAG 24 whereas the lowest HI (0.16) was recorded in TMV2. Out of 20 Virginia cultivars, the highest pod



yield (193 g m^{-2}) was recorded in CSMG 84-1 whereas the lowest pod yield (100 g m^{-2}) was recorded in Girnar 2 under protective irrigation. Under rain-fed condition the highest pod yield (152 g m^{-2}) was recorded in CSMG 9510 whereas the lowest pod yield (84 g m^{-2}) was recorded in Somnath.

Physiological and biochemical studies on groundnut genotypes under transient water deficit stress

Another experiment was conducted in pot culture under protected net house condition with 6 genotypes viz. JL 286, TPG 41, HNG 10, GG 20, CSMG 84-1 and GG 11 (two each from SB, VB and VR habit group respectively) to study the genotypic variation with regard to tolerance of oxidative stress under well and limited (50%) watered condition. Significant reduction in relative water content (RWC) was observed in all the genotypes, among this highest reduction was observed in JL 286 followed by HNG 10 (Figure 5). Maximum increase in H_2O_2 content under stress in pod development stage was observed in TPG 41 ($4.1 \mu\text{mol g}^{-1} \text{FW}$) followed by JL 286 ($3.9 \mu\text{mol g}^{-1} \text{FW}$). Similarly, SOR content and lipid peroxidation was also more under stress condition compared to control plants. Activity of antioxidant enzymes viz. SOD, CAT, POD, GR and APX was increased under water deficit stress. Post-harvest analysis of seed quality parameters indicated reduction in oil content in all genotypes under stress, whereas content of glucose, sucrose and raffinose like oligosaccharides (RFOs) were increased (Figure 6) which could play important role in stress tolerance. The results suggest that increase in some of the metabolite could be the reason for lesser oil production (Figure 7) in these genotypes under water deficit stress. From this study it can be said that Spanish group of genotypes were more susceptible to water deficit stress compared to Virginia group.

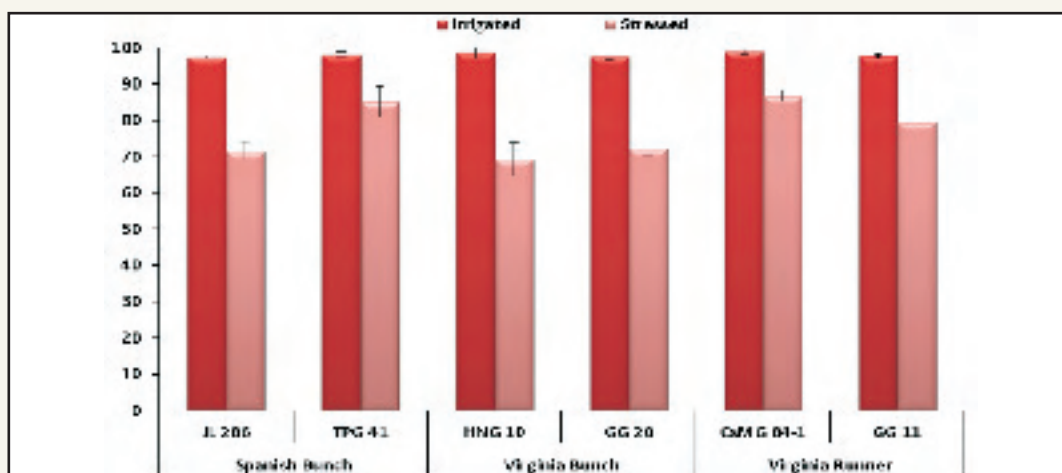


Figure 5. Effect of water deficit stress on relative water content (%)



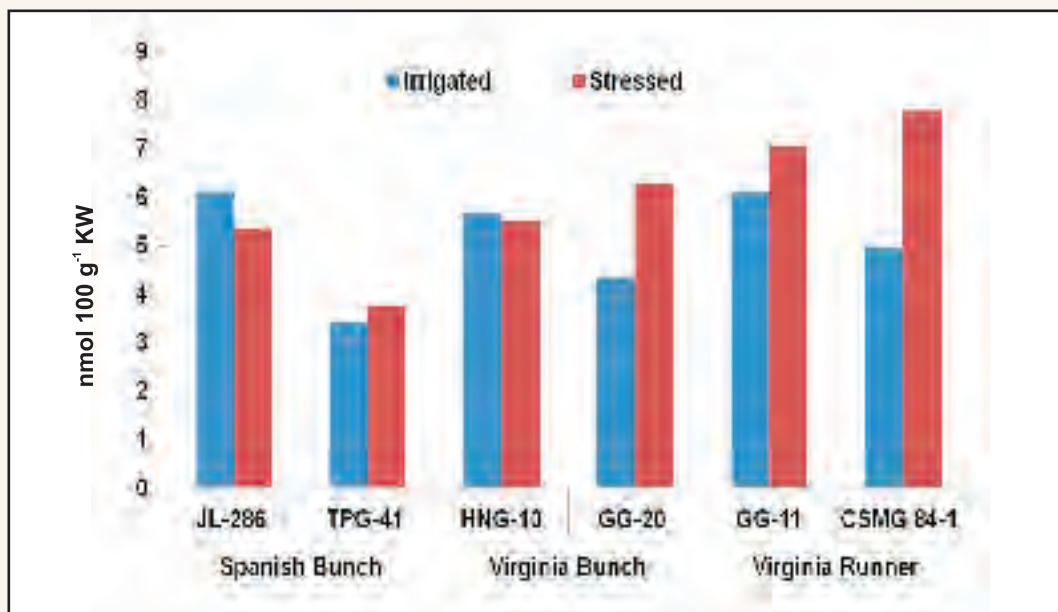


Figure 6. Effect of water deficit stress on raffinose like oligo (RFOs) accumulation

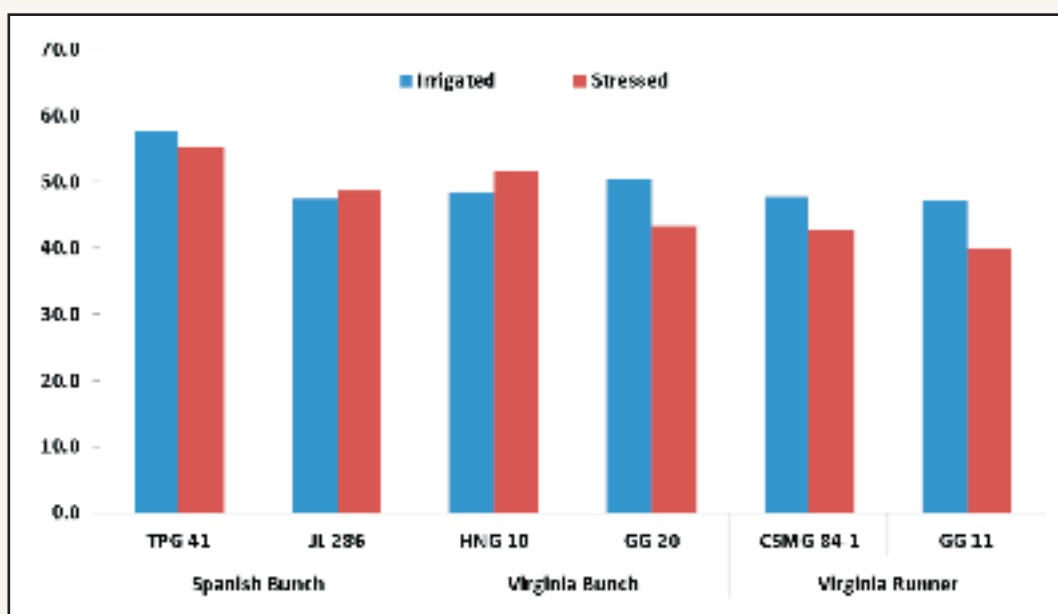
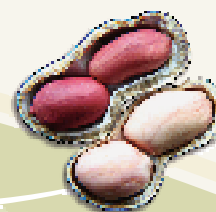


Figure 7. Effect of water deficit stress on oil production (%)



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

(K. K. PAL AND R. DEY)

Consortium of beneficial bacteria

Evaluation of delivery systems for consortia of microorganisms for enhancing the growth and yield of groundnut

In *kharif* 2011, seven delivery systems for application of a microbial consortium comprising six beneficial bacteria were evaluated in a field trial with groundnut cultivar TG 37A. The bacterial consortium consisted of PGPR [*Pseudomonas fluorescens* BHU1 and *Pseudomonas maculicola* S1(6)], PSM (*Pseudomonas* sp. BM8 and *Bacillus polymyxa* H5) and groundnut rhizobia (NRCG 4 and NC 92). FYM, talcum powder, kaoline, sterile farm soil, charcoal, groundnut seed, and irrigation water were used as the carrier of consortium.

All the delivery systems enhanced the length of shoot and root with a maximum effect of FYM on shoot length. Compared to un-inoculated control, an improvement of 16% in pod yield was obtained by application of consortium through charcoal. While use of FYM, farm soil and kaoline, resulted in 13%, 15% and 8% improvement of pod yield, respectively. An improvement of 11% in pod yield was obtained by application of consortium as seed coating. In most of the treatments an enhancement of haulm yield was also recorded.

Table 1. Effect of various delivery-systems for application of bacterial-consortium on growth and yield of groundnut cultivar TG 37A (*kharif* 2011)

Delivery system	SL (cm p ⁻¹)	HY (kg ha ⁻¹)	PY (kg ha ⁻¹)	Shelling Out-turn (%)
Seed	62.1	3032	1915	61.8
FYM	64.4	2995	1952	61.8
Talcum	62.0	2935	1885	61.3
Irrigation	61.6	3362	1772	61.0
Kaoline	61.5	3145	1860	62.1
Soil	61.4	3770	1980	62.7
Charcoal	61.6	3112	2007	63.0
Control	58.3	2917	1727	59.8
CD (5%)	1.3	109	101	1.1



Evaluation of various AM fungi for promoting growth and yield of groundnut

A field trial was conducted during summer 2011 to study the effects of inoculation of AM fungi on the growth and yield of groundnut cultivar TG 37A. Four AM fungal cultures viz., *Glomus etunicatum*, *Glomus fasciculatum*, *Glomus mosseae*, and *Gigaspora scutellospora* were evaluated. Inoculation with AM fungi improved the growth of groundnut in terms of shoot and root growth, and number and mass of nodules. Application of *G. mosseae* significantly enhanced the pod yield by 13% over uninoculated control (Table 2). The haulm yield, hundred-seed mass and shelling out-turn improved significantly in the treatment with *G. fasciculatum*. In the pot trial inoculation with AM fungi resulted in enhancement of root and shoot growth and nodulation. Inoculation with *Glomus mosseae* and *G. scutellospora* significantly improved the pod yield and VAM root colonization.

Table 2. Effect of inoculation of AM fungi on the growth and yield of groundnut cultivar TG 37A (summer 2011)

AM fungus	PY (kg ha ⁻¹)	SL (cm p ⁻¹)	HY (kg ha ⁻¹)	Shelling out-turn (%)
<i>G. etunicatum</i>	2769	41.3	5520	65.6
<i>G. fasciculatum</i>	2704	44.7	6203	68.0
<i>G. mosseae</i>	3088	42.8	5770	67.5
<i>G. scutellospora</i>	2897	41.8	6006	65.4
Un-inoculated control	2742	39.5	5743	64.9
CD (5%)	203	2.3	328	1.1

Groundnut-rhizobia

Evaluation of new strains of groundnut rhizobia

A field trial was conducted during *kharif* 2011 to evaluate the newly isolated *nod⁺nif⁺* competitive strains of groundnut rhizobia. Six strains viz., RH17, RH29, SRR7, RH11, PAS17-2, and RH20 having additional traits like production of siderophore and IAA like substances, were tested along with standard culture NC 92. Compared to control (un-inoculated), the inoculation with the newly isolated strains of groundnut rhizobia RH11, RH17, RH20 and NC 92 enhanced the pod yield of cultivar TG 37A and the strain RH11 was adjudged the best (Table 3). Inoculation with rhizobia also improved the BNF parameters.

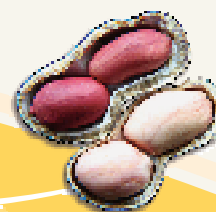


Table 3. Effect of inoculation of newly isolated rhizobia on the growth, yield and BNF parameters in groundnut, cultivar TG 37A (*kharif*2011)

Treatment	PY (kg ha ⁻¹)	HY (kg ha ⁻¹)	Shelling out-turn (%)	NN p ⁻¹
Un-inoculated (control)	1200	3375	57.7	20
NC92	1440	3642	59.1	42
RH17	1437	3792	59.1	49
RH29	1205	3525	58.9	41
SRR7	1180	3535	58.7	43
RH11	1525	4072	60.2	50
PAS17-2	1172	3395	58.6	41
RH20	1370	3760	58.6	39
CD (5%)	104	205	1.3	9.4

Development of suppressive soils

Testing of DAPG-producing fluorescent pseudomonads for suppression of soil-borne fungal pathogens (*kharif*2011)

The fluorescent pseudomonads are known to produce 2, 4-diacetylphloroglucinol (2, 4-DAPG) which is antifungal and inhibits the soil-borne fungal pathogens. To develop suppressive soils to naturally suppress the fungal pathogens, DAPG-producing fluorescent pseudomonads were isolated from the rhizosphere of groundnut. Seventy fluorescent pseudomonads were tested *in vitro* for their inhibitory effect on soil-borne fungal pathogens like *A. niger*, *A. flavus* and *S. rolfii*. After screening in pots, twelve DAPG-producing fluorescent pseudomonads, highly antagonistic to *A. niger* and *S. rolfii*, were evaluated in field condition for their potential in development of suppressive soils for management of *S. rolfii* and *A. niger*. Application of DAPG-producing fluorescent pseudomonads like *Pseudomonas putida* DAPG2 and *P. fluorescens* FP82 reduced the plant mortality due to stem rot from 87% when inoculated with pathogen only to 53% when treated with these strains, with cultivar GG 20. In case of *Aspergillus niger*, the incidence of collar rot was less than 20% when inoculated with pathogen alone and therefore no comparison was made. However, application of *P. putida* DAPG2, *P. putida* DAPG3, fluorescent pseudomonads strains FP86, FP94, FP121, FP133 and FP82 significantly enhanced the pod yield of groundnut, cultivar GG 20 (Table 4). Application of DAPG-producing fluorescent pseudomonads, reduced the population of *A. niger* in soil (Table 5).

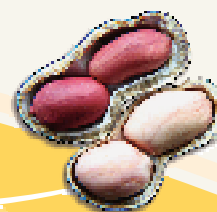


Table 4. Development of suppressive soils to *Aspergillus niger*, cultivar GG 20 (kharif2011)

Treatment	PY (kg ha ⁻¹)	HY (kg ha ⁻¹)	Shelling out- turn (%)
Control	1775	4607	64.9
+Pathogen	1671	4290	64.4
+DAPG2	2093	5047	67.0
+DAPG3	2190	5117	68.0
+DAPG4	1744	4580	65.8
+DAPG7	1820	4783	66.5
+FP20	1873	4910	65.9
+FP46	1818	4713	66.7
+FP86	1903	4713	65.4
+FP93	1880	4890	65.9
+FP94	2076	5056	65.9
+FP121	2030	5003	66.1
+FP133	1908	4900	67.1
+FP82	1947	4886	66.8
CD (5%)	112	223	1.2

Table 5. Influence of application of DAPG-producing groundnut rhizobacteria on the soil population of *Aspergillus niger*

Isolate	Population (CFU g ⁻¹ soil) of <i>Aspergillus niger</i>			
	Before application in soil	Inoculum load (CFU g ⁻¹ carrier)	After 15 days	After 30 days
Control	25 X 10 ¹	-	ND	ND
+Pathogen	25 X 10 ¹	31X 10 ⁶	360 X 10 ³	163 X 10 ³
+DAPG2	25 X 10 ¹	31X 10 ⁶	65 X 10 ³	32 X 10 ³
+DAPG3	25 X 10 ¹	31X 10 ⁶	57 X 10 ³	20 X 10 ³
+DAPG4	25 X 10 ¹	31X 10 ⁶	63 X 10 ³	27 X 10 ³
+DAPG7	25 X 10 ¹	31X 10 ⁶	62 X 10 ³	37X 10 ³
+FP94	25 X 10 ¹	31X 10 ⁶	71 X 10 ³	26 X 10 ³
+FP82	25 X 10 ¹	31X 10 ⁶	70 X 10 ³	29X 10 ³
+FP121	25 X 10 ¹	31X 10 ⁶	38 X 10 ³	17X 10 ³



Evaluation of DAPG-producing fluorescent pseudomonads for enhancing growth and yield of groundnut

In *rabi*-summer 2011, seven DAPG-producing fluorescent pseudomonads were evaluated in field conditions. These pseudomonad were selected on the basis of their performance in pot-trials for having multiple plant growth promoting traits (production of IAA and siderophore; P-solubilization, ammonification and ACC deaminase activity, etc.) besides the ability of suppressing soil-borne fungal pathogens like *A. niger*, *A. flavus* and *S. rolfii*.

Application of *P. putida* DAPG2, DAPG3, DAPG4 and *P. fluorescens* FP98 significantly enhanced pod yield of groundnut cultivar TG 37A (Table 6). The maximum increase was obtained with DAPG3 (13%). In *kharif* 2011, apart from these seven cultures, *P. fluorescens* DAPG6 and *P. fluorescens* FP98 also significantly enhanced the pod yield of cultivar TG 37A. The maximum increase in yield was recorded with DAPG6 (19%).

Table 6. Effect of inoculation of DAPG-producing fluorescent pseudomonads on growth and yield of groundnut cultivar TG 37A (summer 2011)

Treatment	PY (kg ha ⁻¹)	HY (kg ha ⁻¹)	Shelling out-turn (%)
Control	1967	4850	63.9
DAPG1	2027	5102	63.3
DAPG2	2214	5190	66.5
DAPG3	2216	5212	67.3
DAPG4	2156	5075	66.0
DAPG5	2023	5447	62.9
DAPG6	2005	5218	64.8
FP98	2154	5590	66.6
CD (5%)	153	369	1.5

Effect of application of different doses of Mo on the parameters of BNF and yield of groundnut

In a pot trial, application of Mo improved the BNF and yield attributes like number of nodules and biomass; length and dry weight of shoot and root; and pod yield. Maximum benefit was observed when Mo was applied @ 0.50 kg ha⁻¹.

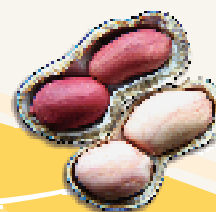


Deposition of cultures and sequences with NAIMCC

Twelve agriculturally important bacterial cultures were deposited to the National Agriculturally Important Microbial Culture Collection (NAIMCC) at NBAIM, Mau and the accession numbers were obtained. Eighty-four 16S rRNA sequences of different bacteria were submitted to NCBI and the accession numbers were obtained (Table 7).

Table 7. Details of the deposition of cultures and 16S rRNA sequences

Organisms	Number	Type	Repository	Accession Number
PGPR	12	Culture	NBAIM	NAIMCC-B-762 to NAIMCC-B-764; NAIMCC-B-00944 to NAIMCC-B-00955
Archaea	25	16S rRNA sequence	NCBI	JF802138, JF802141, JF802142, JF802144- JF802165
Bacilli	31	16S rRNA sequence	NCBI	JF802166-JF802196



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

(A. L. SINGH¹, K. A. KALARIA¹, K. CHAKRABORTY¹, S. K. BISHI¹, D. BHADURI¹, H. N. MEENA¹, M. DATTA², Y. RAMAKRISHNA², K. A. PATHAK², S. BISWAS², I. M. SINGH², A. MIRJALAM², M. SINGH², R. BHAGAWATI², N. PRAKASH², V. K. CHOUDHURY² AND S. CHAKRABORTY²)

¹Directorate of Groundnut Research, Junagadh

²ICAR Research Complex for NEH Region

Sub project 01: Mineral nutrient requirements and related disorders in groundnut

(A. L. SINGH, K. A. KALARIA, K. CHAKRABORTY, S. K. BISHI, D. BHADURI AND H. N. MEENA)

Nutrition of groundnut cultivars varying in their seed-size

Past studies have indicated that the large-seeded groundnut cultivars require more P, Ca and K for their filling than that required by medium- and small-seed cultivars. Thus pod nutrition of 50 genotypes varying in pod structure and seed size was studied for macronutrients (P and K) as well as micronutrients (Zn and B) in a field experiment. The genotypes were grown in field with two combinations of fertilizers ($P_{50} + K_{100}$ and $P_{50} + K_{100} + (2 \text{ kg ha}^{-1}) \text{ Zn} + (1 \text{ kg ha}^{-1}) \text{ B}$). Depending upon the seed size, a wide variation in the response was observed. The genotypes NRCG 11057, ICGV 86590, NRCGs 12085, 11073, and 2063 responded well to all the nutrients. The genotypes NRCG 7599, 11057, 11535, 2063, JSP 19 and JL 24, however, showed a better response to B and Zn. Both the kernels and shells of large-seeded cultivars had higher P and Ca contents compared to those of medium- and small-seed size genotypes. Application of B and Zn, resulted in increase in the contents of these elements both in kernels and shells with a more pronounced effect in the large-seeded genotypes. Thus the increase in the pod yield due to P, K, Zn and B could be attributed to increase in the length and width of both seeds and pods.

Studies on the Ni and Co nutrition in groundnut

In micro-plot studies, application of small doses of Ni and Co (0.05 and 0.10 kg ha^{-1} , respectively) increased nodulation, growth and yield of groundnut cultivars GG 2, GG 7, ICGS 76 and GG 20. It was noted that all the groundnut cultivars performed well up to



0.10 kg ha⁻¹ Ni. The responses of Co, however, varied with cultivars, and was observed only up to 0.05 kg ha⁻¹ in ICGS 76 and up to 0.10 kg ha⁻¹ in GG 2, GG 7 and TG 37A. Two years of study revealed that both Ni and Co are beneficial for enhancing nodulation and pod yield and should be applied wherever responses are observed.

Seed treatment with micronutrients

The application of Mo as seed treatment with sodium molybdate at 0.5 kg ha⁻¹ with and without Ca and P (5 kg ha⁻¹) in four groundnut cultivars (GG 2, GG 7, ICGS 76 and GG 20) revealed that there was a significant increase in yield of all the four cultivars due to application of Mo. In general, the application of Ca and P exerted a synergistic effect with the application of Mo. The seeds must be, however sown immediately after seed treatment and proper soil moisture must be maintained during germination, failing which the treatment may result in poor germination.

Yield potential of various nutrient efficient lines

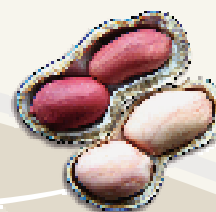
The yield potential and cation and anion contents of leaf sap and root exudates of 26 groundnut genotypes comprising both nutrient-efficient and -inefficient ones, were studied by raising these under high management during summer season. A wide variation was observed in the composition of the root exudates as well as leaf sap of groundnut genotypes which under high management showed 2.5-6.5 t ha⁻¹ yield potential. There was a positive indication of high cation contents (in leaf sap or root exudates) and high yield. The concentration of cation/anion in the leaves of inefficient cultivars was generally lower than those of the efficient genotypes.

Screening mini-core germplasm for fertilizer response and high nutrient density

The 182 accessions belonging to mini-core germplasm accessions (constituted by ICRISAT) were evaluated for their response to fertilizer application and micronutrient density in the kernels. Due to excessive rains very poor pod yield, however, were recorded. The pod yield varied from 30 g m⁻² yield to as high as 250 g m⁻² with an average of 90 g m⁻².

Studies on Zn and B responses in groundnut cultivars

A total of 171 groundnut cultivars were grown to study their response to application of Zn and B. Due to excessive rainfall, the yield levels were low with an average yield of 980 kg ha⁻¹. All cultivars did not respond to application of these micronutrients. The pod yield increased to 1300 kg ha⁻¹ with application of Zn and 1190 kg ha⁻¹ with application of B. These cultivars could be classified into some of the high and low yielding and responsive cultivars to these micronutrients are:



- High-yielding (>150 g pod m^{-2}) cultivars responsive to Zn: JSP 19, CSMG 84-1, CSMG 9510, CSMG 884, ICGS 76, B 95, M 335, GG 13, Chitra, ICGS 76, M 522, M 13, GG 16 and Girnar 2
- High-yielding (>150 g pod m^{-2}) cultivars responsive to B: CSMG 84-1, GG 16, GG 13, CSMG 884, M 522, ICGS 76, Chitra, CSMG 9510, JSP 19 and Girnar 2
- Cultivars responsive to both Zn and B: JSP 19, ICGS 76, CSMG 9510, Chitra, CSMG 884 and Girnar 2
- Low yielding cultivars not responding to Zn and B: Chico, TG 3, MH 1, Jyoti, MH 4, CO1 and Jawan

Screening groundnut cultivars for high Zn content in seeds

In an experiment, seeds of 103 groundnut cultivars were analyzed for Zn and Fe contents, and also for some other nutrients. The Zn concentration in the seeds of cultivars was in the range of 40-65 $mg\ kg^{-1}$ with a mean value of 53 $mg\ kg^{-1}$ during first year and 38-68 $mg\ kg^{-1}$ Zn with a mean value of 56 $mg\ kg^{-1}$ Zn during second year. The Fe concentration in seed was in the range of 30-190 $mg\ kg^{-1}$ with a mean value of 90 $mg\ kg^{-1}$ Fe in the first year of experimentation. In the subsequent year the Fe concentration in seed ranged from 60-250 $mg\ kg^{-1}$ with a mean value of 120 $mg\ kg^{-1}$ Fe. When the data of two years were pooled, the Zn content in seeds ranged from 39-67 $mg\ kg^{-1}$ with a mean of 55 $mg\ kg^{-1}$. Accordingly the groundnut cultivars were categorized in various categories. The pooled data on Zn concentration of seed revealed that of the 103 groundnut cultivars, 16 were low in Zn density showing less than 51 $mg\ kg^{-1}$, 70 cultivars were medium in Zn density showing 51-63 $mg\ kg^{-1}$ Zn in their seeds. However, 17 cultivars having more than 63 $mg\ kg^{-1}$ Zn in their seeds, were categorized as high Zn density groundnut cultivars and are listed below.

- Groundnut with high Zn in seed (> 63 ppm): TKG 19 A, BG 3, Somnath, ICGV 86590, M 145, M 197, M 13, CO 1, B 95, Tirupati 3, Gangapuri, CO 2, , KRG 1, CSMG 884, GG 7, TAG 24.
- Groundnut with high Fe (>150 ppm): M 145, M 13, DSG 1, AK 12-24, TAG 24, ALR 3, JSP 19, MH 4, Somnath, ICGV 86031, ICGV 86325, Tirupati 3, GG 2

From the two years of study it was conclude that though seasonal variations occurred, there are certain high Zn density groundnut cultivars which need extensive cultivation and consumption as food to combat the Zn malnutrition in India.

Zinc Bio-fortification in groundnut

In a study conducted on 60 groundnut cultivars, an aqueous solution of 0.2% zinc sulphate was sprayed on the foliage, thrice during the season i.e. at 40, 55 and 70 DAE at a rate of 500, 1000 and 1000 $L\ ha^{-1}$, respectively. The application influenced yield and the yield attributes, checked over-growth of the foliage and also increased the seed Zn content.



The mean Zn concentrations in seeds of 60 groundnut cultivars was 50 mg kg^{-1} (range $32\text{-}67 \text{ mg kg}^{-1}$) which due to spray increased to 58 mg kg^{-1} (range $40\text{-}70 \text{ mg kg}^{-1}$). Under normal conditions, seeds of 29 cultivars showed 50 mg kg^{-1} and more Zn and 31 cultivars showed less than 50 mg kg^{-1} Zn, but with application of Zn the number of cultivars showing above 50 mg kg^{-1} Zn increased to 51 and only 9 cultivars left with less than 50 mg kg^{-1} Zn. So much so with application of Zn seeds of 30 cultivars showed 60 mg kg^{-1} and above Zn which otherwise were only 10 without Zn.

Overall (average of 60 cultivars) there was 16% increased in the seed Zn content in groundnut cultivars due to foliar application of Zn. However, these responses varied with cultivars and there was 0 to 60% increase in seed Zn content over control. It was interesting to note that due to foliar application of Zn, the groundnut cultivars with seed Zn 50 mg kg^{-1} and above, 5 showed negative response (-2 to -8%), 11 showed marginal increase ($2\text{-}5\%$), 10 showed $11\text{-}20\%$ increase and only 4 of them showed more than 20% increase in seed Zn. Similarly, in the cultivars with seed Zn less than 50 mg kg^{-1} foliar application of Zn, 2 showed negative response (-2%), 4 showed marginal increase ($2\text{-}8\%$), 6 showed $11\text{-}20\%$ increase, but 19 of them showed more than 20% increase in seed Zn. This clearly indicated that the groundnut cultivars with low seed Zn are more responsive to foliar application than the cultivars with high seed Zn. Some of the cultivars not responding to foliar application in increasing seed Zn indicated their genetic makeup.

Thus foliar application of Zinc sulphate is recommended to increase Zn content of groundnut seed. Further the groundnut growers are recommended to use Zn responsive high Zn density cultivars.

Sub-project 02: Management of soil acidity and related problems of groundnut (A. L. SINGH¹ AND M. DATTA²)

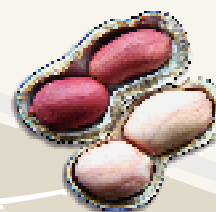
¹Directorate of Groundnut Research, Junagadh

²ICAR Research Complex for NEH Region

Screening of groundnut genotypes for Al-toxicity tolerance

In sand culture

Thirty-four groundnut varieties were screened for their tolerance of Al-toxicity ($1000 \mu\text{M}$ of Al as AlCl_3) in pot where Al-toxicity clearly affected roots and plant growth 25-30 days after sowing reducing yields. Based on the relative performance, the groundnut varieties GG7, M 335, ICGV 86590, HNG 69, R 9251 and GG 16 showed comparatively more tolerance to Al-toxicity than others.



Field Screening in acid soils

The screening of groundnut germplasm and cultivars, is a regular feature of the project and by now about 150 germplasm lines were tested in the Acid soils of NEH region at different locations (Tripura, Mizoram, and Nagaland) both under fertilized (Lime 500 kg ha⁻¹, FYM 10 t ha⁻¹ and P₂O₅ 50 kg ha⁻¹) and unfertilized conditions and several promising lines showing tolerances to Al-toxicity were identified (NRCGs 11551, 2538, 11656). The performance of 46 groundnut germplasm screened during 2011 at Tripura against the soil acidity condition, are presented in Table 1.

Experiment on organic farming

In NEH region, various approaches to organic farming were tested along with the traditional farmer practices to overcome poor availability of lime and chemical fertilizers and also to reduce the cost of cultivation. Over a period of 5-6 years it was noticed that in Nagaland and Mizoram, the bun-farming was not only more akin to nature but also practical for poor farmers.

In a field experiment at Nagaland, the effect of inorganic and organic sources of nutrients on different varieties of groundnut at pH 4.7 was evaluated. The use of organic and 50% organic and 50% NPK (F 1) was found to be superior to NPK (F 2) and 25% organic + 75% NPK (F 3).

