

वार्षिक प्रतिवेदन **ANNUAL REPORT** **2013-14**



मूँगफली अनुसंधान निदेशालय

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Directorate of Groundnut Research

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

वार्षिक प्रतिवेदन Annual Report 2013-14



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A lady selling the groundnut in Tiruvannamalai district of Tamil Nadu

A rich groundnut harvest kept for drying

PBS 16040- A promising breeding line of DGR

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PREFACE

I feel extremely happy in presenting the Annual Report of DGR for year 2013-14. For the groundnut farmers, this was a good rainfall year as they reaped a bumper harvest. According to the tentative estimates there was a production of 9.14 million tons from an area of 6.99 million ha with a yield of 1307 kg/ha. For this year, the Govt. of India hiked the minimum support price for groundnut from ₹ 3700 to ₹ 4000 per quintal. During this fiscal year 5,11,662 metric tons of groundnut was exported which earned foreign exchange worth ₹ 3,212 crores.

In this year three genotypes, RG 578, JSP 49, and RG 530 were identified for release in West Bengal, Odisha, Jharkhand and Manipur for cultivation in *kharif*. In addition, two genotypes, viz., CTMG 6 (for Karnataka, Maharashtra, Tamil Nadu and Andhra Pradesh) and ALG 06-320 (for Tamil Nadu and Andhra Pradesh) were identified for cultivation in *rabi*-summer. During the year, a total of 12995.85 q breeder seed comprising 51 varieties was produced. Eight hundred front line demonstrations were conducted across the country to demonstrate the new and improved production technologies for groundnut.

During 2013-14, the DGR became an ISO 9001:2008 certified institution. A DGR Vision-2050 and RFD document was also prepared.

The DGR, in association with Junagadh Agricultural University and the Indian Society for Plant Physiology organized a four-day (13-16 December, 2013) National Conference on 'Current Trends in Plant Biology Research' for the first time at Junagadh. About 450 participants presented and discussed their research work in the areas of modern plant biology research.

Utilization of the grants was to the tune of ₹ 361.00 lakhs under head 'Plan' and ₹ 939.53 lakhs under the head 'Non-Plan' for DGR and ₹ 870.00 lakhs for AICRP-Groundnut a nearly cent per cent utilization. In addition, the funds received through the externally funded projects were also utilized effectively. During 2013-14, five scientists of this directorate went abroad on deputation to attend various trainings and conferences.

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 arduous task of compiling, editing and overseeing the printing. I sincerely appreciate their efforts in bringing out this report. I thank all the scientists of DGR as well as those of AICRP-G for their hard work towards generating the data reported in this volume.

I shall be grateful to receive comments from the readers on the content and style of presentation of this report.

J.B. Misra
Director

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EXECUTIVE SUMMARY

CROP IMPROVEMENT

- Ten fresh crosses were attempted to enhance thermo-stability, uniform maturity, shelling out turn, tolerance to drought stress and yield attributes. To broaden the genetic base of the cultivated groundnut, one interspecific derivative CS 1 was used in the hybridization programme.
- Selections were made in the segregating materials and the selections were advanced to the respective next filial generations. In F_6 a total of 29 superior and non-segregating new advanced breeding lines were identified.
- A total of 14 crosses identified in F_3 to F_6 were supplied to AICRPG centres, Jalgaon and Kadiri for further location specific selection.
- In summer 2013, twenty plant-to-progenies of new advanced breeding lines were raised to enhance seed of these lines. In kharif 2013, seed of 16 advanced breeding lines was enhanced for their evaluation in station trials or national trials of AICRPG.
- Out of 13 advanced breeding lines four lines PBS16038, PBS11077, PBS16023 and PBS30055 were identified having moderate drought tolerance.
- In *kharif* 2013, out of 93 advanced breeding lines four lines PBS 21113, PBS 25098, PBS 15027 and PBS 25033 were found superior than best checks and the later two lines qualified station trials for further evaluation under national trials of AICRPG.
- Sixteen crosses were effected in *kharif* 2013, for developing varieties resistant/tolerant of major biotic stresses. The mean success rate of the entire hybridization programme was in the range of 4.59% to 43.10% with average of 18.33%.
- Among the advanced crosses, 12 advanced breeding lines were identified which comprised of three of Spanish bunch and nine Virginia bunch group.
- Based on two-year yield evaluation (*kharif* 2012 and 2013) trials, an advanced breeding line (PBS 22080) was found superior to the best check varieties GG 20 and Somnath. Hence, it would enter AICRPG trials.
- Two year screening of advanced breeding lines in *kharif* 2012 and 2013, only one genotype (PBS 12032) was identified as resistant to leaf spot and rust.
- Ten crosses were attempted for incorporating the trait of large-seed along with high yield and other traits of confectionery quality in *kharif* 2013.
- In summer-2013, from nineteen cross combinations generated during *kharif*-2012, 122 single plant progenies were selected for further generation advancement.
- Two large-seeded advanced breeding lines; PBS 19018 and PBS 19022 were proposed for AICRP-G for *rabi* summer trials.
- Among Valencia mini core germplasm lines, NRCG 14379, NRCG 14335 and NRCG 14497 were identified for high shelling (>70%), NRCG 14444 for low oil content (47%), and NRCG 14445 (for high protein content (32.4%).



- In Spanish germplasm lines highest shelling outturn was found in NRCG 14324 (74.6%), and the shortest duration in NRCG 14425 (109 days).
- Between Bikaner and Junagadh, the performance of genotypes was better at Bikaner for physical traits of pod and seed and consequently pod yield also.
- During summer 2013, for nutrient use efficiency, 94 true F_1 s were identified and four crosses advanced to F_3 and two crosses were to F_4 generation.
- During summer 2013, TG 37A recorded high yield under both with and without phosphorus application.
- During kharif 2013, eight crosses were attempted for incorporating P use efficiency and genotypes PBS 22080 and PBS 29017 were found to have high pod yield under treatment having no phosphorus application.
- During kharif 2013, 34 elite breeding lines with high pod yield were identified in F_3 and F_4 generations.
- A total of 106 accessions in 6 sections viz. *Arachis* (46), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (4), *Procumbentes* (9) and *Rhizomatosae* (39) were maintained in the field gene bank.
- Twenty-three inter specific derivatives (pre-bred material) and 62 accessions/cultivars have been newly acquired. Sixteen diverse synthetics (doubled amphidiploids), were also been obtained from ICRI, Patancheru
- A total of 1415 accessions were supplied to 34 groundnut scientists viz. DGR (1094), SAUs (19), AICRP-G (185), and other ICAR institutes (117) for its use in the groundnut improvement programme.
- 1434 accessions were multiplied for seed enhancement and conservation for long term storage at NBPGR, New Delhi and for medium term storage at this directorate. 471 accessions of base collection have been deposited with NBPGR, New Delhi for long term conservation.
- Out of four hundred germplasm accessions evaluated for four quality traits viz. protein, oil, sugars, fatty acid composition, seven accessions for high oil content viz., NRCG 1476 (54.9%), NRCG 14366 (54.5%), NRCG 10580 (52.1%), NRCG 11716 (51.8%), NRCG 10943 (50.8%), NRCG 11273 (50.3%), and NRCG 11909 (50.2%); eight accessions for high protein content, NRCG 7128 (35.6%), NRCG 6213 (34.1%), NRCG 11651 (33.9%), NRCG 10655 (32.7%), NRCG 11183 (32.4%), NRCG 12213 (32.3%), NRCG 12383 (31.5%) and, NRCG 12731 (31.1%) have been identified.
- One accession NRCG 12447 having low oil content (44.6) coupled with high protein (34.8%) and the other accession NRCG 10580 with high oil content (52.15) coupled with low protein (26.9%) have been identified and can be used as donors in breeding confectionery types.
- The SPTA-PCR was done using 3 independent transgenic events of mtID.
- The Southern analysis of the mtID transgenic has shown single insertion in T2 and T3 generations.
- From the publically available ESTs using MISA search, 2784 unigenes containing 3373 SSR sequences were identified and 2703 primer-pairs were designed (*in silico*). Further 81 primer pairs were synthesized and validated on selected disease resistant and susceptible genotypes.



- Although on the basis of phenotypic data on rust and LLS, the 174 varieties were classified into three groups viz., resistant, moderate and susceptible the STRUCTURE analysis of SSR data revealed that there were only two major groups.
- Interspecific breeding lines with higher pod yield and resistant to stem rot have been identified.
- Interspecific breeding lines resistant to stem rot, with large kernel and higher pod yield have been identified.
- RILs for tolerance to water deficit stress have been developed and promising genotypes were identified.
- SSRs polymorphic to parents resistant and susceptible to PBNB have been identified.

CROPPROTECTION

- Minimum leaf spots and rust incidence was recorded in genotype CS-113, and was identified as potential donor parent.
- Under in vitro conditions, the highest inhibition (38.9%) of *Aspergillus niger* was achieved with *Trichoderma viride*, whereas *T. saturnisporium* recorded the highest inhibition (37.1%) against *A. flavus*. Another strain of *T. viride* from Dharwad was found to be the best (65.9% inhibition) against *Sclerotium rolfsii*.
- Different genotypes were screened for resistance to stem rot and collar rot pathogens in sick soil. The lowest disease incidence was recorded in CS 405.
- A combination of application of *Trichoderma harzianum* isolate T-170, ploughing with mould-board, and soil solarization with transparent polythene sheets, was found quite effective for management of stem rot.
- For management of leaf spots and rust diseases, spray of difenoconazole and tebuconazole were found effective.
- Nativio and Cabrio were found effective for *Alternaria* blight, which often appears in groundnut grown during summer.
- Compared to kernels, infection of *A. flavus* on pods was higher in summer as well as in *kharif*. The aflatoxin contamination in kernels varied widely among the samples and the treatments (crops for rotation or fallow). In general, although rotation with crops or fallow reduced the population of *A. flavus* in soil, the level of aflatoxin contamination in kernel was variable.
- Aflatoxin contamination was detected in all the gleaned pod samples and 48% of freshly harvested samples. Above 4 ppb was detected in 66.7% gleaned pod samples and 3.7% in freshly harvested samples. Maximum contamination of aflatoxin was 23ppb and 6ppb in gleaned pods and freshly harvested pods, respectively. Groundnut pods treated with castor oil, eucalyptus oil, neem oil and pongamia oil at 10% (v/w) or neem oil at 5% (v/w) concentrations were not affected by bruchid.
- The genotype, NRCG 1308 was observed to have lowest number of eggs laid (13.5) and adults emerged (10.0). However, the damage and weight loss on both the pods and kernels were non-significant.



- The treatment of acephate 25% + fenvalerate 3% @ 0.028% and monocrotophos @ 0.04% at 30 & 45 DAG were most effective in managing the leafhopper and thrips population as compared to other tested chemicals.
- Amongst three pesticides tested for their efficacy in managing sucking pests, the standard check monocrotophos 36 SL @ 1.2ml/L was most effective (4.5 hoppers/5 sweeps and 5.4 hoppers/5 sweeps after 1st and 2nd spray, respectively) while Azadirachtin 1.5% @ 7.5 ml/L treatment recorded the lowest number of thrips (2.1/5 sweeps) after second spray.
- Amongst the 18 strains of *Pseudomonas fluorescence* evaluated for nematocidal activity, the cell-free filtrates of five strains (Pf1, Pf3, Pf5, Pf6 and Pf7) caused mortality of *Meloidogyne arenaria* (J2) in the range of 81.5 to 87.4% with highest in Pf3.
- Two isolates of entomopathogenic nematodes were isolated from groundnut field.
- The *Heterorhabditis* spp caused 28% larval mortality of *S. litura* at 2 IJs/cm², which increased to 100% at 20 IJs/cm² after 96 h exposure period in 3rd instar larvae of *S. litura*.
- The Pf1 and Pf3 strains of fluorescent pseudomonads inhibited the peanut root-knot nematode, *M. arenaria* penetration in groundnut roots by 41% and 36%, respectively

CROPPRODUCTION

- Application of sulphur through SSP @ 40 kg ha⁻¹ to groundnut significantly improved system productivity (groundnut-pod equivalent yield), net returns and benefit cost ratio of summer groundnut-maize cropping system over 20 kg ha⁻¹ through any source and was at par with elemental sulphur (cosavet).
- Application of irrigation water at 6-day intervals through drip or 15-day intervals through check basin method did not significantly decline the productivity and economic returns over 4-day intervals through drip or 10-day intervals through check basin method. Further, fertigation with 75% NPK resulted in saving of 25% fertilizers besides improving the productivity and economic returns. Drip irrigation also saved 33.2% irrigation water over conventional method.
- Application of hydrogel @ 2.5 kg/ha along with integrated nutrient management and polythene mulch were found significantly better for obtaining higher productivity and economic returns from summer groundnut under drip irrigation.
- Use of polythene mulch significantly improved pod and haulm yields of *kharif* groundnut by 23.5 and 20.7% over no mulch, respectively. Application of 75% NPK through drip significantly improved pod and haulm yields by 12.0 and 18.9% over 50% NPK. Thus, effecting saving of 25% NPK with drip irrigation over RDF with check basin method of irrigation.
- Pod and haulm yields of *kharif* groundnut were significantly higher under irrigated condition over rainfed condition. Furthermore, application of hydrogel @ 1.5 kg ha⁻¹ significantly improved pod and haulm yields over control and was at par with succeeding levels.



- Tillage practices did not significantly affect growth attributes (except LAI), yield attributes and, pod and haulm yield even though MT and ZT improved pod yield by 15 and 23% and haulm yield by 34 and 55% respectively, as compared to NT. Residue management practices and Cassia mulch also could not significantly affect growth attributes, yield attributes and, pod and haulm yield. Even though, WCR improved haulm yield by 35% but slightly decreased pod yield as compared to NR. MT and ZT gave 31% and 50% ($P < 0.01$) higher net returns over NT while ZT gave 15% higher net returns ($P < 0.01$) over MT. B:C ratio increased significantly in the order $ZT > MT > NT$ ($P < 0.01$). WR and WCR gave slightly higher net returns over NR. There was no significant effect of tillage and residue management practices on different soil phosphorus (P) fractions (organic, inorganic and residual P).
- Groundnut-greengram cropping system produced significantly higher pod yield of groundnut (1268 kg/ha) over sole groundnut, groundnut-wheat, groundnut-wheat-greengram (GM) and intercropped groundnut. Groundnut-wheat-Sesbania cropping system produced significantly higher haulm yield (2667 kg/ha) as compared to sole groundnut and intercropped groundnut. Seed and stalk yields of pigeonpea did not differ significantly due to intercropping with groundnut and preceding green manuring crops.
- Water having four levels of salinity (0.5 to 6 dS m⁻¹) was used in groundnut – cluster bean rotation for one year (2013-14). It was concluded that 2-3 dS m⁻¹ salinity of water was the threshold salinity but the yield of dry fodder of cluster bean was significantly lower at all the saline water irrigation levels compared to that of control (0.5 dS m⁻¹).
- Significantly higher pod yield was recorded with the application of 2 dS/m saline irrigation water in both (Kharif & Summer) season but it was at par with control (0.5 dS m⁻¹).
- Further, the significant differences in pod and haulm yields were observed within the varieties. The pod yields of TG 37A and haulm yield of GG 2 were significantly higher to each other in kharif season. Moreover, performance of normal seed with salinity sensitized seed was at par.
- Significantly higher pod and haulm yield with 23.32% and 19.78% were recorded under polythene mulch as compare to no mulch, respectively.
- Application of potassium @ 60 kg ha⁻¹ ameliorated the effect of water salinity by countering the effect of salinity.
- The management practices like use of polythene mulch with drip irrigation and reduced tillage with crop residues recycling were found most effective for enhanced availability (>20%) and uptake (20-35%) of soil-P with plant growth in groundnut.
- Generally, response of phosphorus fertilizers was found in-consistent except 50, 60 and 70 kg phosphorus per hectare for pod and haulm yield of groundnut during both summer and kharif seasons. Supply of phosphorus through SSP was also found better than DAP in kharif season.
- An effort was made to categorize the high and low productivity districts of major groundnut growing states based on the threshold productivity values of both *rabi*-summer and *kharif* seasons to identify the



soil-related constraints affecting the productivity of groundnut at a national scale.

- Few districts of very high (>2500 kg/ha) and high (>2000 kg/ha) productivity were identified for the country based on the average of three years' consecutive cropping seasons.
- Ten high Fe and 15 high Zn density groundnut cultivars were identified.
- 187 groundnut cultivars were screened for iron chlorosis and tolerant ones were identified

BASIC SCIENCES

- In stem rot susceptible genotypes, glucose content decreased after infection which implied that glucose was utilized by pathogen for growth and development.
- Induced level of phenylalanine ammonia lyase enzyme was about 2-folds in stem rot tolerant genotypes as compared to susceptible ones.
- In 41 popular groundnut genotypes, the antioxidant activity was observed in the range of 1.04 (JGN-23) to 6.97 (R-2001-3) $\mu\text{mol Trolox equivalent/g kernels}$.
- Virginia genotypes had higher O/L ratio (1.16-2.4) than the Spanish genotypes (0.92-1.24).
- On the basis of response to soil-application and foliar-spray of Fe, out of 60 genotypes, 26 and 15 genotypes respectively were selected as iron efficient and inefficient based on the visual chlorotic rate and the chlorophyll content, active Fe content and yield parameters.
- The enzyme ferric chelate reductase (FCR) was more in Fe efficient genotypes than Fe-inefficient which is a physiological adaptation to Fe deficiency.
- The antioxidant system was up regulated under Fe deficiency.
- The elemental concentration of Zn and Mn enhanced under Fe deficiency.
- Early sowing prolonged the period to attain 50% flowering by 5-6 days compared to normal and late-sown plants.
- Membrane stability reduced in all the cultivars with increase in meanday/night temperatures.
- The rate of photosynthesis in groundnut at 45 DAS did not changed in early and late sowing condition.
- Membrane lipid peroxidation measured in terms of TBARs content also showed partial destabilization of membrane.
- The net photosynthesis rate significantly decreased from $28.1 \mu\text{mol m}^{-2} \text{s}^{-1}$ in well irrigated to $25.2 \mu\text{mol m}^{-2} \text{s}^{-1}$ due to 25% of well irrigation treatment.
- JAL 42 recorded the highest photosynthesis rate ($32.6 \mu\text{mol m}^{-2} \text{s}^{-1}$) which was statistically at par with ICGV91114 ($30.9 \mu\text{mol m}^{-2} \text{s}^{-1}$)
- The irrigation treatment significantly reduced the pod yield from 232.9 gm^{-2} in well irrigated to 148.6 gm^{-2} in 25% irrigation treatment, however, the pod yield in 50% irrigation (212.0 gm^{-2}) was at par with the control
- The highest pod yield under 25% irrigation was in JAL 42 (222.4 gm^{-2}) which was statistically at par with Girnar 3 (212.9 gm^{-2})



- Variety GG20 ranked first among the varieties evaluated for the Φ PSII value (0.283) where as the lowest value of Φ PSII was found in JL 24 (0.191). The NPQ increased from 1.4 in 100% irrigation to 1.7 in 25% irrigation.
- Inoculation with the newly isolated competitive strains of groundnut rhizobia RH11, SRR7, and PAS17-2 enhanced the pod yield of cultivar TG 37A and the strain SRR7 was adjudged to be the best.
- The application of DAPG-producing fluorescent pseudomonads (identified for having antifungal activities against major soil-borne fungal pathogens) enhanced the growth and improved the pod yield by 11% in cultivar TG37A.
- Application of DAPG-producing fluorescent pseudomonads also checked the plant mortality due to collar rot from 10% in control to 2-6% in different treatments with DAPG-producing fluorescent pseudomonads.
- Different non-Bt bacterial isolates were obtained from the naturally dead larvae of *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fabricus) following standard techniques. Evaluation of non-Bt bacilli (LS1, LS2, LS4, LS5, LS6, LSH1 and LSH2) in leaf bioassay for control of *Spodoptera* resulted in 100% larval mortality with bacilli LS13 and LS14.
- Ten groundnut endophytes, tolerant to high temperature and salinity stress, were identified. Besides, seven groundnut rhizobia tolerant to 10% NaCl in the medium were also identified.
- Twelve genomic islands (5.4 KB to 71 KB) have been identified in *Bacillus* sp. NSP9.1 which might be involved in providing moderate halophilism to this organism.

SOCIAL SCIENCES

- In Andhra Pradesh during 2009-12, the improved variety Kadairi 6 performed (36%) over the prevalent TMV2, especially when grown under INM component. Thus this variety was identified for bridging the existing wide yield gaps in the state. In Gujarat the new variety GG-5 was found superior to widely prevalent GG-20 in *Kharif* and TPG 41 against GG-2 in *Rabi/Summer*.
- In Karnataka, varieties like GBPD-4 and R-2001-2 performed much better (36% and 42% more yield) against the old but still prevalent variety JL-24 in *kharif* and *rabi/summer* respectively. Whereas in Maharashtra, JL-501 showed high potential to bridge yield gap-I when demonstrated with INM and IWM components in both *kharif* and *rabi/summer* seasons. In case of Tamil Nadu the 2009-12 FLD data, revealed that the variety ALR-3 was having the best potential to bridge yield gaps.
- Analysis also revealed that in *kharif* situation, promotion of improved variety along with IPDM and INM practices had a better possibility to bridge yield gaps. For *rabi/summer* situation, application of PGPR component along with the use of improved variety holds a good potential.
- Exploitable Yield Reservoir (EYR) estimation revealed that in *rabi/summer*, if the available new technologies are adopted by the groundnut farmers, about 2.3 million tones of groundnut production could be achieved in place of existing 1.6 million tones, and in *kharif*, 7.9 million tons in place of the



existing 3.1 million tones.

- Analysis of factors contributing to high productivity in Tamil Nadu revealed that the existing general agro-climatic situations ensures a minimum yield (1673Kg/ha) in high productivity areas in India.
- In Gujarat cultivation of cotton was more input intensive than that of groundnut. This may be one of the reasons for low returns in groundnut.
- In Gujarat higher technical efficiency was observed at cotton farms than groundnut farms.

PUBLICATIONS, TRAININGS, SEMINAR ETC.

- Forty-eight research papers were published (including accepted ones) during 2013-14 in various national and international journals.
- Nearly all the scientists participated and presented their research findings in one or more national and international conferences, seminars and other fora.
- During 2013-14, in DGR, seven trainings/ symposia/ seminars were organized for the farmers, scientists and students, covering different aspects of groundnut improvement technologies.
- The National Conference of Plant Physiology-2013 on “Current Trends in Plant Biology Research” was jointly organized by the Directorate of Groundnut Research, Junagadh; JAU, Junagadh and ISPP, New Delhi at JAU, Junagadh. The main focus of this conference was on physiological aspects related to agriculture and life-sciences. Approximately 400 scientists/researchers from various universities/research institutions across the country participated and shared their research outcomes and exchanged their views on aforesaid theme.
- During 2013-14, five DGR scientists went abroad on deputation to attend various trainings, conferences etc.



PROJECT01: BREEDING FOR TOLERANCE TO ABIOTIC STRESSES IN GROUNDNUT

(CHUNILAL, NARENDER KUMAR AND ANITA MANN)

Hybridization, selection and generation advancement in segregating generations

During *kharif* 2013, ten fresh crosses were attempted to enhance thermo-stability, uniform maturity, shelling out turn, and tolerance to drought stress and yield attributes (Table 1a). In F_2 generation six of the eight crosses were selected and bulked cross wise. Two crosses which did not show segregation were apparently doubtful and, hence were rejected. Empirical selection in F_3 and onward generations was exercised at the time of harvesting which was based on the perceived pod yield, plant characters, pod numbers, pod shape and pod filling. In F_3 one cross out of 8 crosses, was found inferior and hence rejected, while in remaining crosses superior plants were bulked cross wise. In F_4 also one poor performing cross was rejected. In remaining crosses a total of 54 single plants were selected to raise single plant progenies in next generation. Likewise 74 single plants were selected in F_5 of nine crosses.

A total of 14 crosses in different generations (F_3 to F_6) were identified for their location specific evaluation at AICRPG centers.

Table 1a. Cross wise pollinations attempted, hybrid pods harvested and crossing success during *kharif* 2013 season

Parents	Trait of interest	Buds pollinated (no.)	F_1 pods harvested (no.)	Crossing Success rate (%)
Girnar 2 x ICGS 44	High Thermo-stability	288	60	21
Girnar 2 x NRCG 14425	Uniform Maturity	231	80	35
TAG 24 x NRCG CS 444	Low SLA with very high branches No	281	70	25
TG 37A x NRCG CS 444	Low SLA with very high branches No	317	144	45
PBS 14081 x NRCG 14405	High shelling	363	36	10
TAG 24 x NRCG 12107	High Shelling	246	72	29
TG 37A x NRCG 12107	High Shelling	276	127	46
PBS 16038 x CS 1	Drought tolerance (Low SLA)	352	65	18
PBS 14060 x ICGS 76	Drought tolerance	224	23	10
PBS 15041 x ICGS 76	Drought tolerance	267	114	43
Total and average		2845	791	28



Raising of F_1 generation and identification of true hybrids

Ten crosses attempted in *kharif* 2012 were raised in summer 2013 along with 14 parental lines involved in these crosses. Sixty two true hybrid plants were identified on the basis of vigor of the plant, pod characters and other dominant male characters in these crosses; and then harvested plant wise for further advancement in *kharif* 2013 (Table 1b).

Table 1b. Identification of true hybrid plants in summer 2013

Parents	Objective of cross	True hybrid plants selected (no.)
Gimar 2 x CS 385	High SCMR and Low SLA	6
Gimar 3 x CS 409	Drought tolerance	16
Gimar 2 x PBS 14081	High yield and pod number	6
PBS 14081 x CS 410	Drought tolerance (high SCMR, low SLA)	10
PBS 15031 x ICGS 44	High thermo-stability	5
Gimar 3 x NRCG 14425	Uniform maturity	6
PBS 14081 x NRCG 14405	High shelling	1
PBS 21087 x CS 1	Drought tolerance (Low SLA)	6
PBS 16038 x CS 1	Drought tolerance (Low SLA)	1
JAL 42 x CS 385	Drought tolerance	5

New advanced breeding lines developed

In stabilized (non-segregating) F_2 generation raised as single plant progenies of 8 crosses, 29 advanced breeding lines were selected which comprised of 5 Spanish and 24 Virginia types (Table 2).

Maintenance breeding and seed enhancement

Seeds of 20 new advanced breeding lines (PBS15049, PBS15050, PBS 15051, PBS15052, PBS15053, PBS15054, PBS25101, PBS 25102, PBS25103, PBS25104, PBS25105, PBS25106, PBS 25107, PBS25108, PBS25109, PBS25110, PBS25111, PBS 25112, PBS25113 and PBS25114) developed in *kharif* 2012 were sown in summer 2013 to increase the seed-quantity sufficient to meet the seed requirement for testing these entries in station trials.

Sixteen breeding lines were sown for seed enhancement in *kharif* 2013 to enter these lines in AICRPG trials. These lines were PBS 16038, PBS 16040, PBS 16044, PBS 15031, PBS 14082, PBS 24133, PBS 24134, PBS 24135, PBS 24136, PBS 24137, PBS 24138, PBS 24139, PBS 15041, PBS 25053, PBS 14060 and PBS 14064.



Advanced breeding lines in AICRP-G trails

One advanced breeding line PBS15031 was evaluated under initial varietal trial stage II (Spanish) in summer 2013 and two lines PBS16038 and PBS16040 (Fig. 1, 2 and 3) in initial varietal trial stage II (Spanish) of AICRP-G in *kharif* 2013.

Table 2. Superior advanced breeding lines identified during *kharif* 2013 season

Parents	Advanced breeding lines identified	Parents	Advanced breeding lines identified
Spanish		Virginia	
PBS 12160 x ICR 48	PBS 15055	Girnar 2 x ICGV 91114	PBS 24142
TAG 24 x ICGV 86031	PBS 15056	GG 2 x SG 99	PBS 24143
TAG 24 x ICGV 86031	PBS 15057	GG 2 x SG 99	PBS 26045
GG 2 x SG 99	PBS 16051	TG 37 A x SG 99	PBS 26047
TG 37 A x SG 99	PBS 16052	TG 37 A x SG 99	PBS 26048
Virginia		Girnar 2 x ICGV 97079	PBS 26049
PBS 12160 x ICR 48	PBS 25115	Girnar 2 x ICGV 97079	PBS 24144
PBS 12160 x ICR 48	PBS 25116	Girnar 2 x ICGV 97079	PBS 24145
PBS 12160 x ICR 48	PBS 25117	Girnar 2 x ICGV 97079	PBS 24146
Girnar 2 x ICGV 00350	PBS 21118	GG 20 x CS 19	PBS 24147
Girnar 2 x ICGV 00350	PBS 24140	GG 20 x CS 19	PBS 24148
TAG 24 x ICGV 86031	PBS 24141	GG 20 x CS 19	PBS 24149
TAG 24 x ICGV 86031	PBS 25118	GG 20 x CS 19	PBS 24150
TAG 24 x ICGV 86031	PBS 25119	GG 2 x SG 99	PBS 26044
Girnar 2 x ICGV 91114	PBS 25120	TG 37 A x SG 99	PBS 26046



Fig. 1.
Plant of PBS 15031



Fig. 2.
Plant of PBS 16038



Fig. 3a.
Plant of PBS 16040



Fig. 3b.
Pods of PBS 16040



Fig. 3c.
Kernels of PBS 16040

Station trials for yield evaluation

Ninety-three advanced breeding lines (test entries) developed under the project were evaluated



under different station yield evaluation trials. The plot size under preliminary trials was two-rows each of 5 m and replicated thrice, whereas in case of advanced trials it was five-rows each of 5 m length and replicated three times in a CRBD. Observations were recorded on days to flower initiation (DI) and 50% plants to flower (DF50) on plot basis, WUE-traits (SCMR and SLA, $\text{cm}^2 \text{g}^{-1}$), pod yield (PY, kg ha^{-1}) and days to maturity (DMT) in preliminary trials. In case of advanced trials, observations were recorded on DI and DF50 on plot basis, WUE-traits (SCMR and SLA), PY and kernel yield (KY, kg ha^{-1}), harvest index (HI, %), days to maturity, shelling out turn (SOT, %), hundred seed mass (HSM, g), sound mature kernels (SMK, %), oil and protein contents (%).

Preliminary yield evaluation trial of breeding lines of Spanish groundnut

Twelve advanced breeding lines of Spanish bunch groundnut along with four check varieties (GG 7, JL 501, SG 99 and TG 37A) were evaluated. The genotypes differed significantly for all the six traits studied. Among the check varieties, GG 7 was early for flowering traits and SG 99 for SCMR. For SLA, PY and DMT, TG 37A was the best check variety. Among the test entries, PBS 15053 and PBS 11090 performed significantly superior to the best check variety TG 37A for SLA and DMT, respectively. However, very poor pod yields were recorded in both these entries (Table 3).

Table 3. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield traits in preliminary yield evaluation trial (*kharif*2013)

Genotypes	Traits					
	SCMR	SLA	PY	DTM	DFI	DF50
PBS11085	26	198	1554	108	25	29
PBS15044	30	196	1497	116	28	32
PBS15054	27	189	1338	109	24	31
PBS15052	25	237	1210	104	28	33
PBS15021	28	199	1204	115	25	30
PBS15051	26	206	1041	104	26	32
PBS15050	23	226	1024	110	26	29
PBS11090	31	191	855	99*	27	33
PBS15053	24	132*	577	109	26	32
GG 7	24	230	1459	112	24	29
JL 501	28	208	1302	103	26	32
SG 99	32	220	1359	109	26	32
TG 37 A	28	198	2240	101	28	34
Mean	22	156	1041	81	21	26
CD (5%)	4	53	540	2	2	4

*Significant at $P \leq 0.05$



Advanced yield evaluation trial of breeding lines of Spanish groundnut

Twelve advanced breeding lines of Spanish bunch groundnut along with four check varieties (GG 7, JL 501, SG 99, TG 37A) were evaluated in kharif 2013. ANOVA indicated highly significant differences due to genotypes for all the traits studied except for DF50, PY, KY and SMK. The test entries PBS 11092, PBS 14080 and PBS 15027 were found superior for seed size (HKW), PBS 14080, PBS 15020 and PBS 15047 for oil, and PBS 15048 for protein content. For the remaining traits, no test entry was found to be superior (Table 4).

Table 4. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (kharif2013)

Genotypes	Traits									
	SCMR	SLA	PY	KY	Hlp	DTM	SOT	HKW	Oil	Protein
PBS 15028	29	231	1489	896	38	104	60	35	47	33
PBS 15027	32	193	1476	985	41	104	67	44*	46	34
PBS 15020	29	211	1471	864	40	106	59	39	51*	28
PBS 15029	32	221	1370	786	33	102	57	32	47	33
PBS 15047	24	229	1324	888	30	104	67	34	50*	29
PBS 15022	27	185	1291	768	41	104	60	30	46	34
PBS 11092	27	206	1054	707	42	101	67	49*	47	32
PBS 14080	24	214	955	554	28	105	58	47*	50*	29
PBS 15048	28	232	854	527	52	106	62	42	45	35*
GG 7	22	224	1023	707	37	101	69	39	46	34
JL 501	25	224	1094	656	44	104	61	35	47	33
SG 99	30	198	1155	740	39	101	64	39	48	31
TG 37 A	26	224	1111	690	44	107	62	35	46	33
Mean	22	174	979	610	32	84	51	23	29	24
CD (5%)	5	34	NS	NS	12	2	6	4	1	1

*Significant at $P \leq 0.05$

Six advanced breeding lines were evaluated over two seasons of kharif 2012 and 2013. ANOVA over pooled means indicated genotypic differences for all the traits studied and variation due to seasons was significant for most of these traits. Interactions between seasons and genotypes was also significant for traits namely, SCMR, HKW and protein content. Comparisons of genotypic means indicated that one advanced breeding line PBS 15027 was found significantly superior for pod and kernel yields over the best check varieties viz. SG 99 and GG 7 respectively for these traits. This line also performed significantly superior to the best check variety for SCMR and protein content. Advanced breeding line PBS 15029 also exhibited significant SCMR and protein



content. The line PBS 15048 had significantly superior kernel attributes like HKW and SMK, in addition to its superior HI (Table 5).

Table 5. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (*kharif* 2012 and 2013)

Genotypes	Traits										
	SCMR	SLA	PY	KY	HIp	HKW	HSMK	SMK	SOT	Oil	Protein
PBS 11092	30	179	1502	1029	38	48*	62*	49	68	48	30
PBS 11088	26	215	1336	924	35	36	44	62	69	48	30
PBS 14078	29	206	1775	1038	32	31	43	44	59	48	31
PBS 15027	32*	179	1971*	1374*	38	43	56	58	69	46	32*
PBS 15029	32*	203	1828	1094	37	33	42	42	59	47	32*
PBS 15048	29	206	1441	936	52*	46*	58*	62*	64	48	31
GG 7	28	194	1631	1161	38	43	54	71	71	49	29
JL 501	27	198	1623	1098	44	36	47	51	66	49	30
SG 99	33	169	1679	1095	35	40	52	46	65	49	30
TG 37 A	29	191	1634	1084	43	38	49	59	65	49	29
Mean	23	194	1445	946	34	30	39	48	66	48	24
CD 5%	4	21	252	159	7	3	5	13	3	2	2

*Significant at $P \leq 0.05$

Preliminary yield evaluation trial of breeding lines of Virginia groundnut

Forty advanced Virginia bunch breeding lines (test entries) along with three check varieties (GG 20, Somnath and Kaushal) were evaluated. ANOVA indicated that genotypes significantly differed for all the traits except DFI and DF50. The check variety Somnath was adjudged to be the best check for SCMR and Kaushal for SLA. For PY and DTM, GG 20 was found to be the best check variety. When the means of the test entries were compared with that of the best check variety, it was found that PBS 21110 was significantly superior for SCMR. Significantly superior PY was observed in PBS 21113; in addition to this test entry also took significantly less number of days for maturity. Other test entries significantly early in maturity were PBS 21110, PBS 21112, PBS 21114, PBS 25023 and PBS 25095 (Table 6).

Advanced yield evaluation trial of breeding lines of Virginia groundnut (*Single year evaluation*)

Eighteen advanced Virginia bunch breeding lines (test entries) along with three check varieties (GG 20, Somnath and Kaushal) were evaluated. ANOVA indicated highly significant differences due to genotypes for all the traits studied except DFI and DF50. The check variety



GG 20 was adjudged to be the best check for PY. Two test entries PBS 25033 and PBS 25098 were found to register significantly higher pod yield over the best check variety. This genotype also gave significantly higher HIp and protein content. In PBS 24106 also significantly higher protein content was observed over the best check variety Somnath. For remaining traits no test entry was found to perform superior over the best check variety for the respective traits (Table 7).

Nine advanced breeding Virginia lines were evaluated over two seasons of kharif 2012 and 2013 along with three check varieties GG 20, Somnath and Kaushal. ANOVA over pooled means indicated that the genotypic differences as well as differences due to seasons were highly significant for all the traits studied. The check variety GG 20, a popular variety of the region, was found to be the best check variety for PY and KY. The test entry (advanced breeding line) PBS 25033 was found to be significantly superior for PY and KY over this best check variety. This line also registered significantly superior HI. For remaining traits no test entry was found to be superior over the best check variety (Table 8).

Table 6. Performance of selected advanced Virginia breeding lines for SCMR, SLA and yield traits in preliminary yield evaluation trial (*kharif*2013)

Genotype	Traits					
	SCMR	SLA	PY	DFI	DF50	DTM
PBS 21113	30	208	1598*	29	34	104*
PBS 25101	33	207	1370	27	34	116
PBS 21108	31	222	1297	28	34	114
PBS 21111	32	218	1263	25	31	112
PBS 25041	30	192	1242	27	34	119
PBS 21109	30	227	1185	28	33	110
PBS 25079	29	211	1169	29	35	115
PBS 21114	32	208	1167	27	33	104*
PBS 25095	31	186	1163	26	32	111*
PBS 25103	26	212	1129	28	34	118
PBS 25106	31	211	1086	28	33	113
PBS 25023	29	199	1085	28	34	111*
PBS 21112	31	213	1069	28	34	111*
PBS 21110	33*	228	1035	27	33	111*
GG 20	29	195	1254	28	34	114
Somnath	27	197	1154	27	32	117
Kaushal	29	190	802	27	33	117
Mean	29	210	963	28	33	115
CD (5%)	4	32	320	3	3	3

*Significant at $P \leq 0.05$

Drought Screening Nurseries

A total of 306 advanced breeding lines were raised in three different drought screening nurseries in augmented design with three checks and three blocks in each case with an objective of screening these lines under natural drought stress conditions. As there were continuous rains in *kharif* season, screening of this material was not conclusive.

Genotypic responses of Spanish groundnut advanced breeding lines to drought stresses

Sixteen groundnut genotypes were tested in summer 2013 at DGR, Junagadh in a split plot design with water treatments (WTr), fully irrigated and simulated water-deficit conditions at multiple



stages (55 to 77 and 84 to 104 DAE), as main plots and genotypes as sub plots. Observations were recorded days after emergence (DAE) to flower initiation (FI) and 50 % of plants to flower (F_{50}) (on plot basis), SCMR and SLA on 55th DAE. Relative water content (RWC, %) was recorded at 73 DAE when the stressed plots had received last irrigation on 55 DAE. Post-harvest observations were recorded on pod (PY) and kernel (KY) yields (kg ha^{-1}). Genotypic responses to moisture deficit were assessed through drought tolerance parameters for pod yield, namely mean productivity, MP (Rosielle and Hamblin, 1981) drought susceptibility index, DSI (Fischer and Maurer, 1978) and drought tolerance efficiency, DTE (Fischer and Wood, 1981) and per cent change in performance under water-deficit stress conditions.

For traits namely, FI, F_{50} , SCMR and SLA, as the water-deficit stress was not imposed, single factor analysis of variance for 16 genotypes with six replications was performed. Significant genotypic differences were observed for FI, F_{50} , SCMR and SLA. Six advanced breeding lines namely, PBS16038, PBS16031, PBS16023, JUN' 27, PBS11058, and PBS15031 performed significantly superior over check varieties for SCMR; and JUN 27 for SLA. RWC was recorded on 73rd DAE when the stressed plots had received last irrigation on 55 DAE (18 days after last irrigation). Significant differences due to irrigation treatments were observed for PY and KY. The advanced line PBS30055 performed significantly superior over the best check variety TG 37A both for PY and KY across the irrigation treatments, in addition to PBS11077 for PY (Table 9). Based on the MP, PBS 30055 (Fig. 4) was found to be most tolerant advanced breeding line followed by PBS16038 and PBS11077. TG 37A was found to be the most tolerant one based on the DSI, DTE and % change of PY due to drought stress. Among the advanced breeding lines PBS16038 was found to be the most tolerant one followed by PBS11077, PBS16023 and PBS30055 based on these three droughts tolerance parameters (Fig. 5).

Table 7. Performance of selected advanced Virginia breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (kharif 2013)

Genotypes	Traits									
	SCMR	SLA	PY	KY	DFI	DF50	HIp	DTM	SOT	HKW
PBS 25033	31	191	1380	940	27	31	38	113	70	41
PBS 25076	29	214	1039	690	25	29	24	110	66	53
PBS 25080	26	235	1066	730	27	31	26	112	68	46
PBS 25098	26	223	1512*	914	28	32	37	116	61	44
GG 20	33	179	1080	882	25	30	27	109	76	54
Somnath	30	201	1064	745	28	34	22	121	70	59
Kaushal	29	203	926	650	28	35	22	119	70	40
CD (5%)	3	24	256	181	3	4	10	15	4	4

*Significant at $P \leq 0.05$



Table 8. Performance of selected advanced Virginia breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (*kharif* 2012 and 2013)

Genotypes	Traits									
	SCMR	SLA	PY	KY	HIp	HKW	SMK	SOT	Oil	Protein
PBS 25033	30	179	1820*	1236*	37*	37	45	68	47	33
PBS 24106	31	199	1453	901	25	37	49	63	48	31
PBS 24116	28	209	1446	952	25	42	45	66	50	29
PBS 25098	30	193	1415	874	35	41	51	62	48	31
PBS 24114	30	193	1358	884	23	41	45	66	49	30
PBS 24130	27	203	1214	836	21	37	50	69	50	28
PBS 25100	30	194	1141	757	30	44	48	67	49	30
PBS 26025	28	207	1025	695	22	40	49	68	46	33*
PBS 25099	29	195	995	699	29	31	38	70	46	34*
GG 20	33	163	1436	1017	29	49	55	72	53	26
Somnath	31	174	1381	959	24	51	61	70	49	30
Kaushal	31	169	1200	813	25	36	52	68	51	27
Mean	30	190	1172	782	24	41	49	67	49	25
CD (5%)	3	23	243	177	7	4	11	3	1	2

*Significant at $P \leq 0.05$



Fig. 4: PBS 30055 under irrigated and drought stress situation

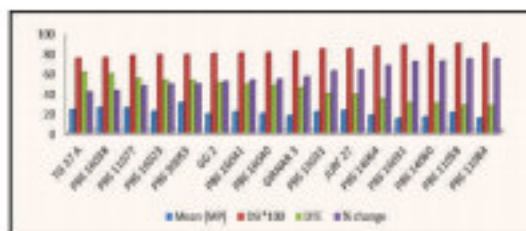


Fig. 5: Characterization of advanced breeding lines based on the parameters of drought tolerance

Table 9. Performance of selected advanced breeding lines for PY, KY, HIp and RWC under irrigated (Irr) and drought stress (Drt) situation in summer 2013

Genotypes		PBS 11077	PBS 16038	PBS 15031	PBS 16023	PBS 30055	GG 2	Girnar 3	TG 37 A	CD (5%)
PY	Irr	3182	3109	2933	2751	3916	2459	2289	2838	
	Drt	1706	1817	1137	1429	2027	1214	1020	1699	
	Mean	2444	2463	2035	2090	2972*	1837	1655	2269	352
KY	Irr	2123	1992	1827	1760	2336	1668	1440	1774	
	Drt	1082	1149	654	750	1158	774	622	1033	
	Mean	1602	1571	1240	1255	1747*	1221	1031	1404	232
HIp	Irr	40	36	32	30	36	30	30	38	
	Drt	35	18	14	16	21	20	22	19	
	Mean	38*	27	23	23	29	25	26	28	12.4
RWC	Irr	88	90	89	90	89	89	91	88	
	Drt	75	73	86	68	63	60	66	64	
	Mean	82	82	88*	79	76	75	79	76	8.62

*Significant at $P \leq 0.05$



PROJECT 02 : BREEDING AND GENETIC STUDIES ON TOLERANCE OF BIOTIC STRESSES IN GROUNDNUT

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Crosses effected

Sixteen crosses were effected in kharif 2013 to develop improved varieties resistant/tolerant of foliar diseases, stem rot, *Alternaria* leaf spot, seed coat resistance to *A. flavus*, *Spodoptera* and sucking pest (Table 1). The number of harvested crossed pods varied from 6 to 109. The mean success rate (%) of the entire hybridisation programme was 18.3, which ranged from 4.6% to 43.1%. The low success rate of hybridization was may be limited time available for pod development when crosses attempted in later stage and squirrels directly damage hybrids pods.