Nutrient management in bold seeded groundnut

The confectionery groundnut varieties require proper moisture and nutrition. In NEH region, where water is not a limiting factor and low temperatures during the pod filling stage provide a congenial environment for high yields. The low temperature during pod filling provides a congenial environment for proper pod filling. However the soil acidity and Al-toxicity, due to high rainfall, may become a major hurdle in realizing the yield potential. Hence field experiments were conducted with groundnut cultivar GG 7 and applying various combinations of organic and inorganic sources of nutrients as an ameliorative measure to counter the soil acidity and Al-toxicity and thus identify the key nutrients for successful cultivation of large-seeded varieties. The productivity parameters recorded at Tripura for different treatments, viz. T₁: control, T₂: P₅₀, T₃: K₁₀₀, T₄:Lime (2.5 t ha⁻¹), T₅:P₅₀ + Lime(2.5 t ha⁻¹), T₆: P₅₀ + K₁₀₀ + Lime (2.5 t ha⁻¹), T₇: P₅₀ + K₁₀₀ + Lime(2.5 t ha⁻¹) +Boric acid (13 Kg ha⁻¹). T₈: P₅₀ + K₁₀₀ + Lime(2.5 t ha⁻¹) +cowdung (10 t ha⁻¹) are presented in Table 2.



Table 1. Performance of groundnut germplasm

Groundnut Variety	No of pod plant ⁻¹	Pod wt (g plant ⁻¹)	Seed wt (g plant ⁻¹)	Plant wt (g plant ⁻¹)
NRCG 12423	8	9.00	6.33	8.66
NRCG 12927	14	7.66	4.66	9.00
NRCG 12393	19	13.7	9.33	20.7
NRCG 12334	18	10.7	8.00	14.7
NRCG 11769	16	17.0	7.33	24.0
NRCG 10388	9	8.33	5.66	10.7
NRCG 12174	12	11.7	8.66	19.3
NRCG 5295	11	7.33	4.33	15.0
NRCG 10798	10	9.66	6.00	11.3
NRCG 11276	18	15.0	10.7	14.0
NRCG 11700	14	13.3	9.33	11.0
NRCG 12348	14	13.3	8.00	14.0
NRCG 5001	22	24.7	8.33	38.3
NRCG 11289	17	8.33	5.33	11.3
NRCG 12148	14	8.66	4.00	13.7
NRCG 12700	12	8.66	5.00	9.33
NRCG 2190	9	6.66	3.33	7.33
NRCG 11154	8	5.33	2.00	9.66
NRCG 12899	7	6.66	3.33	9.66
NRCG 10541	5	7.66	3.66	10.0
NRCG 8963	6	4.66	2.33	6.00
NRCG 12671	1	6.66	3.33	4.66
NRCG 11275	7	7.66	4.00	13.3
NRCG 11450	16	6.00	3.33	13.7
NRCG 12273	9	9.00	4.00	16.7
NRCG 12319	14	9.33	4.66	8.33
NRCG 10456	12	8.33	2.33	26.3
NRCG 12921	12	5.33	3.00	11.0
NRCG 10496	11	5.00	2.66	6.33
NRCG 12272	7	4.33	1.66	8.33
NRCG 12698	7	4.00	2.00	7.66
NRCG 3198	14	6.00	2.66	12.7
NRCG 2203	7	8.00	5.00	18.3
NRCG 6937	15	4.33	1.66	10.7
NRCG 11682	6	10.7	6.33	14.3
NRCG 10259	8	5.33	5.66	25.0
NRCG 8428	6	5.66	2.33	9.66
NRCG 3491	6	3.33	2.00	19.3
NRCG 5405	5	4.66	1.66	9.00
NRCG 10456	8	3.33	2.00	15.3
NRCG 201	7	4.66	2.66	4.33
NRCG 11126	7	4.00	1.66	4.33
NRCG 5001	4	4.33	2.33	4.00
NRCG 11653	4	3.00	1.33	3.66
SEM (±)	2.17	1.62	1.41	3.05
CD (5%)	1.35	1.17	1.09	1.60

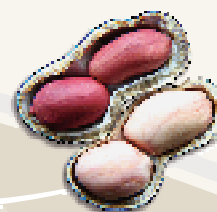


Table 2. Nutrition of bold seeded groundnut in acid soils

Treatments	No of pod (plant ⁻¹)	Pod wt (g plant ⁻¹)	Plant weight (g plant ⁻¹)	No of seed (plant ⁻¹)
T ₁ - control	14	18.9	26.5	21
T ₂ - P ₅₀	19	20.3	20.0	30
T ₃ - K ₁₀₀	16	17.4	18.4	27
T ₄ -Lime (2.5t ha ⁻¹)	15	19.2	16.2	24
T ₅ - P ₅₀ + Lime(2.5t ha ⁻¹)	21	26.2	20.9	31
T ₆ - P ₅₀ + K ₁₀₀ + Lime(2.5t ha ⁻¹)	25	37.1	30.7	42
T ₇ - P ₅₀ +K ₁₀₀ +Lime	24	29.1	37.2	37
Boric acid (13 kg ha ⁻¹)				
T ₈ - P ₅₀ + K ₁₀₀ + Lime(2.5t ha ⁻¹) cowdung (10 t ha ⁻¹)	28	40.5	37.9	43
SEM (±)	2.89	4.30	7.11	5.28
C.D (5%)	1.71	2.09	2.68	2.31

The treatment T₈ comprising phosphate (50 kg P₂O₅ ha⁻¹), potash (100 kg K₂O ha⁻¹), lime (2.5 t ha⁻¹) and cowdung (10 t ha⁻¹) resulted in the highest pod yield of 0.42 t ha⁻¹ with 28 pods and 40.5 g pods per plant.

In another experiment conducted at Tripura, in the unfertilized condition very poor pod (only 290 kg ha⁻¹ and haulm (220 kg ha⁻¹) yields were obtained while the application of lime, phosphorus and potash gave a pod yield of 780 kg ha⁻¹ and haulm yield 930 kg ha⁻¹. The results thus established the importance of application of lime and phosphorus in acid soils. Additional application of FYM further enhanced the pod (1120 kg ha⁻¹) and haulm (1030 kg ha⁻¹) yields.

Use of micronutrient in bold-seeded groundnut variety in Acid soil

The influence of application of various micronutrients on the productivity parameters of groundnut variety GG 7 was studied at Tripura. The treatments were: M₁: control, M₂: ZnSO₄, M₃: Ammonium molybdate, M₄:boric acid, M₅: Ammonium molybdate + boric acid, M₆: ZnSO₄ + boric acid. The results are presented in Table 3.

Table 3. Productivity parameters of groundnut variety GG 7

Treatments	No. of pod (plant ⁻¹)	Pod weight (g plant ⁻¹)	Seed weight (g plant ⁻¹)	No. of seed (plant ⁻¹)
M ₁ - control	10	8.73	5.66	19
M ₂	16	15.0	7.66	31
M ₃	16	29.4	17.6	39
M ₄	25	19.5	8.43	25
M ₅	14	9.18	4.77	12
M ₆	10	8.96	3.21	9
SEM (±)	3.48	2.01	0.53	1.16
C.D (5%)	1.95	1.47	0.76	1.12



It is indicated from the Table 3 that the treatment combination M_3 after the application of Molybdenum could produce the highest pod weight plant^{-1} 29.4, seed weight $17.6 \text{ g plant}^{-1}$ and 39 seeds plant^{-1} .

In Mizoram, the effect of various components and sources of Integrated Nutrient Management in groundnut was evaluated on bold seeded variety ICGS 76. The maximum pod yield of $2310 \text{ (kg ha}^{-1}\text{)}$ was obtained with $P_{50} + K_{50} + \text{Lime } 2.5 \text{ t ha}^{-1} + \text{boron} + \text{molybdenum}$ which was significantly superior to $P_{50} + \text{BF}$, P_{50} and control. In another experiment at Mizoram the groundnut varieties ICGS 76 and TG 37A when evaluated under different fertility levels maximum pod yield of 1570 and 2110 kg ha^{-1} , were recorded with ICGS 76 and TG 37A, respectively, with application of $P_{50} + K_{100} + \text{Lime } 2.5 \text{ t ha}^{-1} + \text{FYM } 10 \text{ t ha}^{-1}$. The performance of TG 37A was better than ICGS 76 in response to the nutrient application.

Several years of study reveals that P, Ca, K and B and many a time N also are the key nutrients in acid soils of the NEH region where these deficiencies are induced and for achieving required yield and quality in large-seeded groundnut application of P, Ca and B and organic fertilizers are most critical. The study with various fertilizers, lime and FYM has shown that it is essential to fertilize the large-seeded groundnut with essential elements and with proper management it was possible to harvest about 2000 kg ha^{-1} pod yield. The, combination of organic with inorganic sources was better than the lone use of inorganic fertilizers in acid soils.

Sub-Project 03: Development of sustainable production technologies for north-eastern India

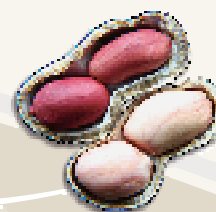
(A. L. SINGH¹, M. DATTA², Y. RAMAKRISHNA², K. A. PATHAK², S. BISWAS², I. M. SINGH², A. MIRJALAM², M. SINGH², R. BHAGAWATI², N. PRAKASH², V. K. CHOUDHURY² AND S. CHAKRABORTY²)

¹Directorate of Groundnut Research, Junagadh

²ICAR Research Complex for NEH Region

Evaluation of recently released cultivars and nutrient efficient lines

Field evaluation of groundnut varieties, for their tolerance of soil acidity and Al-toxicity and finally high pod yield in NEH region is a regular feature, and by now more than 100 varieties have been tested and many of them have been recommended. During past 5 years about 40 genotypes comprising of released cultivars and nutrient efficient lines were evaluated in NEH region and the high yielding groundnut genotypes with good amount of tolerance to soil acidity, insect pest and foliar diseases were identified for various states:



- Mizoram: ICGS 76, ICGV 88448, CSMG 84-1, ICGV 86590, TKG 19A, GG 20, M 13.
- Tripura: ICGS 76, GG 13, M 13, TG 37A, Kaushal, NRCG 7599, 6450, 6155
- Arunachal Pradesh: ICGV 86590, GG 7, NRCG 1308 and 7599.
- Nagaland: ICGS 76, CSMG 84-1 GG 7, FeESG 8 and 10 and NRCG CS 268, 148

At Tripura the productivity parameters of 14 genotypes, ICGS 76, GG 2, GG 13, TG 37 A, FeESG 10, FeESG 8, K 134, GG 6, SB XI, GG 11, Kaushal, GG 4, GG 2, GG 8 with NPK (40:60:50) and cowdung (5 t ha⁻¹) are presented in Table 4. The number of pod, pod and seed weight in groundnut underwent a variation from 9.4 to 17, 6.9 to 21.2, and 4.8 to 21.2 g plant⁻¹ respectively.

Identification of suitable groundnut varieties for various intercropping systems

In Tripura, the Groundnut var. GG7 was grown in intercropping (2:2) with rice, sesamum, cowpea and maize with NPK dose 40:60:50 kg ha⁻¹ in combination with cowdung (5 t ha⁻¹). Treatment combinations N₁: Rice sole crop, N₂:Sesamum sole crop, N₃:Maize sole crop, N₄:Groundnut sole crop, N₅: Groundnut: Rice (2:2), N₆:Groundnut: Sesamum (2:2), N₇: Groundnut: Maize (2:2) are presented in Table 5.

Evaluation of confectionery groundnut genotypes in NEH region

With no limitation of water, the NEH region offers high potential for growing confectionery groundnut, 10-15 confectionery / large seeded groundnut varieties, (viz., GG 20, HNG 10, ICGS 76, BAU 13, TPG 41, GG 7, Somnath, NRCG CS 148, 268 and 281) were evaluated for their yield potential in NEH region under high management conditions of (FYM (10 t ha⁻¹) PSM, PGPR and all fertilizers). Four years of study in Mizoram, Tripura, Barapani and Nagaland reveals that though all these groundnut genotypes performed well in NEH and hence any one of these could be used, however the BAU 13, GG 20, CSMG 84-1, ICGS 76 and NRCGCS 148 were superior yielding ones. But these large seeded groundnuts should not be grown in low fertility soils, where the performance of these was very poor.



Table 4. Productivity parameters of 14 groundnut varieties

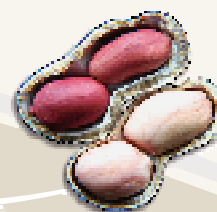
Groundnut variety	No. of pod (plant ⁻¹)	Pod weight (g plant ⁻¹)	Plant weight (g plant ⁻¹)	No of seed (plant ⁻¹)
ICGS 76	15	21.1	40.1	21
GG 2	13	15.1	27.6	20
GG 13	14	17.2	28.0	20
TG 37 A	16	15.1	21.0	21
FeESG 10	12	10.7	19.3	20
FeESG 8	9	6.88	29.0	13
K 134	14	20.9	39.4	20
GG 6	11	8.10	20.2	17
SB XI	15	13.7	27.1	21
GG 11	16	21.2	35.9	22
Kaushal	17	18.2	47.1	29
GG 4	12	9.55	26.6	17
GG 2	13	13.4	33.8	24
GG 8	15	14.6	28.2	24
SE (±)	2.61	3.00	6.92	4.15
CD (5 %)	1.56	1.67	2.54	1.96

Table 5. Productivity in intercropping experiment with groundnut

Treatments	No of pods (plant ⁻¹)	Pod weight (g plant ⁻¹)	Seed weight (g plant ⁻¹)	No of Seeds (plant ⁻¹)	Shelling (%)	Equivalent Yield (kg ha ⁻¹)
N1	-	-	-	-	-	450
N2	-	-	-	-	-	520
N3	-	-	-	-	-	150
N4	15	15.0	11.6	11	77.1	1200
N5	19	17.1	13.1	11	76.6	1600
N6	17	16.3	12.7	11	77.5	1210
N7	18	13.4	10.3	9	76.6	1180
SEM (±)	1.21	1.16	1.22	1.15	76.6	-
CD (5%)	1.26	1.23	1.27	1.23	10.06	-

*Selling price (kg⁻¹) of Groundnut, Sesamum, Rice, and Maize are ₹ 30, 35, 10 and 20 respectively.

In Nagaland, 11 groundnut varieties/ nutrient efficient lines were evaluated for their yield potential where all these recorded more than 1800 kg ha⁻¹ pod yield with maximum yield in FeESG 10 (3280 kg ha⁻¹) followed by NRCG CS 148, GG 7 and ICGS 76.



Effect of different sources of boron

Performance of bold-seeded groundnut variety ICGS 76 was evaluated with different boron sources to determine the boron requirement of bold-seeded groundnut during *kharif* at Mizoram using treatments comprised of different boron sources either foliar application (three spray at 15 days interval after 30 DAS) or as soil application or as seed dressing at a spacing of 45cm x 10cm using fertilizer dose of NPK @ 20:30:40 kg ha⁻¹. The data presented in Table-6 revealed that maximum pod yield of 2152 kg ha⁻¹ was recorded with application of Chemiebore (2 kg ha⁻¹ B) as foliar spray which was at par with application of borax as soil application (20 kg ha⁻¹), Boric acid soil application and Colemanite (20 kg ha⁻¹) soil application 2097, 2091 and 2032 kg ha⁻¹, respectively.

Table 6. Effect of different sources of boron on yield of groundnut during *kharif* 2011

Treatment	Height (cm)	Pods (plant ⁻¹)	Pod yield (q ha ⁻¹)
Agricol (Colemanite) Soil	28.3	12	20.3
Agricol Seed Dressing	22.6	12	17.4
Chemiebore, Foliar Spray	27.5	15	21.5
Solubor-Soil application	25.8	10	15.7
Solubor- Foliar Spray	27.6	12	18.0
Borosol Soil application	24.4	11	15.8
Borosol Foliar Spray	20.3	14	17.5
Borax Soil application	22.5	12	21.0
Boric acid Soil application	28.5	13	21.0
Control (no boron)	20.3	9	14.1
SEm ±	1.7	4.65	1.22
C.D. (5%)	5	13.9	3.67



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

(N. K. JAIN, H. N. MEENA, D. BHADURI AND K. K. PAL)

Development of technology for application of citric acid in groundnut to enhance the P availability

The experiment was initiated during summer 2009 in order to find out a suitable mode of citric acid application for increasing the availability of soil phosphorus to groundnut. The experiment, consisted of five modes of application (Unfertilized, 2 t FYM ha⁻¹, 1 t FYM ha⁻¹, 250 kg SSP ha⁻¹ and 125 kg SSP ha⁻¹) in main plots and four levels of citric acid (0, 2, 4 and 6 kg ha⁻¹) in sub-plots having split plot design with three replications.

Application of FYM @ 2 t ha⁻¹ significantly improved pod and haulm yields of groundnut over rest of treatments with 20.1 and 12.4% superiority, respectively as compared to unfertilized plot (Table 1). However, application of 250 kg SSP ha⁻¹ was found at par for pod and haulm yields and application of 1 t FYM ha⁻¹ for haulm yield only. The highest net returns (₹ 53,854 ha⁻¹) and B: C ratio (2.69:1) was also recorded with 2 t FYM ha⁻¹ while phosphorus availability after crop harvest was maximum in 250 kg SSP ha⁻¹ (24.5 kg P ha⁻¹). Further, the highest pod (1793 kg ha⁻¹) and haulm yields (4413 kg ha⁻¹) was observed with the application of 2 kg citric acid ha⁻¹ as compared to other citric acid levels which was significantly superior over the control only. Maximum net returns (₹ 53,711 ha⁻¹) and B: C ratio (2.70:1) was also obtained with 2 kg citric acid ha⁻¹ while phosphorus availability after crop harvest was maximum in 6 kg citric acid ha⁻¹ (24.6 kg P ha⁻¹). The interaction effect of mode of application and levels of citric acid was found non-significant. Over all, application of 2 t FYM ha⁻¹ along with 2 kg citric acid ha⁻¹ was found better in terms of pod as well as haulm yields as well as realization of economic returns.

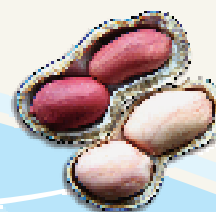


Table 1. Effect of mode and doses of application of citric acid on pod and haulm yields of groundnut (summer 2011)

Treatment	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Mode of application		
Unfertilized (Control)	1469	3926
2 t FYM ha ⁻¹	1764	4413
1 t FYM ha ⁻¹	1575	4230
250 kg SSP ha ⁻¹	1740	4184
125 kg SSP ha ⁻¹	1552	3936
CD (5%)	178	447
Dose of citric acid (kg ha⁻¹)		
0 (Control)	1525	3926
2	1793	4413
4	1608	4230
6	1555	4184
CD (5%)	185	363

Sulphur-management in summer groundnut-maize cropping system

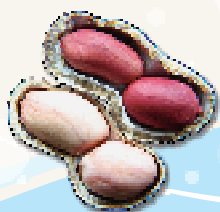
A field experiment was conducted in summer 2011 with the objectives to study the effect of levels and sources of sulphur on productivity of summer groundnut-maize cropping system and to find out the most viable treatment combination for groundnut-maize cropping system. The experiment, consisting of combinations of three different sources of sulphur (gypsum, cosavet and SSP) and three levels of sulphur (20, 40 and 60 kg S ha⁻¹) along with one absolute control applied to summer groundnut, allotted to main plot and three levels of sulphur (0, 75 and 100% of recommended dose of sulphur to maize) applied to succeeding maize, was laid out in split plot design with three replications.

During summer 2011 it was observed that all the treatments had significant effect on pod and haulm yields of groundnut over the absolute control. Further, different sources and levels of sulphur did not bring out any perceptible variation on yields. The succeeding crop of maize was sown during first week of July, 2011 but the crop was damaged and eaten by stray animals. Hence, grain yield was not recorded.

Revalidation of fertilizer doses (N:P:K) for summer groundnut production

The experiment was taken up to revisit the recommendations for application of nitrogen, phosphorus and potassium fertilizers for summer groundnut. A total of 27 combinations, comprising each nutrient at three different levels, were evaluated.

Application of 37.5 kg N ha⁻¹ significantly increased pod and haulm yields over RDF i.e. 25 kg N ha⁻¹ which was found at par with 50 kg N ha⁻¹ (Table 2). Similarly, with each



successive increase in phosphorus levels significantly improved pod and haulm yields up to 70 kg P_2O_5 ha⁻¹ and further, a non-significant increase was observed at the higher level. Similarly, application of potassium significantly enhanced pod and haulm yields up to 30 kg K_2O ha⁻¹. All growth and yield parameters were also found in similar trend. Due to addition of nutrients, soil fertility status also improved significantly as compared to initial status. In general, application of 37.5 kg N, 70 kg P_2O_5 and 30 kg K_2O ha⁻¹ was found effective in improving groundnut yield as well as soil fertility status.

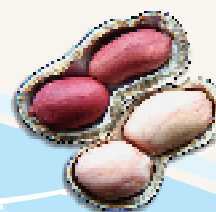
Table 2. Effect of nitrogen, phosphorus and potassium on yield of groundnut (summer 2011)

Treatment	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
N levels (kg ha⁻¹)		
25	1900	4074
37.5	2093	4356
50	2166	4367
CD (5%)	180	237
P levels (kg P_2O_5 ha⁻¹)		
50	1820	3970
70	2149	4369
90	2190	4458
CD (5%)	180	237
K levels (kg K_2O ha⁻¹)		
0	1815	4075
30	2140	4335
60	2203	4386
CD (5%)	180	237

Effect of irrigation intervals and fertigation on groundnut productivity under drip irrigation

The experiment was laid out during summer 2011 with the objectives to study the effect of irrigation intervals and fertigation on productivity of groundnut and to work out fertilizer and water savings under drip irrigation. The experiment consists of two irrigation intervals i.e. irrigation at 4-day intervals (10-day intervals in F_1) and irrigation at 6-day intervals, (15-day intervals in F_1), allotted to main plots and four fertigation schedules (100% NPK in furrows with check basin method of irrigation, 50, 75 and 100% NPK through drip), allotted to sub-plots, was laid out in split plot design with three replications.

Application of irrigation water either at 4-or 6-day intervals through drip (10- or 15-day intervals under check basin irrigation) did not affect pod and haulm yields of groundnut



significantly. Thus, there will be saving of 15.4% water under drip and 26.0% water under check basin method of irrigation, if irrigated at 6-day intervals through drip and 15-day intervals through check basin method of irrigation.

Crop fertilized with 75% NPK through drip significantly enhanced pod and haulm yields by 16.8 and 15.1%, respectively over 50% NPK through drip and was at par with 100% NPK through drip and 100% NPK placed in furrows with check basin irrigation. Thus, there will be saving of 25% NPK over RDF. However, the interaction effect of irrigation intervals and fertigation schedules on pod and haulm yields was not found significant.

Effect of polythene mulch, hydrogel and nutrient management on groundnut under drip irrigation

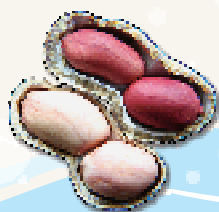
The experiment was initiated in summer 2011 to study the effect of polythene mulch, hydrogel and nutrient management on productivity of groundnut. The experiment, consisting of two mulching treatments i.e. with and without polythene mulch assigned to main plots, three levels of hydrogel i.e. 0, 2.5 and 5.0 kg ha⁻¹ assigned to sub-plots and three nutrient management schedules i.e. organic, inorganic and integrated nutrient management assigned to sub-sub plots, was laid in split-split plot design with three replications.

The pod and haulm yields of groundnut increased significantly with the use of polythene mulch to the tune of 11.3 and 20.5%, respectively as compared to without mulch treatment.

Application of hydrogel @ 2.5 kg ha⁻¹ significantly improved both pod and haulm yields over the control and beyond which no significant response was recorded. The improvement in pod and haulm yields was 6.0 and 10.7% over control, respectively. Data further showed that integrated use of organic manures, inorganic fertilizers and biofertilizers also improved pod and haulm yields significantly by 10.2 and 8.6% over inorganic fertilization, respectively. However, the interaction effect of polythene mulch, hydrogel and nutrient management schedule on pod and haulm yields was not found significant.

Effect of different combination of nutrient sources on growth, yield and quality of summer groundnut

The experiment was conducted during summer 2011 in a randomized block design with three replications in 8 m x 5 m net plot size. The treatments comprised



T ₁	Control
T ₂	10 t FYM ha ⁻¹
T ₃	25:50:00 kg recommended NPK + 5 t FYM + 500 kg gypsum ha ⁻¹
T ₄	Farmer's practices (45-70-40 NPK kg ha ⁻¹)
T ₅	40-60-60 kg urea + SSP + MOP ha ⁻¹
T ₆	40-60-60 kg urea + DAP + MOP + 250 kg gypsum ha ⁻¹
T ₇	40-60-60 kg ammonium sulphate + SSP + MOP ha ⁻¹
T ₈	40-60-60 kg ammonium sulphate + DAP + MOP + 250 kg gypsum ha ⁻¹
T ₉	40-60-60 kg urea + SSP + MOP + 10:2:1 kg Fe Zn B ha ⁻¹
T ₁₀	40-60-60 kg urea + DAP + MOP + 250 kg gypsum + 10:2:1 kg Fe Zn B ha ⁻¹
T ₁₁	40-60-60 kg ammonium sulphate + SSP + MOP + 10:2:1 kg Fe Zn B ha ⁻¹
T ₁₂	40-60-60 kg ammonium sulphate + DAP + MOP + 250 kg gypsum + 10:2:1 kg Fe Zn B ha ⁻¹
T ₁₃	RDF + 5 t FYM + 500 kg gypsum + 10:2:1 kg Fe Zn B ha ⁻¹
T ₁₄	10 t FYM + 10:2:1 kg Fe Zn B ha ⁻¹

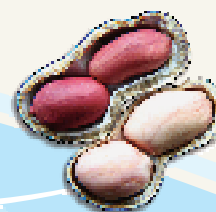
Pod and haulm yields of groundnut increased significantly with the application of 40-60-60 kg ammonium sulphate + SSP + MOP + 10:2:1 kg Fe Zn B ha⁻¹ (T₁₁) over rest of the treatments except T₃, T₉, T₁₀, T₁₂, T₁₃ and T₁₄.

Optimization of fertilizer doses for specific yield targets through IPNS in groundnut

A field experiment was initiated during *kharif* 2009 to optimize fertilizer doses for specific yield targets through IPNS. In the first step to create fertility gradient in the field and generation of basic data on nutrients (N, P, K, S, Ca, B) requirement (kg t⁻¹), per cent contribution from soil, fertilizers and FYM, and to calculate soil and fertilizer efficiencies, seven different treatments were applied to create the fertility gradient in the field as per following details:

T ₁	Control
T ₂	Farmers' practice (41-46-25 kg NPK ha ⁻¹)
T ₃	30-40-50-80-25-30-2-1 kg NPKCaSMgZnB ha ⁻¹
T ₄	40-60-75-125-30-40-3-1 kg NPKCaSMgZnB ha ⁻¹
T ₅	50-80-100-150-40-50-4-1.5 kg NPKCaSMgZnB ha ⁻¹
T ₆	60-100-125-200-50-60-5-2 kg NPKCaSMgZnB ha ⁻¹
T ₇	12 t FYM ha ⁻¹

Data (Table 3 and 4) revealed that maximum pod (1381 and 2626 kg ha⁻¹) and haulm yields (4938 and 8025 kg ha⁻¹) were recorded with the treatment T₆ in both the varieties i.e.



GG 7 and GG 20, respectively which was significantly superior over all the other treatments except T₅ and T₄. All other parameters showed almost similar trend. Maximum soil nitrogen and phosphorus status after harvest was also recorded under the treatment T₆ in both the varieties.

Table 3. Effect of different treatments on yield and yield attributes of groundnut (variety GG 7)

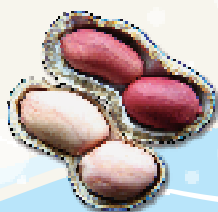
Treatment	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	100-kernel wt (g)	Mature pods (no. plant ⁻¹)	Immature pods (no. plant ⁻¹)
T ₁	937	3909	17.3	21.7	8.3
T ₂	1111	4012	18.0	23.3	7.7
T ₃	1105	4321	18.7	24.0	5.3
T ₄	1183	4424	19.3	25.3	6.7
T ₅	1266	4527	20.0	26.3	8.0
T ₆	1381	4938	22.3	30.3	6.7
T ₇	956	4012	19.3	22.0	10.0
CD (5 %)	232	609	2.8	4.0	NS

Table 4. Effect of different treatments on yield and yield attributes of groundnut (variety GG 20)

Treatment	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	100-kernel wt (g)	Mature pods (no. plant ⁻¹)	Immature pods (no. plant ⁻¹)
T ₁	1872	5556	24.7	32.0	6.0
T ₂	2180	6173	26.0	31.0	8.0
T ₃	2202	6996	26.3	34.0	9.0
T ₄	2494	7613	26.7	36.0	5.0
T ₅	2531	7922	27.3	39.7	8.0
T ₆	2626	8025	28.7	45.7	9.7
T ₇	2161	6687	26.0	32.0	9.3
CD (5 %)	352	897	1.8	7.7	NS

Optimization of water and nutrient requirements for groundnut with and without polythene mulch under drip irrigation system

A field experiment was initiated during *kharif* 2011 to study the effect of polythene mulch and to optimise the nutrient and water requirements for groundnut under drip irrigation. The experiment, consisting of two mulching treatments i.e. with and without polythene mulch, allotted to main plots and five fertigation schedules (50, 75 and 100% RDF through drip, 100% RDF as furrow placement with drip irrigation and 100% RDF as furrow placement with check basin method of irrigation) allotted to sub plots, was laid out in split plot design with three replications.



Pod yield of groundnut raised under polythene mulch improved significantly by 43.1% over control i.e., without mulch. Dry weight plant⁻¹, number and weight of mature pods plant⁻¹ were also influenced significantly with polythene mulch. Number and weight of immature pods plant⁻¹ and 100-kernel weight did not differ significantly.

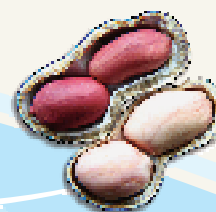
Data further showed that pod yield improved significantly by 13.2% with the application of 75% NPK through drip over its preceding level and was at par with rest of the treatments. However, maximum values of plant dry weight, number and weight of mature pods plant⁻¹ were found under treatment 100% RDF in furrows with check basin method of irrigation and had significant edge over 50% RDF supplied through drip only. None of the treatments had significant effect on number and weight of immature pods plant⁻¹ and 100-kernel weight. Thus, there will be saving of 25%NPK with drip irrigation over RDF with check basin method of irrigation. However, the interaction effect of mulching treatments and fertigation schedules on pod and haulm yields was not found significant.