Table 1. Crosses effected in kharif 2013

Name of crosses	Purpose	F1 pods (No.)	Success rate (%)
BAU 13 × CS 196	Foliar Disease Resistance	31	16.8
CS 281 × CS 196	Foliar Disease Resistance	50	20.1
GG 20 × GPBD 4	Foliar Disease Resistance	19	08.3
GG 20 × CS 196	Foliar Disease Resistance	13	07.0
GPBD 4 × CS 196	Foliar Disease Resistance	102	31.4
GG 20 × CS 319	Stem rot resistance	25	11.7
TG 37 A × CS 319	Stem rot resistance	109	35.6
TAG 24 × CS 349	Tolerance to <i>Alternaria</i> leaf spot	88	36.9
GG 20 × JCG 88	High yield and tolerance to seed coat resistance	17	08.2
CTMG 6 × BG 2	High yield and tolerance to <i>Spodoptera</i>	50	43.1
GG 20 × NRCG 357	High yield and wide adaptability	12	4.6
TG 37A × NRCG 357	High yield and wide adaptability	39	13.9
GG 20 × CS 319	Genetics of stem rot resistance	49	14.2
TG 37 A × CS 319	Genetics of stem rot resistance	45	12.2
CS 319 × GG 20	High yield and stem rot resistance	06	08.1
CS 319 × TG 37 A	High yield and stem rot resistance	15	21.1
Average		41.8	18.3

Identification of true hybrids

Ten different crosses were raised in summer 2013 to identify true F₁'s effected for developing



resistant genotypes to foliar diseases, stem rot, aflatoxin, PBNB and sucking pests of groundnut (Table 2). The number of harvested crossed pods varied from 43 to 125. The mean success rate (%) of the entire hybridisation programme was 31.3, which ranged from 23.7% to 48.7%. A total 152 probable single plants have been identified as true hybrids in all the ten crosses. Maximum number (34) probable true F_1 's in the cross RHRG 06083 $\times$ ICGV 86031 and the lowest number (7) in the cross of GG 20 $\times$ CS 19 have been identified.

Table 2. Details of F_1 's raised and true hybrids isolated in Summer 2013

Name of crosses	Purpose	F_1 pods obtained (No.)	Crossing Success (%)	True hybrids isolated (No.)
BAU 13 $\times$ CS 196	Foliar Disease Resistance	47	26.5	9
CS 281 $\times$ CS 196	Foliar Disease Resistance	69	35.7	15
GG 20 $\times$ GPBD 4	Foliar Disease Resistance	45	27.9	18
GG 20 $\times$ CS 196	Foliar Disease Resistance	47	26.7	16
GPBD 4 $\times$ CS 196	Foliar Disease Resistance	57	25.4	12
GG 20 $\times$ CS 19	Stem rot resistance	43	23.7	7
TG 37 A $\times$ CS 19	Stem rot resistance	76	48.7	9
J 11 $\times$ GG 20	Aflatoxin resistance	64	25.0	12
ICGV 00350 $\times$ JSP39	Tolerance to stem rot	125	44.1	20
RHRG 06083 $\times$ ICGV 86031	High yield and multiple tolerance of sucking pest and PBNB resistant	84	28.6	34
Total		657	31.2	152

Advancement of different filial generations

The breeding materials generated earlier were advanced to next higher filial generation in *kharif* 2013. Progenies of 43 crosses were advanced to different filial generations (F_2 - F_6). The numbers of crosses in early generations (up to F_4) were 29 and 14 in advanced generation. In F_5 generation, individual plant progenies of ten crosses were raised to identify high yielding stable genotypes, among these crosses 12 advanced breeding lines were identified of which three of Spanish and nine of Virginia botanical group.

Development and generation advancement of mapping populations

Summer 2013: Three mapping population were advanced to next filial generation through SSD method during summer 2013 (Table 3). Among them two population were for seed coat resistance to *A. flavus* (GG 20 $\times$ J 11 and ICGV 00350 $\times$ J11) in F_2 generation and one population for tolerance to stem rot (GG 20 $\times$ JSP 39) in the F_3 generation.



Table 3. Mapping Populations (RILs) in different generations in Summer 2013

Generations	Cross	Purpose	RILs
F ₃	GG 20 × J11	Seed coat resistance	174
	ICGV 00350 × J11	Seed coat resistance	392
F ₅	GG 20 × JSP39	Tolerance of stem rot	377

Kharif 2013: The mapping populations developed earlier were advanced to next filial generation in *kharif* 2013 (Table 4). A total five mapping populations were in F₄ generation, among these three (GG 20 × CS 19, GG 20 × CS 75, GG 20 × CS 83) meant for tolerance to stem rot and two (GG 20 × J 11 and ICGV 00350 × J 11) meant for seed coat resistance to *A. flavus*. A total two mapping populations were in F₅ generation, in which one (JL 24 × VG 9816) meant for resistance of foliar diseases and one (GG 20 × CS 19) for tolerance to stem rot. In F₆, one mapping population (GG 20 × JSP39) was raised to identify stable genotypes, among these a total 344 RILs were obtained to study tolerance/resistance of stem rot.

Generations	Cross Purpose	RILs
F ₄ GG 20 × CS 19	Tolerance of stem rot	344 (359)
GG 20 × CS 75	Tolerance of stem rot	273 (296)
GG 20 × CS 83	Tolerance of stem rot	224 (245)
GG 20 × J 11	Seed coat resistance to <i>A. flavus</i>	158 (170)
ICGV 00350 × J 11	Seed coat resistance to <i>A. flavus</i>	387 (392)
F ₅ JL 24 × VG 9816	Resistance of foliar diseases	301 (358)
GG 20 × CS 19	Tolerance of stem rot	129 (134)
F ₆ GG 20 × JSP39	Tolerance of stem rot	344 (377)

* Figures in parenthesis indicate the original number of RILs raised in *kharif* 2012 season

Yield evaluation of advanced breeding lines

Summer 2013: Five Spanish advanced breeding lines (PBS 12180, 12181, 12183, 12185, 12186) along with two checks (TAG 24 and Dh 86) were evaluated in RBD with three replications in five row for yield and its component traits in summer, 2013. Pooled analysis of variance indicated significant differences due to genotypes for pod yield in both the environment. Among the two check varieties, Dh 86 was found to be the best check for pod yield (1968 kg/ha) and it was found that Dh 86 out yielded all the genotypes.

Kharif 2013:

First year evaluation: A total nineteen advanced breeding lines, seven of Virginia bunch and 12 of Spanish bunch along with checks *viz.* GG 20 and Somnath for Virginia bunch and GG 7, TG 37A, GG 5 for Spanish bunch genotypes were used for yield evaluation. The results revealed that



none of the genotype significantly surpass the best check for pod and kernel yield (kg/ha), shelling outturn and harvest index.

Second year evaluation: Sixteen advanced breeding lines, five of Spanish bunch type and 11 of Virginia bunch type were evaluated for yield and its component traits in a RBD with three replications during *kharif* 2012 and 2013. To evaluate the Spanish bunch advanced breeding lines, the check varieties GG 7 and TG 37A were used while in case of Virginia bunch advanced breeding lines, GG 20 and Somnath were employed. For number of pods/plant, among the Spanish group, one genotype PBS 12181 was found significantly superior over the check variety TG 37A (10) while among Virginia group, three genotypes (PBS 22080, PBS 22081, PBS 22091) found significantly superior over best check variety GG 20 (7). For pod and kernel yield (kg/ha), only one Virginia bunch genotype PBS 22080 (2392 kg of pod and 1709 kg of kernel/ha) was found significantly superior over best check variety Somnath (1456 kg of pod and 980 kg of kernel/ha). Four Virginia bunch advanced breeding line, PBS 22080 (42%), PBS 22081 (33%), PBS 22086 (35%) and PBS 22091 (33%) was found significantly superior over the best check Somnath (27%) for pod harvest index.

Based on two year (*kharif* 2012 and *kharif* 2013) pod and kernel yield results indicated that only one advanced breeding line (PBS 22080) was found significantly superior over best check variety. Hence, this elite breeding genotype was identified as high yielding and further it need to be evaluated at multi-location for yield and other component traits under AICRPG trials.

Development, multiplication and distribution of breeding materials to different AICRP-G centres

Development of new advanced breeding lines

A total 12 new advanced breeding lines were developed during *kharif* 2013, of which three lines (PBS 12209, PBS 12210, PBS 12211) belonged to Spanish and nine lines (PBS 22108, PBS 22109, PBS 22110, PBS 22111, PBS 22112, PBS 22113, PBS 22114, PBS 22115, PBS 22116) belongs to Virginia group.

Multiplication of breeding materials

Summer 2013: A total of 14 new advanced breeding lines (developed in *kharif* 2012) were mass



Fig.1 PBS 22080- A high yielding elite genotype identified



multiplied to get sufficient seed for further yield evaluation and screening against different biotic stresses.

Kharif 2013: A total of 36 advanced breeding lines, of which 13 belonged to Spanish bunch with no maintenance lines and 23 belonged to Virginia bunch with 15 maintenance lines were mass multiplied to get sufficient seed for conducting yield trials as well as screening for different biotic stresses.

Multiplication of AICRP-G lines:

Seeds of two elite advanced breeding lines (PBS 22066 and PBS 22067) were mass multiplied in the *kharif* 2013 to get sufficient seeds for yield evaluation at multi-locations under AICRP-G trials during *kharif* 2014.

Distribution of breeding materials to different AICRP-G centres

The breeding material of thirteen different crosses from four segregating generations (F_3 to F_6 generation) was selected and supplied to six AICRP-G centres to effect location specific selections for different biotic stresses during *kharif* 2013 (Table 5).

Screening of genotypes for tolerance of stem rot under sick plot

Summer 2013: A total 46 advanced breeding lines along with resistant genotype CS 19 and two popular high yielding varieties (GG 20, GG 2) were screened in replicated trial for resistant to stem rot under sick plot during summer 2013. Data were recorded on per cent infection at the time of harvesting. Results revealed that four genotypes (PBS 12167, 12168, 18057, 22074) recorded less than 20% disease as compared to the resistant genotype CS 19 (32.47%). The confirmation on durability and stability of resistance to stem rot, these advanced breeding lines need to be screen one or more year for final confirmation.

Kharif 2013: A total 46 advanced breeding lines along with tolerant genotype CS 19 and two popular high yielding varieties (GG 20, GG 2) were screened in replicated trial for resistant to stem rot under sick plot during *kharif* 2013. Data were recorded on per cent disease incidence at the time of harvesting. The disease incidence varied between 2.1 to 55.6% among the genotypes. Results revealed that 17 genotypes (PBS 12029, 12067, 12116, 12163, 12167, 12169, 12172, 12186, 13022, 18004, 18029, 18033, 18038, 18045, 18055, 18064, 22062) recorded less than 10% disease incidence as compared to the resistant genotype CS 19 (55.6%) and high yielding varieties GG 20 (45%) and GG 2 (33.6%). The disease incidence was not so high for screening due to high rainfall during *kharif* 2013. Therefore, results on durability and stability of resistance to stem rot will be screen one or more year for confirmation under sick plot.

Screening of advanced breeding lines for resistance of *in-vitro* colonization by *A. flavus*

Summer 2013: A total 54 groundnut genotypes were screened for *in-vitro* colonization by *A.*



Cross	Objective	Pod wt (g)	Centre
F₂ segregating generation			
J 11 × GG 20	Aflatoxin resistance	150	ARS, Durgapura
ICGV 00350 × JSP39	Tolerance to stem rot	600	RRRS, Vyara, ARS, Shirgaon
RHRG 06083 × ICGV 86031	High yield and multiple tolerance of insect pest and PBND resistant	1500	RCA, Udaipur, RRRS, Vyara ARS, Shirgaon
F₂ segregating generation			
ICGV 00351 × ICGS 44	Tole. of PBND & wide adaptability	660	RCA, Udaipur, RRRS, Vyara
TMV Gn 13 × VG 9816	Tole. of foliar diseases and PBND	800	RCA, Udaipur, ARS, Durgapura
GPBD 4 × VG 9816	Tole. of foliar diseases and PBND	190	RRRS, Vyara
GG 20 × J 11	Tolerant to Aflaroot (<i>A. flavus</i>)	430	ARS, Durgapura
GG 20 × OG 52-1	Tolerant to collar rot	830	RRRS, Vyara, OUAT, Bhubaneswar
TG 37 A × Kadiri 3	High yield and resistant to PBND	580	RCA, Udaipur, ARS Jalgaon
Dh 86 × Gimara 1	High yield and tolerance to sucking pest	1230	RCA, Udaipur, RRRS, Vyara, ARS, Durgapura
F₂ segregating generation			
GG 20 × SGL 4233	Tolerance to collar rot	400	ARS, Shirgaon, ARS, Durgapura
TG 37 A × SGL 4233	Tolerance to collar rot	200	RRRS, Vyara
F₂ segregating generation			
TG 37 A × VG 9816	PBND Tolerance	290R	CA, Udaipur, ARS Jalgaon

flavus at pod as well as kernel levels during summer 2013 using modified progressive 1-4 scale suggested by Thakur *et al.*, 2003. Genotype PBS 18055 recorded lowest seed infection (1.5) while cultivar TG 37A (4.0) recorded highest seed infection. For pod infection, genotype PBS 12066 (1.0) recorded lowest and genotype PBS 12167 (2.80) recorded highest pod infection. Simultaneously remaining fresh seeds of these genotypes were used to estimate aflatoxin content (AFB1) in the kernel. The results revealed that aflatoxin content in kernel was in the ranged from 0.0 to 4 ppb. Maximum aflatoxin content was recorded in the genotype PBS 18062. Most of the genotype free from aflatoxin content except few genotypes like PBS 18064 (3.27ppb), TAG 24



(3.40ppb) and TG37A (2.63 ppb).

Kharif 2013: A total 60 groundnut genotypes along with cultivar J11 screened for in vitro colonization by *A. flavus* at pod as well as kernel levels using modified progressive 1-4 scale suggested by Thakur et al., 2003. The seed infection ranged from 1.0 to 2.2 while pod infection ranged from 1.0 to 2.1. Seed coat resistant to *A. flavus* infection cultivar J11 recorded a score 1.4 and 1.0 for kernel and pod respectively. The results indicated that due to low seed and pod infection in all the genotypes valid conclusion cannot ascertain. Hence, one more season need to be screening these genotypes to validate the results.

Screening of advanced breeding lines for foliar disease resistance

Summer 2013: A total 45 advanced breeding lines were screened for resistant to *Alternaria* leaf spot with resistant/tolerant check viz., CS 349. The experiment was conducted under natural field condition in RBD with three replications and disease was score using modified 1-9 scale. Maximum disease score was observed in genotype PBS 18037 (8 on 1-9 scale). However, some genotypes like PBS 12169, PBS 18062 and PBS 12190 showed resistance or tolerant reaction (<4.7 on 1-9 scale) which was at par with resistant check CS 349 (4.3 on 1-9 scale) to *Alternaria* leaf spot. Therefore, these advanced breeding lines need to be tested for one more year for valid conclusion.

Kharif 2013: A total 60 genotypes with two resistant check viz., GPBD 4 (high yielding foliar disease resistant variety) and CS 85 (foliar disease resistance interspecific derivative) screened in replicated trial under natural condition for resistance of foliar diseases (late leaf spot and rust) during *kharif*, 2013. The maximum disease pressure for late leaf spot and rust was 8 on modified 1- 9 point scale while minimum was 2 and 2.7 for leaf spot and rust respectively in the cultivar GPBD 4. The study revealed only one genotype, PBS 12032 was found resistant (recorded a disease score ≤ 3) to leaf spot and rust on a modified 1- 9 point scale. Four genotypes viz., PBS 12066, 12167, 18062 and 22050 were found moderately resistant (recorded a disease score ≤ 6) to both diseases. Two genotypes PBS 12067 and PBS 18064 found resistant to rust (recorded a) and moderate resistant to leaf spot (recorded a disease score ≤ 6). Based on the two year screening results in *kharif* 2012 and 2013, only one genotype (PBS 12032) was identified as resistant (disease score ≤ 3 on 1-9 point scale) to leaf spot and rust while seven genotypes (PBS 12038, 12066, 12067, 12167, 18062, 18064 and PBS 22050) identified tolerant (disease score ≤ 6 on 1-9 point scale) to leaf spot and rust.

An another experiment comprising of 40 genotypes with resistant check GPBD 4 (high yielding foliar disease resistant variety) were screened in replicated trial under natural condition for resistance of foliar diseases (late leaf spot and rust) during *kharif*, 2013. The study revealed only



one genotype, PBS 22098 was found resistant (recorded a disease score ≤ 3) to leaf spot and rust on a modified 1-9 point scale while two genotypes PBS 12185 and PBS 12186 found resistant to rust only. Therefore, results on stability of resistance of foliar diseases will be confirmed for one or more year under high disease pressure.

Screening of advanced breeding lines for resistance/tolerance of sucking pests

Summer 2013: Five Spanish advanced breeding lines of (PBS 12180, 12181, 12183, 12185, 12186) along with two checks (TAG 24 and Dh 86) were screened for sucking pests in Summer, 2013. Leaf hopper population was significant at 60 and 75 days while non-significant at 45 and 90 days. At 60 and 75 days, all the genotypes (PBS 12180, 12181, 12183, 12185, 12186) recorded less plant population than the ETL level (5hopper/5sweep). Thrips population was non-significant throughout crop period. Another trial comprising 50 genotypes were also screened for sucking pests. Leaf hopper population was significant at 45, 60, 75 and 90 days. Among them five advanced breeding lines (PBS 12018, 18035, 18037, 18038 and 18045) recorded lower population than ETL at all the stages. Maximum population of thrips was observed at 60 and 75 days. Thrips population was significant only at 60 and 75 days. At 60 days, only one genotype (PBS 12029) showed lowest population. At 75 days, four genotypes (PBS 12168, 18033, 18055 and 18064) recorded lowest population of thrips.

Kharif 2013: A total 60 advanced breeding lines in two rows with three replication along with resistant/tolerant check viz., ICGV 86031 for jassid, thrips, leaf minor and *Spodoptera* were screened during *kharif* 2013. The results indicated that non-significant differences observed among the genotypes for leafhoppers and thrips. Hence, none of the genotypes was found to be least preferred either by leafhoppers and thrips. Another experiment comprising of 20 genotypes were also screened for jassid and thrips. The results were non-significant due to lower pest loads with respect to insect population (number of hopper and thrips per five sweeps) and hence, no genotype was found to be least preferred by leafhoppers and thrips.

Screening of advanced breeding lines for resistance of root knot nematode

Five advanced breeding lines (PBS 12180, PBS 12181, PBS 12183, PBS 12185 and PBS 12186) along with one high yielding variety GG 20 were screened for root knot nematode (*M. arenaria*) in a pot experiment during *kharif* 2013. Disease reactions of these genotypes for root-knot nematode were recorded on basis of number of root galls in each genotype. The number of root galls were lowest in genotype PBS 12185 (63) and highest in genotype PBS 12183 (95). It was found that all the genotypes were susceptible based on root-gall index.



PROJECT 03 : GENETIC IMPROVEMENT IN GROUNDNUT FOR LARGE SEED AND CONFECTIONERY TRAITS

(M.C. DAGLA, M.K. MAHATMA, NARENDRA KUMAR AND AJAY B.C.)

SUMMER-2013

Identification of true hybrid plants

Nineteen crosses generated during *kharif*-2012 were raised along with their fourteen parents. One hundred and twenty-two hybrid plants were identified and their pods were harvested separately for further advancement.

Table 1: Hybrids identified and selected as individual plants in F₁ generation.

Crosses	Traits of interest	No. of F ₁ Pods harvested	No. of sown seeds	No. of Hybrid plants
TPG 41 x S 230	High O/L ratio	83	72	21
ICGV 97079 x Dh 3-30	Low oil	108	51	20
GPBD 4 x Dh 3-30	High protein and Low oil	82	51	15
ICGV 97079 x MH 4	Short duration	90	81	30
Gangapuri x M 13	High sugar	30	65	9
MH 4 x M 13	Short duration	4	4	2
BAU 13 x CS 268	Large seed	51	33	12
BAU 13 x GG 20	High yield	53	36	8
BAU 13 x GPBD 4	High protein	46	39	15
CS 281 x GG 20	High yield	71	30	16
CS 281 x GPBD 4	High protein	91	39	21
CS 281 x Chico	Large seed	9	13	4
ICGV 07368 x Chico	Large seed	1	1	1
Chico x CS 281	Large seed	2	3	2
Chico x ICGV 07368	Large seed	2	1	0
BAU 13 x NRCG 14492	Large seed	21	30	1
NRCG 14492 x BAU 13	Large seed	20	31	5
Gangapuri x NRCG14492	High sugar	57	82	19
NRCG14492 x Gangapuri	High sugar	17	23	16
Total		838	685	122

Multiplication

One Spanish and 17 Virginia advanced breeding lines were multiplied to conduct a trial for evaluating their performance for yield and confectionery traits.

Evaluation of Spanish Bunch germplasm lines for yield and confectionery traits

Fifty six Spanish germplasm lines with 4 checks (TG 37 A, TPG 41, GG 7 and TKG 19 A) were evaluated in randomized block design. Every genotype was grown in single row of 5 m length and spacing between rows and plants within row were kept at 60 and 10 cm, respectively. Although,



these genotypes were not in the grade of large-seeded, and range of hundred kernel weights was 24 to 48 g. Yet, these genotypes showed a good range of yield related traits as well as biochemical parameters. Some genotypes have been identified for yield attributes which are given below:

1. Total dry matter (>40g): NRCGs 14424, 14437, 14476, 14504.
2. Harvest Index (>30%): NRCGs 14389, 14430 and 14501.
3. Pod yield per plant (>10g): NRCGs 14343, 14368, 14407, 14424, 14430, 14472.
4. Number of pods/plant (>12): NRCGs 14348, 14365, 14377, 14407, 14430, 14434, 14440, 14472, 14485, 14501.
5. Shelling (>70%): NRCGs 14349, 14350, 14351, 14364, 14380, 14389, 14398, 14430, 14440, 14456, 14470, 14471, 14498, 14500, and 14501.

Evaluation of Valencia germplasm lines for yield and confectionery traits

Twenty eight Valencia germplasm lines with 2 checks (Gangapuri and MH4) were evaluated in randomized block design. Every genotype was grown in single row of 5 m length and spacing between rows and plants within row were kept at 60 and 10cm, respectively. Although, these genotypes were not in the grade of large-seeded and range of hundred kernel weights was 27 to 53 g. Yet certain genotypes were identified for yield attributes were given below:

1. Total dry matter (>30g): NRCGs 14328, 14344, 14419, 14426, 14435, 14454, 14492, 14496.
2. Harvest Index (>25%): NRCGs 14452, 14468 and 14507.
3. Pod yield (>10g): NRCG 14435.
4. Number of pods/plant (>10): NRCG 14379.
5. High shelling (>70%): NRCG 14379.

For final conclusion these both trials will be repeated in summer-2014.

KHARIF-2013

Hybridization

During *kharif*-2013, ten crosses were attempted to incorporate large kernel size coupled with high yield and other confectionery traits. A total of 2270 buds were pollinated and 368 probable hybrid pods were harvested with a 16.4% success rate.

Generation advancement

The F_1 generations of 9 crosses were sown and two crosses were rejected. Among the remaining seven crosses, true F_2 s (segregating) lines were identified and advanced. The selected crosses were cross-wise bulk-harvested for advancing to next generation. Ten crosses in F_2 were sown and one was rejected. Among the remaining nine crosses, single plants were selected and forwarded. Twenty crosses in F_3 were sown and two crosses were rejected. Among the



remaining eighteen crosses, individual plants were selected and advanced. Similarly, seven crosses were advanced from F_3 to F_6 generation.

Table 2: Crossing programme in *Kharif*-2013

S N	Crosses	Trait of interest	No. of buds pollinated	No. of F_1 pods	Success Rate (%)
1	BAU 13 x CS 281	Large seed	157	21	13.3
2	BAU 13 x GG 20	Large seed	162	19	11.7
3	BAU 13 x GPBD 4	Large seed	171	14	8.1
4	CS 281 x GG 20	Large seed	215	35	16.2
5	CS 281 x GPBD 4	Large seed	244	43	17.6
6	ICGV 97079 x Dh 3-30	Large seed	404	33	8.1
7	BAU 13 x NRCG 14492	Large seed	188	21	11.1
8	NRCG 14492 x BAU 13	Large seed	125	31	24.8
9	Gangapuri x NRCG 14492	High sugar	265	94	35.4
10	NRCG 14492 x Gangapuri	High sugar	97	21	21.6
Total			2270	367	16.42

New Advanced Breeding Lines from F_6 Generation

In F_6 generation, six crosses were sown and one cross was rejected. Among the remaining five crosses, seven advanced breeding lines (PBS 29205, PBS 29206, PBS 29207, PBS 29208, PBS 29209, PBS 29210 and PBS 29211) were selected as individual plants on the basis of their phenotypic traits (these lines belong to Virginia habit group). These individual plants will be multiplied in the next season for making sufficient seeds to conduct their evaluation trial.

Multiplication and maintenance of genotypes

The following materials were multiplied:

1. Spanish advanced breeding lines: 10
2. Virginia advanced breeding lines: 35
3. Large-seeded varieties: 25
4. Multiplication of two ABLs PBS 19018 and PBS 19022 for AICRP-G trials

So far, about 100 developed large-seed advanced breeding lines, belonging to Virginia and Spanish habit groups are being maintained in every *kharif* season.

Large-seed Virginia bunch yield evaluation trial

One yield evaluation trial was conducted during *kharif*-12 and *kharif*-13. There were fifteen Virginia ABLs and three checks GG 20, BAU 13 and M 13. Data were recorded on yield parameters and some confectionery traits. On the basis of data of two year, enough genetic variability for all the studied traits could be discerned. For pod yield, GG 20 was the best check, and none of the advanced breeding line surpassed this check. For hundred kernel weight (HKW),



the check BAU 13 had the highest HKW of 52g. Hundred sound mature kernels weight ranged from 64 g in PBS 29087 to 91 g in PBS 29148.

Large-seed Spanish bunch yield evaluation trial

Another yield evaluation trial was conducted during *kharif*-12 and *kharif*-13. There were seven Spanish ABLs and one check TPG 41. Data were recorded on yield parameters and some quality traits required for confectionery purpose. On the basis of analysis of two year data, enough genetic variability was observed for all the studied traits. For pod yield, only two advanced breeding lines PBS 19023 and PBS 19024 surpassed the check TPG 41 but the difference was not significant.

Evaluation of large-seed Virginia advanced breeding lines (ABLs) for yield and confectionery traits at Bikaner and Junagadh locations

A trial comprising of 26 large-seeded Virginia ABLs with four checks (GG 20, BAU 13, Somnath and M 13) was conducted at Junagadh and Bikaner. At both the locations yield as well as confectionery traits showed enough genetic variability. There were vast differences for every studied trait between both the locations.

Table 3: General means of yield and confectionery traits of the large-seeded Virginia genotypes at both locations

S N	Traits	Bikaner			Junagadh		
		Mean	Range		Mean	Range	
			Min	Max		Min	Max
1	Pod yield plant ⁻¹ (g)	45.7	10.0	63.0	4.5	1.8	6.8
2	Harvest Index (%)	51.4	31.0	68.9	30.6	20.6	37.8
3	Shelling outturn (%)	65.7	53.1	75.6	68.6	61.4	76.0
4	Pods plant ⁻¹ (No.)	41.4	15.0	64.0	5.0	3.1	7.3
5	100-kernel weight (g)	74.3	56.0	90.0	50.6	41.1	64.1
6	100-sound mature kernel	111.1	90.0	142.0	84.0	65.9	111.5
7	Sound mature kernels (%)	54.7	41.3	77.0	44.6	30.7	67.0
8	Oil content (%)	49.3	44.2	53.5	48.0	44.9	51.9
9	Protein content (%)	29.1	24.2	35.5	31.1	26.9	34.8
10	Sugar content (%)	4.2	3.1	5.6	4.7	3.8	5.7

Evaluation of Valencia and Spanish germplasm lines for yield and confectionery traits

This evaluation was done in two consequent *kharif* seasons in 2012 and 2013. On the basis of pooled analysis, among the Valencia germplasm lines high shelling outturn (>70%) was observed in NRCG 14379, NRCG 14335 and NRCG 14497, lowest and highest oil content produced in NRCG 14444 (46.8%) and NRCG 14468 (51.6%), respectively, highest and lowest protein produced in NRCG 14445 (32.4%) and NRCG 14468 (24.9%) respectively, and highest pod yield per hectare exhibited in NRCG 14452 (833kg). In Spanish germplasm lines highest shelling outturn recorded in NRCG 14324 (74.6%), shortest duration in NRCG 14425 (109 days).



**PROJECT 04 : BREEDING AND GENETIC STUDIES FOR NUTRIENT USE
EFFICIENCY IN GROUNDNUT**

(AJAY B.C., M.C. DAGLA, K.A. KALARIYA AND H.N. MEENA)

Hybridization, selection and generation advancement

In kharif, 2013 five crosses were attempted in field and three crosses in concrete blocks using NRCG 1308 (identified as P- efficient) as a donor. Five crosses involving NRCG 1308 are part of diallele experiment involving 15 crosses (five each from large seed, biotic and P-use efficiency trials) and were repeated for the second year during kharif 2013. Three crosses attempted in concrete blocks were rejected due to poor pod setting. On an average success rate under field condition was 32%.

Eight crosses effected during kharif 2012 were raised during summer 2013 and 94 true F_1 s were identified. Four crosses namely Girnar 3 $\times$ FDRS 10, TG 37A $\times$ FDRS 10, TG 37A $\times$ NRCG 7320 and TPG 41 $\times$ NRCG 7320 were advanced from F_1 to F_2 generation. These four crosses were raised in 41 rows of 5 meter each out of which 31 rows segregating for different characters were selected. Fifty-two elite genotypes were identified based on pods per plant from three crosses in F_2 generation. Two crosses namely Girnar 3 $\times$ FDRS 10 and TG 37A $\times$ FDRS 10 were advanced from F_2 to F_3 generations and eight elite genotypes were identified based on number of pods per plant. After harvest, the segregating generations were bulked through single seed descent (SSD) method. Eight crosses involving GG 20, TPG 41, TG 37A and Girnar 3 as female and FDRS 10 and NRCG 7320 as male were advanced from F_2 to F_3 generation by single seed descent method.

Generation advancement of elite breeding material

Elite breeding lines identified during summer 2013 were raised in individual progeny rows during kharif 2013 for generation advancement. In F_3 generation, out of 47 elite breeding lines sown, 18 lines were rejected on the basis of pod number and pod yield and 29 lines were selected. In F_4 generation, out of 13 lines sown, 5 lines were selected and harvested individually.

To study yield parameters in different generations under low-P conditions

Experiment was laid out to study the yield related traits under treatment having no external phosphorus application. Study involved five generations (P_1 , P_2 , F_1 , F_2 and F_3) of two cross viz. TG 37A $\times$ FDRS 10 and Girnar 3 $\times$ FDRS 10 (Table 3). In cross Girnar 3 $\times$ FDRS 10 pod yield in F_1 and F_2 generation ranged from 1.1 – 46.7 and 0.5 – 28.5; shelling per cent in F_1 and F_2 generation ranged from 19.2 – 86.0 and 25.6 – 86.7 respectively. 100 kernel weight in F_1 and F_2 generation ranged from 15.0 – 70.0 and 11.0 – 76.0. In cross TG 37A $\times$ FDRS 10 pod yield ranged from 3.1 –



21.4 and 3.9 – 21.2; shelling per cent ranged from respectively in F_1 and F_2 generation 38.5 – 70.9 and 48.5 – 74.7 and 100 kernel weight ranged from 10.5 – 43.1 and 24.8 – 43.9 respectively in F_1 and F_2 generations.

Screening of genotypes phosphorus uptake during summer 2013

Twenty-four genotypes were screened for P-uptake during summer 2013. Experiment consisted of threetreatments, (i) T_1 : Without any application of P, (ii) T_2 : application of P @ 50 kg ha⁻¹ and (iii) T_3 : Application of phosphorus @100 50 kg ha⁻¹. Nitrogen @ 50 kg ha⁻¹ and Potassium 60 kg ha⁻¹ were applied in all the three treatments. Analysis of variance indicated significant differences for genotypes, phosphorus levels and genotype × phosphorus interaction with respect to pod yield per plant, shelling per cent, 100 kernel weight (g) and shoot weight per plant (g) (Table 4). Root weight per plant (g) displayed significant differences for genotype and genotype × phosphorus levels interactions. Girnar 3 had high pod yield under T_1 whereas TG 37A recorded high yield under T_1 and T_2 . Genotype ICG 221 and FeESG 8 recorded high shoot weight under T_1 and T_3 respectively. Genotype NRCG 162 performed poorly for pod yield and root weight.

Screening of advanced breeding lines for phosphorus use efficiency

In Kharif-2013, 48 advanced breeding lines developed in plant breeding section were evaluated for phosphorus use efficiency in comparison to P-efficient genotypes reported in groundnut. 48 advanced breeding lines were evaluated in comparison to P-efficient (ICGV 86590 and SP 250A) and P-inefficient (NRCG 162 and NRCG 7320) genotypes used as checks under two phosphorous levels (i) With P and Nitrogen (50 kg ha⁻¹), Phosphorous (50 kg ha⁻¹) and Potassium (60 kg ha⁻¹) (T_1); (ii) Without P but with Nitrogen (50 kg ha⁻¹), Phosphorous (0 kg ha⁻¹) and Potassium (60 kg ha⁻¹) (T_2). Analysis of variance indicated significant genotypic differences for pod yield per plant, dry matter, shelling out turn and 100 seed weight. Overall genotypic performance reduced under low-P compared to normal-P for pod yield per plant, 100 seed weight and shelling out turn. Under low-P, performance of genotypes PBS 22080 and PBS 29017 were superior to best check (ICGV 86590) for pod yield. Among advanced breeding lines screened, PBS 29170, PBS 29171 and PBS 22088 had low pod yield under low-P and none of these were inferior to inferior-check NRCG 7320.



**PROJECT 05 : GERMPLASM MANAGEMENT OF CULTIVATED GROUNDNUT
 (*ARACHIS HYPOGAEA* L.) AND ITS WILD RELATIVES**

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

Field maintenance of wild *Arachis* germplasm

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

Acquisition and distribution of germplasm accessions

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

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

Distribution of germplasm

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

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

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

- general accessions (420),
- DGR mini-core collection (167),



- ICRISAT mini-Core collection (184),
- accessions repatriated from ICRISAT (431),
- released varieties (187),
- morphological variants (45)

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

Characterisation of germplasm

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

Reference collection for water-use efficiency

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

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



In *kharif* season, the accessions matured around 110 days, and the early (103 d) was being NRCG 12642 and the late maturing (123 d) being NRCG 14427. The pod yield of these accessions ranged as low as 1.5 g (NRCG 6064) to as high as 10.6 g (NRCG 12713). The range of HSM was from 20.0 g (NRCG 666) to 68.8 g (NRCG 5405). The shelling outturn ranged from 47.1% (NRCG 12736) to 82.5 (NRCG 2190). However, the seed weight of this accession NRCG 2190 was low (34.0 g/100 kernel). A high shelling outturn of >70% was observed in 36 accessions.

Large-seed accessions

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

Twenty-eight large-seed accessions belonging to the *ssp hypogaea* along with two check varieties were characterised for 17 descriptor traits in *kharif* 2013 in RBD with two replications. The days to maturity of these accessions ranged from 115 (NRCG 12131) to 124 days (NRCG 11977). Pod yield ranged from 2.4 g (NRCG 12083) to 13.6 g plant⁻¹ (NRCG 10059). HSM ranged from as low as 47.0 g (NRCG 11960) to 76.5 g (NRCG 12139). Twelve other accessions had hundred seed mass of 60 g and above. Shelling out-turn ranged from 58.3% (NRCG 11976) to 74.6% (NRCG 10059). One accession, NRCG 10059 was found promising for pod yield, and HSM.

Characterisation of Valencia accessions for table purpose

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



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

Identification of promising entries for quality traits

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

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

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

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



Screening of germplasm for tolerance of soil borne diseases (stem rot and collar rot) and nematodes

For tolerance to stem rot

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

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

For tolerance to collar rot (*Aspergillus niger*)

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

Tolerance to nematodes

A total of 776 accessions- 448 accessions at JAU Junagadh, and 318 accessions at Anand- were screened for over three years for tolerance of *M. arenaria* and *M. javanica* through All India Network Project on Nematodes (AINPN). At Junagadh, seven genotypes viz., NRCG 14424; JVB 2114; JSSP HPS 28; OG 953, OG 951, K 1274, KGN 33 were found resistant against *M. arenaria*. Eleven genotypes, ICGs 13048, 11187, 13006, 11206, 11429, 13120, OG 52-1, Somnath, Chitra, Kaushal and M 13 were found resistant against *M. javanica*.



PROJECT 06 : DEVELOPING TRANSGENIC RESISTANCE IN GROUNDNUT TO ABIOTIC STRESS AND VIRAL DISEASES

(RADHAKRISHNAN T., G.P. MISHRA, P.P. THIRUMALAISAMY, ABHAY KUMAR* AND M.V. NATARAJA) *On study leave

Genetic transformation

Generation advancement of transgenic events

The transgenic events which were in different generations were advanced so as to have event-wise bulk in uniformly in one generation. The following transgenic events were grown and bulked:

***Cry1F* transgenics**

- Seventy-two plants from three events were advanced to T2 generation
- Thirty-one plants from one event was advanced to T3 generation
- Seeds from 1049 plants from eight events in T3 generation were stored

***MtD* transgenics**

- Sixty-four plants from four events were advanced to T3 generation and 582 seeds stored
- Twenty-nine plants from four events were advanced to T4 generation and 203 seeds stored

***DREB1A* transgenics**

- Sixty-eight plants from 12 events were advanced to T2 generation and 144 seeds were stored

***TSV-CP+PBNVNC* (dual) transgenics**

- Two hundred and four plants from 8 events were advanced to T2 generation and 356 seeds were stored
- One hundred and eighteen plants from 2 events were advanced to T3 generation and 243 seeds were stored
- Fifty five plants from 4 events were advanced to T4 generation.

Deducing the flanking sequences of the transgene insertion

Since there were inconsistencies in the results from the Tail-PCR protocols used earlier, a new protocol of genome walking was adopted to determine the site of insertion of the



transgenes. The SPTA-PCR was conducted using 3 independent transgenic events of *mtlD*. The 8 fragments finally isolated after the HS-PCR and LS-PCR were cloned and sequenced. However, the results deviated from the expected sequences.

Southern-blot analysis

Southern blotting was initially optimized using transgenic tobacco containing *Annexin* gene (three events). The probe detection limit was also determined using different concentrations of purified *Annexin* gene PCR product. The analysis of the *mtlD* transgenic has shown single insertion in T2 and T3 generations. Single copy events were selected for further screening (Fig1)

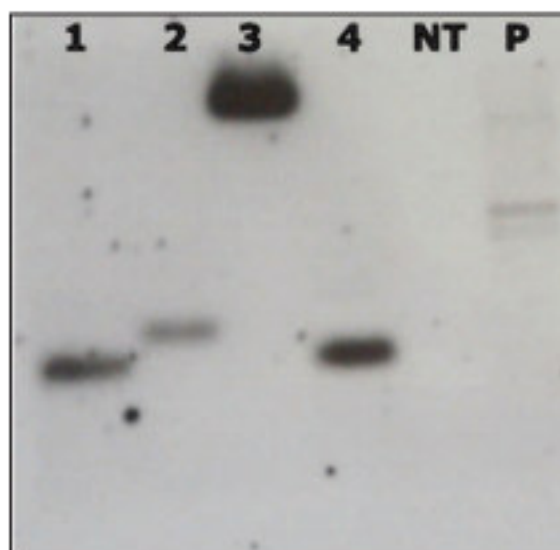


Fig 1. Genomic Southern analysis of *mtlD* transgenics. 1-4 transgenic events, NT non-transgenic plant DNA, P plasmid DNA.



**PROJECT 07 : DEVELOPMENT AND ASSOCIATION OF MOLECULAR MARKERS
FOR RESISTANCE TO BIOTIC STRESSES (FUNGAL-DISEASES) IN
GROUNDNUT**

(GYAN P. MISHRA, RADHAKRISHNAN T., A.L. RATHNAKUMAR, S.K.
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Parental polymorphism and genotyping of F_2 for mapping of foliar disease resistance gene(s)

Thirty-one SSR markers which have earlier been identified as linked to rust and LLS resistance gene(s) in groundnut by several researchers (Table 1) were used for marker validation. These were tested for parental polymorphism (on resistant *viz.* CS196, GPBD4 and susceptible GG20) and F_2 genotyping for the crosses (cross 1: GG20 x GPBD4 and cross 2: GG20 x CS196). Out of 31 SSRs, 12 primer pairs were found to be polymorphic between parent of cross 1 and 07 primers between the parent of cross 2. Genotyping was carried out using polymorphic primers PM137 and GM2301, and it was observed that all F_2 population of cross 1 and 2 were having genotype similar to that of female parent. This could be because of marker distortion, which needs further confirmation.

Table 1. List of SSR markers used known to be associated with LLS and/or rust diseases.