Effect of different combinations of nutrient sources on growth, yield and quality of *kharif* groundnut

The experiment was conducted during *kharif* 2011 in a randomized block design with three replications in 5 m x 8 m net plot size. The experiment comprised 14 treatments namely:

- T₁ Control
- T₂ 10 t FYM ha⁻¹
- T₃ 12.5:25:0 kg recommended NPK + 5 t +500 kg gypsum ha⁻¹
- T₄ Farmer's practices (20-50-25 kg NPK ha⁻¹)
- T₅ 20-40-30 kg urea + SSP + MOP ha⁻¹
- T₆ 20-40-30 kg urea + DAP + MOP + 250 kg gypsum ha⁻¹
- T₇ 20-40-30 kg ammonium sulphate + SSP + MOP ha⁻¹
- T₈ 20-40-30 kg ammonium sulphate + DAP + MOP + 250 kg gypsum ha⁻¹
- T₉ 20-40-30 kg urea + SSP + MOP + 10:2:1 kg Fe Zn B ha⁻¹
- T₁₀ 20-40-30 kg urea + DAP + MOP + 250 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹
- T₁₁ 20-40-30 kg ammonium sulphate + SSP + MOP + 10:2:1 kg Fe Zn B ha⁻¹
- T₁₂ 20-40-30 kg ammonium sulphate + DAP + MOP + 250 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹
- T₁₃ 12.5:25:0 kg recommended NPK + FYM 5 t +500 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹
- T₁₄ 10 t FYM + 10:2:1 kg Fe Zn B ha⁻¹

A significantly higher pod yield (1506 kg ha⁻¹) was obtained in treatment T₁₀ which was at par with T₉, T₁₁, T₁₂, T₁₃, T₁₄ and T₃. However, haulm yield (3630 kg ha⁻¹) was



significantly higher in treatment T_{11} followed by T_3 . Therefore, treatment T_{10} and T_{11} were statistically superior over rest of the treatments in terms of pod and haulm yields, respectively.

Optimization of doses of hydrogel for irrigated as well as rainfed *kharif* groundnut

The experiment was initiated during *kharif* 2010. It comprised two irrigation schedules, one fully irrigated and another rainfed (without any protective irrigation), which both were allotted to main plots and four levels of hydrogel (0, 1.5, 2.0 and 2.5 kg ha⁻¹), allotted to sub plots, was laid out in split plot design with three replications. The crop was raised with full recommended package of practices. Irrigation schedule did not affect yield attributes as well as pod and haulm yields significantly.

Application of hydrogel @ 2.0 and 2.5 kg ha⁻¹, being at par with each other as well with 1.5 kg hydrogel ha⁻¹, significantly improved the pod yield by 17.6 and 19.2% and haulm yield by 9.1 and 11.0% over no use of hydrogel, respectively. Number of pegs plant⁻¹ (75 DAS), number and weight of mature pods plant⁻¹ also showed more or less similar trend. However, the interaction effect of irrigation schedules and hydrogel levels on pod and haulm yields was not found significant.

Revalidation of fertilizer doses (N:P:K) for *kharif* groundnut production

The experiment was taken up to revisit the recommendations for application of nitrogen, phosphorus and potassium fertilizers for *kharif* groundnut. A total of 27 combinations, comprising each nutrient at three different levels, were tested. Results (Table 5) revealed that successive increase in nitrogen levels up to 25 kg ha⁻¹ significantly increased pod and haulm yields of groundnut which was found non-significant with further increase in nitrogen level. The increase in pod and haulm yields due to 25 kg N ha⁻¹ was 17.1 and 31.1% over recommended dose of nitrogen (12.5 kg N ha⁻¹), respectively. Groundnut fertilized up to 60 kg P₂O₅ ha⁻¹ recorded significantly higher pod yield while application of 80 kg P₂O₅ ha⁻¹ recorded significantly higher haulm yield over recommended phosphorus dose.

Application of potassium up to 30 kg K₂O ha⁻¹ registered 23.6 and 22.5% significantly higher pod and haulm yields over control, respectively. 100-kernel mass did not differ significantly due to various treatments. Due to addition of each nutrient, soil fertility status also improved as compared to its initial status.

On the basis of three years' pooled data, it may be concluded that application of 25 kg N, 60 kg P₂O₅ and 30 kg K₂O ha⁻¹ significantly improved the productivity of *kharif* groundnut over RDF. However, the interaction effect of nitrogen, phosphorus and potassium on yield was found non-significant.

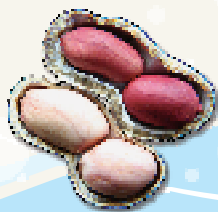


Table 5. Effect of nitrogen, phosphorus and potassium on pod and haulm yields of *kharif* groundnut (2011)

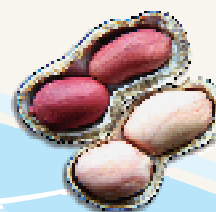
Treatment	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)	100- kernel wt (g)
N levels (kg ha⁻¹)			
12.5	1111	1718	29.63
25	1301	2253	29.52
37.5	1373	2541	30.67
CD(5 %)	98	312	NS
P levels (kg P₂O₅ ha⁻¹)			
40	1099	1910	29.37
60	1303	2202	29.63
80	1382	2401	30.81
CD(5 %)	98	312	NS
K levels (kg K₂O ha⁻¹)			
0	1074	1886	30.26
30	1327	2311	29.48
60	1384	2315	30.07
CD(5 %)	98	312	NS

Soil test based fertilizer recommendations for balanced fertilization in groundnut

To develop soil test based fertilizer recommendations for balanced fertilization in groundnut, an exhaust crop of maize was sown during *rabi* 2011-12. Three fertility strips viz. N₀-P₀-K₀ (0-0-0), N₁-P₁-K₁ (100-40-30) and N₂-P₂-K₂ (200-80-60), each of 700 m² was created to establish a fertility gradient for the test crop. Sources of N, P, K used were urea, SSP and MOP. Full doses of P and K as per treatments was applied at sowing while N was applied in three splits (half at sowing, 1/4th at 50 DAS, and 1/4th at 65 DAS). The crop was raised with standard package of practices with need-based irrigation. Harvesting was completed on 14th February, 2012 after maturation of the cobs. Soil samples were collected after harvesting to analyse soil fertility status. Cobs were separated from the plants strip-wise, later seeds from the cobs were detached and weight of the grains were recorded.

Table 7. Effect of different treatments on yield and soil fertility status after harvest of maize

Fertility blocks	Soil N (kg ha ⁻¹)	Soil P (kg ha ⁻¹)	Grain yield (t ha ⁻¹)	Stover yield (t ha ⁻¹)
Strip I	70.0	15.5	1.55	7.86
Strip II	106.6	29.3	3.00	9.57
Strip III	131.7	36.5	2.12	15.29



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

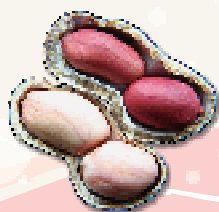
(H. N. MEENA, D. BHADURI, K. A. KALARIYA AND K. CHAKRABORTY)

Use of saline water in groundnut based cropping system

Ground water forms an important source of irrigation next to surface water in arid, semi-arid and coastal regions of the country. About 33 percent of total utilizable potential of the ground water in such regions are of poor quality. In Gujarat, particularly in Saurashtra region, farmers generally raise only one rain-fed crop of groundnut and keep fields fallow in the *rabi* (winter season) as they can not use under ground saline water for irrigation on the one hand and non availability of canal water for irrigation on the other hand. An experiment was started in the year 2002 and continued upto till date with the objective of exploring the possibility of using saline ground water for irrigation in different crop rotations (groundnut-groundnut, groundnut-wheat, groundnut-mustard, groundnut-bajra and groundnut-cowpea). After the several years of experimentation, results concluded that instead of taking single crop of groundnut in coastal area of Saurashtra region, farmers can take one more crop in *rabi*-summer season for their economic benefit by using saline water of 2-3 dS m⁻¹ salinity as supplementary irrigation in *kharif* groundnut, and in *rabi*-summer season, 4-6 dS m⁻¹ salinity of water can be used to irrigate wheat, mustard and bajra crops for their optimum yield (about 1000 kg ha⁻¹ groundnut, 1500 kg ha⁻¹ mustard, 3500 kg ha⁻¹ wheat and 3300 kg ha⁻¹ bajra), whereas saline water was unsuitable for irrigation of summer groundnut and cowpea without management practices because of build up of high soil salinity in root zone (EC_{iw} = 4 dS m⁻¹ in groundnut and EC_{iw} = 6 dS m⁻¹ in wheat, mustard and bajra) that adversely affected absorption of water by plants even though the soil had enough water. This resulted in stunted growth of plants and further significant decrease in yield. Prolonged use of saline water for irrigation increased the soil pH from 7.8 in 2002 to 8.4 in 2011, which also possibly deteriorated the soil health and affected the yield. The oil content in groundnut kernels and mustard seeds also decreased significantly with increased salinity of the water from 0.5 to 6 dS m⁻¹.

Use of poor quality (saline) water in groundnut based cropping system in saline black clay soil

After the harvest of groundnut in *kharif* 2010, cowpea in summer season was sown by using saline water irrigation having water salinity levels of 0.5, 2, 4 and 6 dS m⁻¹. Results (Table 1) showed that decreasing trend in fresh pod yield of cowpea with an increase in soil and water salinity from 0.9 to 6.6 and 0.5 to 6 dS m⁻¹ respectively. The fresh pod yield was



significantly lower in all the treatments in comparison to control (0.5 dS m^{-1}). Soil salinity buildup at harvest of cowpea crop as a result of saline water irrigation was 0.88, 4.34, 4.91 and 6.58 dS m^{-1} , respectively.

Kharif groundnut was taken in 2011 to test the eight released varieties namely TPG 41, GG 6, Girnar 3, GG 8, SG 99, TG 37A, GG 7 and R 2001-3 under Spanish group in the saline environment having salinity levels of 0.5, 2, 4 and 6 dS m^{-1} . The five meter rows length of each variety and two supplementary irrigations were given. The performances of the said varieties were normal under salinity condition. It was observed that (Table 2) the pod and haulm yields of all the varieties were at par upto the irrigation of saline water of 2 dS m^{-1} but significant difference was recorded at a water salinity of 4 and 6 dS m^{-1} in comparison to water salinity of 0.5 dS m^{-1} (control). Further, the significant difference in pod and haulm yield were also recorded within the varieties and significantly higher pod and haulm yield was recorded in TPG 41 (1128 kg ha^{-1}) and R 2001-3 (2413 kg ha^{-1}), respectively under Spanish group. The pod yields of the varieties TPG 41, R 2001-3, GG 8, TG 37A, GG 6, Girnar 3, GG 7 and SG 99 were in decreasing order under saline environment. Almost similar trend was observed for other yield contributing characters under saline environment.

Table 1. Effect of salinity on yield and yield contributing characters of summer cowpea

ECiw (dS m^{-1})	ECe (dS m^{-1})	Plant height at harvest (cm)	Root length at harvest (cm)	No. of branches plant ⁻¹
0.5	0.9	44.5	13.1	4.0
2.0	4.3	41.1	12.2	3.5
4.0	4.9	40.1	12.0	3.4
6.0	6.6	33.1	10.7	3.0
CD(5 %)	2.2	4.1	NS	0.6
ECiw (dS m^{-1})	ECe (dS m^{-1})	Dry plant weight (g)	Dry root weight (g)	Fresh pod yield (kg ha^{-1})
0.5	0.9	26.4	3.5	3046
2.0	4.3	22.5	2.8	2301
4.0	4.9	21.6	2.7	1426
6.0	6.6	18.0	2.5	404
CD(5 %)	2.2	5.4	NS	338

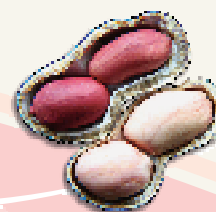


Table 2. Effect of saline water irrigation on pod and haulm yield of *kharif* groundnut

Treatments	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Salinity level (dS m⁻¹)		
0.5	1554	2858
2.0	1467	2723
4.0	689	1631
6.0	142	694
CD (5 %)	111	157
Genotype		
TPG 41	1128	2218
GG 6	937	1729
Girnar 3	881	2004
GG 8	1034	2074
SG 99	847	2199
TG 37A	994	1851
GG 7	864	1723
R 2001-3	1079	2413
CD (5 %)	110	211

Assessment of ameliorative effects of potassium under salinity stress in groundnut cultivars

The experiment was conducted during summer 2011 to ameliorate the salinity effect by the application of levels of potassium in two contrasting cultivars. The treatment consisted of three levels of salinity (0.5, 2 and 4 dS m⁻¹) and two levels of potassium (0 and 30 kg ha⁻¹) in two contrasting cultivars (GG 2 and TG 37A). The results revealed that with successive increase in water salinity upto 4 dS m⁻¹, there was decrease in pod yield of groundnut but significant reduction was obtained with the application of 4 dS m⁻¹ saline water as compared to control (0.5 dS m⁻¹) by 45.4% and within the cultivars TG 37A was found to tolerant more water salinity and gave 43.7% higher yield over GG 2. However, the application of 30 kg K₂O ha⁻¹ ameliorated the salinity stress and improved the pod yield of groundnut by 3.5% over the control.



PROJECT 08: MANAGEMENT OF GERMPLASM OF CULTIVATED GROUNDNUT (*A. HYPOGAEAL*.) AND ITS WILD RELATIVES

(A. L. RATHNAKUMAR, S. K. BERA AND M. C. DAGLA)

Field maintenance of wild *Arachis* germplasm

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

Acquisition and distribution of germplasm accessions

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

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

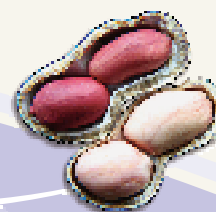
A total of 189 diverse germplasm accessions and advanced breeding lines having desirable morpho-physiological traits which were identified earlier were multiplied during summer 2011. Ten DUS reference varieties have also been multiplied. In *kharif*, 1211 accessions were multiplied. These included voucher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

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

Fifty-one large seeded accessions, 59 exotic accessions, 75 mini-core accessions and 30 WUE accessions were sown under two replications for characterisation. However, due to excessive rainfall in the season the yield levels were low (<10 g plant⁻¹) in most of the accessions. Hence, for proper characterisation of the vegetative, reproductive and pod traits this activity will be repeated during *kharif* 2012.

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

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



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

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

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

Screening of Valencia accessions for table purpose

From 2000 Valencia accessions available based on minimal passport data, 200 accessions were short-listed on the basis of country of origin. These accessions belonged to 15 different countries. These accessions were screened visually at the time of harvest for pod yield and pod features. On the basis of high yield, 51 accessions were short-listed and evaluated in a replicated randomised block design for sixteen agronomic and yield traits during summer 2011. Mean days to maturity of the accessions was 109. Pod yield ranged from 5.7 g (NRCG 14329) to 13.6 g plant⁻¹ (14163). Hundred seed mass ranged from 29.5 g (NRCG 14451) to 52.0 g (NRCG 14432). Shelling out-turn ranged from 50.4% (NRCG 14188) to 73.8% (NRCG 14163). While in *kharif*, the yield levels of these 50 accessions were low due to incessant high rainfall received at peak flowering and pod formation stages and hence the true genetic potential of these accessions could not be assessed. Hence, this experiment will be repeated in *kharif* 2012.



Screening of germplasm for tolerance of *S. rolfsii*

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

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

Parameter	10 DAIS		20 DAIS		30 DAIS	
	Irrn.	Str.	Irrn.	Str.	Irrn.	Str.
Mean SCMR	37.7	40.5	40.2	40.8	38.9	38.6
Range	28-45	39-45	35-46	34-48	27-45	34-46
CV (%)	4.6	5.0	6.0	9.4	6.2	10.5
CD (5%)	3.6	4.1	4.9	5.2	4.9	6.1

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

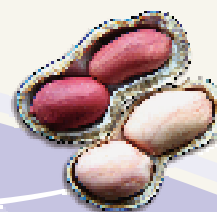
Table 2. Mean SLA (g cm⁻²) in irrigated and moisture deficit stress conditions

Parameter	10 DAIS		20 DAIS		30 DAIS	
	Irrn.	Str.	Irrn.	Str.	Irrn.	Str.
Mean SLA	190.7	166.1	175.9	176.9	172.5	167.6
Range	146-240	140-187	149-214	141-205	151-197	149-183
CV (%)	8.8	7.5	10.2	8.6	8.9	9.2
CD (5%)	34.7	12.3	49.7	15.2	42.1	15.6

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

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

Genotype	Pod yield (g plant ⁻¹)	
	Irrigated	Stress
ICGV 86590	20.5	8.9 (56.6%)
GG 2	17.3	8.5 (50.9%)
ICGV 87846	16.4	9.5 (48.2%)
DRG 12	14.3	7.1 (50.3%)
Kadiri 3	13.3	8.3 (37.6%)
GAUG 10	12.5	9.0 (29.1%)
M 197	10.5	7.8 (25.7%)
CD (5%)	6.9	3.0



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

(RADHAKRISHNAN T., A. L. RATHNAKUMAR, CHUNI LAL, S.K. BERA AND ABHAY KUMAR)

Genetic transformation

Transformation of groundnut (*A. hypogaea* L. cv. GG 20) with the plant defensin duo genes (*Rs-AFP2* (*Raphanus sativus* anti-fungal protein 2 in tandem with *Tfgd2* *Trigonella foenum graecum* defensin 2)

After rooting, 635 putative transgenic plants produced from de-embryonated cotyledons having well-developed roots, were transferred to the pots for hardening in a glasshouse. Of these 372 plants (58.5%) survived and only 14 plants (3.76 %) were found to be PCR positive for the plant defensin duo genes and *nptII* gene and all the 14 could be confirmed by dot-blot assay. The expression of transgenes was confirmed by RT-PCR too (Figure 1).

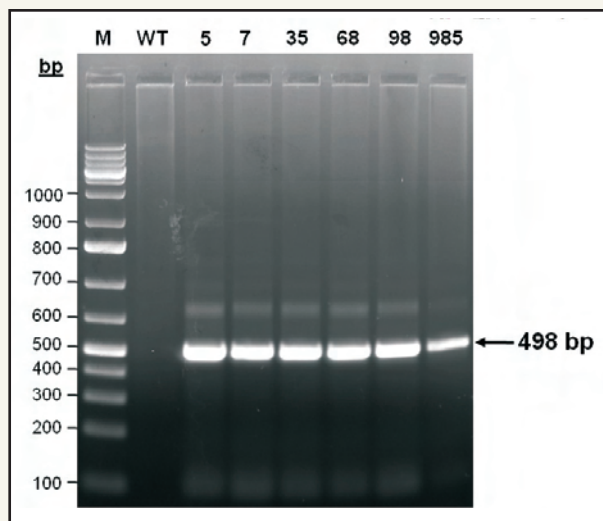


Figure 1. RT-PCR analysis of T₀ defensin transgenic plants. RT-PCR amplification with total RNA as the template and defensin gene-specific primers to amplify a region of 500 bp

All the 14 T₀ transgenic plants were harvested after maturity and 149 seeds thus obtained were sown in pots for raising T₁ plants in a glasshouse. Only 117 seeds germinated (79%) and out of these only 75 plants tested positive with PCR using defensin gene-specific primers and *nptII* gene specific primers (Figure 2) while 42 tested negative.



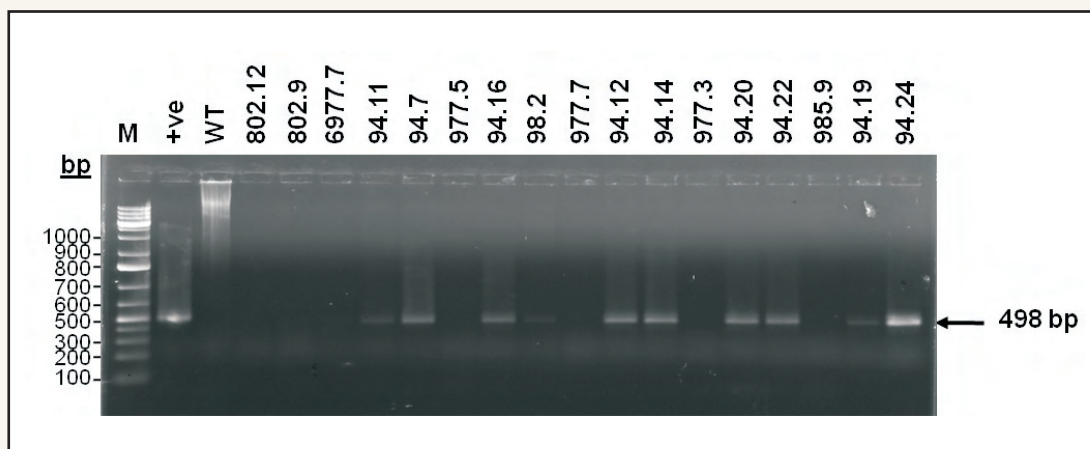


Figure 2. Screening of T₁ transgenic plants with defensin gene-specific primer. Lane M=100 bp DNA ladder; Lane 2 = positive control with defensin plasmid DNA as template; Lane 3 = Wild Type GG 20 plant; Lane 4 to 20 = T₁ transgenic lines

The segregation analysis of transgene (ratios of PCR-positive to PCR-negative) plants of 14 lines) using goodness-of-fit Chi-square tests indicated that *defensin* gene segregation ratios in T₁ progeny of DEF-68 and DEF-202 were not significantly different from 3:1 ($p > 0.05$).

Transformation of groundnut (*A. hypogaea* L. cv. GG 20) with mannitol-1-phosphate dehydrogenase (*mtlD*) gene construct

The PCR-confirmed 160 T₁ plants were harvested at maturity and their 1200 seeds sown in the pots in a glass house to obtain the T₂ generation. Only 952 seeds (79%) germinated of which 580 plants tested positive by PCR using *defensin* gene-specific primers (Figure 3).

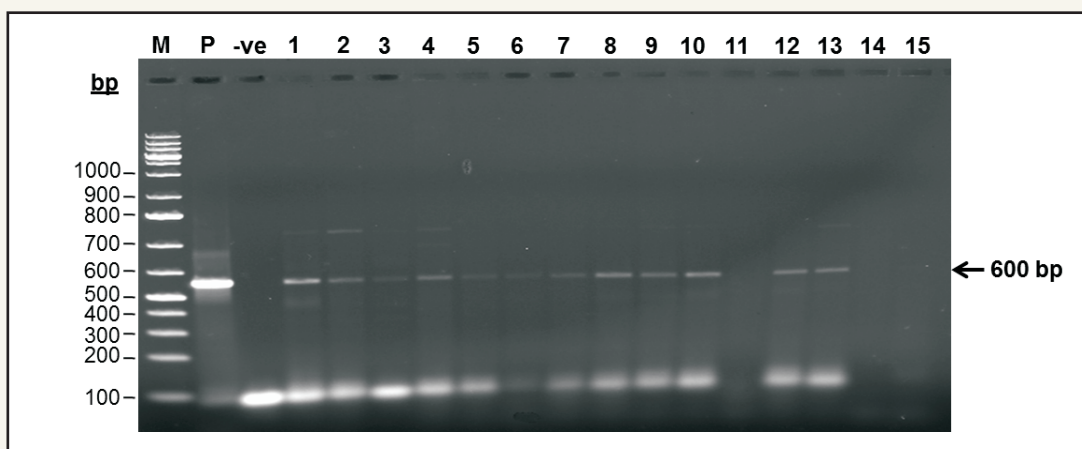
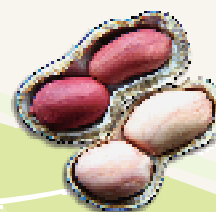


Figure 3. Screening of T₂ *mtlD* transgenics using gene-specific primer



The T₂ *mtlD* transgenics were characterized for the following physiological parameters in laboratory conditions:

Response to salinity

Soon after germination, seeds of four transgenic lines along with wild type GG 20 were subjected to different levels of salinity (0, 50, 100, 150, 200 mM NaCl). All the transgenic lines grew well in different levels of pressure of salinity while the wild type could not withstand the salinity of 200 mM (Figure 4).



Figure 4. Response of groundnut transgenic under salinity stress

The proline, chlorophyll and relative water contents of leaves, of salinity exposed T₂ transgenic seedlings were higher than those of wild plants while the membrane electrolyte leakage was low in transgenic lines as compared to the wild type.

Response to PEG-induced water deficit stress

Polyethylene glycol induced (PEG-induced) water deficit stress caused reduction in shoot growth with increasing levels of PEG (0, 5, 10, 15, and 20%). The transgenic lines, however, survived at all the levels of PEG used however, mortality was observed in wild type plants at 20% PEG (Figure. 5).



Figure 5. Response of groundnut transgenic to PEG induced water deficit stress



Development of Transgenic Resistance to Bud Necrosis Disease (PBNV) and Stem Necrosis Disease (TSV)

Seventy-three confirmed events for CP gene of TSV, 45 for NC gene of PBNV and 19 for dual construct were advanced to T_2 generation. The representative homozygous T_2 transgenic lines of *PBNV* were analysed for their expression pattern using Real Time PCR.

Using the $2^{-\Delta\Delta C_T}$ method, the relative expression of *PBNV-CP* transcript in transgenic groundnut lines was interpreted (Figure 6). The bar denotes the fold expression as compared to the lowest expressing plant 905.02 which is taken as the calibrator. The figure shows that the expression of the transgenic plant 879.01 was almost similar with reference to the calibrator. Three transgenic lines 1041.21, 656.1.02 and 417.48.05 showed 132, 81 and 93 times the expression level; while the transgenic lines 887.04, 443.15.01 and 689.01.02 showed highly significant level of expression as compared to the calibrator to the tune of more than 150 folds (Figure 6).

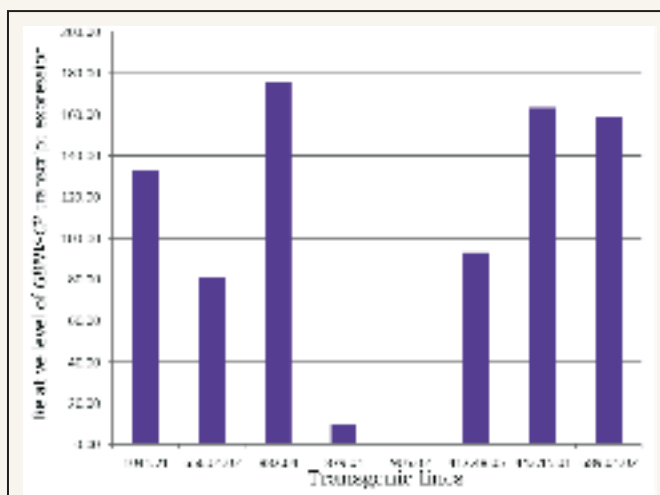
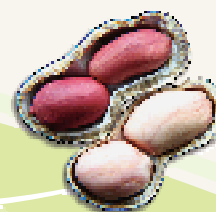


Figure 6. Histogram of the relative expression of GBNV transcript in the 8 T_2 transgenic groundnut lines. The level of GBNV transcript in T_2 plants was normalized with reference to 18S rRNA taken as an internal control. Transgenic line no. 905.02 is the calibrator (The calibrator whose relative expression is arbitrarily set as equal to one is defined as the sample giving the highest ΔC_T value which corresponds to the lowest level of transcripts. The quantification of the relative transcript levels was performed using the comparative $\Delta\Delta C_T$ method)

The representative homozygous T_2 transgenic lines of *TSV* were analysed for their expression pattern using Real Time PCR. Using the $2^{-\Delta\Delta C_T}$ method, the relative expression of *TSV-NC* transcript in transgenic groundnut lines was interpreted (Figure 6). The bar denotes the fold expression as compared to the lowest expressing plant 227.01.02.03 which is taken



as the calibrator. The figure shows that the expression of the transgenic plant 227.01.02.02 and 191 was almost similar with reference to the calibrator. Four transgenic lines 219.03.02.05, 209.09.01.02, 22.15.08 and 276 showed more than 2 times the expression level; while the transgenic lines 22.15.07, showed 3.25 folds expression relative to that of the calibrator (Figure 7).

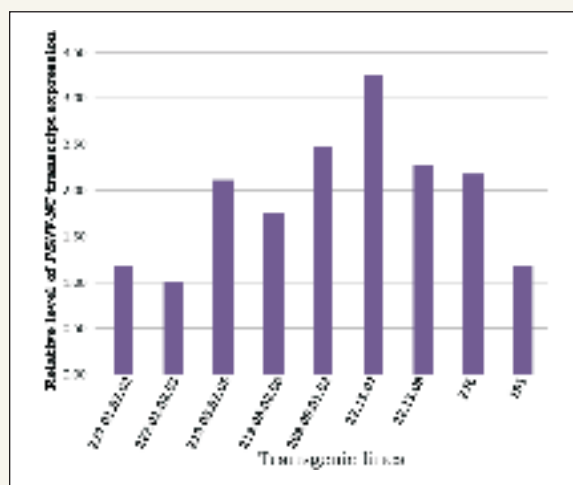


Figure 7. Histogram of the relative expression of TSV transcript in the 9 T_2 transgenic groundnut lines. The level of TSV transcript in T_2 plants was normalized with reference to 18S rRNA taken as an internal control (Transgenic line no. 227.01.02.03 was the calibrator)

Marker assisted breeding

Genotyping of the F_2 and F_3 hybrids of the crosses made for developing mapping populations, and the generation advancement to RILs. The progenies from the following crosses made for developing RILs were genotyped.

S.No.	Crosses	Plants genotyped	Generation
For tolerance of stem rot:			
1	GG 20 x CS 19	681	F_4
2	GG 20 x CS 19	372	F_3
3	GG 20 x CS 75	302	F_3
4	GG 20 x CS 83	258	F_3
5	GG 20 x JSP 39	566	F_4
Tolerance of rust, LLS:			
1	JL 24 x VG 9816	380	F_4



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

(S. K. BISHI)

Estimation of oil, and fatty acid profiling of important groundnut genotypes

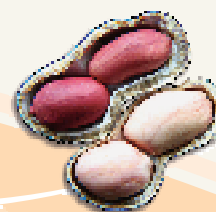
Kernel samples of 31 popular groundnut varieties were evaluated for their oil contents and fatty acid profiles. The oil content was in the range of 46.7% (CSMG 84-1) to 52.9% (GG 20) with a mean value of 50.5%. The varieties having high oil content (>52%) were GG 20, VRI 2, DH 86, TMV 10, SG 99 and Mallika. The fatty acid profiles of these varieties showed that palmitic acid, stearic acid, oleic acid and linoleic acid together accounted for more than 96% of the total fatty acids with mean values of 14.5%, 3.0%, 46.9% and 32.1%, respectively. The stability index (O/L ratio) of the oil ranged between 0.94 (ICGV 91114) to 2.73 (BAU13). Varieties having better oil stability (O/L ratio > 2) were BAU 13, Mallika, Girnar 3, GG 20, TMV 10, ICGS 76 and B 95.