S. No.	MARKERS	No.	MARKERS	No.	MARKERS
1	IPAHM103	12	PM 137	23	seq4A05
2	GM 1536	13	PM 3	24	gi56931710
3	GM 2079	14	PMc 588	25	Ah4-26
4	GM 2301	15	seq2B10	26	GM1573
5	seq16F1	16	seq8E12	27	GM1009
6	seq17F6	17	seq8D9	28	GM2009
7	seq13A7	18	seq16C6	29	PM179
8	seq5D5	19	PM50	30	Ah4-24
9	seq3A1	20	seq2F5	31	TC11H06
10	PM 375	21	seq13A10		
11	PM 384	22	PM35		

Generation advancement of crosses and confirmation of F_2 using SSR markers

Two crosses were attempted during kharif 2013 with the objective to develop mapping population and also for the transfer of different fungal disease resistance genes through



backcrossing. The F_{1s} recovered for each cross were grown and identified using the molecular markers. For the crosses GJG17 x GPBD4 and GJG22 x ICGV86590 a total of 91 and 97 confirmed F_{1s} respectively, were obtained. These are grown to raise F_2 and for its further backcrossing with its respective recurrent parent. The details of the crosses attempted, traits, F_{1s} recovered and true F_{1s} identified were given in the Table 2.

Table 2. List of different crosses attempted and confirmed F_1 s based on marker data.

Crosses attempted	No of putative F_1 s recovered	Confirmed F_1 s (using markers)	Polymorphic markers	Remarks
GJG17 x GPBD4	245 seeds	91	IDT- 163, 833, 183, 651, 645, 1232, 1474, 1471	Tolerance to stem rot and foliar-fungal diseases
GJG22 x ICGV86590	310 seeds	97	IDT-1117, 89, 833, 645, 1471	Tolerance to Collar rot and foliar-fungal diseases

Genotyping of released varieties for foliar disease-resistance

A total of 174 released varieties were studied for the rust and LLS linked marker validation using SSR markers which are earlier identified by several workers as associated/linked to rust and LLS resistance gene(s) in groundnut. Bayesian clustering analyses using STRUCTURE v2.2 was done to infer the number of cluster (K) and the probability of individual assigned to each cluster. Although based on phenotypic data on foliar fungal disease (i.e. rust and LLS) the 174 varieties could be classified into three groups viz. resistant, moderate and susceptible ones but, STRUCTURE analysis revealed K=2 which means there are two major groups based on SSR marker analysis. Further data analysis for marker polymorphism and its association with disease resistance is under progress.

Development of novel EST derived SSR markers with functional relevance to biotic stresses

With an aim to develop novel and functional markers (EST derived SSRs) having relevance to biotic stress in peanut, publically available (178490) EST sequences of *Arachis hypogaea* L. were downloaded (November, 2013) from NCBI database and pre-processing was done by removing vector sequences expending Cross_Match. The ESTs were assembled by employing TGICL program to cut down sequence redundancy. A total of 16,468 unigenes were generated by TGICL program which included 13,429 contigs and 3039 singletons.

The assembled sequences were scanned by using Perl script MicroSatellite (MISA) for



identification of SSRs. MISA search for SSR revealed that total 2784 unigenes containing SSR sequences with 3373 number of SSRs. Total numbers of sequences having more than one SSR were 487 (17.4%), where as 289 (10.3%) sequences were found to possess SSRs in compound formation. The SSR containing sequences were subjected to Blast2GO analysis in order to identify tentative function of sequences. Results revealed that 72.8% sequences have functional annotation. Among the total SSRs, 657 SSRs (19.5%) belonged to class I (≥ 20 nts) while 2716 SSRs (80.5%) belonged to class (≥ 10 but < 20 nts).

SSR containing sequences having functional relevance to the biotic stresses were selected and utilized for development of EST-SSR primer pairs with the Primer3 program. As many as 2703 primer pairs were designed (*in silico*) and 81 primer pairs based on their functional relevance to biotic stress were selected for validation on 11 disease resistant and susceptible genotypes. A total of 81 EST-SSR primer pairs having functional relevance to biotic stress were validated on eight disease resistant (GPBD4, ICGV86590, JSP-39, ALR 2, R 2001-3, VG9506, CS85, CS319) and three susceptible (GG20, JL24, TG 37 A) genotypes, and seven primer-pairs displayed polymorphism within the genotypes, GPBD-4 (resistant) and GG-20 (susceptible). Present approach of mining data bases for the development of novel EST-SSR is cost effective and a reliable tool which adds to the genomic resources for groundnut. In future, all the newly developed markers will be validated for its amplification and polymorphism in different genotypes.



**PROJECT 08 : UTILIZATION OF WILD *ARACHIS* GENE POOLS FOR
GROUNDNUT IMPROVEMENT**

(S.K. BERA, CHUNILAL, P.P. THIRUMALAISAMI AND AJAY B.C.)

Initial evaluation of breeding lines for yield and resistance to stem rot disease

Stem rot caused by *Sclerotium rolfsii* is one of the major soil disease in groundnut and causes 30-40% yield loss. NRCGCS-19, an interspecific breeding line resistant to stem rot has been developed earlier at DGR. GG-20, an elite cultivar, susceptible to stem rot was hybridized with CS-19 to transfer the resistance into GG-20. The breeding lines developed using GG-20 and CS-19 were evaluated separately for yield and resistance to stem rot.

Evaluation for yield

A total of 208 breeding lines along with checks were sown in augmented design with four blocks. Each genotype was sown in one line of five meter bed during summer season. Observations on yield and related traits were recorded at harvest. Two breeding lines, 25-5-9 and 25-1-22 were found promising with significantly higher pod yield over the check. The experiment was repeated during rainy season and seven breeding lines 25-5-32sel, 25-5-32, 25-01-8, 25-02-21sel, 25-02-21, 25-01-12, 25-7-39 were found promising with significantly superior to check for pod yield. However, breeding lines 25-2-21 and 25-5-9 were found promising based on pooled analysis for both summer and rainy seasons.

Screening for resistance to stem rot

Two hundred and eighty breeding lines along with checks were screened for resistance to stem rot in sick soil under field conditions during summer season. Each line was sown in one line of five meter bed with replications following recommended management practices. Inoculums were added in the soil at regular intervals to maintain optimum disease pressure throughout the crop stages. Plant population was recorded prior to adding inoculums and at the time of harvest. Pod infection was recorded at harvest. Among the RILs, mortality ranged from 0 to 33% while pod infection from 0 to 100%. RIL 25-5-31 was found promising with low mortality along with low pod infection.

The screening was repeated in sick soil under pot conditions during rainy season. Each line was sown in two replications maintaining 10 plants in each replication. Inoculums were added in the soil at regular intervals to maintain optimum disease pressure throughout the crop stages. Plant population was recorded prior to adding inoculums and at the time of harvest. Pod infection was recorded at harvest. Mortality ranged from 0 to 65%, while pod infection ranged from 0 to 100% among RILs. However, wide variations observed in mortality and pod infection across



replications, indicated poor reproducibility of the screening technique adopted. Similarly, wide variations were also observed between lines and seasons.

In a separate experiment, 402 lines were evaluated in augmented design with four blocks during rainy 2012 and 2013 seasons. Breeding lines developed for increased resistance to stem rot using various resistant sources viz, OG-52-1, ICGV-86590, CS-19. Each line was sown in single line of five meter bed following recommended crop management practice. Based on pooled analysis, 33 out of 402 lines were found significantly superior to checks for pod yield. Performance of these lines will be further confirmed.

Advanced screening of interspecific breeding lines for resistance to stem rot

Based on screening of 286 interspecific breeding lines for resistance to stem rot under taken during rainy and summer seasons from 2005 to 2008, 42 lines were found promising. Disease incidence was higher during rainy season compared to summer season. Further confirmation of these 42 promising lines for resistance to stem rot was carried out in concrete block with sick soil under field conditions and earthen pot with sick soil under laboratory conditions. Interspecific lines NRCGCS-131, NRCGCS-99, NRCGCS-47 and NRCGCS-319 were found promising against stem rot during early stages and later stages of crop growth. The interspecific line NRCGCS-319 was found most stable one with comparatively lower pooled disease incidence over concrete block and laboratory conditions.

Characterization of breeding lines for tolerance to water deficit stress

Drought is one of the major abiotic stresses limiting the groundnut productivity worldwide. The available germplasm has been characterized for tolerance to drought and the genotypes TMV2NLM and NRCG-4747 have been reported as tolerant and susceptible to water deficit stress, respectively. The genotype NRCG-4747 was hybridized with TMV2NLM and 67 F₃ single plant progenies along with two parents were characterized for yield and water deficit traits during rainy season. Evaluation was done in RBD with three replications. Each line was sown in one line of five meter bed and observations were recorded in 65 days after sowing and at harvest. Transgressive segregants with significantly higher biological yield, pod yield, harvest index, hundred kernel mass, SPAD chlorophyll meter reading and specific leaf area over best parents were observed.

Advanced evaluation of breeding lines with high hundred seed mass

Mutants developed from an interspecific pre-breeding line with high seed mass were evaluated during summer. Thirty-three mutants along with three checks were evaluated in RBD with three replications. Each genotype was sown in one line of five meter with 45 cm spacing between the



lines. Observations on yield and related traits were recorded at harvest. Among the checks, TAG 24 recorded highest pod yield (126 g/10 plants). None of the mutants were found significantly superior in pod yield over the best check TAG-24. However, 11 mutant lines recorded significantly higher hundred seed mass (HSM) than best check TPG-41. The experiment was repeated in the rainy season. A total of five lines 281-21/1 (VR), 281-21/3 (VB), 281-40/1 (VR), 281-21/2 (SB) and 281-40/2 (VR) recorded significantly higher pod yield over the checks. These lines could be more adapted to rainfed conditions rather irrigated conditions. However, no genotypes could significantly out yield the checks based on pooled analysis of summer and rainy seasons. Thus mutants need to be evaluated for one additional year under rainfed conditions.

Screening of interspecific breeding lines for resistance to rust and late leaf spot

Segregating progenies (F_{5-6}) developed from the cross J11 x *A. pusilla* were evaluated for resistance to rust and late leaf spot at Aliyarnagar, a natural hot spot for these two diseases during rainy season. Hundred and forty-six lines along with checks were sown in single line of five meter. Susceptible checks (TMV 2, Co 2 and JL-24) recorded maximum incidence of diseases (rust score: 7-8 and LLS score: 8-9) while resistant checks (GPBD4, VRI(Gn)6 and ALG-06-320) recorded minimum incidence of diseases (rust score: 0-2 and LLS score: 0-2) in 0-9 standard disease scale. Interspecific line NRCGCS-574 was found promising for resistance to both rust and LLS with score of zero and two respectively.

Study of genetic polymorphism

- i. The genotypes NRCG4747 - susceptible to drought, and TMV2NLM- tolerant to drought, were screened with 110 SSRs. Out of which 21 SSRs were found polymorphic between two genotypes. Sixty-nine single plant progenies developed using NRCG-4747 and TMV2NLM are to be screened with polymorphic primers.
- ii. The genotypes JL-24 - susceptible to PBNB and NRCGCS-86 -resistant to PBNB were screened with 500 SSRs. Out of which 101 SSRs were found polymorphic between two genotypes and 350 single plant progenies developed using JL-24 and NRCGCS-86 are to be screened further with polymorphic primers.

Hybridization:

Hybridization for six different crosses was attempted during rainy season (table 1). Maximum number of pollination was made for the cross GG-20 x NRCGCS-319, from which 111 probable cross-pods were harvested. Lowest number of probable cross pods was harvested from 391 pollinations made for the cross combination GG-20 X (J11X *A. kemf-mercadoi*). These probable cross pods will be sown during summer season for selection of true hybrids and generation advancement.



Table 1 : Details of cross combination, number of bud pollinated and probable cross pods harvested during rainy season

Cross combination	Pollination made	Putative cross pod harvested	No of kernels
GG-20 x NRCGCS-319	800	111	131
GG-20 x CS-19	762	113	140
GG-20 X (J11X <i>A. kemf-mercadoi</i>)	391	54	66
JL24 x NRCGCS-85	422	113	157
NRCG4747 x TMV2NLM	354	95	130
ICGV-06100 x (ICGV-06100 x SunOleic95R BC ₂ F ₁)	712	105	111

Seed multiplication

- i. Seeds of 34 wild *Arachis* species, 70 interspecific breeding lines resistant to multiple diseases, 584 interspecific breeding lines, 36 genetic stocks were multiplied and maintained for further use in breeding programme.
- ii. Seed of 16 promising advanced interspecific breeding lines (NRCGCS-425, NRCGCS-264, NRCGCS-401, NRCGCS-253, NRCGCS-369, NRCGCS-298, NRCGCS-240, NRCGCS-363, NRCGCS-332, NRCGCS-287, NRCGCS-291, NRCGCS-349, NRCGCS-280, NRCGCS-305, NRCGCS-414, NRCGCS-435, NRCGCS-264, NRCGCS-240, NRCGCS-349) were multiplied both in summer and rainy seasons for AICRPG testing.



PROJECT 09 : DEVELOPMENT OF MANAGEMENT MODULE FOR SOIL BORNE DISEASES OF GROUNDNUT

(RAM DUTTA, A. L. RATHNAKUMAR, P.P. THIRUMALAISAMY AND K.S. JADON)

Screening of genotypes for resistance to stem rot, rust, ELS and LLS (*kharif-13*)

The experiment was conducted in length row of one meter with two replications. Altogether, ninety-nine interspecific genotypes were screened for resistance stem rot disease. However, observation on leaf spots (early and late) and rust were also recorded. The highest (90%) germination was recorded with CS-16 followed by 80% in CS-29. However, the germination was very less (37.5%) in CS-70. As far as the yield is in concern, the maximum yield of 30.00 g (pod yield) was recorded from one meter length row with CS-05, followed by 29.3 g with CS-82 and CS-74 (28.00 g), the minimum pod yield (7.50 g) was recorded with CS-04.

Stem rot: The stem rot could not be noticed in three genotypes namely CS-26, CS-42, CS-116. Whereas, the disease was recorded with minimum disease incidence (3.1 %) with CS-110 followed by CS-16 (3.6%) at par with CS-30, CS-81. Genotype CS-111 was recorded with 4.2% stem rot followed by CS-41 and CS-117 with 4.5%. Four genotypes, namely CS-55, CS-67, CS-75 and CS-114 were recorded with 5.0% disease. Another, 17 genotypes were recorded the disease ranging from 5.6 to 9.7%. However, the highest disease incidence (73.1%) was recorded with CS-91.

Rust: The minimum rust with rating 3.0 (of 1-9 rating) was recorded with CS-113 followed by CS-59 having disease rating of 4.0, whereas CS-30 and CS-111 could be rated at 5.5 (in 1-9 rating). However, the maximum disease rating of 8.0 was recorded with 16 genotypes including check GG-2.

Early Leaf Spot: Minimum (4.0 of 1-9 rating) early leaf spot was observed in CS-59 at par with CS-113 followed by CS-42 which was recorded with rating 5.0. However, the highest disease rating (7.5) in CS-117, which was above to check variety GG-2 (recorded 7.0 rating).

Late Leaf Spot: The minimum (2.0 of 1-9 rating) late leaf spot was recorded with CS-113 followed by 2.5 rating with CS-106, CS-120, CS-132, and 3.0 in CS-32, CS-33, CS-45, CS-59, CS-60, CS-62, CS-67, CS-71, CS-98, CS-111 and CS-116. Twenty-seven genotypes were recorded with moderate rating of 3.5, whereas 13 genotypes were recorded with disease rating of 4.0, another 13 genotypes were recorded with rating 4.5. However, rests of the genotypes recorded more than 5.0 rating (in 1-9 rating scale) and were not fit.



Efficacy of *Trichoderma* species/isolates on groundnut disease management.

The *in-vitro* bio-efficacy of eleven *Trichoderma* spp./isolates, namely *T. viride*, *T. harzianum* S1, *T. koningiopsis*, *T. brevicompactum*, *T. longibrachiatum*, *T. virens*, *T. saturnisporium*, *T. harzianum* S2, *T. asperellum*, *T. harzianum* T170, *T. viride* DH was tested against four foliar pathogens i.e. *Sclerotium rolfsii*, *Aspergillus niger*, *A. flavus* and *Alternaria* spp.

- Monoculture of *Sclerotium rolfsii*, *Aspergillus niger* and *A. flavus*, were recorded an average radial growth of 8.4 cm, 8.0 cm and 7.2 cm respectively at 3 days (72 hrs) whereas, *Alternaria* sp. took 8 days (192 hrs) for radial growth of 8 cm. In the dual culture plates, interaction of *Alternaria* sp. – *Trichoderma* sp. occurred 5 days after inoculation whereas in *S. rolfsii* - *Trichoderma* sp., interaction occurred 3-4 days after inoculation, and in *A. niger* and *A. flavus* - *Trichoderma* sp., interaction occurred 2-3 days after inoculation. The growth inhibition (%) of pathogens by *Trichoderma* sp. was recorded highest in *Alternaria* sp. (79.6%) followed by *S. rolfsii* (65.9%), *A. niger* (38.9%) and *A. flavus* (37.1%).
- In case of *A. niger*, the highest inhibition was achieved in dual culture with *T. viride* (38.9%) followed by *T. asperellum* (38.0%) however, the minimum inhibition was recorded with *T. longibrachiatum* (16.3%). The strain, *T. saturnisporium* recorded highest inhibition (37.1%) of *A. flavus* followed by *T. longibrachiatum* (36.7%). However, the minimum inhibition was observed in dual culture of *T. koningiopsi* - *A. flavus* (17.2%).
- In case of *S. rolfsii*, the highest inhibition was observed with *T. viride* DH (65.9%) followed by *T. asperellum* (64.8%) however, the minimum inhibition was recorded with *T. harzianum* S1 (42.0%).
- In case of *Alternaria* sp., the highest inhibition was recorded with *T. longibrachiatum* (79.6%) followed by *T. saturnisporium* (79.2%), and the minimum inhibition was recorded by *T. brevicompactum* (63.9%). Mustafa et al. (2009) reported that the highest inhibition of *A. alternata* by *T. longibrachiatum* (50.7%). The strain, *T. asperellum* achieved highest mean radial growth inhibition (52.1%) in all the four pathogens followed by *T. saturnisporium* (50.6%) however, the minimum inhibition was observed with *T. koningiopsis* (37.6%).

Morphological characterization of *Trichoderma* species

Morphological characterization of nine species of *Trichoderma* namely, *T. viride*, *T. harzianum* S1, *T. koningiopsis*, *T. brevicompactum*, *T. longibrachiatum*, *T. virens*, *T. saturnisporium*, *T. harzianum* S2, *T. asperellum* was carried out.



- The radial growth was high (90 mm after 72 hrs. at 29°C) in *T. harzianum* S1, *T. longibrachiatum*, *T. virens*, *T. saturnisporium*, *T. harzianum* S2 and *T. asperellum*. The slow growth was recorded in *T. viride* (18 mm after 72 hrs. at 29°C).
- Yellow pigmentation was observed in *T. harzianum* S1, *T. longibrachiatum*, *T. virens*, *T. saturnisporium* and *T. harzianum* S2.
- Microscopic examination showed that size of conidia, conidiophores and phialide were within range of reference isolates. Some *Trichoderma* spp. showed little variation with reference which may possible because of temperature and media variation. Variations were observed in conidia, phialide and conidiophores.

Effect of *Trichoderma* spp./strains on growth of groundnut and management of groundnut diseases (pot experiment in kharif-13)

A pot experiment on effect of *Trichoderma* spp./strains on growth of groundnut and management of groundnut diseases was carried out with seven *Trichoderma* spp./ strains namely, *T. harzianum* S1, *T. koningiopsis*, *T. brevicompactum*, *T. longibrachiatum*, *T. virens*, *Trichoderma* T-170, *Trichoderma*-Dharwad. Seeds soaked in tap water served as control and dry seeds sown served as absolute control. Fifteen seeds were soaked for 15.30 hrs. using 20 ml *Trichoderma* suspension (made out of Jaggery Medium) of each species/ isolate. Soil drench application of 50 ml *Trichoderma* suspension of each species/ isolate was given for each pot after one month of crop. The data revealed that:

- *T. longibrachiatum* was found effective in managing foliar diseases viz. early leaf spot (disease rating 3.0), late leaf spot (4.0) and rust (4.33), where the minimum disease rating was observed.
- *Trichoderma brevicompactum* was found producing maximum shoot length (38.0 cm) and number (2.3) of secondary branches. However, the maximum (13.3 cm) root length and number (6) of branches/ plant were produced by *Trichoderma*-Dharward isolate)



PROJECT 10: MANAGEMENT OF PATHOGENS IN GROUNDNUT

(KULDEEP SINGH JADON, P.P. THIRUMALAISAMY, RAM DUTTA
AND PRASANNAHOLLAJER)

Screening of genotypes for *Sclerotium* stem rot

Among forty interspecific genotypes screened for resistance to stem rot (*Sclerotium rolfsii*) in summer 2013, the disease incidence was low (below 20%) in CS 405, 407, 428, 434, 364 and 377 and above 80% in CS 403, 415, 416 and 422. Among forty interspecific genotypes screened for resistance to collar rot (*Aspergillus niger*) in summer 2013, the disease incidence was low (below 20%) in CS 405, 413, 414 and 417 and high incidence was recorded in CS 402 (54.6%).

Among forty-nine PBS genotypes screened for resistance to stem rot (*Sclerotium rolfsii*) in summer 2013, the disease incidence (18%-58%) was lower in PBS-18057 (18%) genotype whereas disease incidence was higher in PBS-22065 (58%). The same PBS genotypes also screened for resistance to stem rot (*Sclerotium rolfsii*) and foliar diseases in *kharif* 2013, the disease incidence (stem rot) was low (below 15%) in PBS-18029, 12163, 18033, 18064, 22062, 12067, 13022, 18045, 12167, 12116, 18004, 18038, 18055, 12029, 12172, 12186, 12169, 13003, 22065, 12032, 22059, 18057, 18006, 12038, 12175, 12181, 12183, 12185 and 22066 whereas 45% disease incidence was recorded in check variety GG 20. The leaf spot (ELS and LLS) severity was low (below 5 in 1-9 rating scale) in PBS-12032, 12066, 12038 and 12067, and above 7 in PBS-12181 and 12183, whereas severity of rust was low (below 5 in 1-9 rating scale) in PBS-12032, 18064, 18062, 12066, 12067, 12038 and 13003 and above 7 in PBS-12185, 13022, 18038, 18055, 13021 and 18006.

Management of *Sclerotium* stem rot disease using bio-agents

For the management of *Sclerotium* stem rot, isolates of *Trichoderma* (T-170 and Dharwad), *Pseudomonas* (DGR and TNAU- Pf-1) and there combinations were used. Incidence of stem rot was recorded in the range of 17.4% to 28.3% and 3.2% to 6.7% in summer and *kharif* experiments respectively.

Effect of tillage and cultural practices for management of *Sclerotium* stem rot

Among different tillage (harrow, cultivator, mouldboard and disc) and cultural practices (soil solarisation, and sowing in flat bed and raised bed), the disease incidence was less in soil solarization (4.2%) using transparent polythene sheets compared to control (9.5%) in summer,



whereas in *kharif* the lowest disease incidence was recorded in the mouldboard plough (2.3%) and disc plough (2.2%) compared to sowing in furrows (3.4%).

Management of foliar diseases in groundnut using fungicides

Among fifteen fungicides used to manage foliar diseases in summer 2013, the lowest severity of *Alternaria* blight (4.3) was recorded using modified 1-9 scale in two spray of tebuconazole 50% + trifloxystrobin 25% @ 0.01% (Nativo) at 45 & 60 DAS. Similar efficiency in reducing severity of diseases was recorded in pyraclostrobin 5% + metiram 55% @ 0.98% (CabrioTM). Whereas, disease severity of *Alternaria* blight in control was 7.3. Among fifteen fungicides used to manage the leaf spots (early and late) and rust in *kharif* 2013, the lowest severity of leaf spots (5.5) and rust (7.3) was recorded using modified 1-9 scale in two spray of difenoconazole @ 0.025% at 45 & 60 DAS. Similar efficiency in reducing severity of diseases was recorded in tebuconazole @ 0.15% (leaf spots 6.3 and rust 7.5). Whereas, disease severity of leaf spots and rust in control was 8.0 and 7.8, respectively.

Survey of major soil borne, foliar and *Alternaria* leaf diseases of groundnut in the major groundnut producing states of India

The survey of major diseases in groundnut was carried out in Gujarat (districts: Junagadh, Rajkot, Amreli, Porbander and Jamnagar), Andhra Pradesh (districts: Kadiri and Anantapur) and Tamil Nadu (districts: Pollachi, Tirupur and Erode) in summer 2013. *Alternaria* leaf blight was observed in all the surveyed area. Leaf spots and rust were present in the range of 3-7 in 1-9 scale at Pollachi and Tirupur districts and leaf spots (3-5 in 1-9 scale) alone present on groundnut at Erode district. Groundnut bud necrosis disease was present in farmers' field at Junagadh, Jamnagar, Rajkot and Amreli (2-16%) and at Kadiri and Anantapur (24-43%). In Kadiri and Anantapur, groundnut stem necrosis disease was present in the range of 18-38%. The incidence of dry root rot was 12-34% at Kadiri, and Anantapur and 4-18% at Pollachi. Stem rot and collar rot were present in most of the fields, with low incidence (below 10%).



PROJECT II : DEVELOPMENT OF PRACTICES FOR MANAGEMENT OF AFLATOXIN CONTAMINATION IN GROUNDNUT

(P.P. THIRUMALAIKAMY, K.S. JADON AND AJOY SAHA)

Effect of crop rotation on aflataxin contamination in groundnut kernels

Population of *A. flavus* in soil, infection on pods and kernels, and aflataxin contamination in kernels were estimated in a rotation system of *kharif* groundnut with maize, sorghum, groundnut and fallow in summer.

Table 1. Effect of crop rotation on aflatoxin contamination

Variety	Treatment	Season						
		Summer 2013				<i>Kharif</i> 2013		
		Population of <i>A. flavus</i> ($\times 10^3$ cfu/g soil)		Seed infection (%)	Aflatoxin content (ppb)	Population of <i>A. flavus</i> ($\times 10^3$ cfu/g soil)		Seed infection (%)
		Before sowing	At harvesting			Before sowing	At harvesting	
TG 37	Maize	9.5	8.0	-	-	4.0	3.3	18.0
	Sorghum	6.3	8.2	-	-	4.0	7.0	22.0
	Fallow	7.0	6.7	-	-	4.0	4.3	7.0
	Groundnut	10.8	5.5	2.0	30.0	3.0	3.7	32.0

In summer, the population of *A. flavus* was smaller in soil at harvest compared to that of before sowing. The population of *A. flavus* was smaller prior to sowing than that recorded after harvest in *kharif*. The decrease in soil population of *A. flavus* in summer could be attributed to rise in soil temperature and rotation of groundnut with non-host crops. Infection of *A. flavus* on pods was higher than on kernels irrespective of the season. The aflatoxin contamination in kernels varied widely among the samples and the treatments (crops for rotation or fallow). In general, although rotation with crops or fallow reduced the population of *A. flavus* in soil, level of aflatoxin contamination in kernel was variable.

Aflatoxin contamination in stripped and gleaned pods

Freshly stripped and gleaned pods were collected from farmers field in *kharif* 2013 for analysis of aflatoxin contamination in groundnut kernels. Aflatoxin contamination was detected (1ppb and above) in all the gleaned pod samples and 48% of freshly harvested samples. Above 4ppb was detected in 66.7% gleaned pod samples and 3.7% in freshly harvested samples. Maximum contamination of aflatoxin was 23ppb and 6ppb in gleaned pods and freshly harvested pods, respectively.



Determination of moisture content for safe storage

Pods and kernels stored in ambient temperature (27-32°C) at moisture content $\geq 8.6\%$ and $\geq 7.1\%$ favours the growth of *A. flavus*.

Effect of salts on growth of *Aspergillus flavus* and aflatoxin contamination

Adding of common salt (15%) or rock salt (10%) on stored pods adversely affected the germination of spores and also growth of colonies. Baking soda, however, proved to be equally effective even at much lower a concentration (2%).

S. No.	Place of collection	Aflatoxin contamination (ppb)	
		Stripped pods	Gleaned pods
1.	Junagadh	0	9
		1	9
		0	10
		2	4
2.	Vadal, Junagadh	0	8
		0	6
		1	1
		3	4
3.	Khambha, Lodhika, Rajkot	3	22
		0	18
		0	18
		0	23
4.	Chibhda, Lodhika, Rajkot	0	2
		2	2
		1	2
		2	2
5.	Jetalsar, Junagadh	6	3
		0	3
		0	3
		2	3
6.	Lodhika, Rajkot	0	9
		0	11
		0	12
		0	9
		2	12
		1	13
		3	5

Table 3. Aflatoxin contamination in freshly stripped and gleaned pods

S. No.	Details	Stripped pods	Gleaned pods
1	Samples got aflatoxin contamination	48%	100%
2	Samples got above 4ppb	3.7%	66.7%
3	Maximum level of aflatoxin contamination	6 ppb	23%



PROJECT 12: DEVELOPMENT OF TECHNOLOGY FOR MANAGEMENT OF STORAGE PESTS OF GROUNDNUT

(NATARAJA, M.V., POONAM JASROTIA AND HARISH, G.*)

*On study leave w.e.f. 5th August, 2013**Effect of essential oils on bruchid beetle incidence in stored groundnut (Kharif, 2013)**

Four essential oils (castor, eucalyptus, neem and pongamia) were evaluated for their bio-efficacy against bruchid beetle, *C. serratus* under storage conditions at two different doses (5 and 10 % v/w). The lowest numbers of eggs (2.3 per 100 g pods) were laid in treatment with neem oil 10% (v/w). The treatment was at par with castor oil 10% (v/w) (2.5 eggs per 100 g pods) and significantly superior over untreated control (68.2 eggs per 100 g pods). There was no adult emergence in the groundnut pods treated with castor oil, eucalyptus oil, neem oil and pongamia oil at 10% (v/w) concentration. Groundnut pods treated with castor oil, eucalyptus oil, neem oil and pongamia oil at 10% (v/w) and neem oil at 5% (v/w) concentrations recorded no damage to pods and kernels.

Screening of groundnut genotypes for bruchid beetle (Kharif, 2013)

Ten groundnut genotypes were screened for resistance to bruchids. There were no significant differences in egg laying capacity and emergence rate of adult beetles, and also in the per cent damage caused to kernels by beetles. However, variety Girnar-2 exhibited lowest pod (57.9%) and kernel damage (64.5%) as compared to other genotypes.

Screening groundnut genotypes against bruchid (Rabi-summer, 2014)

The groundnut genotypes (eight) grown under different doses of phosphorous fertilization were screened for resistance to bruchids. The genotype, NRCG 1308 was observed to have lowest number of eggs laid (13.5) and adults emerged (10.0). The damage (%) and weight loss (%) observed on both the pods and kernels were non-significant.



PROJECT 13 : MANAGEMENT OF INSECT-PESTS OF GROUNDNUT

(POONAM JASROTIA, PRASANNA HOLAJJER AND NATARAJA M.V.)

Bio-efficacy of insecticide combinations against sucking groundnut pests (*Kharif*, 2013)

After first spray, the standard check, monocrotophos @ 0.04% at 30 & 45 DAG had lowest number (4.8 hoppers/5 sweeps) of hoppers followed by treatment acephate 25% + fenvalerate 3% @ 0.028% at 30 DAG (5.1 hoppers/5 sweeps). Both the treatments were at par with each other in reducing the leafhopper population. The treatment of acephate 25% + fenvalerate 3% @ 0.028% at 30 DAG and 45 DAG (4.7 hoppers/5 sweeps) proved to be most effective after second spray followed by monocrotophos @ 0.04% at 30 & 45 DAG (5.3 hoppers/5 sweeps) in managing the leafhopper population. The same two treatments were found to be effective in reducing thrips populations. There were significant differences among treatments means for pod yield, however the highest yield (1645.7 kg ha⁻¹) was recorded in treatment, quinolphos 28.5% + cypermethrin 1% @ 0.31% at 30 & 45 DAG and lowest in treatment, chlorpyrifos 50% + cypermethrin 5% @ 0.055% at 30 DAG.

Evaluation of bio-pesticides against insect pests of groundnut (*Kharif*, 2013)

Three bio-pesticides were tested for their efficacy in managing sucking pests (leafhopper and thrips) of groundnut during *Kharif*-2013. After the first spray the treatment, Azadirachtin 1.5% @ 2.5 ml/L was proved to be least effective (15.2 hoppers/ 5 sweeps) treatment in managing leafhopper population while after second spray, Ponneem @ 6ml/L became the least effective (15.5 hoppers/5 sweeps) treatment in checking hopper population. The most effective treatment was of monocrotophos 36 SL @ 1.2ml/L and recorded population of 4.5 hoppers/5 sweeps and 5.4 hoppers/5 sweeps after first and second spray, respectively. The treatment, Ponneem @ 2ml/L recorded maximum number of thrips (4.2/5 sweeps) as compared to Azadirachtin 1.5% @ 7.5 ml/L treatment which recorded the lowest number of thrips (2.1/ 5 sweeps) after second spray. The highest (2966 kg ha⁻¹) yield was recorded in treatment Azadirachtin 1.5% @ 7.5 ml/L.

Survey of viral diseases in Andhra Pradesh and Karnataka

A survey was conducted in areas around Kadiri, Andhra Pradesh and Raichur, Karnataka to determine the disease incidence of viral diseases. In areas around Kadiri, the incidence of Peanut



Stem Necrosis Disease (PSND) ranged from 2-8% while peanut bud necrosis disease (PBND) incidence was only 2%. The incidence of PBND in Raichur, Koppal and Lingasugur areas varied from 5-40, 10-15 and 5-8%, respectively. The thrips species were collected from these areas and sent for identification.

Collection and identification of thrips from groundnut fields in Saurashtra region of Gujarat (Kharif, 2013)

The thrips specimens collected from groundnut ecosystems of Junagadh comprised of *Caliothrips indicus*, *Megalurothrips usitatus*, *Scirtothrips dorsalis* and *Anaphothrips sudanensis*.

Evaluation of bio-pesticides against insect pests of groundnut (Rabi-summer, 2014)

Three bio-pesticides were tested for their efficacy in managing sucking pests (leafhopper and thrips) of groundnut during Rabi-summer, 2014. The treatments were imposed (1st and 2nd sprays), observations were recorded on insect populations. The post-harvest observations are yet to be recorded.

Impact of N and K fertilization on insect-pests of groundnut (Rabi-summer, 2014)

Experiment was carried out in split-plot design to evaluate the impact of three levels of N and K fertilizations on insect-pests of groundnut during Rabi-summer, 2014. The layout was designed; treatments imposed and weekly observations on insect-pests were recorded by using the yellow and blue sticky traps. The post-harvest observations are yet to be recorded.



**PROJECT 14: STUDIES ON NEMATODES ASSOCIATED WITH PLANT AND INSECTS IN
GROUNDNUT ECO-SYSTEM**

(PRASANNAHOLAJER, RINKU DEY AND POONAM JASROTIA)

**Evaluation of plant growth promoting rhizobacteria for their bio-nematicidal potential against
peanut root-knot nematode, *Meloidogyne arenaria***

In vitro study was undertaken to evaluate eighteen strains of fluorescent pseudomonads for their nematicidal potential against peanut root-knot nematode, *Meloidogyne arenaria*. Cell-free filtrate was obtained by passing supernatant of four-day-old culture through Millipore filter of 0.22µm. Percent mortality of *M. arenaria* (J2) was calculated by exposing infective juveniles (J2) of *M. arenaria* (J2) to undiluted cell-free filtrate (100%) and its dilutions of 75% and 50% for a period of 24h, 48h and 72h. Significant differences in mortality were observed after an exposure period of 24h, 48h and 72h in all the concentrations of cell-free filtrate as compared to medium (control) and water (control). The study inferred that mortality was directly related to concentration of cell-free filtrate and exposure period indicating that with increase in concentration, there was a corresponding increase in percent mortality. After 72h exposure period at 100% concentration, five strains (Pf1, Pf3, Pf5, Pf6 and Pf7) caused percent mortality in the range of 81.5 to 87.4 with highest in Pf3, three strains (Pf4, Pf12 and Pf14) caused percent mortality in the range of 60.0 to 67.7, nine strains (Pf2, Pf8, Pf10, Pf11, Pf13, Pf15, Pf16, Pf17 and Pf18) caused percent mortality in the range of 40.2 to 54.5 and stains Pf9 caused 34.8% mortality in *M. arenaria* (J2).

Evaluation of selected PGPRs on nematode egg hatching

Effect of cell-free filtrate (100%) of four strains (Pf1, Pf3, Pf5 and Pf7) of fluorescent pseudomonads on hatching of peanut root-knot nematode, *Meloidogyne arenaria* revealed significant inhibition in hatching in cell-free filtrate of all four strains as compared to medium (Control) and water (Control). The cumulative percent hatching of *M. arenaria* in cell-free filtrate was slow and gradual during the entire period of incubation. Only 24.6, 18.1, 17.9 and 23.6% of the J2 hatched up to day 12, in Pf1, Pf3, Pf5 and Pf7 strains respectively, compared to 67.1% in medium (Control) and 87.7% in water (Control).

Isolation of entomopathogenic nematodes from groundnut production system

Entomopathogenic nematodes were recovered directly from the soil using a *Galleria*-trap technique. Ten soil samples were collected from groundnut field. Each samples consisting of 500cc soil. Five last instar larvae of *Galleria mellonella* (Lepidoptera, Galleriidae) were kept in soil and left for one week before removal. After one week, dead larvae were removed and placed into white traps to collect



emerging infective juveniles of entomopathogenic nematodes. Infective juvenile nematodes were collected after their emergence from the insects. Among the ten samples, two soil samples contained entomopathogenic nematodes.

Evaluation of entomopathogenic nematodes on *Spodoptera litura* - a major pest of groundnut

Infectivity of entomopathogenic nematodes *Heterorhabditis* spp against tobacco caterpillar, *Spodoptera litura* was studied in the laboratory. The 3rd instar larvae of *S. litura* were exposed to infective juveniles (IJs) *Heterorhabditis* spp. @ 2, 5, 10, 20 and 40 IJs cm⁻² under laboratory condition. Significant increase in mortality of *S. litura* with increase in IJs concentration was observed. The *Heterorhabditis* spp caused 28% larval mortality at 2 IJs/cm⁻², which increased to 100% mortality at 20 IJs/cm⁻² after 96 h exposure period in 3rd instar larvae of *S. litura*.

Effect of plant growth promoting rhizobacteria on nematode penetration.

Effect of two strains (Pf1 and Pf3) of fluorescent pseudomonads on nematode penetration in groundnut was studied. The cups (200 cm³) filled with sterilised soil drenched with 5 ml suspension (Pf1 and Pf3) at a concentration of 3×10^8 cfu/ml and control received water only. The peanut root-knot nematodes were inoculated @ 2 J2/cc soil. The plants were harvested 15 days after sowing and root systems were evaluated for numbers of juveniles (J2) in roots. The Pf1 and Pf3 strains of fluorescent pseudomonads inhibited the peanut root-knot nematode, *M. arenaria* penetration in groundnut roots by 41 % and 36 % respectively.



PROJECT 15: INFLUENCE OF ABIOTIC AND BIOTIC STRESSES ON METABOLOMES OF GROUNDNUT

(M.K. MAHATMA, K.S. JADON, POONAM JASROTIA, ANITA MANN AND AJOY SAHA)

Sugar profiles and enzyme activities of groundnut genotypes during stem rot infection

Groundnut genotypes showing high (GG 20 and TG 37A) moderate (JSP 39) and low disease incidence (CS 319 and CS 19) were grown in three sets during both summer and *kharif* season under greenhouse condition. One set kept as control and another two were infected by *Sclerotium rolfsii* at 30 and 60 days after sowing (DAS). Sugars were extracted from both infected and non-infected stems at 24, 28 and 96 hours after infection (h.a.i.) and analysed by Ion chromatography (Fig.1). Results showed that glucose content increased in infected stem of CS 319 and CS 19 as compared to non-infected stems at 30DAS (48 h.a.i.) (60 DAS (24 h.a.i.)), while decreased in other genotypes which showing higher disease incidence. Thus results revealed that glucose was utilized by pathogen for growth and disease development. Myo-inositol content was decreased in infected stem of CS 319 and CS 19 while increased in other genotypes which showed higher disease incidence at both 30 and 60 DAS (Table 1). Stem sucrose content and total free amino acids decreased in all genotypes after infection regardless of resistance or susceptibility. After infection, tolerant genotypes showed higher increase in activity of phenylalanine ammonia lyase enzyme as compared to susceptible genotypes. Whereas, polyphenol oxidase activity was higher in the stem of susceptible genotypes after infection.

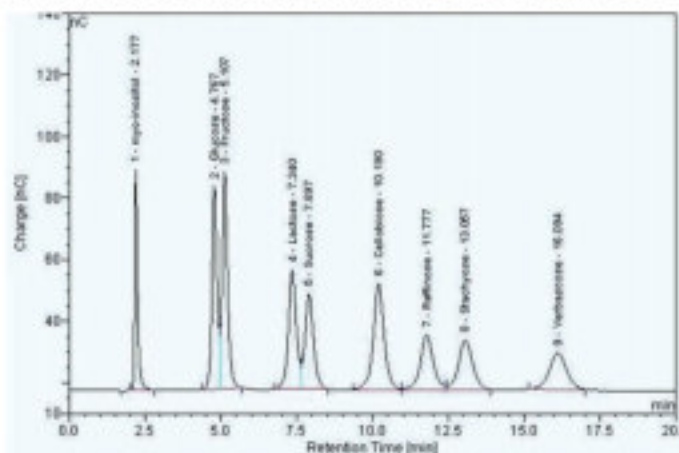


Figure 1. Separation of standard sugars by Ion Chromatography

Antioxidant activity in the kernels of popular groundnut genotypes

Kernel samples of 41 popular groundnut genotypes were analysed for antioxidant activity, total phenols and total free amino acids content. Maximum antioxidant activity was observed in R-8808 (6.97 $\mu\text{mol TE/g}$ kernel) followed by R-2001-3 (6.64 $\mu\text{mol TE/g}$ kernel) while minimum in JGN-23 (1.04 $\mu\text{mol TE/g}$ kernel). Higher antioxidant activity (above average + SD, 5.10 $\mu\text{mol TE/g}$ kernel) observed in 7 cultivars out of which 6 were from Spanish bunch group. Thus cultivars belonging to Spanish bunch group showed higher antioxidant activity.



Table 1: Stem myo-inositol content (ppm) at 30 DAS

Genotypes	24 hai		48 hai		96 hai	
	C	I	C	I	C	I
CS 19	7065	3197	4363	3044	3843	3182
CS 319	5794	3028	3919	3336	4005	3298
GG 16	6971	3280	4177	3493	3473	2544
GG 20	5380	3923	3410	6082	3146	5021
TG 37A	7067	2544	4160	3411	3334	3947

Table 2: Stem glucose content (ppm) at 60 DAS

Genotypes	24 hai		48 hai		72 hai	
	C	I	C	I	C	I
CS 19	1650	2598	2993	1254	1061	641
CS 319	1477	6362	4809	1499	1911	508
GG 16	6847	3414	7567	2403	865	216
GG 20	3272	2870	2952	888	536	435
TG 37A	5376	3223	4927	3637	1360	593

DAS: days after sowing, hai : hour after infection, C: control, I: infected

Effect of water deficit stress on sugar profiles of groundnut

Under moisture deficit stress condition leaf samples from 12 genotypes were taken from normal irrigated field, 50% of required irrigation field and 25% of required irrigation field. Mannitol content was observed in the leaves of 50% irrigated field and 25% irrigated field. Lower content of trehalose, glucose and sucrose was observed in 50% irrigated field and 25% irrigated field.