Characterization of mini-core (Spanish group) germplasm for oil, protein, sugars and O/L ratio

The oil content of kernel samples of 60 Spanish groundnut genotypes belonging to DGR mini-core germplasm collection was in the range of 46.1 to 55.8% with a mean value of 49.8%. Palmitic acid, stearic acid, oleic acid and linoleic acid contents, were in the range of 12.5 to 25.3%, 2.6 to 5.1%, 40.1 to 52.1% and 17.8 to 40%, respectively. The O/L ratio of the oil of these genotypes was in the range of 1.02 to 2.79 with a mean value of 1.3. The glucose and sucrose contents were in the range of 10 to 210 mg100 g⁻¹, 4.9 to 14.6 g 100 g⁻¹ and the GSO's (galactosyl-oligosachharide sugars, which causes flatulence) were in the range of 0.09 to 4.88 g 100 g⁻¹. The following correlations were observed between quality attributes:

- Direct between glucose and sucrose contents
- Inverse between sucrose content and O/L ratio
- Direct between palmitic acid and stearic or oleic acid
- Inverse between palmitic and linoleic acid
- Inverse between oleic acid and linoleic acid
- Direct correlation between oil content and O/L ratio

The study showed the feasibility for developing high-oil groundnut cultivars with high O/L ratio as this O/L ratio is positively correlated with oil content. The study also indicated the content of GSO's in the germplasm accessions, however, was not correlated with any other constituent studied. A few germplasm accessions were identified with low levels of GSO's but having relatively low oil content (46-49%).



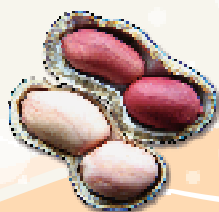
Effect of water-deficit stress on quality of groundnut

In a field experiment, three tolerant (TPG 41, GG 20 and CSMG 84-1) and three susceptible (JL 286, HNG 10 and GG 11) genotypes were grown separately under water deficit (50% CPE) and well irrigated (100% CPE) conditions. After harvest and curing of pods, the kernels were analyzed for quality traits. The results indicated that :

- Oil content was adversely affected and the change was more pronounced in tolerant genotypes.
- The sugars (glucose, sucrose and GSO's) increased due to stress and the effect was more pronounced in tolerant genotypes.
- The fatty acid composition was relatively stable in tolerant genotypes.

Oil and protein estimation of different groundnut genotypes

The kernel samples of the experimental produce from various AICRP-G centers and sections of DGR were evaluated for quality traits. In 2011, oil content was evaluated in 260 samples from different sections of DGR and in 257 samples received from various AICRP-G centres. Over 5,200 samples from ICRISAT and various sections of DGR were analyzed for oil, protein and moisture content by NIR spectroscopy.



PROJECT 11: BIOTRANSFORMATION OF GROUNDNUT BY-PRODUCTS INTO USEFUL PRODUCTS

(R. DEY, K. K. PAL AND S. K. BISHI)

Identification and evaluation of thermo-tolerant and salinity tolerant proteolytic bacteria

Identification of proteolytic bacteria

Eight proteolytic bacterial cultures, selected earlier for their tolerance of high temperatures and high concentration of salt and heavy metals (Ni, Co, Hg, Cd: 0.5 mM to 12.5 mM), were identified by 16S rRNA sequencing. While F1, F6 and SP 8-14 were identified as *Bacillus subtilis* subsp. *subtilis*, P1 and SP5-14 were identified as *Bacillus sonorensis*. Two other isolates viz. P6 and P7 were identified as *Brevibacillus halotolerans*. The remaining one isolate, P4 could not be identified as it has similarity of only 79% with the existing sequence database (Table 1).

Table 1. Identification of proteolytic bacteria by 16S rRNA sequencing

Isolate	Coverage	MI (%)	Identified as
F1	100	99	<i>Bacillus subtilis</i> subsp. <i>subtilis</i> F1
F6	100	99	<i>Bacillus subtilis</i> subsp. <i>subtilis</i> F6
P 1	100	99	<i>Bacillus sonorensis</i> P1
P4	99	79	Yet to be identified
P6	100	98	<i>Brevibacterium halotolerans</i> P6
P7	97	98	<i>Brevibacterium halotolerans</i> P7
SP5-14	100	97	<i>Bacillus sonorensis</i> SP5-14
SP8-14	100	99	<i>Bacillus subtilis</i> subsp. <i>subtilis</i> SP8-14

Effect of cations on the activity of proteolytic enzyme

The proteolytic enzymes produced by both *Brevibacillus halotolerans* P6 and *Bacillus subtilis* subsp. *subtilis* SP8-14 by fermentation of de-oiled groundnut cakes at 60°C and 50°C, respectively, were studied to evaluate the effect of cations on the activities of proteases. It was found that Mg^{2+} , Ca^{2+} , Zn^{2+} , and Cd^{2+} had no significant effect on the activity of protease produced by *Brevibacillus halotolerans* P6 upto 100 mM concentration. However, other cations like Al^{3+} , Hg^{2+} and Mn^{2+} reduced the enzyme activity drastically after 2.0 mM, 2.0 mM and 1.5 mM concentration, respectively. Presence of Ni^{2+} , Cu^{2+} and Fe^{3+} in the assay medium enhanced the activity several times indicating that the proteases produced by *Brevibacillus halotolerans* P6 were metalloenzymes. Presence of Ni^{2+} at 1.5 mM concentration enhanced the activity 22 times (Table 2).

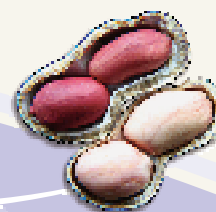


Table 2. Effect of cations on the activity of proteases obtained from de-oiled groundnut cake by fermentation employing *Brevibacterium halotolerans* P6 at 60°C (Activity IUml⁻¹ crude extract)

Conc. (mM)	Mg ⁺²	Ca ⁺²	Zn ⁺²	Mn ⁺²	Hg ⁺²	Al ⁺³	Cd ⁺²	Ni ⁺²
0	315.5	315.5	315.5	315.5	315.5	315.5	315.5	315.5
0.25	324.2	307.3	293.1	287.1	324.2	258.3	290.0	5329
0.5	327.5	261.0	268.1	305.1	373.8	305.7	323.7	6609
1.0	273.5	280.9	354.7	259.4	335.9	265.9	310.0	6342
1.5	336.7	241.4	350.4	289.3	283.9	277.3	318.2	7034
2.0	307.9	262.1	352.5	158.6	297.0	280.6	285.5	5727
2.5	245.7	239.2	263.7	170.5	173.8	161.8	270.8	2719
5.0	256.6	260.4	257.7	153.7	183.6	159.1	252.8	3019

In case of the proteases produced by *Bacillus subtilis* subsp. *subtilis* SP8-14, the cations Mg²⁺ and Ca²⁺ had no impact on the activity up to 100 mM concentration. However, presence of Zn²⁺, Mn²⁺, Hg²⁺, Al³⁺ and Cd²⁺ drastically reduced the activity of proteases beyond 2.0 mM concentration. Similar to the proteases produced by P6, presence of Ni²⁺, Cu²⁺ and Fe³⁺ enhanced the activity of proteases produced by *Bacillus subtilis* subsp. *subtilis* SP8-14 several times. Presence of Ni²⁺ at 0.50 mM concentration enhanced the activity 15 times indicating that the enzymes are metalloenzymes (Table 3).

Table 3. Effect of cations on the activity of proteases obtained from de-oiled groundnut cake by fermentation employing *Bacillus subtilis* subsp. *subtilis* SP8-14 at 50°C

Conc. (mM)	Mg ⁺²	Ca ⁺²	Zn ⁺²	Mn ⁺²	Hg ⁺²	Al ⁺³	Cd ⁺²	Ni ⁺²
0	431.5	431.5	431.5	431.5	431.5	431.5	431.5	431.5
0.25	480.6	443.5	433.2	465.9	547.1	478.4	486.6	6157
0.50	397.2	462.6	478.4	457.7	470.8	485.5	503.5	6816
1.0	475.1	489.3	465.3	458.8	538.3	440.8	518.2	6582
1.5	465.6	442.7	494.7	518.2	450.6	379.2	519.8	6173
2.0	438.1	439.7	471.9	439.2	505.1	426.1	474.6	5754
2.5	443.5	415.7	359.1	297.5	260.4	248.5	355.8	4288
5.0	451.7	446.3	351.4	265.4	279.5	234.3	361.8	3967

Compatibility of proteases with commercial detergents

The compatibility and cleansing action of the proteases with the commercial detergents was also studied. Muslin cloth pieces stained with tea were used as the test material. It was observed that use of hard water drastically reduced the washability of the available detergents at 100 mM of NaCl. However, addition of enzymes produced by P6 and SP8-14 improved the cleaning efficiency of the detergents with hard water. Addition of these enzymes to the commercially available detergents, not containing proteases, also improved the cleaning efficiency of the detergents.



PROJECT 12: PREVENTION AND MANAGEMENT OF MYCOTOXIN CONTAMINATION IN GROUNDNUT

(THIRUMALAISAMY P. P. AND K. S. JADON)

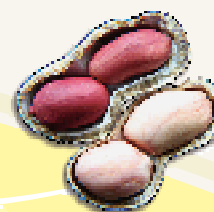
Effect of long-term crop rotation/cropping system on soil population of *Aspergillus flavus* and post-harvest aflatoxin contamination

In the long-term crop rotation experiment (groundnut in *kharif* followed by maize, sorghum, groundnut, or fallow land in summer), soil population of *A. flavus* was estimated. The results are given in table 1.

Table 1. Soil population of *Aspergillus flavus* and aflatoxin contamination in groundnut (cv. TG 37A)

Treatment	Season							
	summer 2011			kharif2011				
	<i>A. flavus</i> population (x10 ³ cfu g ⁻¹ soil)		Aflatoxin (µg kg ⁻¹ kernel)	Seed infection (%)	<i>A. flavus</i> population (x10 ³ cfu g ⁻¹ soil)		Aflatoxin (µg kg ⁻¹ kernel)	Seed infection (%)
	Before sowing	After harvesting			Before sowing	After harvesting		
Maize	60.0	44.3	-	-	25.2	8.7	0.2	2.5
Sorghum	51.7	47.3	-	-	42.3	9.7	2.6	6.7
Fallow	46.7	42.7	-	-	9.8	10.8	3.3	2.5
Groundnut	60.0	56.8	8.9	6.7	19.0	10.7	3.0	8.3

In both seasons, the soil population of *A. flavus* was lower at the time of harvest than at the time of sowing. There, however, was a reduction in population in the groundnut-groundnut rotation. The overall reduction in population could be ascribed to high soil temperature (upto 44°C) which prevailed in summer at the time of harvest. The seed infection was 6.7% and aflatoxin load was 8.9 ppb ($\mu\text{g kg}^{-1}$ kernel) in summer produce. Whereas, in the *kharif* produce, the seed infection was 2.5, 6.7, 2.5, and 8.3% in groundnut crop grown in maize, sorghum, fallow, and groundnut rotation plots, respectively with corresponding values of 0.2, 2.6, 3.3 and 3.0 ppb for aflatoxin load.



PROJECT 13: IMPACT ASSESSMENT OF IMPROVED GROUNDNUT PRODUCTION TECHNOLOGIES: SUSTAINABLE LIVELIHOOD ANALYSIS

(G. GOVINDARAJ, NARAYANAN G. AND A. P. MISHRA)

Groundnut cultivars GG 20 and GG 2 are popularly grown in Saurashtra region of Gujarat during *kharif* and *rabi*, respectively. Over the years these varieties are being replaced by the improved variety TG 37A. Hence, to study the productivity and profitability of TG 37A over the other varieties, a survey was undertaken in Saurashtra region of Gujarat. The survey was conducted in Upleta taluk of Rajkot district during *kharif* 2011 and the data were collected through personal interviews with farmers for summer crop as the *kharif* crop was still in the fields.

Socio-economic status of the sample farmers

The average age of farmers was 48 years and having 23 years of experience of growing groundnut crop. Three-fifth of the farmers had education upto secondary to higher secondary level. Agriculture is the main occupation of the farmers in the study area. The farm size was 3.20 ha and only 5% farmers had access to extension personnel of university, research institutes, or agricultural department.

Farmer perception on improved *vis-a-vis* prevalent variety grown during last summer season

According to the perception of the farmers, during summer there was 20% yield advantage with TG 37A over GG 2, due to better germination and formation of a larger number of pods per plant. Compared to GG 2, the plants of TG 37A suffered much lower incidence of disease and pests. The pod and kernel of TG 37A, however, were of medium size but smaller than those of GG 2. Due to medium size of pods, the price fetched by TG 37A was 9% lower than that of GG 2 but this was compensated for by the higher yield of TG 37A (Table 1).



Table 1. Farmer perceptions on improved variety TG 37 A vis-à-vis GG 2 grown in *rabi* season

Attribute	TG 37 A	GG 2
Germination (%)	95	83
Yield (kg ha ⁻¹)	3550	2950
No. of pods per plant (range)	20-30	12-20
Duration (days)	105	110
Insect Incidence -low/moderate/high	low	low
Disease Incidence		
Stem rot	low	moderate
Tikka	low	moderate
Uniformity in maturity	uniform	variation
Pod size	medium	Larger
Kernel size	medium	Larger
Price for summer 2010 produce (₹ kg ⁻¹)	33	36
Acceptability of fodder to animals	less preferred	highly preferred
Fodder yield (Kg ha ⁻¹)	1440	1520

Economic potential of improved variety TG 37A vis-à-vis GG 2

The results of survey indicated that during summer yield of TG 37A was 3550 kg ha⁻¹ while 2950 kg ha⁻¹ of GG 2. The gross returns was ₹ 1,21,470 ha⁻¹ with TG 37A and ₹ 1,00,760 ha⁻¹ with GG 2. Thus there was an increment of 9.6% in the gross returns by adopting TG 37A and 7.4% increment in the net returns by adopting TG 37A in place of GG 2. The B:C ratio was 2.85 for TG 37A and 2.80 for GG 2 (Table 2).

Table 2. Economic potential of improved variety TG 37A vis-à-vis GG 2

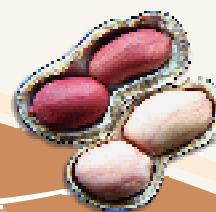
Indicators	TG 37A	GG 2
Pod yield (kg ha ⁻¹)	3550	2950
Haulm yield (kg ha ⁻¹)	1440	1520
Gross return	121470	110760
Cost of cultivation (₹ ha ⁻¹)	42485	39542
Net returns (₹ ha ⁻¹)	78985	71218
B:C ratio	2.85	2.80

Frequency of seed replacement

Only 7% of the farmers replaced their seed every year, while 10% replaced it in the third year and 83% in the fourth year.

Technology assessment and refinement

To create awareness among the tribal farmers and motivate them to adopt improved varieties, 10 on-farm trials were laid out during summer 2012 in Talala taluk of Junagadh district. The improved variety TG 37A was taken up for comparison with the prevalent varieties like GG 20 and GG 2.



Validation of improved technologies in farmers' field

With a view to validate the recommended technologies, 81 on-farm trials were arranged in Kodinar taluk of Junagadh district in summer 2012. The crop would be harvested in May 2012.

Farmers' visits to DGR

During the year (April 2011 to March 2012) a total of nine groups of farmers, students, and officers visited DGR. Altogether 265 visitors from various states viz., Gujarat, Rajasthan, Madhya Pradesh and Karnataka visited DGR. The visits were sponsored by the State Department of Agriculture or State Agricultural University concerned. The visitors were taken round field-experiments, laboratories, museum, library, etc. and meetings for their interaction with the scientist were also organized.



PROJECT 14: BREEDING FOR LARGE-SEEDED AND CONFECTIONERY GROUNDNUT

(M. C. DAGLA, RADHAKRISHNAN T., A. L. RATHNAKUMAR, CHUNILAL, S. K. BISHI, NARENDRA KUMAR AND AJAY B. C.)

Hybridization

During *kharif* 2011, eleven crosses were attempted to incorporate the trait of large-seed along with high yield and other confectionery quality traits (high O/L ratio, high protein and low oil content). A total of 2438 buds were pollinated and 476 probable hybrid pods were harvested with a success rate of 20%.

Table 1. Crossing programme in *kharif* 2011

Parentage	Purpose	Buds pollinated (no.)	F ₁ pods harvested (no.)	Success (%)
GG 20 x GPBD 4	High shelling out-turn and high protein	290	35	12
TPG 41 x S 230	Large seed and high O/L ratio	393	83	21
GPBD 4 x S 230	High protein and high O/L ratio	295	51	17
ICGV 97079 x Dh 3-30	High yield and low oil	249	72	29
GPBD 4 x Dh 3 30	High protein and low oil	221	46	21
S 230 x Dh 3-30	High O/L ratio	161	20	12
ICGV 97079 x MH 4	High yield	234	64	27
GG 20 x MH 4	High shelling out-turn	181	32	18
GPBD 4 x MH 4	High protein	176	50	28
S 230 x MH 4	High O/L ratio	165	15	9
Dh 3-30 x MH 4	Low oil	73	8	11
	Total	2438	476	20

Identification of true hybrids

Ten crosses (F_{1s}) made in *kharif* 2010, were raised along with their seven parents in summer 2011 and true hybrids were identified and the pods were harvested separately for further advancement. Among the ten cross combinations, 138 single plant progenies (SPP) were selected for further generation advancement.



Table 2. Identification of true hybrids in summer 2011

Parentage	Purpose	SPP
ICGV 97079 x TPG 41	High yield and large seed	3
ICGV 97079 x GG 20	High yield	13
ICGV 97079 x GPBD 4	High yield and high protein	14
ICGV 97079 x S 230	High yield and high O/L ratio	12
TPG 41 x GG 20	Large seed and high shelling out-turn	23
TPG 41 x GPBD 4	Large seed and high protein content	14
TPG 41 x Dh 3-30	Large seed	17
TPG 41 x MH 4	Large seed	7
GG 20 x S 230	High shelling out-turn and high O/L ratio	27
GG 20 x Dh 3-30	High yield	8
Total		138

Generation advancement and selection of new advanced breeding lines

The F_2 generations of 11 crosses were sown and true F_2 s (segregating) were identified. The identified crosses were bulk-harvested cross-wise for advancing to next generation. Seven crosses in F_3 were sown and progenies were harvested in bulk. Six crosses in F_4 were advanced without selection. Similarly, 9 crosses were advanced from F_5 to F_6 generations. Phenotypic selections were carried out in F_6 and F_7 generations having stabilized material. In F_6 generation, five new advanced breeding lines (ABLs) were developed from four cross combinations and likewise in F_7 generation, twelve advanced breeding lines were developed from eleven cross combinations.

Multiplication and maintenance

Ten advanced breeding lines of Spanish group were sown in summer 2011 to produce sufficient seeds to conduct a trial for evaluating their performance for quality traits. Twenty-two advanced breeding lines (2 Spanish, 20 Virginia) were multiplied and 45 lines (4 Spanish, 41 Virginia) were maintained in *kharij* 2011.

Segregating materials sent to AICRP-G Centers

As four AICRP-G Centers (Rahuri, Shrigan, Hanumangarh and Durgapura) have congenial environment and suitable soils for production of large-seeded groundnut. So, segregating materials of 6 selected crosses were sent to these centers for site specific selection and further advancement.



Table 5. Segregating materials sent to AICRP-G centers from *kharif* 2011

Crosses	Generation	Purpose	Pod Weight(g)	AICRP-G Centre
TG 40 x ICGV 00440	F ₄	Increase seed size	150	Rahuri
		and high yield	165	Shirgaon
ICGV 99101 x CS 148	F ₅	Increase seed size	155	Shirgaon
		and high yield		
ICGV 99101 x CS 148	F ₆	Increase seed size	200	Rahuri
		and high yield	155	Durgapura
PBS 29077 x ICGV 89214	F ₆	Increase seed size	140	Durgapura
		and high yield	140	Hanumangarh
PBS 29077 x ICGV 97040	F ₆	Increase seed size	240	Durgapura
		and high yield		
PBS 29078 x CS 148	F ₆	Increase seed size	185	Hanumangarh
		and high yield		

Screening trial for yield and quality traits

Twenty groundnut genotypes comprising 16 advanced breeding lines developed for large-seed types and four check varieties (TPG 41, GG 20, M 13 and BAU 13) were evaluated for their performance in *kharif* 2011. Highly significant differences due to genotypes were found for all the traits studied. Among the bold seeded checks, M 13 was found to be superior for yield, and none of the ABLs could surpass the check in yield. But in other physical quality traits of kernel, there were ABLs which were significantly superior in the desirable direction of traits (Table 6). PBS 29146 was found to be better for maximum traits like HKW (53 g), SMK (92%), HSMK (65 g), KL (17 mm) and with maximum KW (9.2 mm). For shelling out-turn only one entry PBS 29163 was superior with a value of 75%, and it was also superior for HKW (47 g) and KW (8.7 mm). Eleven ABLs were superior to check for HKW, but HKW higher than 50 g was found only in PBS 29141, PBS 29146, PBS 29147 and PBS 29153. Maximum KL was observed in PBS 19014 (18 mm) followed by PBS 29138 (17.3 mm), PBS 29106 (17 mm) and PBS 29146 (16.9 mm). Maximum KW was observed in PBS 29146 (9.2 mm) followed by PBS 29143 (8.9 mm), PBS 29141 (8.8 mm), PBS 29147, PBS 29151 and PBS 29163 (8.7 mm each) and PBS 29142 (8.6 mm).

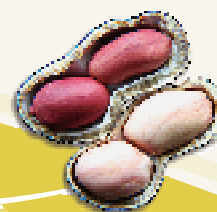


Table 6. Performance of ABLs for physical quality traits in screening trial *kharif* 2011

Genotype	SOT (%)	HKW (g)	SMK (%)	HSMK (g)	KL (mm)	KW (mm)
PBS 19014	55	43.2	34.7	53.9	18.0*	8.3
PBS 29106	64	43.5	34.7	55.0	17.0*	7.9
PBS 29137	63	49.3*	40.7	60.4*	16.6	7.8
PBS 29138	64	49.6*	39.0	60.8*	17.3*	7.9
PBS 29141	64	50.7*	91.7*	64.0*	15.7	8.8*
PBS 29142	64	45.9*	45.9	55.0	15.0	8.6*
PBS 29143	65	48.8*	92.3*	59.2	15.9	8.9*
PBS 29146	64	53.0*	92.3*	64.5*	16.9*	9.2*
PBS 29147	65	51.2*	95.0*	62.5*	14.8	8.7*
PBS 29151	63	45.7*	94.0*	56.8*	15.2	8.7*
PBS 29153	65	52.0*	94.0*	62.3*	15.8	8.5
PBS 29155	66	49.6*	36.7	63.3*	16.5	8.5
PBS 29163	75*	46.7*	38.7	59.1	15.1	8.7*
M 13 (Check)	68	44.2	87.3	56.4	16.0	8.1
CD (5%)	1.5	1.9	2.4	3.5	0.6	0.4

*Significant at $p=0.05$

Note: SOT- Shelling out-turn, HKW- Hundred Kernel weight, SMK- Sound Mature Kernels, HSMK- Hundred Sound Mature Kernel, KL- Kernel Length and KW- Kernel Width.

Advanced Yield Trial (AYT) for Spanish Bunch ABLs

An AYT was conducted during summer 2011. There were six ABLs and two checks viz. TPG 41 and TG 37A of the Spanish group. For all the traits studied enough variability was observed. The best check was TPG 41 for almost all the traits. PBS 19022 was found to be superior to check TPG 41 for pod yield per plant (20.5 g), total biomass production (68 g), haulm yield, number of pods per plant (14), kernel yield per plant (11.6 g). This genotype was also found to be superior for quality traits like shelling out-turn, hundred kernel weight (64 g), seed count (163), sound mature kernel (78%) and sugar content (12%). PBS 19024 was identified for high protein content (28.2%) and total biomass production (65 g). Another line PBS 19018 was identified for high sugar content (10.5%). The test entries which were significantly superior for yield and quality traits are given in Table 7.



Table 7. Superior ABLs for yield and quality traits in AYT summer 2011

Traits	TPG 41 (check)	Superior genotypes
TBP (g)	50	PBS 19022 (68), PBS 19023 (68), PBS 19024 (65)
PYP (g)	16.9	PBS 19022 (20.5)
HI	29.1	PBS 19022 (36.7)
PYH (kg)	2828	PBS 19022 (3423)
HKW (g)	49.1	PBS 19020 (58.7), PBS 19021 (60.4), PBS 19022 (63.4), PBS 19023 (60.9)
Seed Count	210	PBS 19021 (165), PBS 19022 (163),
SMK (%)	74	PBS 19018 (82), PBS 19020 (80), PBS 19021 (85), PBS 19022 (78), PBS 19023 (79)
Protein (%)	22.6	PBS 19024 (28.2)
Sugar (%)	7.9	PBS 19018 (10.5), PBS 19022 (11.8)

Note: TBP- Total Biomass Production, PYP- Pod Yield per Plant, HI- Harvest Index and PYH- Pod Yield per Hectare.

Advanced Yield Trial (AYT)

Twenty groundnut genotypes comprising of sixteen ABLs developed for large-seed types and four check varieties (TPG 41, GG 20, M 13 and BAU 13) were evaluated for their performance in *kharif* 2011. Highly significant differences due to genotypes were found for all the traits studied. PBS 29148 was found to be superior for pod yield per plant (8.3 g), HKW (55 g), HSMK (68 g), KL (18.1 mm) and KW (9.5 mm) against superior check M 13. Similarly, PBS 29152 was also found to be superior for pod yield per plant (8 g), HKW (46 g), HSMK (59 g) and KW (8.8 mm). For HKW 8 ABLs were superior to check M 13 (40 g), but except for PBS 29148, none of the ABLs surpassed the 50 g HKW. PBS 29144 and PBS 29150 surpassed the check for SMK (94 and 91% respectively), HSMK (62.8 and 57.7 g respectively) and HKW (49.7 and 43.7 g respectively). Six ABLs were found to be superior for HSMK, but only three entries exceeded 60 g, these were PBS 29098 (60.2 g); it also showed the maximum KL (18 mm), PBS 29144 (62.8 g) and PBS 29148 (68 g).



Table 8. Performance of ABLs for yield and physical quality traits in AYT *kharif* 2011

Genotypes	PYP (g)	PYH (kg)	HKW (g)	SMK (%)	HSMK (g)	KL (mm)	KW (mm)
PBS 19022	5.2	861	46.0*	84.7	57.9*	17.0	8.2
PBS 19023	5.3	889	44.3*	82.0	55.7	17.1	8.0
PBS 29098	4.4	727	47.4*	80.7	60.2*	18.0*	8.4
PBS 29115	6.1	1011	42.5*	85.3	56.5	15.9	8.4
PBS 29144	6.5	1077	49.7*	93.7*	62.8*	15.8	8.1
PBS 29148	8.3*	1377*	54.9*	89.0	67.9*	18.1*	9.5*
PBS 29150	7.0	1166	43.7*	91.0*	57.7*	15.6	8.5
PBS 29152	8.0*	1327*	46.3*	87.0	58.9*	15.3	8.8*
M 13 (Check)	7.4	1238	39.8	83.3	54.7	16.4	7.9
CD (5%)	0.4	71	1.6	7.0	2.3	1.0	0.6

*Significant at $p=0.05$



PROJECT 15: UTILIZATION OF WILD ARACHIS GENE POOLS FOR GROUNDNUT IMPROVEMENT

(S. K. BERA, A. L. SINGH, RADHAKRISHNAN T., CHUNI LAL,
THIRUMALAISAMI P.P., ABHAY KUMAR AND K.A. KALARIYA)

Rabi

Advanced evaluation of Spanish bunch genotypes

Twelve selected Spanish bunch genotypes along with 4 checks were sown in RBD with three replications for confirmation of pod yield and related traits. Each genotype was sown on five rows of three-metre each. No inference, however, could be drawn as the wild animals damaged the experiment.

Initial evaluation of Spanish bunch genotypes

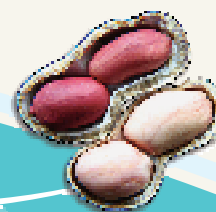
Spanish bunch genotypes (37) and 4 checks (GG 7, TAG 24, TG 26 and TG 37A) were sown in RBD with three replications. Each genotype was sown in a single three-metre row. Pod yield of test genotypes did not differ significantly from that of the best check (GG 7). However, the pod yield of 19 genotypes was higher than that of GG 7. Genotype CS 396 was found promising for high pod yield, SHT, HKM, SMK and SCMR.

Screening of interspecific derivatives at UAS, Raichur

During *rabi*, interspecific derivatives were sown at UAS, Raichur (a natural hot spot for PBND) for confirmation of field resistance to PBND. Each genotype was sown in single five-metre row. Disease incidence was recorded at 60 days after germination and also at harvest. Out of 424 derivatives, in both *kharif* 2010 and *rabi* 2011 seasons, 118 were found resistant to PBND with a disease score of <5% compared to that of 60% for the susceptible check. The resistance in these genotypes needs to be further confirmed through artificial inoculation before using these as donors in crop improvement programme.

Characterization of RILs at Raichur

The RILs, emanating from cross 'GG 20 x CS 19', were sown along with susceptible checks at UAS, Raichur for phenotyping (for incidence of stem rot and PBND). Each RIL was sown in a single three-metre row. Among 308 RILs, for stem rot as many as 155 genotypes were found to be resistant and only 68 were susceptible whereas for PBND, 197 were resistant and 35 susceptible.



Generation advancement

Progenies of 5 crosses and 12 back-crosses were sown at UAS, Raichur for generation advancement during summer. A total of 446 single plant selections were made from 5 F_4 and 12 BC_1F_2 populations on the basis of pod yield and resistance to PBNB and stem rot. These progenies will be advanced further under natural disease pressure for identification of high-yielding genotypes resistant to PBNB and stem rot.

CS 281 is a high-yielding and large-seeded interspecific breeding line. The pods of this genotype have a deep constriction which is considered an undesirable trait. Kernels of CS 281 were treated with chemical mutagens for removing deep-constriction. For generation advancement, 42 M_4 progenies were sown on three rows of five-metre each and 38 single plant selections showing a wide range of pod size and depth of constriction (including a few without any constriction) were advanced to next generation.

Two large seeded interspecific breeding lines viz., CS 281 and CS 148 matured in 115- 130 days after germination during *rabi* season. These two genotypes were crossed with an early maturing genotype Chico. F_1 , F_2 and BC_1 progenies of crosses Chico x CS 148, Chico x CS 281 and CS 148 x CS 281 were sown during summer for generation advancement and selection and on the basis of pod size and period of maturity, 27 selections were made.

Seed multiplication

Seeds of six promising interspecific genotypes (CS 268, CS 281, CS 401, CS 253, CS 287 and CS 264) were multiplied during summer and 35 kg pods each of these genotypes were supplied to AICRP-G centres for evaluation. Besides, seeds of 34 mutant stocks and 35 multiple disease resistant (MDR) lines were also multiplied for conservation in the NBPGR, New Delhi.

Germplasm registered

Proposal for registration of 10 multiple disease-resistant lines developed at DGR were submitted to the NBPGR in May 2011. The Plant Germplasm Registration Committee (PGRC) approved the registration of four in its XXIVth meeting held on November 29, 2011 (Table 1). These pre-breeding interspecific genotypes are resistant or tolerant to rust, ELS, LLS, stem rot and PBNB, and can be used as donor for breeding groundnut varieties tolerant to these disease.