Effect of temperature stress on groundnut kernel quality

Quality analysis of 10 genotypes sown under different dates revealed that oil content and O/L ratio decreased in almost all genotypes due to higher temperature during maturation while sucrose and protein content increased.

Effect of fertilizers and FYM on kernel quality of different groundnut genotypes

In a field experiment twenty five groundnut genotypes were grown under plots having no-fertilizers (T1), recommended dose of fertilizers (T2) and farmyard manure. The study revealed 1-9% variation in oil content among 25 groundnut genotypes. Highest oil content observed in GG-20 (58%). Maximum Oil content (4.2 %) increased in GG-5 due to fertilizer application and in B-95 due to FYM compared to control. An appreciable increase was observed in O/L ratio in some genotype under fertilizer (1.1-1.7 fold) and FYM (1.1-1.9 fold) treatments as compared to control. Total sugars and phenols content also increased (10-20%) in some genotypes under fertilizer and FYM treatments as compared to control.

Evaluation of quality in cultivars, breeding material and germplasm collection

Spanish (30) and Virginia (30) genotypes were analysed for quality characteristics. Results showed that Spanish genotypes had higher mean oil content (48.52%) than Virginia (47.30%) while Virginia genotypes had higher O/L ratio (1.16-2.4) than Spanish (0.92-1.24).

Oil content of 200 groundnut samples from different section of DGR were measured by standard solvent extraction method. Around 3000 samples from different sections of DGR were analyzed for oil, protein and moisture content by NIR spectroscopy.



PROJECT 16: DEVELOPMENT OF TECHNOLOGIES FOR ENHANCING RESOURCE USE EFFICIENCY IN GROUNDNUT-BASED CROPPING SYSTEMS

(N.K. JAIN, R.A. JAT, H.N. MEENA, R.S. YADAV, A. SAHA AND M.D. MEENA)

Response of summer groundnut to plant population and fertilizer doses under drip and check basin method of irrigation A field experiment was conducted during summer, 2013 to know the effect of plant stand and nutrient-and-water management in groundnut. The treatments consisting of two irrigation methods viz. check basin and drip irrigation, three plant population densities viz. 100, 125 and 150% plant population and three fertilizer doses viz. 75, 100 and 125% RDF (recommended dose of fertilizers), were tested in split-split plot design with three replications. In drip irrigation, 25% of N and K and 50% of P were applied as basal dose and remaining amount of N and K was fertigated in four equal splits while that of P was fertigated in two equal splits starting from 20 days after sowing. In case of check basin irrigation, 50% of N and whole of P and K were applied as basal dose while 50% of N was applied in two equal splits at 20 and 40 days after sowing.

Drip irrigation increased pod and haulm yields as well as net returns compared to check basin irrigation but differences were not significant at 5% level of probability. Increasing plant population to 150% gave higher pod and haulm yields and net returns over both 100 and 125% plant population but only haulm yield was significantly higher over 100 and 125% plant population ($P < 0.05$). Decreasing RDF from 100 to 75% significantly reduced pod yield but on the other hand increasing RDF to 125% could not significantly increase pod yield. While haulm yield and net returns increased with increasing doses of RDF but differences were not significant at 5% level of probability. Interaction effect of plant population densities and irrigation methods on net returns were found significant. 150% plant population under check basin method of irrigation, produced highest net returns compared to all other treatment combinations, and 100% plant population and 125% plant population under drip irrigation provided significantly higher net returns ($P < 0.05$) over 125% plant population under check basin method of irrigation.

Effect of fungicide 'Tebuconazole' at different application rates on soil enzymatic activities in groundnut

An experiment was conducted during summer 2013 with two applications of the tebuconazole as foliar spray starting at 42 days after sowing followed by second spraying at 15-day intervals at field rate (FR: 187.5 g a.i. ha⁻¹), 2-times FR (2FR: 375 g a.i. ha⁻¹) and 10-times FR (10FR: 1875 g



a.i. ha⁻¹), to investigate its effect on soil enzymatic activities as well as their persistence in soil and groundnut plant along with the determination of its harvest time residues in groundnut kernel and plant.

Tebuconazole degraded rapidly in groundnut plant and residues were found only at 10 and 15 days after the last spray in case FR and 2 FR, respectively. The first order half-lives of tebuconazole in groundnut plant was 3.4~5.1 days. The half-lives of the tebuconazole in the soil varied from 10.6 to 14.5 days. MBC values for the three treatments were significantly lower than that of the untreated control from the day of last application. However, soil MBC recovered at 15 and 30 days after the last application at FR and values were on the 7th day and 2 FR rate, respectively, but it was lower throughout the period in case of 10 FR.

The tebuconazole application at FR and 2FR decreased the FDA content up to day 15 and values were recovered on 30 days onwards but remained lower in contrast to control at 10 FR application rate. At FR and 2 FR tebuconazole significantly decreased DHA activities only on 0 day and 1 day sample and it recovered subsequently but remained lower on all the sampling days at application rate of 10 FR.

Decreased activity of acid phosphatase was observed, whereas alkaline phosphatase activity remained unchanged throughout the periods. Residues of tebuconazole in groundnut kernels were below the detection level at the time of harvest. No differences were observed among fungicide treatments at FR, 2FR and control for pod yield, which was significantly lower at 10 FR. Present work thus demonstrated that tebuconazole application might not cause any permanent detrimental effect on the soil enzymatic parameters at least at FR and 2FR and also directs that tebuconazole is safe from the human and environmental contamination point of view.



PROJECT 17: DEVELOPMENT OF CONSERVATION AGRICULTURE TECHNOLOGIES FOR GROUNDNUT-BASED CROPPING SYSTEM(S)

(RAM A. JAT, N.K. JAIN AND R.S. YADAV)

Developing Conservation Agriculture technology for groundnut-wheat cropping system.

A field experiment was conducted during kharif, 2013 to know effect of three tillage practices viz. normal tillage (NT), minimum tillage (MT) and zero tillage (ZT) and three residue management practices viz. no residue application (NR), wheat residue application (WR) and wheat residue application + *Cassia tora* mulch (WCR) in groundnut. The experiment was laid out in split plot design with three replications. Tillage practices could not significantly affect growth attributes (except LAI), yield attributes and, pod and haulm yield significantly. Both zero tillage (ZT) and minimum tillage (MT) improved number of branches per plant, plant height and LAI (80DAS) over normal tillage (NT) but only ZT could significantly improve LAI over NT ($P < 0.05$). Similarly both ZT and MT improved number of mature and immature pods per plant, weight of mature and immature pods per plant and 100 seed weight over NT. Number of plants per meter row length was less in both ZT and MT as compared to NT. Root weight was more in MT compared to both NT and ZT. MT and ZT improved pod yield by 15 and 23% and haulm yield by 34 and 55% respectively, as compared to NT.

Residue management practices and *Cassia* mulch also could not significantly affect growth attributes, yield attributes and, pod and haulm yield. No residue application (NR), wheat residue application (WR) and wheat residue application + *Cassia* mulch (WCR) were found to have variable effects on growth and yield attributes and, pod and haulm yield. Even though, WCR improved haulm yield by 35% but slightly decreased pod yield as compared to NR.

Both tillage and residue management practices could not significantly affect oil and protein content; but ZT was found to slightly decrease oil content and increase protein content as compared to NT.

ZT decreased cost of cultivation by 15% compared to NT. Net returns were significantly affected by tillage practices; MT and ZT gave 31% and 50% ($P < 0.01$) higher net returns over NT while ZT gave 15% higher net returns ($P < 0.01$) over MT. B:C ratio was significantly increased in the order $ZT > MT > NT$ ($P < 0.01$). WCR increased cost of cultivation by 27% over NR. No remarkable difference was found in net returns due to residue management practices and *Cassia*



mulch but WR and WCR gave slightly higher net returns over NR. WCR gave significantly lesser B:C ratio compared to both WR and NR ($P < 0.05$).

There was no significant effect of tillage and residue management practices on different soil phosphorus (P) fractions (organic, inorganic and residual P). Irrespective of tillage and residue management practices, the majority of applied P and/or the P mineralized in the soil got accumulated as inorganic P. However, soil organic P and residual P slightly increased in MT and NT, respectively.

Enhancing carbon sequestration in groundnut-based cropping systems by conservation tillage and residue incorporation

In order to enhance carbon sequestration in groundnut-based cropping systems by conservation tillage and residue incorporation, a field experiment was conducted during kharif 2013. The experiment, consisted of 14 various treatment combinations viz., groundnut-monoculture, groundnut-Sesbania (green manuring), groundnut-greengram (green manuring), groundnut-wheat, groundnut-wheat-Sesbania (green manuring), groundnut-wheat-greengram (green manuring), groundnut-wheat-(wheat stubble incorporation), groundnut-wheat (zero tillage), groundnut-wheat (zero tillage)-Sesbania (green manuring), groundnut-wheat (zero tillage)-greengram (green manuring), groundnut-wheat (zero tillage)-wheat (stubble incorporation), groundnut+pigeonpea, groundnut+pigeonpea-Sesbania (green manuring) and groundnut+pigeonpea-greengram (green manuring), was laid out in randomized block design with three replications.

Results of *kharif* 2013 indicated that groundnut-greengram (GM) cropping system produced maximum pod yield of groundnut (1268 kg/ha) over other cropping systems under various tillage, residue incorporation and green manuring treatments applied during preceding rabi and summer seasons and was significantly superior only over sole groundnut, groundnut-wheat, groundnut-wheat-greengram (GM) and intercropped groundnut. On the other hand, maximum haulm yield (2667 kg/ha) was recorded in groundnut-wheat-Sesbania (GM) cropping system which was significantly higher over sole groundnut and intercropped groundnut only. Seed and stalk yields of pigeonpea did not differ significantly due to intercropping with groundnut and preceding green manuring crops.



PROJECT 18: MANAGEMENT OF SOIL AND IRRIGATION WATER SALINITY IN GROUNDNUT

(H.N. MEENA, R.S. YADAV AND D. BHADURI)

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

After the harvesting of groundnut in kharif 2012, rabi-summer cluster bean was sown by using saline irrigation water having salinity of 0.5, 2, 4 and 6 dS m⁻¹. The salinity buildup in soil at harvest of cluster bean with use of different irrigation water salinity levels was 2.78, 5.12, 7.05 and 8.68 dS m⁻¹, respectively. A decreasing trend was observed (Table 1) in fresh pod and dry fodder yield of cluster bean with increasing level of soil (2.78 to 8.68 dS m⁻¹) and water (0.5 to 6.0 dS m⁻¹) salinity. The fresh pod and dry fodder yield of cluster bean were significantly lower in all the treatments as compared to those of fresh irrigation water (i.e., control) but the fresh pod yield was at par up to 2.0 and 5.12 dS m⁻¹ water and soil salinity, respectively. Available nitrogen, phosphorus and potassium also decreased with increase in salinity levels while significant increase in availability of sodium was recorded with increase in soil and water salinity. Similar trends were observed with different nutrient concentrations in different plant parts of the cluster bean.

Table 1: Effect of salinity on yield and yield contributing characters of cluster bean

EC _{iw} (dS m ⁻¹)	EC _e (dS m ⁻¹)	Plant height (cm)	Root length (cm)	Plant stand (no. ha ⁻¹)	Dry plant weight (g)	Fresh pod yield (kg ha ⁻¹)	Dry fodder yield (kg ha ⁻¹)
0.5	2.78	85.87	18.93	280	36.26	9455	2064
2.0	5.12	72.67	18.47	215	24.02	9197	1595
4.0	7.05	66.20	17.47	204	19.94	7770	1142
6.0	8.68	56.40	16.07	123	13.56	5003	503
CD (P=0.05)	2.09	13.07	NS	56	5.36	1448	339

Effect of polythene mulch and potassium fertilizer on groundnut yield under salinity stress

The experiment was conducted during summer 2013 to ameliorate the effect of salinity by the application of polythene mulch and potassium fertilizer. The treatment consisted of three levels of salinity (0.5, 2 and 4 dS m⁻¹), two levels of mulching (polythene mulch and without mulch) and



three levels of potassium (0, 30 and 60 kg ha⁻¹). The results revealed that significantly higher pod yield was recorded with the application of 2 dS/m saline irrigation water but it was at par with control and significant reduction was recorded at 4 dS/m as compare to 2 dS/m but it was also at par with the control. The percent reduction at 4 dS/m was 14.7% as compare to 2 dS/m saline irrigation water. The haulm yield of groundnut was significantly lower in all the treatments as compared to those of fresh irrigation water (i.e., control). Further, significantly higher pod and haulm yield with 23.32% and 19.78% were recorded under polythene mulch as compare to no mulch, respectively. The application of potassium @ 60 kg ha⁻¹ improved the pod and haulm yield of groundnut by 11.25% and 4.85% respectively indicating ameliorative effect of potassium on salinity stress.

Table 2: Effect of saline irrigation water, polythene mulch and potassium fertilizer on yield of summer groundnut

ECiw (dS m ⁻¹)	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Salinity levels	Salinity levels	Salinity levels
0.5	2770	4722
2	2972	4000
4	2590	3611
CD (P=0.05)	232	423
Mulching		
Mulch	3067	4481
No Mulch	2487	3741
CD (P=0.05)	190	346
Potassium levels (kg ha⁻¹)		
0	2675	4000
30	2681	4139
60	2976	4194
CD (P=0.05)	232	NS

Effect of conditioning of crop under salinity on enhancing salinity tolerance in the next generation

Kharif groundnut was taken in 2013 to test the performance of two released varieties namely TG 37A and GG-2 using normal seeds and seeds from salinity conditioned crop in four salinity levels of saline irrigation water with 0.5, 2, 4 and 6 dS m⁻¹, respectively. Two lines of five meter rows of each variety (fresh and induced tolerance) were sown in this experiment. It was observed that the pod and haulm yield of both the varieties were at par up to 2 dS m⁻¹ irrigation water salinity but significant difference was recorded at a water salinity of 4 and 6dS/m in comparison to water



salinity of 0.5 dS m^{-1} control (Table 3). Further, the significant difference in pod and haulm yield were also recorded within the varieties with significantly higher pod yield in TG 37A (1502 kg ha^{-1}) over GG 2 (1316 kg ha^{-1}) while haulm yield in GG 2 (4195 kg ha^{-1}) over TG 37A (2305 kg ha^{-1}). The reduction in pod yield of GG 2 was 14.13% and haulm yield of TG 37A was 81.99%, respectively. However, non-significant difference was observed between normal seeds and salinity induced groundnut seeds. Almost a similar trend was observed for other yield contributing characters also.

Table 3: Effect of saline irrigation water on yield of crop raised from normal seeds and salinity sensitized seeds groundnut seeds of different groundnut cultivars during *kharif* season

ECiw (dS m^{-1})	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Salinity levels	Salinity levels	Salinity levels
0.5	1801	4549
2	2052	4026
4	1272	2667
6	509	1758
CD ($P=0.05$)	393	1405
Groundnut variety		
TG 37A	1502	2305
GG 2	1316	4195
CD ($P=0.05$)	139	318
seed Type		
Fresh seed	1388	3216
Salinity induced	1429	3284
seedCD ($P=0.05$)	NS	NS



PROJECT 19: DEVELOPMENT OF MANAGEMENT PRACTICES FOR ENHANCING AVAILABILITY OF SOIL PHOSPHORUS IN GROUNDNUT CULTIVATION

(R.S. YADAV, H.N. MEENA, D. BADHURI AND AJAY B.C.)

In-situ measurement of bio-available soil phosphorus and its relationship with plant P uptake under different management practices in groundnut

Bicarbonate charged anion exchange resins were put in the rhizosphere and non-rhizosphere soils at vegetative, flowering and pod filling stages of groundnut (cv. TG 37A) grown under field experiments having different water, nutrient and land management practices. Simultaneously, soil and plant samples were also collected for analysis of phosphorus. Availability of soil phosphorus was considerably altered by nutrient sources, raised bed, polythene mulch (PM) and drip irrigation. Raised bed with PM under drip irrigation was found most effective for enhancing availability (>20%) of soil phosphorus as well as uptake (20-35%) by the plants consistently with plant growth. The Olsen's-P decreased with plant growth by 40-60% which might be taken by the plant under all the experiments. However, resin-P increased by 2 to 4 times both under rhizosphere and non-rhizosphere soils with plant growth indicating the most labile pool of soil phosphorus. In general, in-situ measurement of resin-P was found about 40-60% of the Olsen's-P under different management practices. The phosphorus uptake by the plants was weakly correlated with both Olsen's-P ($r^2=0.43$) as well as resin-P ($r^2=0.38$) and strongly correlated with biomass accumulation ($r^2=0.84$) of groundnut.

Optimum phosphorus requirement for summer groundnut in calcareous soil

Summer 2013: Groundnut crop (cv. TG 37 A) was grown with 0 to 100 kg P_2O_5 ha⁻¹ with 10 kg incremental levels for each treatment during summer 2013. Grain as well as haulm yield of groundnut was significantly ($p=0.05$) differed among different levels of soil phosphorus. However, plant growth and yield parameters were found non-significant except root growth up

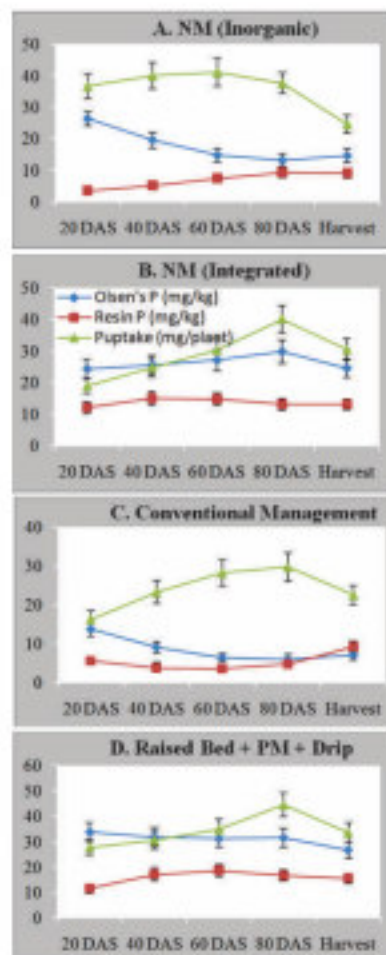


Fig.1: Changes in soil phosphorus availability and uptake by plants with plant growth under different management practices in calcareous vertisols (NM; Nutrient management, PM; Polythene mulch, DAS; Days after sowing)



to 60 DAS with phosphorus levels. The highest grain as well as haulm yield of groundnut was observed with application of 50 to 70 kg phosphorus per hectare. The highest phosphorus content in the plants was observed at flowering stage (i.e. up to 60 DAS). Activities of phosphatases (acid and alkaline) enzymes in the soil were also measured at three different growth stages (30, 60 and 90 DAS) of the crop. Irrespective to phosphorus levels the phosphatases activities were progressively increasing with the plant growth up to 60 DAS for acid and up to 90 DAS for alkaline phosphatases. The effect of phosphorus levels on soil phosphatases activities were found non-responsive which might be due to high phosphorus buffering capacity of the calcareous *vertisols* under study. In general, higher phosphatases activities were observed at lower levels of phosphorus application.

Kharif 2013: Groundnut crop (cv. TG 37 A) was grown with 0 to 70 kg P_2O_5 ha⁻¹ supplied as DAP and SSP with 10 kg incremental levels for each treatment during *Kharif* 2013. There was no application of phosphorus in control plot. Grain as well as haulm yield of groundnut was significantly ($p=0.05$) differed among phosphorus levels. However, plant growth and yield parameters were found non-significant with phosphorus levels except root nodulation. The highest grain as well as haulm yield of groundnut was observed with application of 50 to 60 kg phosphorus per hectare. Supply of phosphorus through SSP was found better than DAP in terms of groundnut yield. The phosphorus fertilizer use efficiency was ranged from 2.2 to 17.4 kg biomass/kg P_2O_5 through DAP while 8.15 to 26.2 kg biomass/kg P_2O_5 as SSP fertilizer source which were considerably higher at lower level P_2O_5 supply under both the sources.

Study on soil phosphorus fractions under different management practices in groundnut

Soil samples were drawn from field experiments conducted having three different management options including polythene mulch and drip, conservation of tillage and residues incorporation and convention practices of flat bed sowing with flood irrigation and application of RDF in calcareous *vertisols*. A considerable amount (9-20%) of residual soil phosphorus comprises of both inorganic and/or organic phosphorus which is considered as highly recalcitrant and stable was transformed under conservation practices and by use of polythene mulch with drip. On further detailed P-fractionation it was observed that an appreciable amount of water soluble and bicarbonate extractable labile inorganic and organic phosphorus fractions were observed under these management practices which would be the potential source for P nutrition of groundnut. Moreover, these soil-P fractions may also contributed by immediate application of P-fertilizers.