Table 1. Particulars of registration and attributes of multiple disease resistant genotypes

Genotype	Registration no. (CONS/PGRC/12 dt.13.01.2012)	Disease score			Stem rot (%)	PBND (%)
		Rust	ELS	LLS		
NRCGCS 15	INGR11054	3	5	5	5	7
NRCGCS 74	INGR11055	2	4	4	13	16
NRCGCS 186	INGR11056	3	4	4	13	21
NRCGCS 196	INGR11057	3	3	3	9	10

Kharif

Advanced evaluation

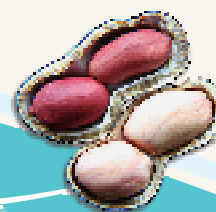
Three Virginia genotypes viz., CS 359, CS 376 and CS 385 identified to be promising in initial evaluation trial over two seasons, were further evaluated under advanced trial for yield and related traits along with two checks (GG 20 and Somnath). The experiment was sown in RBD with three replications. Each genotype was sown on five rows of five metre each. Observation on pod yield and related traits were recorded at harvest. However, the yield of none of the CS lines was more than, the check GG 20.

Initial evaluation

Five freshly developed Spanish interspecific genotypes along with four checks were evaluated for yield and related traits. Experiment was sown in RBD with three replications. Each genotype was sown on a single five-metre row. Observations on pod yield and yield related traits were recorded at harvest. However, the yield of none of the five genotypes was greater than that of the check variety TG 37A.

Freshly developed 29 Virginia bunch genotypes along with two checks were evaluated for pod yield and related traits. Experiment was sown in RBD with 3 replications. Each genotype was sown in a single five-metre row. Although the pod yield of the genotypes did not differ significantly from that of the best check Somnath, the yield of four genotypes viz. CS 273, CS 294, CS 409 and CS 411 was at par with GG 20, an elite cultivar.

In a separate experiment, 27 freshly developed Virginia runner genotypes along with two checks were evaluated. Experiment was sown in RBD with three replications. Each genotype was sown in single five-meter row. The pod yield of the genotypes did not differ significantly from that of the best check, GG 20. However, pod yield of six genotypes viz. CS 311, CS 349, CS 414, CS 418, CS 419 and CS 420 was at par with that of the best check (GG 20).



Segregating materials advanced at Junagadh

One hundred and forty-seven single plant selections have been made from J 11 x *A. pusilla* (F_4) for higher number of primary branch, resistance to major foliar diseases, earliness and higher pod yield. Besides, 15 single plant selections have been made from F_2 population of nine different inter-specific crosses.

Screening of breeding lines at Raichur

For phenotyping for resistance to stem rot 308 RILs developed from cross GG 20 x CS 19 were sown at RARS, Raichur. Each progeny was sown on a single five-metre row. One line of susceptible check was also sown after every five lines of test entries. Disease incidence was recorded at 60 days as well as at the harvest. One hundred and ninety-seven RILs recorded resistant reaction to PBND and 161 RILs recorded a resistant reactions to stem rot out of 308 RILs at harvest.

Frequency distribution of 308 RILs revealed that majority of the populations were resistant to PBND (195 RILs) and stem rot (171 RILs) indicating that one or two major QTLs are responsible for conferring resistance to both PBND as well as stem rot.

Interspecific derivatives found resistant to PBND were sown for confirmation during *kharif* 2011. Each of the 116 resistant lines were sown in a single five-metre row. One line of susceptible check was sown after every five rows of test lines. The disease incidence was recorded at 60 days after sowing and also at harvest. All these 116 lines were found resistant to PBND. Indeed the scorings of individual genotype differed from the scorings of previous season.

Generation advancement at Raichur

Progenies of five crosses and 12 back-crosses were sown at UAS, Raichur for generation advancement during *kharif* 2011. In all 446 single plants of F_4 and BC_1F_3 progenies were sown for further advancement. Depending on the quantity of seed available, each progeny was sown on 2-5 lines based on quantity of seed available. Subsequently, for resistance to PBND, stem-rot and foliar diseases, 384 single plant selections were made from 22 (F_4 and BC_2) populations.

Genetic diversity of PBND resistant lines

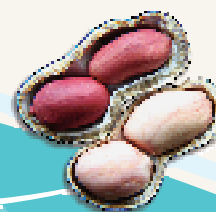
Alongwith susceptible check KRG 1, as many as 115 breeding lines identified earlier for being resistant to PBND, were subjected to molecular marker analysis using 20 SSRs.



Amplification of genomic DNA of 115 interspecific breeding lines and cultivar KRG 1 yielded 219 fragments of which 205 bands were polymorphic. Then number of amplified fragments was in the range of 2 to 34 with sizes of 100 to 300bp. The maximum number of bands (34) was obtained with primer TC2C07 and the minimum with primer PM402. The range of polymorphism observed with the 20 SSRs was 57.14 to 100% with an average value of 92.21%. All the SSR primers produced more than 70% polymorphism except TC3G03 which produced 57.14% polymorphism. The polymorphic information content (PIC) value of 20 primers varied from 0.5 (PM402) to 0.938 (TC9F10), with a mean of 0.820. The marker index (MI) value for 20 SSR primers varied from 50 (PM402) to 92.02 (TC7C06), with a mean value of 75.79. Only 18 SSR primers out of 20, however, were highly polymorphic (> 75%) with an average of 95.31% and 11 fragments per primer.

Twenty polymorphic SSR primers discriminated 116 groundnut genotypes into two major clusters. First cluster comprised 33 genotypes (CS nos. 2, 10, 79, 28, 7, 37, 36, 27, 92, 8, 40, 97, 41, 45, 94, 43, 59, 75, 81, 83, 77, 85, 96, 55, 58, 51, 54, 57, 98, 76, 86, 73 and 82). Second cluster contain 83 genotypes (CS nos. 104, 156, 108, 137, 151, 113, 120, 153, 144, 102, 167, 184, 103, 159, 161, 186, 192, 187, 177, 116, 105, 107, 190, 196, 212, 202, 215, 203, 205, 281, 282, 227, 211, 230, 228, 271, 244, 232, 263, 246, 275, 250, 262, 285, 286, 264, 267, 206, 220, 269, 277, 293, 46, 99, 201, 308, 398, 338, 420, 300, 379, 327, 301, 396, 328, 311, 381, 337, 377, 417, 339, 421, 402, 425, 422, 412, 319, 375, 378, 431, 423, 268 and KRG 1). Two clusters shared 59% similarity between them. Cluster-I was further subdivided into two sub-clusters. First sub-cluster comprised four genotypes (CS nos. 2, 10, 79 and 28) and second sub-cluster contains 29 genotypes (CS Nos. 7, 37, 36, 27, 92, 8, 40, 97, 41, 45, 94, 43, 59, 75, 81, 83, 77, 85, 96, 55, 58, 51, 54, 57, 98, 76, 86, 73 and 82). The minimum similarity (60%) was observed between genotypes 2 and 82 while the maximum (81%) was observed between genotypes 43 and 59 in cluster-I.

The cluster-II was further sub divided into two sub-clusters. Sub-cluster-I contained 22 genotypes (CS nos. 104, 156, 108, 137, 151, 113, 120, 153, 144, 102, 167, 184, 103, 159, 161, 186, 192, 187, 177, 115, 105 and 107) and was further divided two sub-sub-clusters. All the genotypes belonging to sub-cluster-I grouped into one cluster except CS 107. Sub-cluster-II contained 61 genotypes (CS nos. 190, 196, 212, 202, 215, 203, 205, 281, 282, 227, 211, 230, 228, 271, 244, 232, 263, 246, 275, 250, 262, 285, 286, 264, 267, 206, 220, 269, 277, 293, 46, 99, 201, 308, 398, 338, 420, 300, 379, 327, 301, 396, 328, 311, 381, 337, 377, 417, 339, 421, 402, 425, 422, 412, 319, 375, 378, 431, 423, 268 and KRG 1). Except the genotype CS 268, all other genotypes grouped together. Minimum similarity (63%) was observed between CS 104 and CS 268, while maximum (92%) was observed between CS nos. 228 and 271 in cluster-II. Among 116 genotypes studied, CS 268 and CS 28 were



found to be the most diverse. In contrast five genotypes, CS nos. 46, 99, 201, 308 and 398 were similar in diversity. Susceptible cultivar KRG 1 was distantly related with the genotype CS 28 followed by CS 86. According to the levels of incidence of PBNB, the genotype CS 28 was classified as resistant (incidence between 1.1 and 5%) and genotype CS 86 as highly resistant (incidence between 0 and 1%). These two genotypes shared about 60% similarity between themselves.

Genetic diversity of mutants for kernel size

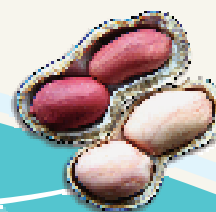
The CS 281 is a large-seeded genotype developed at DGR. The average HKM of this genotype was 79 g. Twelve mutants of CS 281 for kernel size were developed through chemical mutagenesis and the generations were advanced. The HKM of small-kernel mutants viz. 281-5-1, 281-6, 281-7, 281-8, 281-14-1, 281-17-1, 281-17-3 and 281-25-2 was 25.7, 31.7, 33.8, 32.1, 37.8, 31.0, 38.7 and 36.3 g respectively with a mean value of 33.4 g. In contrast, the HKM of large-kernel size mutants viz. 281-2, 281-21-2, 281-25-1, and 281-40-3 was 68.1, 66.5, 63.4 and 64.0 g, respectively with a mean value of 65.5 g. The mean HKM of large-kernel mutants was nearly double that of small-kernel mutants. The kernel length of large-kernel mutants (2.0 cm) was also nearly double that of small-kernel mutants (1.0 cm). The HKM and kernel length of small-kernel mutants and large-kernel mutants were clearly distinct from each other. Molecular diversity analysis of small- and large-kernel mutants along with one of their parent CS 281 was carried out using 35 SSRs (14 AC series, 3 PMC series and 18 TC series). Primer pairs yielded 170 fragments of which 125 bands were polymorphic with an average of 3.57 polymorphic fragments per primer. Number of amplified fragments ranged from 1 to 15. Out of 35 SSRs, 28 were polymorphic. While seven SSR primers viz. AC3F07, TC2C07, TC3B05, TC9C06, TC9H08, TC3E05, and TC2C03 did not produce any polymorphism. The range of polymorphism observed with the 35 SSRs was 0 to 100% with an average value of 62.07%. Among the polymorphic primers, TC3A12 and PMC375 produced a larger number (10 and 15, respectively) of bands. In contrast, the minimum number of bands (1-2) was produced by nine primers viz. AC3F07, TC4D09, TC9H08, TC2C03, AC2C08, AC2C02, AC2C08, AC3C02 and TC3B05.

The PIC value of 35 primers varied from 0.0 (AC3F07, TC4D09, TC9H08, TC2C03) to 0.91 (PMC375), with a mean of 0.63. More than 0.8 PIC value was observed in primer TC3A12, TC4G02, TC9B08, TC11B04, PMC 375, PMC478, TC9H09 and TC3D04. The marker index (MI) value of 35 SSR primers varied from 0.00 (AC3F07, TC4D09, TC2C07, TC3B05, TC9C06, TC9H08, TC3E05, and TC2C03) to 85.45 (TC9B08), with a mean value of 43.41. Primers TC3A12, TC9B08, PMC 375, PMC478 and TC9H09 showed more than 80% marker index value. Majority of the SSR markers used in



this study were highly polymorphic except seven primers and was efficient in revealing the genetic diversity present in the mutant population. Out of these polymorphic primers, TC3A12 was able to distinguish the parent (CS 281) as well as four (281-2, 281-21-2, 281-25-1, 281-40-3) large-kernel mutants from six (281-5-1, 281-6, 281-7, 281-8, 281-14-1 and 281-17-1) small-kernel mutants. Approximately 500bp band was amplified in parent as well as four large-kernel mutants which was absent in six small-kernel mutants. Other two small-kernel mutants (281-17-3 and 281-25-2) amplified the band of 500bp as amplified in large-kernel genotypes. The BSA analysis was done by pooling the DNA samples of all large-kernel genotypes together and small-kernel genotypes together. The same 500bp (approx.) band was amplified in bulked DNA samples of large-kernel mutants which were missing in bulked DNA samples of small-kernel mutants.

The dendrogram was constructed through SHAN clustering and UPGMA analysis. Twenty-eight polymorphic SSR primers could discriminate among 13 groundnut genotypes (4 large kernels, 8 small kernels and their parent). Except for genotype 281-7, the remaining 12 genotypes (281, 281-14-1, 281-2, 281-40-3, 281-5-1, 281-21-2, 281-25-1, 281-6, 281-8, 281-17-1, 281-17-3 and 281-25-2) representing a vast majority grouped in to single cluster (denoted as cluster-I). Cluster-I was further subdivided into two sub clusters. First sub-cluster contained two genotypes (281, 281-14-1) and second sub-cluster contained 10 genotypes (281-2, 281-40-3, 281-5-1, 281-21-2, 281-25-1, 281-6, 281-8, 281-17-1, 281-17-3, 281-25-2). Cluster-II contained only one genotype, 281-7. Maximum similarity (84%) was observed between mutants 281-17-3 and 281-25-2 while the minimum (61%) was observed between mutants, 281-7 and 281-25-2 or 281-17-3. The parent CS-281 was distantly related with its mutant 281-17-3 and 281-25-2.



PROJECT 16: ECONOMIC ANALYSIS OF PRODUCTION, PROCESSING AND UTILIZATION OF GROUNDNUT IN MAJOR GROUNDNUT GROWING STATES OF INDIA

(G. GOVINDARAJ*, A. P. MISHRA AND NARAYANAN G.)

(*till 8th November 2011)

Economics of organic groundnut cultivation in Gujarat

Due to several advantages associated with organic farming, many farmers in Gujarat have taken up organic cultivation of groundnut. Despite its benefits, very little information is available on the organic practices followed by the farmers. Hence, an exercise was initiated to compile various practices followed by the farmers in Gujarat for organic cultivation of groundnut and also to evaluate the economics of organic groundnut cultivation *vis-à-vis* conventional method. Accordingly in Junagadh, 13 villages viz.: Datrana, Bardiva, Babartirth, Samdiyada, Najapur, Rajeshar, Gunadagir, Simachi, Anivada, Moti Kodivar, Pikhori, Titodi and Pimpri in three taluks viz., Mendrada, Maliya hatina and Keshod were surveyed during year 2010-2011.

Socio-economic profile of the farmers

The socio-economic attributes of the farmers growing groundnut by conventional method and organic cultivation differed significantly (Table 1). The relatively large number of effective workers in the families of farmers practicing organic cultivation corroborates to the fact that organic cultivation is more labour intensive. Moreover, as the organic farming needs more compost and livestock based by-products, larger livestock (6.5) with farmers growing organic groundnut (6.5) than those practicing conventional methods (3.0) can be easily understood.

Table 1. Socio-economic profiles of the farmers growing groundnut by organic and conventional methods

Attributes	Organic	Conventional
Age (years)	48	43
Education (score)	9.5	9.0
Experience in farming (years)	22	19
Experience in organic farming (years)	5.0	-
Household size (score)	5.5	4.2
Number of effective workers (score)	3.5	2.6
Livestock (score)	6.5	3.0

The average size of the organic farms was 3.3 ha whereas it was 3.8 ha for the conventional farms. As the farmers' experience with organic farming grew, his area under the organic farming also increased. The price of groundnuts in organic farming was ₹ 2889 q⁻¹ whereas it was ₹ 2712 q⁻¹ in the conventional method. This difference in the sale



price could be attributed to the larger sizes of pod and kernels in organic farming than those from conventional method (Table 2).

Table 2. Farm size, yield and sale price of groundnuts produced by organic and conventional methods

Variables	Organic				Conventional
	<3 years	3-5 years	>5 years	Mean	
Average size of the farm (ha)	4.1	2.9	2.9	3.3	3.8
Organic farm area (ha)	1.7	2.1	2.2	2.0	-
Organic farm area to total land (%)	41	72	76	62	-
Yield (kg ha ⁻¹) during <i>kharif</i> 2010	1625	1741	2181	1849	1920
Sale price (₹ q ⁻¹)	2625-3275			2889	2712

Commercial formulations used by farmers in organic cultivation

Various organic formulations were used by the farmers to supplement nutrients and manage the pests and diseases. The formulations included AAU formulations (Anand Agricultural University), *Panchagavya* or *Panchamrut*, *Jivamrut* 19, *Dharamrut* and other home made formulations. The cost of AAU Formulation-I was ₹2062 ha⁻¹ and that of Formulation-II, which enhances microbial activity in the soil, was ₹2064 ha⁻¹. The cost of *Panchamrut* or *Panchagavya* was ₹948 ha⁻¹ and that of *Jivamrut* 19 was ₹360 ha⁻¹ of *Dharamrut* ₹528 ha⁻¹.

Cost of cultivation and returns in organic vis-à-vis conventional method

The cost of cultivation for organic groundnut was ₹34958 ha⁻¹ while for conventional method it was ₹32806 ha⁻¹. The individual cost of various components contributing to the total cost and the gross and net returns are shown in table 3. The higher gross returns in organic farming were due to marginal increment in the price of organic produce. The higher price for organic groundnut was due to large-size of pods rather than for organic production *per se*. It could be concluded that as such there was not any considerable difference in yield and profit levels between organic and conventional methods. Yet the farmers valued organic farming due to its environment friendly component.

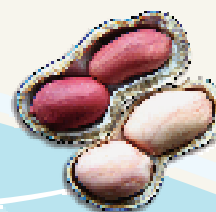


Table 3. Cost of cultivation of organic *vis-à-vis* conventional methods

Component	Conventional	Organic	Change (relative to conventional)
Land preparation	1928	1847	96
Seed	5010	4560	91
Seed treatment and sowing	1385	1439	104
Fertilizer +application cost	6389	8724	137
Weeding and inter-cultural practices	4092	5577	136
Plant protection	1220	462	38
Harvesting and threshing	5922	5815	98
Rental value of land + land revenue	5408	5408	100
Other costs	452	126	28
Total cost of cultivation	31806	33958	107
Pod yield	1720	1849	108
Average price (₹ q ⁻¹)	2712	2889	107
Haulm yield (kg ha ⁻¹)	2352	2577	110
Average price (₹ q ⁻¹)	320	320	100
Total returns (₹)	53990	61664	114
Net returns (₹)	22184	27706	125
Cost of production (₹ kg ⁻¹)	18.49	18.36	

The analysis of the sources of information on organic cultivation indicated that for about 70-80% farmers the source was the nearby agro-service centre, relatives, or NGOs while in a few cases information was received from the fellow farmers. Among factors that motivated the farmers to adopt organic cultivation the singular most important factors were the improvement in soil quality and avoidance of hazards of inorganic cultivation.

Constraints in organic groundnut cultivation

The constraints related to inputs are: high-price of organic inputs, non-availability of inputs in required quantities, and the poor-quality of the available inputs; the constraints related to output are: realization of low yields in the first few years and increase in number of immature pods; and the constraints related to marketing is the absence of local firms interested in organic groundnuts forcing the farmers to market the produce through a middleman. The lack of proper information on the technology for organic cultivation of groundnut and the avenues for undergoing short trainings on the same are to some extent a constraint.

Labour demand and labour-saving options in groundnut

In groundnut cultivation, besides the problems associated with its being a rain-fed crop, the non-availability of labour also adversely affects the completion of various operations in time. There are several technological options to reduce the requirement of human labour for groundnut cultivation. A lot of small and marginal farmers, however,



do not go for these options. This study was conducted in two major groundnut growing states viz., Gujarat and Andhra Pradesh with a view to (i) assessing the expenditure pattern on different sources of labour, ii) quantifying the labour-use from different sources, and iii) estimating the expenditure incurred in labour-saving techniques.

One major groundnut growing district was first identified for each state viz., Anantapur in Andhra Pradesh and Junagadh in Gujarat. Survey was conducted in three villages of one taluk in each district. Finally, 90 respondents (45 in each of the selected taluks) were selected randomly and interviewed using the pre-tested questionnaire. The data thus collected was analysed. The results are presented in table 4 and 5.

Extent of labour-use for various operations

The mean use of human, bullock and machine labour for different operations in groundnut cultivation indicated that the human labour hours required/used for different operations differed in both Gujarat (Junagadh) and Andhra Pradesh (Anantapur). Compared to other operations, the weeding and harvesting operations required very large proportion of human-labour.

Decortication

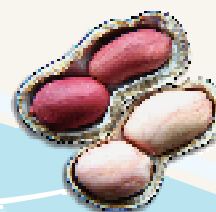
In Andhra Pradesh 82% farmers practiced manual decortication while in Gujarat, in a sharp contrast, only 7% practiced manual decortication as 93% farmers relied on machine decortication. Hence, there is need for promoting machine-decortication in Andhra Pradesh to reduce the human labour-use and drudgery.

Land Preparation

In both the states farmers used only bullock, both bullock and tractor, or tractor alone for land preparation. About two-third of the farmers (62%) in Andhra Pradesh used bullock power whereas in Gujarat only one-third (33%) used it. Partial mechanization (both bullock and tractor), however, was much lower in Andhra Pradesh (13%) than in Gujarat (44%). Use of tractor was nearly the same in both the states.

Sowing

Most of the farmers (87%) used bullock drawn seed drill in Gujarat while only about two-third (69%) of the farmers in Andhra Pradesh used bullock-drawn seed drill. The use of tractor drawn seed drill was by only about 20% and 11% of farmers in Gujarat and Andhra Pradesh, respectively. The non-mechanized sowing was still in practice in Andhra Pradesh by 17% farmers whereas it was insignificant in Gujarat. Thus scope exists for enhancing adoption of mechanised sowing in Andhra Pradesh.



Weeding

In both the states nearly four-fifth of the farmers practiced bullock-drawn inter-cultivation and hand weeding. Although, the human labour-use is nearly half when' bullock inter-cultivation and hand weeding is combined with application of weedicide, only 13% farmers practice this in Gujarat. In Andhra Pradesh, only manual weeding or bullock inter-cultivation + hand weeding was practiced by most of the farmers. There is need for promoting use of weedicide in combination with other methods to further reduce the human labour-use.

Harvesting

In Andhra Pradesh, 90% farmers practice manual harvesting, while in Gujarat only 13% practice it. Hence, there exists a very big scope for popularising labour-saving harvesting techniques in Andhra Pradesh.

Stripping/Threshing

In Gujarat, nearly all the sample farmers and in Andhra Pradesh only 40% farmers practised mechanical threshing. The manual stripping requires about 160 human labour hours per hectare, whereas the requirement is only about 32 human labour hours in mechanical threshing. Hence, mechanised stripping should be further promoted in Andhra Pradesh.

Operation-wise cost incurred across techniques in groundnut cultivation

Operation-wise cost incurred by the farmers in the two states is shown in table 5. In Gujarat, for decortication, land preparation and sowing, although the costs incurred for improved techniques (partial/complete mechanization) was higher than those of conventional methods, it helped the farmers in completing the operations well in time and reduce drudgery. In Andhra Pradesh, except for harvesting, for all other operations, the cost as well as labour-use was quite low due to adoption of partial/complete mechanization methods. The maximum reduction in cost (50%) and labour-use was due to machine decortication and stripping/threshing operations.

The study showed that for groundnut cultivation, the extent of mechanization is relatively high in Gujarat compared to that in Andhra Pradesh. Yet in both the states, considerable scope exists to enhance mechanisation to reduce dependence on human labour and also enable the farmers complete the operations in time and thus reduce drudgery.



Table 4. Operation-wise human, bullock and mechanical labour-use in groundnut cultivation in Gujarat and Andhra Pradesh

Operation and technique	Gujarat				Andhra Pradesh				
	Number of samples (N=45)	Share (%)	Labour hours ha ⁻¹		Number of samples (N=45)	Share (%)	Labour hours ha ⁻¹		
			Human labour	Bullock pair			Mach ines	Human labour	Bullock pair
Decortication (150 kg pods)	-	-	-	-	37	82.2	48.4	-	-
	03	6.7	15.5	-	-	-	-	-	-
	42	93.3	4.3***	-	08	17.8	9.6***	-	1.5
Land preparation	15	33.3	34.3	34.3	28	62.2	31.1	31.1	-
	20	44.4	17.0***	15.6	06	13.3	22.5**	18.0	2.5
	10	22.2	6.6***	-	11	24.4	5.5***	-	5.5
Sowing	-	-	-	-	09	20.0	36.0	18.0	-
	36	80.0	6.5	3.5	31	68.9	14.5***	14.5	-
	09	20.0	4.0	-	05	11.1	4.5***	-	2.5
Weeding	-	-	-	-	06	13.3	199.3	-	-
	34	75.6	115.6	11.6	35	77.8	97.0***	7.0	-
	06	13.3	102.0	-	-	-	-	-	-
	05	11.1	62.0***	6.0	-	-	-	-	-
	-	-	-	-	04	8.9	59.0***	-	3.0
Harvesting	06	13.3	84.0	-	41	91.1	72.0	-	-
	27	60.0	48.0***	6.0	-	-	-	-	-
	12	26.7	42.5***	-	04	8.9	40.0***	-	5.0
Stripping/Threshing	-	-	-	-	27	60.0	160.0***	-	-
	45	100	32.0	-	18	40.0	28.0	-	07

Note: * t-test for human labour use (pair-wise comparison, i.e. conventional vs improved) in different improved techniques was done separately for Gujarat and Andhra Pradesh; *** and ** indicate 1 and 5 per cent significant level, respectively

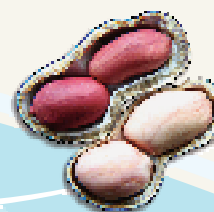


Table 5. Operation-wise cost incurred in groundnut cultivation in Junagadh (Gujarat) and Anantpur (Andhra Pradesh)

Operation and technique	Cost of operation (₹ ha ⁻¹)			
	Junagadh		Anantpur	
	Cost* (₹)	Change over conventional technique (%)	Cost* (₹)	Change over conventional Technique (%)
Decortication (150 kg pods)				
Manual	-	-	500	-
Hand decorticator	300	-	-	-
Machine decorticator (engine operated)	380	+ 26.7	250	- 50.0
Land Preparation				
Bullock	2613	-	2400	-
Bullock + tractor	2869	+ 9.7	2200	- 8.3
Tractor	3125	+ 19.6	2000	- 16.7
Sowing				
Behind country plough	-	-	2400	-
Bullock-drawn seed drill	937	-	1500	- 37.5
Tractor-drawn seed drill	1187	+ 26.7	1400	- 41.6
Weeding				
Hand weeding	-	-	2500	-
Bullock inter-cultivation + hand weeding	3600	-	2300	- 8.0
Tractor inter-cultivation + hand weeding	3600	0.0	-	-
Weedicide (pre-emergence) + inter-cultivation by bullock + hand weeding	2145	- 40.4	-	-
Weedicide (pre-emergence)+ hand weeding	-	-	1750	- 30.0
Harvesting				
Manual	2800	-	2200	-
Bullock digger + manual	2000	- 28.6	-	-
Tractor drawn + manual	2575	- 8.0	2400	+ 9.0
Stripping/Threshing				
Manual	-	-	3000	-
Thresher	1225	-	1500	- 50.0

Note: *Costs calculated on the basis of wage rates, rental values of the machineries and cost of chemicals at the market prevailing rates



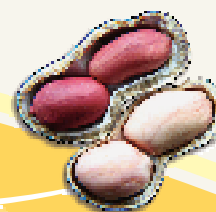
PROJECT 17: BREEDING FOR IMPROVED FODDER QUALITY TRAITS IN GROUNDNUT

(A. L. RATHNAKUMAR, CHUNI LAL, D. BHADURI)

To understand the genetic variation in and inheritance of seven fodder quality traits to propose a suitable breeding method without trading off with pod yield this project was initiated. The results indicated that all the three important yield traits are predominantly under the control of dominance effects together with duplicate epistasis. However, the magnitude of 'h' is less than 'l'. Postponing the selection to later generations with high selection pressure is suggested to isolate superior progenies with high pod, kernel and fodder yields. While the fodder quality traits are non-interacting but are mainly under the control of non-additive gene effects except for the nitrogen content. Hence, early generation selection for nitrogen content would yield desirable results. In view of the strong dominance effects for fibre fractions, total sugars and metabolizable energy, postponing the selection at later stages is recommended.

If the genotypes having high nitrogen content could be identified before harvest in the field itself, it would be easy to isolate a genotype having high pod yield and desirable fodder quality traits. Hence, 12 accessions comprising four in each of Virginia bunch (B 95, ICGS 76, NRCG 9510 and NRCG 14331) and Spanish (ICGV 86590, NRCG 1257, NRCG 5405 and NRCG 14486) types and two each of Virginia runner (CSMG 84-1, Somnath) and Valencia (NRCG 12305 and Gangapuri) types were assessed for SCMR and specific leaf nitrogen at 60, 80 and 100 DAS. The mean SCMR values were in a decreasing trend over the three growth stages while the mean specific leaf nitrogen content were in increasing trend.

The correlation coefficients for the values of SCMR recorded at three different stages of crop growth (60, 80 and 100 DAS) indicated that there was a direct and significant correlation between the SCMR values recorded at 60 DAS and 80 DAS ($r=0.86$); 60 DAS and 100 DAS ($r=0.69$), and 80 DAS and 100 DAS ($r=0.65$). While for nitrogen content significant and direct correlation was observed only between the values for 60 DAS and 80 DAS ($r=0.40$) and for the values of other growth stages, though inverse, the relationship was non-significant. The study clearly indicated that the true assessment of nitrogen content in the fodder can be made only at the time of harvest. The study also indicated that there was no significant relationship between SCMR and specific leaf nitrogen content. The conclusions drawn need to be, however, confirmed by analyzing a larger number of genotypes.



PROJECT 18: DEVELOPMENT OF STATISTICAL MODELS FOR EVALUATION OF FIELD TRIALS ON GROUNDNUT CROP AND DETERMINATION OF SCENARIOS IN AREA, PRODUCTION AND YIELD

(A. P. MISHRA AND G. GOVINDARAJ)

Different statistical forecasting models were used to establish the trends of area, production and productivity of groundnut crop in 16 states of India to classify the states into different segment, which will help the planner to take corrective measures to ascertain the sustainability in production and productivity.

Based on the available databases of groundnut, column chart were drawn and linear, logarithmic, polynomial, power, exponential and moving average forecasting models were used to establish the optimal model for trend evaluation on area, production and productivity for different states. Viewing the R^2 of each equation, it was revealed that polynomial regression equation was the best-suited equation to study the trends in groundnut crop. The best model was selected from polynomial regression equation starting from 4th order to 2nd order for describing trend where, $\sum (A-Y)^2$ = smallest (where Y = collected data and A = forecasted data). The exercise also revealed that 2nd order polynomial regression model was the best-fitted model for the study. Data for sixteen states namely Andhra Pradesh, Bihar, Haryana, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, West Bengal, Tamilnadu, Uttarakhand, Uttar Pradesh, and Chattisgadh of India were taken into consideration to validate the model and study the trend scenarios of different states. Viewing the trends of area, production and productivity (yield) in different states of India, the states were classified into four segments (Table 1).

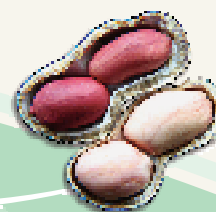
Table 1. Classification of states in four segments based on the trends of area, production and productivity

Segment	Constituent states	Trends		
		Area	Production	Productivity
I	Karnataka, Kerala, Odisha, Tamil Nadu, Uttarakhand, Madhya Pradesh and Chattisgadh	D	D	I
II	Haryana, Gujarat, Rajasthan, West Bengal and Punjab	I	I	I
III	Maharashtra and Andhra Pradesh	D	D	D
IV	Uttar Pradesh and Bihar	I	D	D

D = decrease, I = increase



The available database from 1996-97 to 2007-08 of cotton for area, production and productivity (yield) of seven states viz. Gujarat, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh and Rajasthan was used to validate the 2nd order polynomial regression models on cotton crop also and study the trends of the same to find out the shift of area from groundnut. It was revealed from the study that the four states namely Gujarat, Tamil Nadu, Andhra Pradesh and Madhya Pradesh were showing increasing trends in area, production and yield of cotton. It could therefore be concluded that increase in area of cotton in these four states might be one of the factors for decrease in area under groundnut. In Karnataka and Rajasthan, the area under cotton, however, is having decreasing trends but in Maharashtra area is in constant trend which indicated that the area under cotton crop in these states has no impact on the area under groundnut crop.



ALL INDIA COORDINATED RESEARCH PROJECT ON GROUNDNUT

CROP IMPROVEMENT

Maintenance and evaluation of groundnut germplasm

In *rabi*-summer 2010-11, a total of 1556 groundnut germplasm which included 32 wild species and 95 interspecific hybrid derivatives were multiplied and maintained at four centres viz., Vridhachalam, Anand, Udaipur, and Chinthamani. Whereas in *kharif* 2011, 3385 groundnut germplasm including 39 wild accessions, 144 interspecific hybrid-derivatives were maintained at eight centers viz., Bhubaneswar, Vridhachalam, Jalgaon, Dharwad, Durgapura, Akola, Chinthamani, Shirgaon and Kadiri.

During *rabi*-summer, at Chinthamani, a few advanced breeding lines and varieties were identified for six yield related traits (earliness, <100-day maturity; high-oil content, >50%; high shelling out-turn, >75%; synchronous maturity and tolerance of drought). Five early maturing (~100 days) Spanish advanced breeding lines (ICGX-090093, ICGX-090093, ICGX-090022, ICGX-070061, ICGX-090043) were identified at MPUA&T, Udaipur and three Spanish types with >20-day fresh seed-dormancy have been identified from the inter specific hybrid derivatives developed at TNAU, Vridhachalam.

During *kharif*, 14 interspecific derivatives showing high levels of resistance to rust and or LLS or both and novel interspecific sources of fresh-seed dormancy in Spanish back ground, viz., VG 9401 (33 days) and VG 9404 (30 days) were identified at TNAU, Vridhachalam.

Hybridization

At 18 AICRP-G centres, for developing high-yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses which limit yield, a total of 242 crosses in *rabi*-summer 2010-11 and 227 crosses in *kharif* 2011 were made.

Advancement of generations and selections made

During *rabi*-summer 2010-11, progenies of 1089 crosses were advanced to their respective next filial generation from which, a very large number of (22471) selection was made at 13 AICRP-G centres. In *kharif* 2011, at 18 AICRP-G centres, as many as 12,623 selections in different filial generations were made.

Interspecific hybridization and selections

In *rabi*-summer, using cultivated and agronomically superior varieties as male parents and amphidiploids of wild species as female parents, thirty-two inter-specific crosses were made at Vridhachalam to develop pre-breeding material possessing resistance to foliar diseases and insects. From the advanced generation interspecific hybrid



derivatives, 223 selections were made and 11 genotypes superior to the best local check in respect of yield, shelling out-turn and early-maturity were identified.

In *kharif*, 24 interspecific crosses were made at Vridhachalam. In addition, 11 interspecific hybrid derivatives were evaluated for yield and its components. Four genotypes, VG 9405, VG 9410, VG 0706 and VG 0437 were found promising. Screening of elite interspecific hybrid derivatives for their reactions to rust and LLS at Aliyarnagar (a hot spot for rust and LLS), led to identification of ten genotypes viz., VG 0439, VG 0448, VG 0517, VG 0706, VG 1004, VG 1007, VG 1008, VG 1012, VG 1013, and VG 1016 with high levels of resistance to both rust and LLS; two genotypes viz., VG 0437 and VG 0712 for rust alone and one genotype i.e. VG 9406 for LLS.

Varietal evaluation

Initial varietal trial (IVT-I)

In *rabi*-summer, 14 genotypes and in *kharif* 75 genotypes were evaluated in five zones. The entries are to be evaluated for one more season to ascertain their merit.

Initial varietal trial-I and -II (IVT-I and -II pooled)

In *rabi*-summer, nine entries and three checks which were evaluated in the four zones at 19 test locations in 2009-10 were evaluated again in *rabi*-summer 2010-11. On the basis of pooled results, the kernel yield of one genotype RHRGS 06097 was found to be higher ($>10\%$) than that of the best check, R 2001-3 (ZC). Hence genotype RHRGS 06097 was selected for promotion to AVT.

In Spanish group, two genotypes, RHRG 6083 and JL 776 in Zone III and Zone V and in Virginia group two genotypes CSMG 2005-12 and RG 576 for Zone I; two genotypes KDG 123, RG 576 for Zone II; five genotypes JSP 51, JSP 53, CSMG 2005-28, KDG 123 and NRCG CS 425 for Zone IV; and two genotypes KDG 123 and NRCG CS 425 for Zone were promoted to AVT.

Advanced Varietal Trial (AVT)

There was only one test entry CTMG 6 and three check varieties TAG 24 (NC), R 8808 (ZC) and R 2001-3 (ZC) in zone IIIa (Maharashtra, Karnataka) and two test entries, CTMG 6, ALG 06 320 and three check varieties, TAG 24 (NC), R 8808 (ZC) and R 2001-3 (ZC) in zone IIIb (Tamil Nadu and Andhra Pradesh).

Across different stages of testing, the zonal check variety R 2001-3 recorded high pod (3267 kg ha^{-1}) and kernel (2188 kg ha^{-1}) yields. Over this best check variety, the increase in yield levels of CTMG 6 was 14.2% and 13.7% respectively for pod and kernel yields. While the yield increase observed in CTMG 6 over TAG 24 (NC) was 26.0 and 23.0%; and those over R 8808 (ZC) were 18.5 and 15.6% respectively. Hence, this genotype was proposed for identification in zone III a.



In zone IIIB across different stages of testing, the zonal check variety, R 8808 was the best both for pod (2124 kg ha^{-1}) and kernel (1435 kg ha^{-1}) yield. The entry, CTMG 6 recorded a mean pod yield of 2831 kg ha^{-1} and kernel yield was 1895 kg ha^{-1} over three years of evaluation. Over different check varieties, the increase in pod yield of CTMG 6 was 37.4% over TAG 24; 33.3% over R 8808 and 10.7% over ICGV 00350. Whereas the increase in kernel yield of CTMG 6 over the check varieties was 36.5% over TAG 24; 32.1% over R 8808; and 11.7% over ICGV 00350.

In *kharif*, three genotypes (RG 578, RG 530, and JSP 49 in zone IV) exhibiting high-yields across different stages of testing were proposed for identification.

Breeder seed production

During *kharif* 2011, indents for a total production of 25501.60 q breeder seed of 70 groundnut varieties was received. Considering the availability of nucleus/breeder seed stage-I, however, a production target of a total of 18114.80 q seed of 61 groundnut varieties was assigned to 22 breeder seed producing centres. However, only 2834.65 q breeder seed could be produced in *kharif*. To overcome the shortfall, a compensatory programme was undertaken during *rabi*-summer 2011-12 and the anticipated production would be 17349 q. Thus the total expected production during 2011-12 would be 20183.65 q.

CROPPRODUCTION

Survey of agronomic management practices in the farmer's field

The centres reported that about 65-70% farmers were not following full complement of the recommended package of practices (use high-yielding and disease resistant/tolerant cultivars; adopting proper seed rate; application of balanced fertilizers including gypsum and critical micronutrients like Fe, Zn, Mo and B; seed treatment with bio-fertilizers/fungicides; application of herbicides for weed control).

Broad bed and furrow (BBF) method of planting along with the sprinkler irrigation, and flat bed with hand dibbling method of planting were not in general practice. Use of low or high seed-rate and wider spacing in groundnut was common across the country. Non-availability of good quality seeds of high yielding/improved cultivars in sufficient quantity was the major constraint in adoption of improved varieties.

Sowing methods and integrated nutrient management in rice- groundnut cropping system

At Bhubaneswar centre, among different INM practices in rice-groundnut cropping system in *rabi*-summer, it was observed that the application of recommended dose of nitrogen to rice and recommended dose of P to groundnut was more remunerative. Among different sowing methods of groundnut, sowing with seed-cum-fertilizer drill was found advantageous over the paired-rows, conventional, or criss-cross method of planting.



Evaluation of different methods of irrigation in groundnut during *rabi*-summer

At Junagadh centre, by irrigating groundnut by drip at 100% of average daily transpiration rate on alternate days, 13% more pod yield was obtained over the border strip method (2435 kg ha^{-1}) while at Jalgaon centre, at 80% of average daily transpiration rate, 28.8% more dry pod yield was obtained over the border strip method of irrigation (3123 kg ha^{-1}).

Production maximization of groundnut through nutrient management practices during *rabi*/summer

Analysis of pooled data of *rabi*-summer 2009-10 and 2010-11 at 13 AICRP-G locations revealed that groundnut responded positively to the application of higher and split doses of nitrogen, phosphorus and potassium fertilizers. Application of 150% RDF resulted in 13% more dry pod and 14% more kernel yields over application of 100% RDF.

Application of 100% RDF at the time of sowing and 50 % RDF at 30 days after sowing in addition to application of FYM @ 7.5 t ha^{-1} produced 23% and 25% more pod and kernel yields over the application of 75% RDF at the time of sowing and 25% RDF 30 days after sowing in addition to FYM @ 7.5 t ha^{-1} . Split application of fertilizers (whether 100% RDF or 150% RDF) was found more beneficial in light soils (red sand/lateritic soils) compared to that of heavy soils (medium/deep black soils).

Evaluation of commercially available multi-micronutrient fertilizers and their economic viability in groundnut production during *rabi*-summer

Among various sources of micronutrients, application of *Multiplex* @ 60 kg ha^{-1} at Jalgaon, *Multiplus* @ 40 kg ha^{-1} at Junagadh centre and *Click SF* @ 20 kg ha^{-1} at Vridhachalam resulted in 56, 45 and 64% more pod yield and 102, 60 and 95% more net returns, respectively over the control.

Among the different sources of foliar micronutrient fertilizers for foliar application (30 days after sowing), *Stanes Microfood* @ 5.00 l ha^{-1} at Jalgaon, *Vikas Multimicro* @ 5.00 l ha^{-1} at Junagadh, and *Zincas Green* @ 7.5 l ha^{-1} at Vridhachalam resulted in 45.37, 41.43, and 62.31% more pod yield, respectively and 94.31, 60.97 and 91.17% more net returns, respectively over the control.

Evaluation of pre- and post-emergence herbicides in groundnut in *kharif*

Very effective control of weeds could be achieved by pre-emergence application of pendimethalin 30 EC ($0.75 \text{ to } 1.00 \text{ kg a.i. ha}^{-1}$) + one hand-weeding during 40 to 45 DAS. An effective reduction in weed density was observed with post-emergence application of either quizalofop ethyl 5 EC ($50 \text{ g a.i. ha}^{-1}$) at 20 DAS or imazethapyr ($50 \text{ to } 75 \text{ g a.i. ha}^{-1}$) at 20 DAS. Similar effect was achieved by pre-emergence application of pendimethalin 30 EC ($0.75 \text{ to } 1.00 \text{ kg a.i. ha}^{-1}$) + one hand-weeding at 40 to 45 DAS followed by a post-emergence application of either quizalofop ethyl 5 EC ($50 \text{ g a.i. ha}^{-1}$) at 20 DAS or post-emergence application of imazethapyr ($50 \text{ to } 75 \text{ g a.i. ha}^{-1}$) at 20 DAS.



Nutrient management in Groundnut + Bt-cotton intercropping system in *kharif*

Results of three-year of experimentation at Dharwad on groundnut + Bt-cotton intercropping system (3:1) indicated that application of 100% RDF to groundnut and 150% RDF to Bt-cotton gave the highest groundnut dry pod equivalent yield (6547 kg ha^{-1}) and highest seed cotton equivalent yield (5444 kg ha^{-1}) as compared to application of 100% RDF to groundnut and 100% RDF to Bt-cotton (5978 kg ha^{-1} groundnut dry pod equivalent yield and 4226 kg ha^{-1} seed cotton equivalent yield).

Irrespective of different nutrient management practices, 3:1 groundnut + Bt-cotton intercropping system produced more groundnut dry pod equivalent yield (5700 to 6547 kg ha^{-1}) and seed cotton equivalent yield (4001 to 4618 kg ha^{-1}) over either sole Bt-cotton cropping (2844 to 3830 kg ha^{-1} groundnut dry pod equivalent yield and 2017 to 2716 kg ha^{-1} seed cotton equivalent yield) or sole groundnut cropping system (3389 to 4040 kg ha^{-1} groundnut dry pod equivalent yield and 2424 to 2871 kg ha^{-1} seed cotton equivalent yield).

Likewise, in Junagadh, groundnut + Bt-cotton intercropping system (3:1), application of 100% RDF to groundnut and 150% RDF to Bt-cotton produced much more groundnut dry pod equivalent yield (4051 kg ha^{-1}) as compared to application of 100% RDF to groundnut and 100% RDF to Bt-cotton (3777 kg ha^{-1} groundnut dry pod equivalent yield).

Irrespective of different nutrient management practices, 3:1 groundnut + Bt-cotton intercropping system produced higher groundnut dry pod equivalent yield (3538 to 4051 kg ha^{-1}) over either sole Bt-cotton cropping (2372 to 2673 kg ha^{-1} groundnut dry pod equivalent yield) or sole groundnut cropping system (1704 to 2210 kg ha^{-1} groundnut dry pod equivalent yield).

CROPPROTECTION

Disease situation

Among the foliar diseases, rust and late leaf spot (LLS) were found to be more (8-9) towards the maturity period at Aliyarnagar area while, at Vriddhachalam LLS was found to be more (8-9) towards the maturity period during *rabi*-summer.

Incidences of soil borne pathogens (dry root rot, collar rot and stem rot) in most of the centres, however, were quite low ($<10\%$) during *kharif*. Incidence of PBND was high in *rabi*-summer and *kharif* at Raichur

Disease resistance

Germplasm and interspecific derivatives against major diseases

At Raichur, out of 419 interspecific derivatives screened, 42 genotypes were found resistant to PBND. Two genotypes Chandra and VG 0433 showed $<5\%$ incidence of PBND while Chandra showed resistance reaction to both thrips and PBND.



Field Evaluation of IVT, AVT stage I and AVT stage II entries against major diseases

The centres; Aliyarnagar, Vriddhachalam, Dharwad, Junagadh, Jalgaon, Kadiri, and Raichur screened IVT-I, AVT-I and AVT-II entries for various diseases, as per the hot spot areas. Out of 30 entries, INS-I-10-7 and INS-I-10-21 and AIS-10-8 were resistant to rust while only one entry, INS-I-10-21 was resistant to LLS at Aliyarnagar.

At Vriddhachalam INS-I-10-5, INS-I-10-21, AIS-10-07 and AIS-10-8 were moderately resistant to LLS. At Kadiri centre, a hot spot location for PBNB, incidence of PBNB ranged from 7.5 to 32.3% among the entries. The entries INS-I-2010-2, INS-I-2010-7, INS-I-2010-18, AIS-2010-1 and AIS-2010-3 showed < 10% PBNB. The centre also recorded good incidence of collar rot (0.0 to 49%) and dry root rot (2.4 -34.6%).

Disease management

Management of *Alternaria* leaf spot of groundnut in *rabi*-summer

This trial was conducted in Junagadh at JAU and also at DGR. The results at JAU showed that the application of fungicides mancozeb, copper oxychloride and difenconazole were not only effective in reducing *Alternaria* leaf blight in groundnut but resulted in the highest pod and haulm yields.

At DGR, Junagadh the disease intensity/severity was lower in mancozeb (20.19 and 24.72%) and tebuconazole (20.12 and 24.22%) after the spray, and at harvest, in reducing *Alternaria* leaf blight followed by difenconazole and copper oxychloride. The highest pod and fodder yields were recorded in tebuconazole.

Integrated management of late leaf spot and rust diseases in *kharif*

Among the six treatments tested, seed treatment with Tebuconazole (1.5 g kg⁻¹ + three sprays of Tebuconazole (1.0 ml L⁻¹) (30, 45 and 60 DAS) was found to be the best in reducing rust and LLS with highest pod yield which was followed by seed treatment with Mancozeb (2.0 g kg⁻¹ seed) + three sprays of Hexaconazole (1.0 ml L⁻¹).

Entomology

Insect pest situation

At all the centres, in general sucking pests such as thrips, aphids and jassids were observed to attack the crop during early vegetative stage which was followed by the attack of defoliators. At, Vriddhachalam, however, there was no incidence of sucking pests.

Heavy incidence of *Spodoptera* was observed at Vriddhachalam in *rabi*-summer while at most of the centres this insect was in *kharif*. In *rabi*-summer incidence of leafminer was high at Raichur, Vriddhachalam, Kadiri, Jalgaon, and Mohanpur.



Monitoring of *Spodoptera* and leafminer using pheromone traps in *kharif*

The occurrence of *Spodoptera litura* and leafminer were monitored at Dharwad, Jalgaon, Junagadh, Kadiri, Raichur and Vriddhachalam. The peak period of occurrence was as follows:

Centre	Peak period of occurrence	
	<i>Spodoptera litura</i>	Leaf miner
Dharwad	More pronounced during February-March	More pronounced during February-March
Jagtial	48 th and 28 th standard week	
Jalgaon	14 th standard week	12 th standard week
Junagadh	14 th standard week	
Kadiri		5 th , 10 th , 13 th and 14 th standard week
Raichur	2 nd fortnight of December to middle of January	
Tirupathi	49 th standard week	March
Vriddhachalam	-	12 th standard week

FRONTLINE DEMONSTRATIONS

For *rabi*-summer 2011, a total of 476 FLDs were allotted to 19 centres located in states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal. For *kharif*, altogether 600 FLDs were allotted to 26 centres located in the 11 states (Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Manipur, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Odisha).

The components of improved technology which were covered in FLDs were: Improved Variety (IV), whole package (WP), Integrated Nutrient Management (INM), Plant Growth Promoting Rhizobacteria (PGPR), Integrated Pest Management (IPM), Integrated Disease Management (IDM), Integrated Pest and Disease Management (IPDM), and Integrated Weed Management (IWM).

The results indicated that during *rabi*-summer, the average pod yield of the improved varieties (2600 kg ha⁻¹) was 37% more than that of the varieties (1900 kg ha⁻¹) being used by the farmers. The results of *kharif* indicated that with the use of improved varieties there was an increase in yield from 11.3% (Junagadh) to 38.1% (Aliyarnagar) while the improvement in yield due to adoption of whole package was 32.3% at Aliyarnagar; 23% at Shirgaon, and 16.1% at Jalgaon.



Externally Funded Projects

1. ALL INDIA NETWORK PROJECT ON SOIL BIODIVERSITY-BIOFERTILIZERS

(PI: K.K. PAL, CO-PI: R. DEY)

Funding agency: ICAR

Duration: 01.04.2007-31.03.2012

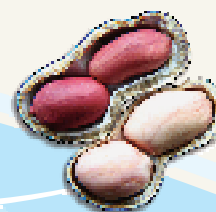
Fund: Rs. 23.00 lakh

Objectives:

- Development of microbial consortia for enhancing nutrient use efficiency and production of groundnut under low input system.
- Microbial diversity in groundnut based cropping systems.

Achievements:

- Different delivery systems of application of the consortium of beneficial bacteria (PGPR: *Pseudomonas* sp. C185; *Pseudomonas* sp. ACC3; PSM: *Pseudomonas* sp. C185 + *B. megaterium*; and groundnut rhizobia: TAL 1000 and NRCG 22) were tested in a field trials both during *rabi*-summer 2011 and *kharif* 2011. The delivery systems included application of the above consortium comprising six compatible bacteria with irrigation water, as seed treatment and through carriers like sterile farm soil, talcum powder, kaoline, charcoal, and FYM. Application of the consortium as formulations in kaoline, sterile soil and through irrigation water significantly enhanced the pod yield of groundnut, cultivar TG 37A. However, maximum yield enhancement was achieved with the application of beneficial consortium through kaoline (18.8% more over control) followed by irrigation water (17.3%) and soil (14.9%). These also resulted in enhancement of shoot and root length and biomass, nodulation, and hundred-kernel mass. The yield of haulm was also enhanced significantly when consortium was applied through FYM and Soil. The other delivery systems like application of formulation as seed treatment, in kaoline, in soil, and in irrigation water also resulted in growth promotion of groundnut plants. However, the yields were at par with the untreated control.
- In *kharif* 2011 trial with cultivar TG 37A, there was significant improvement in the pod yield of groundnut except when applied through irrigation water. However, maximum yield was obtained when consortium was applied through charcoal (14.7%) followed by soil (14.6%) and FYM (14.5%) over uninoculated control. Application of consortium through kaoline, FYM, talcum, soil and charcoal also improved root and shoot length, plant biomass, and shelling out-



turn over uninoculated control. However, application of consortium through soil enhanced the hundred-kernel mass significantly. The best treatment was application of consortium through sterile soil as this treatment improved almost all the parameters significantly.

2. 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 through AMAAS project

Duration: 01.04.2007-31.03.2012

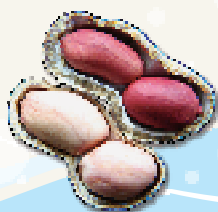
Fund: Rs. 38.10 lakh

Objectives:

- Survey, isolation and characterisation of important bacteria from salt affected areas and salterns of Kutch eco-region of Gujarat.
- Identification of potent salt tolerant strains of bacteria suitable for groundnut cultivation in salt affected areas of Kutch eco-region.
- To study the diversity of representative groups of salt tolerant bacteria obtained from salt affected areas and salterns of Kutch eco-region.
- Exploring source of novel gene(s), if any, of agricultural and industrial importance from diverse extremophiles with special emphasis on biocontrol, salt tolerance, bioactive peptides, industrial enzymes, etc.
- Mapping, cataloguing, and preservation of isolated and identified bacteria in National Repository.

Achievements:

- To understand the mechanisms of extreme osmotolerance in *Haloferax volcanii* H1, functional genomics approach was employed. DDRT-PCR was used to identify differentially expressed transcripts of those genes which might be involved in imparting tolerance at 20% and 35% NaCl. The re-amplified and 185 gel purified differentially expressed transcripts were sequenced. Analysis indicated the expression of a number of hypothetical proteins at 20% and 35% NaCl as compared to those expressed at minimum of 10% NaCl. At the proteomics level, isolated and identified 40 differentially/ over-expressed proteins from *Haloferax volcanii* H1 at 20% and 35% NaCl by 2D electrophoresis. Among these, fumarate hydratase; 2-oxo-3-methylvalerate dehydrogenase; oxoglutarate - ferredoxin oxidoreductase; aminopeptidase,



isocitrate dehydrogenase; phosphopyruvate hydratase; tryptophanase; and glycerol kinase were found to express at higher level of NaCl in *Haloferax volcanii* H1.

- Well characterized cultures of multiple plant growth promoting and salt tolerant strains of *Pseudomonas fluorescens* 232 (NAIMCC-B-762), *Pseudomonas putida* biovar A 330 (NAIMCC-B-763), *Pseudomonas putida* biovar A 357 (NAIMCC-B-764), *Bacillus subtilis* subsp. *subtilis* AMAAS 4 (NAIMCC-B-00944), *Pseudomonas putida* AMAAS124 (NAIMCC-B-00945), *Stenotrophomonas maltophilia* AMAAS 137 (NAIMCC-B-00946), *Stenotrophomonas maltophilia* AMAAS 143 (NAIMCC-B-00947), *Bacillus subtilis* subsp. *subtilis* AMAAS 156 (NAIMCC-B-00948), *Bacillus subtilis* subsp. *subtilis* AMAAS 157 (NAIMCC-B-00949), *Bacillus subtilis* subsp. *subtilis* AMAAS 158 (NAIMCC-B-00950), *Enterococcus cancerogenus* AMAAS 198 (NAIMCC-B-00951), *Stenotrophomonas maltophilia* AMAAS 223 (NAIMCC-B-00952), *Bacillus licheniformis* AMAAS 353 (NAIMCC-B-00953), *Enterobacter* sp. AMAAS 2 (NAIMCC-B-00954), and *Beutenbergia cavernae* AMAAS 46 (NAIMCC-B-00955) developed under AMAAS project at DGR, Junagadh were deposited to NAIM, Mau as National Repository.
- Partial and near complete 16S rDNA sequence data (37 in number; 25 archaea and 12 plant growth promoting rhizobacteria) were submitted to NCBI gene bank (JF JF802138, JF802141, JF802142, JF802144-JF802165; JN391530-JN391541).

3. DIVERSITY ANALYSIS OF BACILLUS AND OTHER PREDOMINANT GENERA IN EXTREME ENVIRONMENTS AND THEIR APPLICATION IN AGRICULTURE

(CCPI: K.K. PAL)

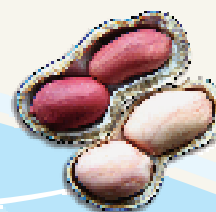
Funding agency: NAIP

Duration: 09.01.2009-31.12.2012

Fund: Rs. 63.89 lakhs

Objectives:

- Diversity analysis and identification of *Bacillus* and predominant genera from various extreme environments.
- Study of diversity of *Bacillus* and other predominant genera in crop association under extreme environment and its validation.
- To understand the mechanisms of adaptation in *Bacillus* and mining of relevant genes.



- Selection of novel strains of *Bacillus thuringiensis* and other *Bacillus* species with insecticidal properties and isolation of novel *cry* and other insecticidal genes.

Achievements:

- To understand the basis of extreme osmotolerance in *Bacillus pumilus* SB49, DDRT-PCR method was employed and three hundred sixty-seven differentially expressed transcripts were isolated and purified.
- Out of the transcripts obtained, 26 transcripts have been cloned to PCR-TRAP cloning vector for developing recombinant vectors and all three hundred sixty-seven transcripts were sequenced.
- Analysis of sequence data of fifty-five differentially expressed transcripts indicated the expression of putative hypothetical proteins at higher salt concentrations.
- Similarly, for developing knock out mutants of *Bacillus pumilus* SB49, eleven of the differentially expressed transcripts (cDNA) have been cloned successfully to the pMUTIN-GFP for using them for isolating knock-out mutants of different traits involved in extreme osmotolerance.
- Intra-cellular solutes of *Bacillus pumilus* SB49 was analysed by XRD and it revealed that there was drastic decrease in the concentration of K at extreme salinity indicating that accumulation of K is not a factor for imparting salinity at extreme conditions.

4. BIOPROSPECTING OF GENES AND ALLELE MINING FOR ABIOTIC STRESS TOLERANCE

(CCPIs: K.K. PAL AND R. DEY)

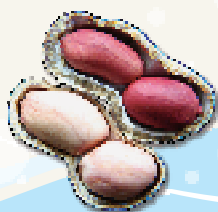
Funding agency: NAIP

Duration: 04.05.2009-31.03.2013

Total fund: Rs. 73.141 lakh

Objectives:

- Isolation and identification of microbes from extreme environments tolerant to salinity, high temperature and desiccation.
- Understanding the mechanisms of tolerance of extreme environments in selected microbes.
- Isolation and identification of gene(s) responsible for imparting tolerance to extreme environments.
- Bioinformatic analysis of the identified genes and the encoded proteins and putative biochemical pathways responsible for abiotic stress tolerance.



Achievements:

- SEM-EDX analysis of intracellular solute during extreme osmotolerance in *Aspergillus sydowii* BF5 revealed the increase in accumulation of Na^+ from apparent concentration of 3.708 (without external NaCl) to 8.007 (35% external NaCl).
- *Aspergillus sydowii* BF5 was also screened for the presence of genes known to impart salinity tolerance in fungi like *ostBA*, *treB*, *ggpS*, Na^+/H^+ antiporter, etc. However, presence of none of the above genes known for osmotolerance was found using the known primers for the genes. Therefore, to understand the mechanisms of extreme osmotolerance and isolation of relevant genes in this unique fungus *Aspergillus sydowii* BF5, which can grow at saturated NaCl condition, DDRT-PCR technique was employed. Eventually 465 differentially expressed transcripts were obtained after covering around 60% of the mRNA obtained from two different conditions viz. 0% and 20% of NaCl. Out of the differentially expressed transcripts, 287 transcripts were re-amplified and 41 were cloned to PCR-TRAP cloning vector. Out of the reamplified differentially expressed transcripts, 191 were sequenced successfully.
- Analysis of the sequence data indicated the differential expression of genes of hypothetical proteins (20 in number) at 20% of NaCl as compared to that expressed without salt. For all remaining sequences, no hits were found against all non-redundant gene bank CDS at NCBI. This indicated the possible involvement of novel genes in extreme osmotolerance in *Aspergillus sydowii* BF5.
- Utilizing the sequence data, the probable genes coding the putative hypothetical proteins were mined from related genera. Primers were designed for amplification, cloning, expression of hypothetical proteins, etc.

5. UNRAVELLING THE BIOCHEMICAL AND MOLECULAR BASIS OF BACTERIAL AND FUNGAL ENDOSYMBIOSIS FOR ALLEVIATION OF ABIOTIC STRESSES IN PLANTS

(CPI: K. K. PAL, CI: R. DEY)

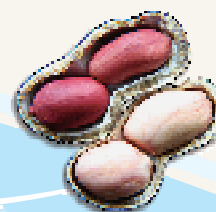
Funding agency: ICAR through NFBSFARA

Duration: 01.06.2011-31.05.2016

Total fund: Rs. 249.2690 lakh

Objectives:

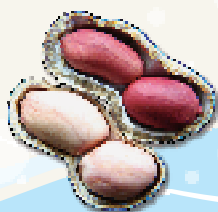
- To identify the role of endosymbionts in imparting moisture, salinity and high temperature tolerance in groundnut and pearl millet in arid, semi-arid areas.
- To understand the physiological, biochemical and molecular bases of imparting tolerance to abiotic stresses by endosymbiotic associations.



- To validate the role of endosymbiotic associations in alleviating abiotic stresses in groundnut and pearl millet under field conditions.

Achievements:

- One hundred and thirty-one bacterial and 20 fungal putative endophytes were isolated from root, stem and seeds of groundnut cultivars Girnar 2, TG 37A (tolerant to moisture deficit stress), GG 2 (tolerant to salinity) and the seeds of some other cultivars, such as, J 11 (seed coat resistance to *A. flavus*), ICGS 11, SG 99 and germplasm accessions like NRCG 12431, 12962, 12732, etc.
- Fifty-two bacterial endophytes evaluated so far were able to grow at 50°C and 5% NaCl. However, only 38 out of 52 isolates could tolerate 10% NaCl concentration. Among the 20 endophytic fungal isolates screened for tolerance to salinity, all the isolates were able to grow at 10% concentration of NaCl. Fourteen out of 52 bacterial endophytes showed strong inhibitory activity against soil-borne fungal pathogens of groundnut viz. *Aspergillus niger*, *Sclerotium rolfsii* and *Aspergillus flavus*. The fungal endophytes like *Aspergillus terreus* and *Aspergillus flavipes* also showed antifungal activity against all three soil-borne fungal pathogens of groundnut.
- Among the bacterial root endophytes of groundnut, organisms belonging to *Bacillus* and *Bacillus* derived genera were predominant. Besides, *Acinetobacter radioresistens*, *Staphylococcus* sp., *Kytococcus* sp., *Pseudomonas fluorescens*, *Enterobacter* sp., *Alcaligenes faecalis* and a number of isolates belonging to uncultured bacterial clones were also obtained indicating that these organisms might be novel ones. Besides, two actinomycetes, *Dietzia* sp. and *Cohnella* sp. were also identified.
- Bacterial stem endophytes of groundnut includes isolates of *Alcaligenes faecalis*, *Kocuria palustris*, *Brevundimonas* sp., *Pantoea agglomerans*, *Pseudomonas aeruginosa*, *Enterobacter ludwigii*, *Enterobacter cloacae*, *Staphylococcus* sp., and a number of isolates of *Bacillus* and *Bacillus* derived genera. The seed endophytes were identified as *Bacillus subtilis*, *Bacillus firmus*, *Pseudomonas* sp., *Bacillus tequilensis* and *Pseudomonas aeruginosa*.
- Majority of the fungal seed endophytes were identified as *Aspergillus terreus* besides *Aspergillus flavipes* and *Penicillium citrinum* were also found.
- On the basis of ARDRA, 52 bacterial endophytes of groundnut were classified into five major and 13 minor clusters indicating presence of variability and diversity among the bacterial endophytes inhabiting the root, stem and seeds of groundnut.



6. ENHANCING CARBON SEQUESTRATION IN GROUNDNUT BASED CROPPING SYSTEMS BY CONSERVATION TILLAGE AND RESIDUE INCORPORATION

(PI: N. K. JAIN, CO-PI: H. N. MEENA AND K. CHAKRABORTY)

Funding agency: DST

Duration: 3 years

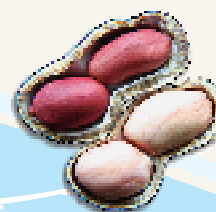
Fund: Rs 45.25 lakhs

Objectives:

- Assessment of above and below groundnut carbon allocation in groundnut based cropping systems.
- Understanding and quantification of the role of cropping systems and conservation practices in allocation of soil organic and inorganic carbon.
- Effect of cropping system and conservation practices on nutrient dynamics in relation to carbon sequestration.
- Study the physiological and biochemical change in groundnut under different cropping systems and management practices.
- Economic assessment of carbon sequestration practices in groundnut based cropping systems.

Achievements

- There was no effect of various conservation practices for different groundnut-based cropping systems on the total biomass, root biomass of groundnut at 30 and 60 DAS, nodulation at all the stages, mature to immature pod ratio and harvest index. But at harvest, the total biomass, root biomass, number of pods plant⁻¹, pod and haulm yields were significantly influenced due to intercropping with pigeonpea. All these parameters were significantly improved in sole cropping under various treatments as compared to intercropping. On an average, sole cropping of groundnut recorded 45.9 and 44.5 % more pod and haulm yields over intercropping with pigeonpea.
- Various groundnut-based intercropping systems did not have any significant influence on total and root biomass of pigeonpea at 40 and 80 DAS as well as at harvest, leaf fall, harvest index, seed and stalk yields of pigeonpea. The seed yield of intercropped pigeonpea ranged from 1786 to 1824 kg ha⁻¹ while stalk yield ranged from 6984-7196 kg ha⁻¹ under various treatments.
- Due to various conservation practices under various groundnut-based cropping systems there was no significant influence on the total and root biomass and number of tillers m⁻¹ row-length of wheat at 30 and 60 DAS as well as at harvest,



grains/spike, harvest index, grain and straw yields of wheat except number of tillers m^{-1} row-length at harvest. On the other hand, total tillers and effective tillers m^{-1} row length at harvest varied significantly due to various tillage practices and these were significantly higher under conventional tillage over zero tillage.

- Significantly higher groundnut-pod equivalent yield (3645 kg ha^{-1}) was obtained under different groundnut-wheat cropping system with and without conservation practices over sole groundnut and groundnut + pigeonpea intercropping systems with *Sesbania* or greengram (green manuring) on mean basis. Similar were the trends for N, P, K and S uptake by different groundnut-based cropping systems.
- There was no significant difference in soil pH, EC and bulk density, soil available nutrients and total nitrogen contents with respect to different treatments. However, total nitrogen content (in some of the plots) and soil pH showed slight increasing trends while EC, bulk density, available N, P, K and S showed declining trends with increase in soil depth from 0-15 cm to 30-60 cm.
- Soil enzyme activities (urease, acid phosphatase, alkaline phosphatase and β -glucosidase) also did not differ significantly under various treatments before commencement of experiment in 0-15 cm soil depth. The values of urease, acid phosphatase, alkaline phosphatase and β -glucosidase activities ranged from 6.48-9.64, 13.6-16.2, 0.735-0.849 and 0.138-0.190 $\mu\text{mol g}^{-1} \text{ min}^{-1} \times 10^{-3}$, respectively.
- Net photosynthesis rate was quite high from the initial stages of the plant ranging from 26.2 – 29.4 $\mu\text{mol m}^{-2} \text{ s}^{-1}$ at 30 DAS and it increased to 29.0 – 33.6 $\mu\text{mol m}^{-2} \text{ s}^{-1}$ at 60 DAS. But with further increase in plant age net photosynthesis rate goes down at 90 DAS (14.5 – 20.3 $\mu\text{mol m}^{-2} \text{ s}^{-1}$). Starch content was found to be highest at 60 DAS in leaf ranging from 130.9 – 158.1 mg g^{-1} dry weight. Total sugar and starch content of the kernel varies from 41.2 – 43.6 and 67.1 – 76.7 mg g^{-1} seed weight respectively. The oil content varies from 51.2 – 52.63 % in the kernel. The difference between treatments was non-significant at all the three stages.

7. EVALUATION OF 'ALLWIN TOP DRIP SPECIAL' THROUGH FERTIGATION IN GROUNDNUT

(PI: N. K. JAIN, CO-PI: H. N. MEENA)

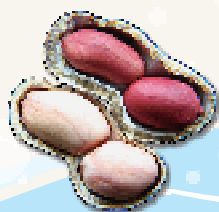
Funding agency: M/s Sree Ramcides Chemicals Pvt. Ltd. Chennai

Duration: 2 years

Fund: Rs. 5.68 lakhs

Objectives:

- To study the performance of 'Allwin Top Drip Special' in comparison to recommended sources of NPK in groundnut.



- To evaluate the effect of 'Allwin Top Drip Special' on growth, yield and economics of groundnut.
- To find out the fertilizer and water savings.

Achievements:

- Application of Allwin Top Drip Special @ 226.5 kg ha⁻¹ as fertigation at 5, 10, 30 and 60 DAS through drip significantly improved productivity and oil yield of groundnut over all the other treatments. Its application through drip also saved 33-34 per cent water as compared to control.

8. ICAR NETWORK PROJECT ON TRANSGENIC CROP

(PI: RADHAKRISHNAN, T, CO-PI: ABHAY KUMAR)

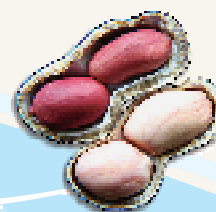
Funding Agency: ICAR

Objective

- Development of transgenic groundnut tolerant to drought/salinity
- Development of transgenic groundnut tolerant to insect / pests

Achievements / Salient findings:

- Two gene constructs *ZAT12* TF and *AtDREB1a* were separately used for incorporating *Agrobacterium* mediated tolerance of abiotic stresses, especially drought and salinity. The progress made is given below.
- i) *BnZAT 12*-TF :
- 34 independent transformants were confirmed in T₀ generation
 - 12 selected lines, now in T₂ have been identified for further screening.
 - Molecular confirmation has been done using PCR, DotBlot and RT-PCR. Segregation analysis has been performed.
- ii) *AtDREB1a* :
- 14 independent transformants were confirmed in T₀ generation
 - 14 selected lines, now in T₂, have been identified for further screening
 - Molecular confirmation has been done using PCR, DotBlot and RT-PCR. Segregation analysis has been performed.



The gene construct *cry1Fa1*, was used for developing groundnut having transgenic resistance to defoliating insects especially *Spodoptera litura*. The progress made is given below.

- i) *cry1Fa1* : • 21 independent transformants were confirmed in T₀ generation
• 8 selected lines are now in T₂ has been selected for further screening
• Molecular confirmation has been done using PCR, DotBlot and RT-PCR. Segregation analysis has been performed.

9. EVALUATION OF GROUNDNUT GERMPLASM FOR MORPHOLOGICAL, PHYSIOLOGICAL AND MOLECULAR CHARACTERS/TRAITS ASSOCIATED WITH DROUGHT TOLERANCE FOR ENHANCING PRODUCTIVITY IN RAIN-DEPENDENT SYSTEM

(PI: RADHAKRISHNAN T., CO PI: A.L. RATHNAKUMAR. AND CHUNILAL)

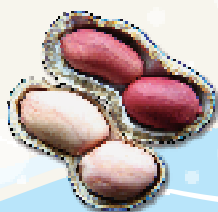
Funding Agency: National Fund for Basic and Strategic Research in Agriculture (NF-BSRA), Indian Council of Agricultural Research

Objectives:

- To evaluate germplasm for both root and shoot parts to integrate the genetic and physiological performance of groundnut for overall identification of the traits associated with efficient water-use efficiency or drought tolerance and high temperature stress.
- To study canopy function and its interaction with drought in terms of both physiological and biochemical parameters such as leaf water relations, osmotic adjustments, efficiency of photosystem (PS II), partitioning of photosynthate.
- To identify potential molecular markers (SSR and ESTs) related to drought and heat stresses and to identify suitable genotypes for subsequent breeding programmes to initiate crosses between identified susceptible and tolerant genotypes for QTLs analysis associated with drought tolerance.

Achievements / salient findings

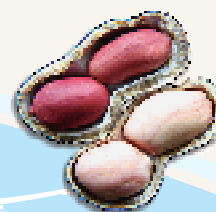
- Various associations between traits such as leaf folding and chlorophyll content, Fv/Fm, SCMR and leaf temperature with pod yield and biomass productivity and maintenance of leaf relative water content clearly indicated that variations in these attributes significantly contribute to the productivity.



- Based on pod yield and total biomass production, drought tolerance index (DTI) was calculated and tolerant and susceptible lines were identified. During rainy season, ICR 3, an advanced breeding line for water-use efficiency, exhibited higher drought tolerance index in terms of both pod yield and total biomass production. While another genotype 'Chico' having early pod maturity period also exhibited higher DTI in terms of both PY and TBM. In addition, ICG 4747 showed lower DTI both in terms of PY and TBM. The list of the genotypes identified is given below.

Genotype	DTI PY	Genotype(s)	DTI TBM
High (Rainy season)			
ICR 3	1.0	NRCG 14464	0.86
NRCG 11236	1.1	NRCG 14416	0.90
Chico	1.7	NRCG 12667	0.92
(drought escape type)			
		Chico	0.10
		ICR 3	1.03
Low (Rainy season)			
NRCG 12630	0.01	NRCG 12591	0.36
ICG 4747	0.15	NRCG 101	0.42
NRCG 12858	0.27	NRCG 3491	0.47
NRCG 12069	0.31	ICG 4747	0.47
		NRCG 11942	0.48
High (Summer season)			
JAL 4	0.48	JUG 12	0.91
JAL 32	0.51	JUG 9	0.93
ICR 42	0.54	ICR 39	0.96
JUG 37	0.55	TIR 14	0.96
TIR 17	0.55		
NRCG 12290	0.58		
Low (Summer season)			
JAL 4	0.58	JAL 4	0.48
TIR 17	0.60	JAL 32	0.51
ICR 42	0.61	ICR 42	0.54
ICR 41	0.61	JUG 37	0.55
NRCG 12290	0.66	TIR 17	0.55
		NRCG 12290	0.58

- Ninety-two genotypes were phenotyped for their physiological parameters which might contribute to water-use efficiency. The parameters viz. root volume, branches plant⁻¹, plant height, pegs plant⁻¹, pods plant⁻¹, root dry weight, root



density, shoot weight, total root and shoot weight, root-shoot ratio, days to 75% flowering, leaf folding (1-10 scale), RWC, SLA, SCMR, Fv/Fm, TEMP, PSII, Fs, Fm', Fo, ETR, and PSII were measured in the population. The associations of the 58 polymorphic loci were worked out using the software *Taseel* and *Powermarker*. Five markers could be associated with primary root length, secondary root length and relative water content.

10. ICAR SEED PROJECT "SEED PRODUCTION IN AGRICULTURAL CROPS"

Nodal officer: Dr. Chuni Lal

Seed Committee: Dr. Chuni Lal, Chairman; Dr. A. L. Rathanakumar, member, Dr. D. L. Parmar, member; Mr. B. M. Chikani, member; Mr. V. K. Sojithra, member secretary

Summary

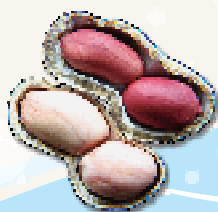
- Seed production of DGR varieties 'Girnar 2' and 'Girnar 3' and BARC, Trombay groundnut variety 'TG 37A' was taken up in the main season *kharif*.
- To make up the production deficits of *kharif* season compensatory seed production was taken up in summer seasons as well.
- *kharif* production was very poor which is attributable mainly to high rainfall and stretched monsoons, and lesser availability of labour at crucial stages.

In summer 2011 seed production of 'TG 37A' variety was taken up in 1.2 ha and 22 q seed of truthfully labeled category was produced.

In *kharif* 2011, the seed production programme for three groundnut varieties ('Girnar 2', 'Girnar 3' and 'TG 37A') was taken up on 7.25 ha land at DGR farm. A combined production target of 80 q of nucleus and truthfully labeled seed 'Girnar 2' and 'Girnar 3', and 'TG 37A' varieties was set. However, due to excessive rains at crucial stages a total of only 18.7 q seed could be produced.

Seed production was also taken up on farmers' fields in villages near Gondal through an NGO, Vishal Agriseeds, and 100.7 q truthfully labeled seed of groundnut variety 'TG 37A' was produced.

As the targets set for *kharif* 2011 could not be attained, a compensatory programme of seed production of three varieties 'Girnar 2', 'Girnar 3' and 'TG 37A' was taken up on 2.9 ha land at DGR farm to produce the seed of different classes (nucleus, breeder and truthfully labeled). Early sowing of seed from the summer crop of variety 'Girnar 2' was used for sowing in the month of January under polythene mulch to ensure germination even at low temperatures which prevail in this month. The crop stand and growth was excellent and a good harvest is expected.





Nucleus seed crop of groundnut variety 'Girnar 2' raised in summer season

11. OVER EXPRESSION OF *PR10* GENE CLONED FROM SALT STRESS TOLERANT CELL LINES OF *ARACHIS HYPOGAEA* IN GROUNDNUT CULTIVAR(S) FOR ABIOTIC STRESS TOLERANCE

(PI: S.K BERA, CO-PI: N.B. SARIN, JNU, NEW DELHI)

Funding Agency: DBT

Duration: 4 years (2009-2013)

Funds: 31.99 Lakhs

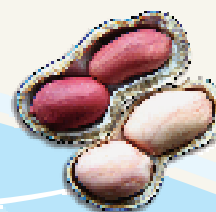
Objective:

- Enhancing salt tolerance of two salt sensitive groundnut cultivars (GG 2 and TAG 24) by overexpressing PR 10 gene, isolated from salt tolerant cell lines of *Arachis hypogaea* L. var JL 24.

Achievements:

Transformation of *Arachis hypogaea*

De-embryonated cotyledons were used as explants for transformation using PR10 gene. Shoots regenerated from de-embryonated cotyledons were selected in kanamycin at 50 mg l⁻¹. Total 700 explants of TAG 24 and GG 2 were infected with *Agrobacterium* culture and sub-cultured for regeneration. All together 1300 shoots were regenerated for TAG 24 and GG 2. Out of 131 tested, the PCR analysis confirmed the presence of PR10 gene in 77 plants. From these 77 PCR positive plants, the integration of PR10 gene was confirmed further in 53 plants by southern analysis.

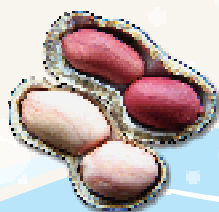


- **RT-PCR analysis of T₀ plants**

The mRNA expression level of the PR10 gene in the putative PCR and southern positive transgenic plants was checked by TR-PCR analysis. The leaves of the putative transgenic and wild type plants were used for the expression analysis of the transgene. Equal amount of total RNA from the control and transgenic plants was used for RT-PCR analysis using gene specific primers of PR10 gene. A 0.5kb PR10 transcript was detected in the leaves of all the transgenic plants, while it was absent in the wild type plant.

- **Test of T₀ transgenic plants for tolerance of salinity**

Leaf discs of equal diameter derived from fully grown mature leaves of T₀ transgenic plants and wild plants floating on different concentration of NaCl (400 mM and 800 mM) showed significant phenotypic difference after 5 days of treatment. The leaf discs from transgenic plants showed a slower senescence compared to those of wild types in both the concentrations of salt. The chlorophyll content of the transgenic leaf discs floating on 400 mM and 800 mM NaCl was 138 and 130 $\mu\text{g g}^{-1}$ fresh weight, respectively while that of wild type was 87.46 and 63.93 $\mu\text{g g}^{-1}$ fresh weight respectively. At 400 mM NaCl, the chlorophyll content of leaf discs of the transgenic plants was 1.57 times that of the wild type leaf discs. At 800 mM NaCl, the chlorophyll content was 2 folds in transgenic groundnut plants as compared to wild type.



PUBLICATIONS

Research articles

- Ajay, B.C., Gowda, M.V.C., Rathnakumar, A.L., Kusuma, V.P., Fiyaz, R.A., Holajjer, P., Ramya, K.T., Govindaraj, G. and Babu, H.P. (2012). Improving genetic attributes of confectionary traits in peanut (*Arachis hypogaea* L.) using multivariate analytical tools. *Journal of Agricultural Sciences*, 4 (3) 247-258.
- Datta, M., Singh, N.P. and Singh, A.L. (2012). A variability in response of groundnut (*Arachis hypogaea* L.) to phosphate application in acid soils of Tripura. *Journal of Environment and Ecology* (in Press).
- Dey, R., Pal, K.K. and Tilak, K.V.B.R. (2011). Influence of soil and plant types on diversity of rhizobacteria. *Proceedings of National Academy of Sciences, India Section B*, DOI 10.1007/s40011-012-0030-4.
- Gautami, B., Pandey, M.K., Vadez, V., Nigam, S.N., Ratnakumar, P., Krishnamurthy, L., Radhakrishnan, T., Gowda, M.V.C., Narasu, M.L., Hoisington, D.A., Knapp, S.J. and Varshney, R. K. (2011). QTL analysis and consensus genetic map for drought tolerance traits based on three RIL populations of cultivated groundnut (*Arachis hypogaea* L.). *Molecular Breeding*, DOI 10.1007/s11032-011-9660-0.
- Govindaraj, G. and Mishra, A.P. (2011). Labour demand and labour-saving options: A case of groundnut crop in India. *Agricultural Economics Research Review*, 24: 423 - 428.
- Hariprasanna, K., Lal, C., Radhakrishnan, T., Gor, H.K. and Chikani, B.M. (2012) Performance of confectionery groundnut cultures of ICRISAT at Junagadh, Gujarat. *Legume Research*, (Communicated).
- Harish, G., Prasanna, H. and Savaliya, S.D. (2011). Mermithid parasitism (Nematoda: Mermithidae) in *Helicoverpa armigera* in Groundnut. *Indian Journal of Nematology*, 41(2): 216-217.
- Harish, G., Prasanna, H., Savaliya, S.D. and Gedia, M.V. (2012). Population density on damage of groundnut by *Caryedon serratus*. *Annals of Plant Protection Sciences*, 20(1): 217-219.
- Harish, G., Rathnakumar, A.L., Kumar, N., Ajay, B.C., Holajjer, P., Savaliya, S.D. and Gedia, M.V. (2012). Comparative response of Groundnut genotypes to bruchid beetle, *Caryedon serratus* Oliver in storage. *Annals of Plant Protection Science*, 20(1): 140-144.
- Jat, R.S., Devidayal, Meena, H.N., Singh, V., and Gedia, M.V. (2011). Long-term effect of nutrient management and rainfall on pod yield of groundnut (*Arachis hypogaea*) in groundnut-based cropping systems. *Indian Journal of Agronomy*, 56(2): 145-9.



- Jat, R.S., Meena, H.N., Singh, A.L., Jaya, N. and Misra, J.B. (2011). Weed management in groundnut (*Arachis hypogaea*) in India – A Review. *Agri. Reviews*, 32(3): 155-71.
- Kalariya, K.A., Singh, A.L., Chakraborty, K., Zala, P.V. and Patel C.B. (2012). Physiology of Groundnut (*Arachis hypogaea* L.) under Water Deficit stress. I Chlorophyll Fluorescence and Photosynthesis. *Indian Journal of Plant Physiology* (Communicated).
- Lal, C. and Hariprasanna, K. (2011). Assessment of early maturity in groundnut (*Arachis hypogaea* L.) based on percent reduction in yield by advancing date of harvest. *Journal of Oilseeds Research*, (Communicated).
- Lal, C., Hariprasanna, K., Chikani, B.M. and Gor, H.K. (2012). Inheritance pattern of harvest index, and surrogates of water-use efficiency and heat tolerance in peanut (*Arachis hypogaea* L.). *Australian Journal of Crop Science*, (Communicated).
- Lal, C., Singh, A.L., Hariprasanna, K., Gor, H.K., Chikani, B.M. and Vidya, C. (2012). Genetics of some nutrients in groundnut (*Arachis hypogaea* L.) under moisture-deficit stress situations. *Legume Research*, 35(1): 40-43.
- Nautiyal, P.C., Ravindra, V., Rathnakumar, A.L., Ajay, B.C. and Zala, P.V. (2012). Genetic variations in photosynthetic rate, pod yield and yield components in Spanish groundnut cultivars under three different environments. *Field Crops Research*, 125: 83-91.
- Pandey, M.K., Gautami, B., Jayakumar, T., Sriswathi, M., Upadhyaya, H.D., Gowda, M.V.C., Radhakrishnan, T., Bertoli, D.J., Knapp, S.J., Cook, D.R., Varshney, R.K. (2011). Highly informative genic and genomic SSR markers to facilitate molecular breeding in cultivated groundnut (*Arachis hypogaea*). *Plant Breeding*, 131(1): 139-147.
- Sharma, N.K., Jain, N. K. and Upadhyay, B. (2011). Response of groundnut (*Arachis hypogaea* L.) to balanced fertilization under sub-humid southern plain zone of Rajasthan. *Legume Research*, 34(4): 273-277.
- Sujay, V., Gowda, M.V.C., Pandey, M.K., Bhat, R.S., Khedikar, Y.P., Nadaf, H.L., Gautami, B., Sarvamangala, C., Lingaraju, S., Radhakrishnan, T., Knapp, S.J. and Varshney, R.K. (2011). QTL analysis and construction of consensus genetic map for foliar disease resistance based on two RIL populations in cultivated groundnut (*Arachis hypogaea* L.), *Molecular Breeding*, DOI 10.1007/s11032-011-9661-z.
- Thirumalaisamy, P.P., Jadon, K.S., Koradia, V.G. and Padavi, R.D. (2011). Efficacy of *Trichoderma harzianum* and *Verticillium lecanii* against stem rot, collar rot and foliar fungal diseases of groundnut. *Journal of Biological Control*, 25(3): 247-250.
- Thomas, M., Pal, K.K., Dey, R., Saxena, A.K., and Dave, S.R. (2012). A novel haloarchaeal lineage widely distributed in the hypersaline marshy environment of little and great Rann of Kutch in India. *Current Science*, (Communicated).
- Thomas, M., Pal, K.K., Dey, R., Saxena, A.K., and Dave, S.R. (2012). Ecology and diversity of haloarchaeal community in the hypersaline little and great Rann of Kutch of India. *Environmental Microbiology*, (Communicated).



Papers presented at symposia/seminars/conferences/other fora

- Bhaduri, D., Meena, H.N., Chakraborty, K. and Jain, N.K. (2012). Study of salt tolerance in groundnut genotypes using stress susceptibility and tolerance indices. (In) *Zonal Seminar on 'Physiological and molecular interventions on sustainable crop productivity under changing climatic conditions'* on 17 January, 2012 at Directorate of Medicinal and Aromatic Plants, Anand, Gujarat, p. 24.
- Chakraborty, K., Kalariya, K.A., Zala, P.V. and Singh, A.L. (2011). Increase in production of reactive oxygen species (ROS) as a secondary response to water deficit stress in groundnut. (In) *Proceedings of National seminar on 'Sustainable crop productivity through physiological interventions'* organized by ISPP at Ramnarain Ruia College, Mumbai from 24-26th November, 2011.
- Chauhan, S.M., Dey, R., Pal, K.K. and Parikh, S.C. (2011). Production of thermo-, salt- and heavy-metal tolerant proteases by biotransformation of de-oiled groundnut cake. (In) *National Conference on 'Environment and biodiversity of India'* organized by Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi on 30-31 December 2011, (AB213), Abstract book page no. 160, published by North East Centre for Environmental Education and Research (NECEER), Imphal.
- Dey, R., Janeesh, E.T., Thomas, M. and Pal, K.K. (2011). Exploiting the diversity of abiotic stress tolerant endophytic microorganisms for management of abiotic stresses in groundnut. (In) *National Symposium on 'Resource utilization through integrated farming system and biodiversity conservation in dryland'* at Kukma, Bhuj on 20-22nd December, 2011, Abstract book page 24 (A-29).
- Ghorai, S., Pal, K.K., Dey, R. and Jasrai, Y.T. (2011). Alleviation of salinity stress in groundnut by application of PGPR. (In) *National Symposium 2011* organised by Deptt. of Botany, USSC, Gujarat University, Ahmedabad from 13-15 October 2011.
- Jadon, K.S. and Thirumalaisamy, P.P. (2012). Aflatoxin: A 50- year odyssey of human, animal and plant pathology. (In) *4th Indo-Korean Conference on 'Integrative bioscience research opportunities and challenges'* on 10-11th February, 2012, organized by Faculty of Science and Home Science, Institute for Home Science and Higher Education for Women, Avinashilingam University Coimbatore- 641 043, Tamil Nadu, India.
- Jadon, K.S. and Thirumalaisamy, P.P. (2012). Production and post-harvest technologies for groundnut free from contamination by aflatoxin. (In) *4th Indo-Korean Conference on 'Integrative bioscience research opportunities and challenges'* on 10-11th February, 2012. Organized by Faculty of Science and Home Science, Institute for Home Science and Higher Education for Women, Avinashilingam University Coimbatore- 641 043, Tamil Nadu, India.
- Jadon, K.S., Thirumalaisamy, P.P., Koradia, V.G. and Padvi, R.D. (2012). Evaluation of Fungicides for Soil Borne Diseases of Groundnut. (In) *3rd Global Conference on 'Plant pathology for food security'* from 10-13th January, 2012 at MPUA&T, Udaipur organized by Indian Society of Mycology and Plant Pathology.



- Jain, N.K. and Misra, J.B. 2011. Crop diversification through groundnut for enhancing resource utilization efficiency: An appraisal. (In) *National Symposium on 'Resource utilization through integrated farming system and biodiversity conservation in drylands*, from 20th - 22nd December, 2011 at Regional Research Station, CAZRI, Kukma, Bhuj.
- Kalariya, K.A., Singh, A.L. and Chakraborty K. (2012). Influence of Water Deficit Stress on Chlorophyll fluorescence in Groundnut. (In) *Proceedings of U.G.C sponsored National seminar on 'New frontiers of plant science for sustainable development'* at Khurda, Odisha from 24-26 February, 2012.
- Kalariya, K.A., Singh, A.L., Chakraborty K., Zala, P.V. and Patel, C.B. (2012). Chlorophyll fluorescence in Groundnut (*Arachis hypogaea* L.) under water-deficit-condition. (In) *Proceeding of Zonal seminar on 'Physiological and molecular interventions on sustainable crop productivity under changing climatic conditions'* jointly organised by ISPP, New Delhi and DMAPR, Anand on 17th January, 2012.
- Meena, H.N., Jat, R.S., Bhaduri, D., Jain, N.K., Bhalodia, P.K. and Kalariya, K.A. (2012). Effect of saline water irrigation on groundnut (*Arachis hypogaea*) and bajra (*Pennisetum glaucum*) cropping system. (In) *Zonal seminar on 'Physiological and molecular interventions on sustainable crop productivity under changing climatic conditions'* on 17 January, 2012 at Directorate of Medicinal and Aromatic Plants, Anand, Gujarat, p.15.
- Pal, K.K. (2011). Exploring Archaeobacteria: The Enduring Excitement. (In) *'Emerging trends in microbial interactions & challenges in human health'* at Nirma University, Ahmedabad, 11-12 October, 2011 on 11th October 2011.
- Pal, K.K., Thomas M. and Dey, R. (2011). Diversity of extreme halophilic archaea of Rann of Kutch: Prospecting for managing abiotic stresses and mining of relevant genes. (In) *National Symposium on 'Resource utilization through integrated farming system and biodiversity conservation in dryland'* Kukma, Bhuj from 20st to 22nd December, 2011, p.23.
- Sherathia, D.N., Patel, I.N., Dalsania, T.L., Savsani, K.A., Dey, R. and Pal, K.K. (2011). Diversity of halophilic bacilli in the hypersaline environments of the Rann of Kutch of Gujarat in India. (In) *National Conference 'Environment and biodiversity of India'* organized by Faculty of Engineering and Technology, Jamia Millia Islamia, N. Delhi on 30th & 31st December 2011, Abstract book, published by North East Centre for Environmental Education and Research (NECEER), Imphal, p. 139.
- Singh A.L., Chaudhari, V. and Misra, J.B. (2011). Zinc fortification in groundnut and identification of Zn responsive cultivars of India. (In) *Proceeding of Zinc Crops 2011 (3rd International Zinc Symposium 2011) 'Improving Crop Production and Human Health'* Hyderabad, India, 10-14 October, 2011. http://www.fertilizer.org/ifa/content/download/67305/982173/version/1/file/2011_zinccrops2011_al_singh_2_abstract.pdf
- Singh, A.L., Chaudhari, V. and Patel, C.B. (2011). Identification of high Zinc density groundnut cultivars to combat Zinc malnutrition in India. (In) *Proceeding of Zinc Crops 2011 (3rd International Zinc Symposium 2011) 'Improving Crop Production and Human Health'* Hyderabad, India, 10-14 October, 2011. http://www.zinccrops2011.com/http://zinccrops2011.com/presentations/2011_zinccrops2011_al_singh_1_abstract.pdf



- Thirumalaisamy P.P., Jadon, K.S., Koradia, V.G. and Padvi, R.D. (2011). Biological control of soil borne and foliar fungal diseases in groundnut. (In) *National Symposium on 'Harnessing biodiversity for biological control of crop pests'* on May 25th & 26th 2011 at NBAII, Bengaluru organized by Society for Bio-control Advancement.
- Thirumalaisamy P.P., Jadon, K.S., Koradia, V.G. and Padvi, R.D. (2011). An integrated approach to the management of major diseases of groundnut. (In) *3rd Global Conference on 'Plant Pathology for Food Security'* from 10th to 13th January, 2012 at MPUA&T, Udaipur organized by Indian Society of Mycology and Plant Pathology.
- Vanparia, S.P., Dey, R. and Pal, K.K. (2011). Prevalence of extreme halophilic fungi in the salterns of the Rann of Kutch of Gujarat. (In) *National Conference on 'Environment and biodiversity of India'* organized by Faculty of Engineering and Technology, Jamia Millia Islamia, N. Delhi on 30th & 31st December 2011, Abstract book, Published by North East Centre for Environmental Education and Research (NECEER), Imphal, p. 159.

Technical bulletins/Manuals/Books/Book chapters:

- NICRA team of Groundnut Pest Surveillance (2011). '*Manual for Groundnut Pest Surveillance*'. Jointly published by National Center for Integrated Pest Management, New Delhi, Central Research Institute for Dry land Agriculture, Hyderabad and Directorate of Groundnut Research, Gujarat. p. 29.
- Jain, N.K., Meena, H.N., Bhalodia, P.K. and Rathnakumar, A.L. (2011). Training Manual on "*Application of polythene mulch technology in groundnut production*" by DGR, Junagadh -362 001, Gujarat, India.
- Mishra, A.P., Govindaraj, G. and Jain, V.K. (2011). Training manual on '*Improved technologies for sustainable production of groundnut*' by Directorate of Groundnut Research, Junagadh, pp. 1-126.
- Mishra, A.P., Govindaraj, G. and Jain, V.K. (2011). Training-manual on '*Seed production and certification in groundnut*' by Directorate of Groundnut Research, Junagadh, pp. 1- 103.
- Mishra, A.P., Govindaraj, G. and Jain, V.K. (2011). Training manual on '*Summer groundnut production technology*' by Directorate of Groundnut Research, Junagadh, 4th to 8th July 2011, pp. 1-107.

Meetings/Trainings Attended

Dr. Radhakrishnan T.

- *Management Development Programme on Leadership Development* (a pre-RMP Programme) at National Academy of Agricultural Research Management (NAARM), Rajendranagar, Hyderabad from November 1st to 21st 2011.
- Training programme on '*Harnessing Intellectual Property for Strategic Competitive and Collaborative Advantage*' at Indian Institute of Management (IIM), Ahmedabad from February 9th to 11th 2012.



- *Annual Kharif Groundnut Researchers Group Meeting* at MPUAT, Udaipur (Rajasthan) from 22nd to 24th April, 2011.
- *Annual Rabi-Summer Groundnut Researchers Group Meeting* at OUA&T, Bhubaneswar (Orissa) on 2nd & 3rd November 2011.
- *Sensitization-cum-Training workshop* for the PME Cell in-charge of HYPM, on 2nd February, 2012 at Central Institute for Fisheries Education, Mumbai.
- *Meeting-cum-workshop of Heads of the Divisions and Regional Stations / Centres* on 14th & 15th June, 2011 at CIAE, Bhopal.

Dr. Chuni Lal

- *Annual review meeting of ICAR Seed Project* on 19th & 20th September 2011 at DR BP Pal auditorium of IARI, New Delhi.
- *RFD orientation meeting* on 21st February, 2012 at Krishi Bhavan, New Delhi.

Dr. K.K. Pal

- Short Training Programme on '*Protection of Plant Varieties & Farmers' Rights, and DUS Testing*' on 27th & 28th January 2012 at DGR, Junagadh.

Dr. H.N. Meena

- *Annual Kharif Groundnut Researchers Group Meeting* at MPUAT, Udaipur (Rajasthan) from 22nd to 24th April, 2011.
- National Training on '*Carbon Sequestration and Carbon Trading*' at ICRISAT, Andhra Pradesh, from 6th to 17th February, 2012.

Dr. Ajay B.C.

- Training on '*Bioinformatics-DNA sequencing*' from 9th to 22nd November 2011, at GKVK, UAS, Bengaluru.

Dr. Narendra Kumar

- *Annual Kharif-2010 Groundnut Workshop* at Maharana Pratap University of Agriculture & Technology (MPUAT), Udaipur from 22nd to 24th April, 2011.
- Visiting Fellow at ICRISAT under Dr. S.N. Nigam (Principal Scientist, Breeding) on '*Groundnut Breeding Methodologies and Seed Systems*' from 19th September to 18th October 2011.
- *Annual Rabi-Summer Groundnut Group Meeting* at Odisha University of Agriculture & Technology (OUAT), Bhubaneswar on 2nd & 3rd November, 2011.
- 21 Days Winter School Training on '*Breeding for Biotic and Abiotic Stresses in Crop Plants: Problems and Perspectives*' from 9th to 29th November, 2011 at Centre for



Plant Breeding and Genetics, Tamil Nadu Agricultural University (TNAU), Coimbatore, TN.

- Short training programme on '*Protection of plant varieties & farmers rights and DUS testing*' at Directorate of Groundnut Research (DGR), Junagadh on 27th & 28th January, 2012.

Mr. Harish G.

- National Meeting on '*Agricultural Entomology for the 21 century: The way Forward*' on 25th & 26th August 2011 at NBAII Bangalore.
- Short course on '*Introduction to Biosystematics of Insects, Mites, Spiders and their Biodiversity*' at NBAII Bangalore from 14th to 23rd November 2011.
- Orientation cum training programme on '*Maintenance, evaluation of germplasm and pre-breeding in groundnut*' at Directorate of Groundnut Research (DGR), Junagadh from 17th to 19th October, 2011.

Mr. Nataraja M.V.

- *Sixth national conference on KVKs* at Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur from 3rd to 5th December, 2011.
- Orientation-cum-training programme on '*Maintenance, evaluation of germplasm and pre-breeding in groundnut*' at Directorate of Groundnut Research (DGR), Junagadh from 17th to 19th December, 2011.
- CAFT training on '*Precision Farming and Insect Pest Management*' from 8th to 28th February, 2012 at Deptt. of Entomology, TNAU.
- *SAU-ICAR-CII regional industry meet* organized by AAU, Anand at Ahmedabad on 16th April 2012.

Dr. Kuldeep Singh Jadon

- National Symposium on '*Harnessing Biodiversity for Biological Control of Crop Pests*' organized by Society for Bio-control Advancement on 25th & 26th May 2011 at NBAII, Bengaluru.
- Global Conference on '*Plant Pathology for Food Security*' from 10th to 13th January, 2012 held at MPUA&T, Udaipur organized by Indian Society of Mycology and Plant Pathology.
- Winter school on '*Diagnostics, Genomics, Implications and Integrated Management of Plant Pathogens*' from 2nd to 22nd November, 2011 at Department of plant pathology, BACA, AAU, Anand (Gujarat).
- Orientation-cum-training programme on '*Maintenance, evaluation of germplasm and pre-breeding in groundnut*' from 17th to 19th October, 2011 at Directorate of Groundnut Research, Junagadh, Gujarat.



- *National workshop of stakeholders in groundnut* on 15th December, 2011 at Directorate of Groundnut Research (DGR), Junagadh, Gujarat.
- *Workshop on IP awareness* on 20th March, 2012 at Directorate of Groundnut Research (DGR), Junagadh, Gujarat.

Dr. P.P. Thirumalaisamy

- National Symposium on '*Harnessing Biodiversity for Biological Control of Crop Pests*' on May 25th & 26th 2011 at NBAIL, Bengaluru organized by Society for Bio-control Advancement.
- Global Conference on '*Plant Pathology for Food Security*' from 10th to 13th January, 2012 at MPUA&T, Udaipur organized by Indian Society of Mycology and Plant Pathology.
- *Indo-Korean conference* on 9th & 10th February, 2012 organized by Faculty of Science and Faculty of Home Science, Institute for Home Science and Higher Education for Women, Avinashilingam University, Coimbatore, TN.
- *National workshop of stakeholders in groundnut* on 15th December, 2011 at Directorate of Groundnut Research (DGR), Junagadh, Gujarat.
- *Workshop on IP awareness* on 20th March, 2012 at Directorate of Groundnut Research (DGR), Junagadh, Gujarat.

Dr. Prasanna Holajjer

- Orientation-cum-training programme on '*Maintenance, evaluation of germplasm and pre-breeding in groundnut*' from 17th to 19th October, 2011 at Directorate of Groundnut Research, Junagadh, Gujarat.
- *National workshop of stakeholders in groundnut* on 15th December, 2011 at Directorate of Groundnut Research (DGR), Junagadh, Gujarat.
- *Workshop on IP awareness* on 20th March, 2012 at Directorate of Groundnut Research (DGR), Junagadh, Gujarat.

Dr. Ajoy Saha

- Orientation-cum-training on '*Maintenance and evaluation of germplasm and pre-breeding in groundnut*' at Directorate of Groundnut Research (DGR), Junagadh from 17th to 19th October, 2011.
- *ICAR-ZTM-BPD meeting cum workshop (West Zone)* at CIRCOT, Mumbai on 13th to 14th January, 2012.
- Short training programme on '*Protection of plant varieties & farmers' rights, and DUS testing*' at Directorate of Groundnut Research (DGR), Junagadh on 27th to 28th January, 2012.
- Workshop on '*Health benefitting phytochemicals from vegetables, fruits and non-food crops*' at Indian Agricultural Research Institute (IARI), N. Delhi from 21st to 23rd March, 2012



Dr. K. Chakraborty

- Bioinformatics training programme on '*Computational Genome Analysis using ANVAYA*' organised by National Agricultural Bioinformatics Grid, IASRI, New Delhi from 22nd to 24th June, 2011.
- Summer school on '*Climate variability and its Impacts on crop production-physiological perspective towards mitigation strategies*' organized by Assam Agricultural University, Jorhat, Assam, from 23rd August, 2011 to 12th September, 2011.
- Orientation-cum-Training on '*Maintenance and evaluation of germplasm and pre-breeding in groundnut*' organized by Directorate of Groundnut Research (DGR), Junagadh from 17th to 19th October, 2011.
- *Annual rabi-summer groundnut workshop* at OUA&T, Bhubaneswar on November 2nd & 3rd 2011.
- Brainstorming session on '*Plant physiology and biochemistry*' at Division of Plant Physiology, IARI, New Delhi on 5th & 6th August, 2011.
- National seminar on '*Sustainable crop productivity through physiological intervention*' at Ramnarain Ruia College, Mumbai, 24th & 26th November, 2011.
- *Meeting of ICAR Seed Platform* at ANGRAU, Hyderabad on 17th December, 2011.
- Zonal seminar on '*Physiological and molecular interventions on sustainable crop productivity under changing climatic conditions*' at DMAPR, Anand, 17th January, 2012.

Dr. K.A. Kalariya

- Winter School on '*Training on instrumental techniques in agriculture and food quality assessment*' organized by Department of Biotechnology from 1st to 21st October, 2011 at Junagadh Agricultural University (JAU), Junagadh, Gujarat.
- Brainstorming session on '*Plant physiology and biochemistry*' at Division of Plant Physiology, IARI, N. Delhi on 5th & 6th August, 2011.
- Zonal seminar on '*Physiological and molecular interventions on sustainable crop productivity under changing climatic conditions*' at DMAPR, Anand on 17th January, 2012.

Dr. D. Bhaduri

- Training programme on '*Data analysis of Natural Resource Management Research using SAS*' at IASRI, N. Delhi from 20th to 25th June, 2011.
- National Consultation on '*Gender Perspective in Agriculture*' organized at NASC complex, Pusa, N. Delhi on 8th & 9th August, 2011.
- Orientation-cum-training on '*Maintenance and evaluation of germplasm and pre-breeding in groundnut*' held at Directorate of Groundnut Research (DGR), Junagadh from 17th to 19th October, 2011.



- Short course on '*Cropping system models-Applications in land resource management*' at ICRISAT, Hyderabad from 5th to 9th December, 2011.
- *Annual Rabi/summer workshop on AICRP groundnut* on 2-3rd November 2011 at OUA&T, Bhubaneswar.

Dr. Narayanan G.

- *Foundation Course for Agricultural Research Service (FOCARS)* at NAARM, Hyderabad, in 93rd FOCARS from 27th April 2011 to 24th August 2011.
- *Annual Rabi-Summer Groundnut Researchers Group Meeting* on 2nd & 3rd November 2011 at OUA&T, Bhubaneswar.
- *6th National Conference on Krishi Vigyan Kendra – 2011* at Jabalpur (MP) from 3rd to 5th December 2011.
- *Farmers' seminar at KVK Junagadh* by Ambuja Cement Foundation at Kodinar, Gujarat on 6th January 2012.
- *ZTM-BPD (West Zone) annual Meeting-cum –Workshop* at CIRCOT, Mumbai on 13th & 14th January 2012.

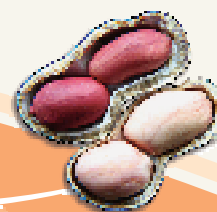
Award/Recognition:

- K. Chakraborty received '*Young Scientist Award (2011-12)*' from Indian Society for Plant Physiology (ISPP), IARI, N. Delhi.
- K.A. Kalariya, A.L. Singh, K. Chakraborty, P.V. Zala and C.B. Patel received *Best poster presentation award* in Zonal seminar on '*Physiological and molecular interventions on sustainable crop productivity under changing climatic conditions*' at DMAPR, Anand on 17th January, 2012.



Human Resource as on 31.03.2012

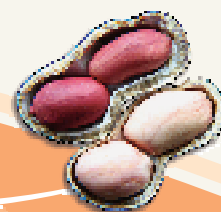
	Name	Designation
1.	Dr. J. B. Misra	Director
2.	Dr. A. L. Singh	Principal Scientist (Plant Physiology)
3.	Dr. T. Radhakrishnan	Principal Scientist (Plant Breeding)
4.	Dr. N. K. Jain	Principal Scientist (Agronomy)
5.	Dr. A. L. Rathnakumar	Principal Scientist (Plant Breeding)
6.	Dr. A. P. Mishra	Senior Scientist (Agril. Statistics)
7.	Dr. Chuni Lal	Senior Scientist (Plant Breeding)
8.	Dr. S. K. Bera	Senior Scientist (Genetics & Cytogenetics)
9.	Dr. K. K. Pal	Senior Scientist (Microbiology)
10.	Dr. Rinku Dey	Senior Scientist (Microbiology)
11.	Dr. Har Narayan Meena	Scientist (Agronomy)
12.	Dr. Manesh Chandra Dagla	Scientist (Plant Breeding)
13.	Sh. Abhay Kumar	Scientist (Plant Biotechnology)
14.	Sh. Sujit Kumar Bishi	Scientist (Plant Biochemistry)
15.	Dr. Thirumalaisamy, P. P.	Scientist (Plant Pathology)
16.	Sh. Harish G.	Scientist (Agril. Entomology)
17.	Dr. Narendra Kumar	Scientist (Plant Breeding)
18.	Dr. Koushik Chakraborty	Scientist (Plant Physiology)
19.	Dr. Debarati Bhaduri	Scientist (Soil Science)
20.	Dr. Kuldeep Singh Jadon	Scientist (Plant Pathology)
21.	Dr. Prasanna Holajjer	Scientist (Nematology)
22.	Dr. K. S. Kalariya	Scientist (Plant Physiology)
23.	Dr. Ajay B. C.	Scientist (Plant Breeding)
24.	Sh. Murlidhar Meena	Scientist (Agril. Economics), joined on 24-12-11
26.	Sh. Nataraja M. V.	Scientist (Agril. Entomology), joined on 02-09-11
27.	Sh. Ajoy Saha	Scientist (Agril. Chemicals), joined on 03-09-11
28.	Dr. Narayanan G.	Scientist (Agril. Extension), joined on 05-10-11
29.	Ms. S. M. Chauhan	Technical Officer, T(7-8)
30.	Sh. D. M. Bhatt	Technical Officer, T(7-8)
31.	Dr. D. L. Parmar	Technical Officer, T(7-8)
32.	Sh. N. R. Ghetia	Technical Officer, T(7-8)
33.	Sh. P. V. Zala	Technical Officer, T(7-8)
34.	Sh. V. G. Koradia	Technical Officer, T(7-8)
35.	Sh. P. K. Bhalodia	Technical Officer, T(7-8)
36.	Dr. R. S. Tomar	Farm Superintendent, T6
37.	Sh. V. K. Sojitra	Technical Officer, T6
38.	Sh. H. B. Lalwani	Technical Officer, T6
39.	Sh. H. M. Hingrajia	Technical Officer, T6



	Name	Designation
40.	Sh. Ranvir Singh	Technical Officer, T6
41.	Dr. S. D. Savaliya	Technical Officer, T6
42.	Dr. H. K. Gor	Technical Officer, T6
43.	Dr. J. R. Dobaria	Technical Officer, T6
44.	Dr. M. V. Gedia	Technical Officer, T6
45.	Sh. P. R. Naik	Technical Officer, T6
46.	Mrs.V. S. Chaudhary	Technical Officer, T6
47.	Sh. Virendra Singh	Technical Officer, T6
48.	Sh. B. M. Chikani	Technical Officer, T6
49.	Sh. D. R. Bhatt	Technical Officer, T5
50.	Sh. R. D. Padavi	Technical Officer, T5
51.	Sh. V. K. Jain	Technical Officer, T5
52.	Sh. H. V. Patel	Technical Officer, T5
53.	Sh. C. B. Patel	Technical Assistant, T4
54.	Sh. J. G. Kalaria	Technical Assistant, T4
55.	Sh. K. H. Koradia	Technical Assistant, T4
56.	Sh. A. M. Vakharia	Technical Assistant, T4
57.	Sh. A. D. Makawana	Technical Assistant, T3
58.	Sh. G. J. Solanki	Technical Assistant, T3
59.	Sh. R. S. Garhwal	Technical Assistant, T3
60.	Sh. Anil Kumar Maurya	Technical Assistant, T3
61.	Sh. Lokesh Kumar	Technical Assistant, T3
62.	Sh. P. B. Garchar	Technical Assistant, T3
63.	Sh. N. M. Safi	Technical Assistant, T3
64.	Sh. B. M. Solanki	Technical Assistant, T2
65.	Sh. G. G. Bhalani	Technical Assistant, T2
66.	Sh. Pitabas Dash	Technical Assistant, T2
67.	Sh. S. M. Sahare	Administrative Officer, joined on 20-04-11
68.	Sh. G. C. Prasad	Finance and Account Officer
69.	Sh. J. B. Bhatt	Assistant Administrative Officer
70.	Sh. R.T.Thakar	Assistant
71.	Sh. M. B. Kher	Security Supervisor
72.	Ms. S. Venugopalan	Assistant
73.	Ms. M. N. Vaghasia	Assistant
74.	Sh. R. D. Nagwadia	Assistant
75.	Sh. C. G. Makwana	UDC
76.	Sh. H. S. Mistry	LDC
77.	Sh. P. N. Solanki	LDC
78.	Ms. Rosamma Joseph	PS to Director



	Name	Designation
79.	Sh. L. V. Tilwani	PA
80.	Sh. Y. S. Karia	PA
81.	Sh. N. M. Pandya	SSS
82.	Sh. D. M. Sachania	SSS
83.	Sh. R. B. Chawda	SSS
84.	Sh. C. N. Jethwa	SSS
85.	Sh. M. B. Sheikh	SSS
86.	Sh. K. T. Kapadia	SSS
87.	Sh. J. G. Agrawat	SSS
88.	Sh. V. N. Kodiatar	SSS
89.	Sh. R. P. Sondarwa	SSS
90.	Sh. G. S. Mori	SSS
91.	Sh. V. M. Chawda	SSS
92.	Mrs. D. S. Sarvaiya	SSS
93.	Sh. N. G. Vadher	SSS
94.	Sh. A. D. Makwana	SSS
95.	Sh. P. M. Solanki	SSS
96.	Sh. B. J. Dabhi	SSS
97.	Sh. C. G. Moradia	SSS



Sanctioned strength, employees on position and their category-wise distribution as on 31.03.2012

Catgory	Sanctioned	On position	General	SC	ST	OBC
Scientific	39 + 1 RMP	30	18	04	03	05
Technical	40	38	23	03	05	07
Administrative	17	14	08	03	0	03
Supporting	19	17	05	03	02	07
Total	115+01	99	54	13	10	22

Discipline and grade-wise sanctioned scientific position

Discipline	Scientist	Sr. Scientist	Pr. Scientist	Total
Agril. Economics	01	-	-	01
Agril. Entomology	02	01	-	03
Agril. Extension	01	-	-	01
Agril. Statistics	-	01	-	01
Agronomy	01	01	01	03
Biochemistry (PS)	01	01	-	02
Biotechnology (PS)	02	01	-	03
Genetics & Cytogenetics	01	01	-	02
Microbiology	01	01	-	02
Plant Breeding	06	02	01	09
Plant Pathology	02	02	01	05
Plant Physiology	02	01	-	03
Soil Science (Pedology)	01	01	-	02
Agril. Engineering	01	-	-	01
Nematology	01	-	-	01
Total	22	14	03	39

Transfer

Sr. No.	Incumbent	Transferred from	Transferred To	With effect from
1.	Dr. P. C. Nautiyal, Principal Scientist	DGR, Junagadh	IARI, New Delhi	20.4.11
2.	Dr. G. Govindaraj, Scientist	DGR, Junagadh	PDADMAS, Bangalore	8.11.11
3.	Sh. Prabhu Dayal, Technical Assistant, T4	DGR, Junagadh	NRC for Agroforestry, Jhansi	15.4.11
4.	Sh. Sugadh Singh, Technical Assistant, T3	DGR, Junagadh	CIR on Goats, Makhdoom	18.6.11



Resignation

- Shri M. H. Kava, LDC, resigned from DGR, Junagadh w.e.f. 03.09.2011.

Financial up gradation

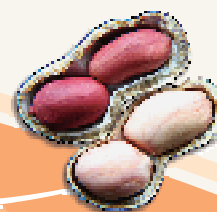
- DPC held on 5-6, April-2011 for Administrative Staff, benefit to one employee.
- DPC held on 24.09.2011 for Administrative Staff, benefit to one employee.
- DPC held on 16.03.2012 for Administrative Staff, benefit to one employee.
- DPC held on 21.03.2012 for Administrative Staff and Scientific Staff, consideration for clearance of probation period, benefit to six employees.

Superannuation

- Sh. R.V. Purohit, Ex Skill Supporting Staff, w.e.f. 19.07.2011

Demise

- Sh. R.V. Purohit, SSS on 16.07.2011



Important Meetings

Research Advisory Committee (RAC)

The 13th meeting of Research Advisory Committee was held at DGR, Junagadh on 2-3 June 2011. Dr. J.H. Kulkarni, former Vice Chancellor, UAS, Dharwad, was the chairman and other members who have participated in the meeting are Dr. S.N. Nigam, Principal Groundnut Breeder, ICRISAT; Dr. A.M. Parakhiya, Director, Extension Education, JAU, Junagadh and Shri Haridasbhai Zala, Progressive Farmer, Vadavi, Junagadh. Presentations on ongoing research projects were made by the PIs or co-PIs which were discussed thoroughly and the work plan was modified keeping in view the remarks of the committee. In their concluding remarks, Chairman and the members of RAC appreciated the good work that has been done at DGR and pointed out the need for reorienting the research work on certain aspects.



13th RAC meeting (2-3 June 2011)

Institute Research Committee (IRC)

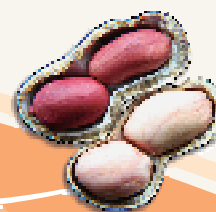
The 57th and 58th meetings of Institute Research Committee were held on 9th June 2011 and 30th January to 1st February 2012, respectively. Both the meetings were chaired by Dr. J.B. Misra, Director, DGR. In both the meetings Dr. Misra urged the scientists to initiate work on new areas of research like seed coating, climate change, harmonizing seed dressing, etc. Other issues like growing labour problem and assignment of work to the new scientists were also discussed. During the meetings, project-wise progress of research work was reviewed and the technical programmes for ensuing seasons were finalized. The PIs of various research projects presented the highlights of work done in their respective projects and then proposed the future plans of work. The plans of work were discussed thoroughly and modified wherever required before being approved by the house.



Quinquennial Review Team (QRT)

The QR team had three meetings to review the DGR and AICRP-G centres research for the period of 2007-2011. The details of the meetings are as follows:

Place	Date	Centers reviewed
DGR, Junagadh	16-17 January, 2012	DGR, Junagadh
TNAU, Coimbatore	15-16 February	Vriddhachalam, Aliyarnagar, Bhavanisagar, Kadiri, Jagtial, Raichur, Dharwad and Chintamani
SKRAU, Durgapura, Jaipur	15-16 March, 2012	Durgapura, Hanumangadh, Udaipur, Mainpuri, Junagadh, Vyara, Jalgaon, Rahuri, Shirgaon and Khargone



General Information

Institute Management Committee

Chairman

Dr. J. B. Misra, Director, DGR, Junagadh

Members

Director of Agriculture (Gujarat), Krishi Bhavan, Sector 10 A, Gandhinagar, Gujarat

Director of Agriculture, Chepuk, Chennai-600 005, Tamil Nadu

Dr. K. L. Dobariya, Research Scientist (Groundnut), Junagadh Agricultural University, Junagadh

Ms. Heerbai Ben Lobi, Jambur, Taluka-Talala, Junagadh

Sh. J. B. Gunde, Post; Patan kodoli, Distt. Kolhapur - 416 202, Maharashtra.

Dr. B. B. Singh, ADG (OP), ICAR, Krishi Bhavan, New Delhi

F & AO, CIRCOT, Mumbai (ex officio)

Dr. A. Henry, Project Coordinator (NNRPL), CAZRI, Jodhpur

Dr. T. Radhakrishnan, Principal Scientist, DGR, Junagadh

Dr. S. R. Bhatt, Principal Scientist, NRC for Plant Biotechnology, IARI, Pusa, New Delhi

Dr. (Mrs.) M. Sujatha, Principal Scientist, DOR, Hyderabad

Member Secretary

Administrative Officer, DGR, Junagadh (ex officio)

Research Advisory Committee

Chairman

Dr. J. H. Kulkarni, Ex-Vice Chancellor, UAS, Dharwad, 'Suggi', Alur Compound 3rd cross, Sadhankeri, Dharwad-580 008, Karnataka

Members

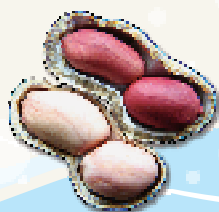
Dr. S. N. Nigam, Principal Scientist (Groundnut), ICRISAT, Patancheru, Hyderabad- 502 324

Dr. V. Muralidharan, Professor (Oilseeds) Plant Breeding & Genetics, TNAU, Coimbatore-641003

Dr. G. S. Jadhav, Ex-Director, Instruction, M.A.U., Parbhani-431402, Maharashtra

Dr. A. M. Parakhia, Director (Extension), JAU, Junagadh

Dr. G. V. Subbarathanam, Retd. Professor of Entomology, Agri. Biotech foundation, ARI Campus, ANGRAU, Rajendranagar, Hyderabad-500 030



Dr. J. B. Misra, Director, Directorate of Groundnut Research, Junagadh-362 001
Assistant Director General (O&P), Indian Council for Agricultural Research, Krishi Bhavan, New Delhi-110 114
Shri Madhubhai Mankad, Progressive Farmer, Salau, Mundra, Kutch
Shri Haridasbhai Bhikhabhai Zala, Progressive Farmer, Post: Vadhavi, Junagadh

Member Secretary

Dr. S. K. Bera, Senior Scientist, DGR, Junagadh

Institute Research Committee

Chairman : Director
Members : All Scientists of DGR, Junagadh
Member Secretary : Dr. Rinku Dey, Senior Scientist

Institute Joint Staff Council

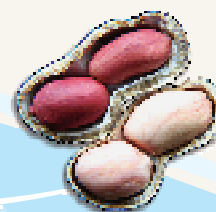
Chairman : Director

Members: Staff side

1. Shri D. R. Bhatt, Secretary-IJSC and Member-CJSC
2. Shri V. K. Jain, Member
3. Shri Y. S. Kariya, Member
4. Mrs. M. N. Vaghasia, Member
5. Shri C. N. Jethwa, Member
6. Shri B. J. Dabhi, Member

Members: Official side

1. Dr. P. C. Nautiyal, Principal Scientist (Transferred to IARI, New Delhi)
2. Dr. Chuni Lal, Senior Scientist
3. Dr. R. Dey, Senior Scientist
4. Shri C. P. Singh, Technical Officer, T7-8 (Transferred to IISR, Lucknow)
5. Administrative officer
6. Finance & Accounts Officer



FINANCE AND ACCOUNTS

EXPENDITURE STATEMENT FOR THE YEAR 2011-12

DGR-Main Unit		₹ in lakhs					
Sr. No.	Budget Head	Non-Plan			Plan		
		BE	RE	Expenditure	BE	RE	Expenditure
1	Establishment	475.00	483.88	483.88	0.00	0.00	0.00
	Charges						
2	Wages	43.00	31.78	32.80	0.00	0.00	0.00
3	Loans & Advances	5.00	10.54	3.47	0.00	0.00	0.00
4	Pension	22.00	25.15	25.21	0.00	0.00	0.00
5	T.A.	5.00	7.00	7.01	12.00	10.50	10.50
6	Recurring Contingencies	68.00	110.14	110.42	170.00	163.00	162.94
7	Works	8.50	35.00	35.00	40.00	23.00	22.81
8	Equipments	5.50	20.00	15.61	129.00	169.50	169.68
9	Furniture	0.00	3.00	0.00	15.00	12.00	12.01
10	IT	0.00	0.00	0.00	10.00	0.00	0.00
11	Books	0.00	0.00	0.00	12.00	10.00	9.99
12	HRD	0.00	0.00	0.00	12.00	12.00	12.00
	Total	632.00	726.49	713.40	400.00	400.00	399.93

AICRP-G

		₹ in lakhs	
S.No.	Budget Head	RE 2011-12 (₹ 944 lakhs)	Expenditure
1	Pay and Allowances	378.02	378.02
2	TA	6.90	6.90
3	Contingency	48.45	48.45
4	Non. Recurring cont.	44.75	44.75
5	HRD	0.75	0.66
6	Need based Research	19.99	19.96
7	Pay and Arrear (VI pay comm.)	429.14	429.14
8	TPS	16.00	13.70
	Total	944.00	941.58



Directorate of Groundnut Research
Post Box No.5, Ivnagar Road,
Junagadh-362 001, Gujarat, India

Phones

Director : 0285-2673382 (direct)
: 0285-2672550 (telefax)
: 0285-2675831 (residence)

EPABX : 0285-2672461/ 2673041

Administrative officer : 0285-2672843

Guest House : 0285-2673629

FAX : 0285-2672550

Telegram : GNUTSEARCH

E-mail : director@nrcg.res.in

URL : <http://www.nrcg.res.in>