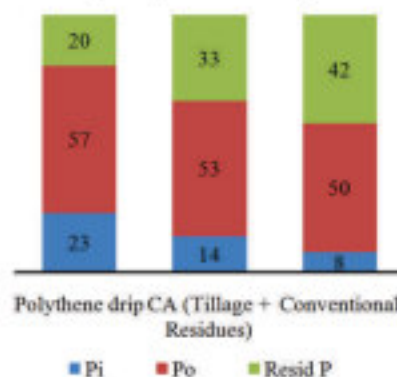


Fig. 2: Changes in P fractions (%) under different management practices



**PROJECT 20: CHARACTERIZATION OF SOIL FERTILITY STATUS USING GIS
TOOLS FOR LOCATION-SPECIFIC NUTRIENT MANAGEMENT IN
GROUNDNUT**

(DEBARATI BHADURI AND R.S. YADAV)

The project initiated with the collection of district wise data of crop production statistics of different groundnut growing states under AICRP-G programmes (22 centres, 5 zones) as well as district level productivity.

Selection of sites

The sites of the proposed study were chosen based on their contribution in national average productivity. Considering that, six major groundnut growing states (Gujarat, Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka and Rajasthan) along with some minor states (Orissa, Uttar Pradesh, West Bengal, Madhya Pradesh, Chattishgarh, Bihar) were taken into account. However few states (Haryana, Nagaland, Himachal Pradesh, Punjab, Uttarakhand) of lower percentage of area coverage and less average productivity were also included in the study.

Categorization of low and high productive areas based on district level groundnut productivity of all over the country

The average productivity of different districts of all major groundnut growing states was analysed. Further it was categorized into high and low productive districts based on the defined threshold productivity values of rabi-summer (1500 kg ha^{-1}) and *kharif* (1000 kg ha^{-1}) cropping seasons. District wise contribution of production and area covered (in terms of percentage) for groundnut was also taken into account for each state. High productivity districts ($>2000 \text{ kg ha}^{-1}$ and $>2500 \text{ kg ha}^{-1}$) of groundnut were also identified for rabi-summer and *kharif* seasons based on mean productivity values of three consecutive years.

Generation of database: Geographical information of selected locations

Collection of geographical database (latitude, longitude, elevation) was another objective of our study that is necessary to generate map output using GIS. Hence, such information was collected for all districts of major groundnut growing states.



PROJECT 21: IRON AND ZINC BIO-FORTIFICATION IN GROUNDNUT

(A.L. SINGH, ANITA MANN, K. CHAKRABORTY AND K.A. KALARIYA)

Response of groundnut cultivars to application of Zn and its influence on Fe and Zn densities in kernels

In a field study, 187 groundnut cultivars were grown under both with (N:P:K::50:50:50 kg/ha and Zn: 2 kg/ha) and without fertilizers to study their response on pod yield and micronutrient enrichment in kernels. There was a large variation in yield with an average of 1520 kg pod/ha. Some of the cultivars did not respond to the fertilizer application. With application of NPK fertilizers, the pod yield increased to 1790 kg/ha and with the application of NPK + Zn there was a further increase up to 1920 kg pod/ha. Out of 187 cultivars, screened for lime-induced iron-chlorosis, 22 did not show any symptoms (tolerant) while several exhibited only moderate symptoms while 20 genotypes exhibited severe symptoms. The tolerant cultivars were: R8808, S230, Kadiri 7, 8, and 9, Tirupati 3, TG 42, Kadiri gold, HNG 69, M 145, M 197, M 522, GJG 22, Champawat, LGN 2, BG1, Mallika, RSB 87, RG 510, RG 425, DH4-3, ICGV87846.

From the previous-year experiments, seeds of 110 cultivars were analyzed for Zn and Fe, as well as a few other nutrients. The following cultivars were identified as:

- High-Zn (>55 ppm): GG 7, GG 20, Tirupati 1, Tirupati 3, Tirupati 4, CO 2, GG 13, ICGS 76, CSMG 884, TAG 24, DH 8, KRG 1, and Gangapuri.
- High-Fe (>150 ppm): M 145, M 13, DSG 1, AK12-24, TAG 24, ALR 3, JSP 19, MH 4, Somnath, ICGV 86031, ICGV 86325, Tirupati 3, and GG 2

The data of two-years indicated that the Zn concentration in seed ranged from 28 to 73 mg kg⁻¹ with a mean value of 49 mg kg⁻¹.

Zinc-biofortification in groundnut

In a field experiment conducted in kharif season, effect of soil and foliar application of various Zn sources on the yield of 20 groundnut cultivars was evaluated. Zinc sulphate was found to be a better than Zn-EDTA.

Spray application of aqueous zinc sulphate (0.2%) on the foliage of field grown 60 groundnut cultivars thrice at 40, 55 and 70 days after emergence (DAE) influenced both yield and yield attributes, checked over-growth of the foliage and increased the seed density of Zn. The mean Zn concentration in seeds was 50 mg kg⁻¹ (range 32-67 mg kg⁻¹) which increased to 58 mg kg⁻¹ due to spray.



Zn and Cu nutrition of groundnut cultivars of various seed-size

As large seed-size groundnut require more macronutrients, a greater response to P, Ca and K application is observed on their pod-filling than those of medium- and small- seed size, cultivars. Pod nutrition of 50 groundnut cultivars differing in their seed size was studied for Ca and micronutrients (Zn and Cu) in a field experiment with fertilizers (Ca 100 kg; Ca 100 kg+ Zn 2 kg ha⁻¹; Ca 100 kg+ Cu 0.5 kg ha⁻¹). Depending on seed size, a wide variation in the response of genotypes was observed. Under unfertilized condition, the pod yield was 1300 kg ha⁻¹ which increased to 1560 kg ha⁻¹ with application of Ca alone; to 1650 kg ha⁻¹ with application of Ca and Zn; and to 1619 kg ha⁻¹ with application of Ca and Cu.

The analysis of experimental material from the previous year study (T₁-control, T₂-P₁₀₀+K₁₀₀ (100kg/ha P₂O₅ and K₂O), T₃-T₂+ 2 kg Zn/ha (as ZnSO₄), T₄- T₃+ 1 kg B/ha (Agricol), indicated three distinct patterns. In general, the large pod and seed size cultivars required more nutrients (K, P, Ca and Zn) however, showed a low content of these nutrients in seeds obtained from the unfertilized crop but cultivars responded to fertilizer application. On the other hand small-seed cultivars had a higher concentration of nutrients than those of large and medium seed-size cultivars raised under unfertilized conditions. Application of fertilizers resulted in increase of concentration of nutrients in the seeds of small and medium seed-size cultivars too but the response of large-seed cultivars to application of fertilizers, however, was more pronounced in large seed-size cultivars.

On an average (of 10 genotypes) from an unfertilized crop, the seeds of small seed size cultivars contained 0.52% P and 0.74% K, 445 ppm Ca and 40 ppm Zn, which with the application of P and K increased slightly to 0.55% P, 521 ppm Ca and 44 ppm Zn. With further addition of Zn, the Zn content increased to 57 ppm. The seeds of large seed size cultivars contained an average (of 20 genotypes) of 0.48 % P and 0.69% K, and 342 ppm Ca and 37 ppm Zn which with application of P and K increased significantly to 0.57% P, 0.78% K, 469 ppm Ca and 43 ppm Zn and with further addition of Zn, the Zn content increased to 55 ppm. The seeds of medium seed-size cultivars from unfertilized crop contained on an average (of 20 genotypes) 0.55 % P and 0.72% K, and 356 ppm Ca and 40 ppm Zn which with application of P and K increased to 0.60% P, 441 ppm Ca and 48 ppm Zn and with further addition of Zn, the Zn content increased to 52 ppm. Thus the concentration of nutrients in seeds in response to fertilizers application depends among others on the seed-size of the cultivars too.



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

The 181 mini-core ICRISAT germplasm accessions were evaluated for their response to fertilizer application on pod yield, SCMR and kernels micronutrient densities. With no fertilizer application, the pod yield ranged from 60-450 g/m² with an average yield of 180 g/m² fertilizers and 210 g/m² with fertilizers. The SCMR of the mini-core genotypes was in the range of 30-47 with mean reading of 41. The analysis of kernels of 181 core collections for nutrients revealed a large variation in K, P, Ca, Fe and Zn contents (Table 1). Some of the high-seed-Zn (>55 ppm) accessions identified included NRCG 14331, 14332, 14420, 14450, 14460, 14470, 14471, 14480, 14484, 14485, and 14499.

Table 1. Nutrient content of mini core accessions

Nutrient	Mean	Range
K (%)	0.65	0.34-0.99
P (%)	0.49	0.32-0.82
S (%)	0.18	0.10-0.44
Ca (ppm)	496	180-956
Fe (ppm)	56	21-99
Zn (ppm)	41	16-90

Screening and mechanism of iron-deficiency chlorosis

For identifying iron-efficient lines using visual chlorotic rating (VCR) at 10, 20, 30 and 65 days after emergence during the cropping season, 114 groundnut genotypes comprising advanced breeding lines and released varieties were screened and categorized into four groups (Table 2).

Fe-ferti-fortification through seed dressing

Five sources of iron (FeSO₄, FeCl₃, Ferric Citrate, FeEDDHA, Fe-EDTA) were evaluated as a seed dressing for their potential to enhance Fe content in seed and improve pod yield of 12 groundnut cultivars. All the sources except FeEDTA improved the pod yield. The analysis of seeds for their Fe content is in progress.

Basic studies on nutrient efficient lines

Wide variation was recorded in the contents of cation and anion in the root exudates and leaf saps of 26 groundnut varieties comprising both nutrient efficient and inefficient ones and having high yield potential during summer season. In general, the high cation contents in both leaf sap and root exudates could be related with the high pod yield.

Tolerant	Moderately tolerant	Susceptible	Highly susceptible
PBS 12169, 12171, 12175, 12183, 13021, 16040, 16044, 19020, 19021, 19024, CS 349, CS 369, Girmar-2, ICGV 00348, RG 425, RG 510, TPG 41, HNG 69, SG 99, GPBD-4, VJ 9521, CSMG 9510, Mallika, Kadri 9, Chintamani	PBS 12032, 12163, 12167, 12168, 12172, 12180 bold, PBS 13003, 13020, 13022, 14083, 16035, 18037, 18045, 18062, PBS 19018, PBS 19022, PBS 19023, PBS 19027, CS 280, CS 287, CS 291, CS 298, CS 401, CS 240, Girmar-3, T28, TMV 3, JL 501, TG 37 A, GG 13, MH 2, LGN 2, GG 16, DG 4-3, Kokan Tapora, Kadri, Harithandra, ICGV 00351, TMV 1, GG 5, GG 20, CSMG 84-1, M 37, DRG 17, JCG 88	PBS 12009, 12018, 12029, 12038, 12066, 12067, 12074, 12092, 12116, 12181, 12185, 12186, 18029, 18033, 18035, 18038, 18057, 14135, CS 296, G-G-8, TMV 4 VG 9816, R 2001-3, PBD 5, VRI 16, JGN 23, LGN 1, ICGV 0350, TMV-13, AK 159, VRI 3, GG-7	NRCG 162, 7472, ICGV 91114, JL 286, Kadri 6, JGN 3, CS 332, PBS 18064, 18055, 18004, 18006, 14042



PROJECT 22: IONOMICS FOR GROUNDNUT GENOTYPES FOR IRON USE EFFICIENCY

(ANITA MANN, A.L. SINGH AND KOUSHIK CHAKRABORTY)

To study the iron deficiency tolerance in Fe-efficient and inefficient groundnut lines.

The experiment was conducted to study the response of groundnut genotypes with different sources of iron supply.

Activity I: To study the level of iron deficiency with fertilizer application

Twenty six groundnut genotypes were sown in the field of Plant Physiology section. Two treatments included control with no fertilizer application and normal recommended NPK fertilizer along with micronutrients. These were applied at the time of sowing in the furrows. The observations were recorded after 30 days of emergence. Visual Chlorotic Rating (VCR) was observed in leaves at 20, 40 and 60 days after emergence on a scale of 1-5. It has been found that the genotypes which showed chlorosis value of 1 in control also showed value 1 with fertilizer application, which means the genotype is unable to take up Fe under both the conditions. The active Fe content was measured in leaves and it has also been found that the genotypes with green leaves have more Fe content with fertilization than in control conditions whereas the genotypes showing yellowing of leaves had less Fe content. The protein content was lowest in NRCG 7579 (2.9 mg/g FW) whereas maximum protein was observed in ICGV 86031 (4.98mg/g FW). The protein content was at par and no significant difference was observed between treatments in all the genotypes irrespective of the level of chlorosis. The micronutrient analysis of leaves revealed highest Fe content than other micronutrients like Zn, Mn and K. This may be due to the factor that Fe deficiency decreases the concentration of other micronutrients which can be further analysed using ionomics.

Activity II: To study the level of iron deficiency with foliar spray of FeSO_4

Fifteen groundnut genotypes were selected to study the effect of foliar spray of iron source i.e. 0.5% FeSO_4 on the appearance of chlorosis. The recommended dose of fertilizers along with micronutrients except Fe were applied at the time of sowing which served as control and foliar spray of iron source at 50 DAE was taken as treatment. The foliar spray of FeSO_4 initially alleviated the symptoms of yellowing or chlorosis but it again appeared after irrigation. The foliar spray of iron source also increased the active Fe content significantly.

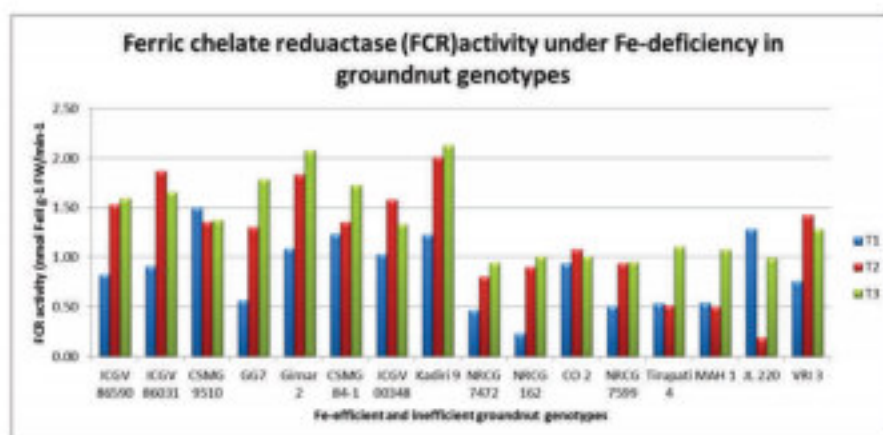
The antioxidant enzymes peroxidase, catalase and superoxide dismutase were also studied in both activities. Post harvest parameters like plant height, no of pods and pod weight, yield also varied among genotypes with different iron source. Based on these studies, these genotypes were



categorized as tolerant and sensitive to iron deficiency and grouped into Fe-efficient and Fe-inefficient genotypes. Out of these thirty-one groundnut genotypes studied, eight Fe-efficient and eight Fe-inefficient genotypes were selected which are being used further in new project no 22.

To study the ionic relation between nutrient efficient and inefficient groundnut varieties.

Eight nutrient efficient and eight nutrient inefficient groundnut genotypes screened for iron chlorosis tolerance in previous experiment were sown in the nutrient blocks with control, Fe deficiency and Fe resupply treatments. Basic parameters of iron chlorosis like VCR, active Fe content, NR activity and chlorophyll content were measured. The antioxidant system including scavenging enzymes catalase, peroxidase and superoxide dismutase with lipid peroxidation were also studied. Protein quantification with Bradford assay was used at standard for enzyme activities. The enzyme ferric chelate reductase (FCR) was analysed in roots of groundnut plants after two days of creating Fe deficiency. The FCR activity was higher in Fe-efficient genotypes than the Fe-inefficient genotypes. The enzyme extract for PEP carboxylase and citrate synthase has been prepared and stored at -80°C for further analysis. To study the physiological mechanism of organic acids accumulation in root and leaves under iron deficiency, roots and fully expanded third leaf of groundnut plants were harvested and oven dried at 60°C for 48 hrs. 100mg of dried matter was extracted in 80% (v/v) ethanol after addition of 1 mg of B-phenyl-glucopyranoside as internal standard. Complete analysis for organic acid analysis using Ion Pac Column in Ion Chromatograph is under process. Post-harvest parameters like plant height, number of pods, pod weight and fodder weight were measured in sixteen groundnut genotypes including Fe-efficient and inefficient. The plant height varied among treatments. The plants with T2 (nutrient solution without Fe source till harvesting) had lesser height than T1 (Fe deficit initially with Fe-resupply after 24 hours) which again had plants with less height in comparison to control (normal nutrient supply).



PROJECT 23: IMPACT OF CLIMATE CHANGE ON GROUNDNUT PHYSIOLOGY AND PRODUCTIVITY

(KOUSHIK CHAKRABORTY, A.L. SINGH, K.A. KALARIYA, M.K. MAHATMA AND R.A. JAT)

Studies on membrane stability and plant water status

The project was formulated with the objectives to study the effect of elevated CO₂ and temperature on physiology and productivity of groundnut cultivars. For this, an experiment was conducted in summer 2013 with 10 groundnut cultivars (SG 99, ICGS 44, ICGV 86031, TPG 41, GG 7, DRG 1, AK 159, TAG 24, TG 37A, JL 24) using staggered sowing method at three different dates (D₁, D₂ and D₃) with 20 days interval and sampling was done at 35-40 DAS. The weekly mean of day/night temperature at the time of sampling was 36.5/20, 38.5/22 and 40/25 °C respectively for D₁, D₂ and D₃ condition. This situation simulates three different temperature regimes for the plants at a particular growth stage. Early sowing prolonged the period to attain 50% flowering by 5-6 days compared to normal and late-sown plants. Germination percentage was also reduced in early as well as late sown condition compared to normal sowing time. Membrane stability reduced in all the cultivars with increase in mean day/night temperature. On an average MSI reduced from 88% to 78% with increase in 3.5/4.0 °C mean day/night temperature.

Effect on photosynthetic response and stomatal conductance

The rate of photosynthesis in groundnut at 45 DAS did not change in early and late sowing condition. The interaction being significant for net photosynthesis rate with the highest rate found in GG 7 (28.9 $\mu\text{mol m}^{-2} \text{s}^{-1}$) under early sowing condition. The stomatal conductance was significantly varied with sowing time and it was increased from 0.346 in early sow to 0.491 in late sowing condition. There was significant difference in rate of transpiration among varieties with the highest in JL 24 and the lowest. The highest transpiration rate was found in (13.4 $\text{mmol m}^{-2} \text{s}^{-1}$) under late sowing condition.

Status of oxidative stress and antioxidant enzyme activities

Membrane lipid peroxidation measured in terms of TBARs content also showed partial destabilization of membrane. Accumulation of H₂O₂ increased under temperature stress in all the cultivars with an average increase from 104 to 139 $\mu\text{mol g}^{-1} \text{FW}$. However, the genotype TG 37A (0.99 $\mu\text{mol g}^{-1} \text{FW}$) and JL 24 (1.21 $\mu\text{mol g}^{-1} \text{FW}$) performed best with least increase in H₂O₂.



content. Accumulation of various osmolyte like proline, glycine betaine and trehalose was more with increase in mean day/night temperature. Activity of different antioxidant enzymes like SOD, CAT, POD and GR increased in almost all the cultivars under high temperature stress.

Table 1. Effect of high temperature stress on RWC, MSI and days to 50% flowering in groundnut cultivars

Cultivar	RWC (%)			MSI (%)			Days to 50% Flowering		
	D ₁	D ₂	D ₃	D ₁	D ₂	D ₃	D ₁	D ₂	D ₃
SG 99	92.2	93.3	87.3	86.4	82.0	78.0	43	40	37
ICGS 44	90.3	92.7	89.7	87.3	80.3	78.6	44	41	38
ICGV 86031	91.7	90.8	89.8	89.7	83.1	74.5	43	41	37
TPG 41	91.0	92.2	87.8	86.9	86.2	78.0	44	41	38
GG 7	92.5	91.5	88.5	88.6	85.2	82.3	44	40	38
DRG 1	90.9	92.7	88.4	86.9	82.7	73.7	44	40	39
AK 159	92.0	93.7	85.7	86.1	86.4	76.2	45	41	39
TAG 24	92.8	92.5	88.7	88.8	86.0	80.6	45	41	40
TG 37A	90.1	92.7	86.0	90.7	83.8	80.7	43	39	36
JL 24	93.8	93.1	87.5	90.0	86.4	82.8	44	40	37
Mean	91.7	92.5	87.9	88.1	84.2	78.5	44	40	38



PROJECT 24: PHYSIOLOGICAL TRAITS ASSOCIATED WITH DROUGHT TOLERANCE IN GROUNDNUT

(K.A. KALARIYA, K. CHAKRABORTY, A.L. SINGH AND M.K. MAHATMA)

Screening of 36 groundnut cultivars under well watered and water deficit condition

In an experiment 36 varieties of Spanish and Virginia groundnut were grown at three different irrigation regimes, Viz., T₁ control (irrigation as per the requirement of crop through drip) T₂ 50% irrigation (drip) and T₃ 25% irrigation (drip) and a significant deviation in physiological parameters was observed. The net photosynthesis rate was significantly decreased from 28.1 $\mu\text{mol m}^{-2} \text{s}^{-1}$ in well irrigated to 25.2 $\mu\text{mol m}^{-2} \text{s}^{-1}$ due to 25 % of well irrigation treatment. Variety JAL 42 recorded the highest rate of photosynthesis (32.6 $\mu\text{mol m}^{-2} \text{s}^{-1}$) which was statistically at par with ICGV91114 (30.9 $\mu\text{mol m}^{-2} \text{s}^{-1}$) whereas the lowest rate of photosynthesis was in HNG 69 which was statistically at par with VRI 2. The Transpiration was highest in TLG 45 (14.1 $\text{mmol m}^{-2} \text{s}^{-1}$) and the lowest in VRI 2 (7.4 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Irrigation at 25% of well irrigated crop has led to significant reduction in SLA from 188 to 177 at 60 DAS. Variety with the highest SLA was Gangapuri (203) which was statistically at par with JL 42 (199) and the lowest SLA was Kadiri 9 (155). Limited water supply increased SCMR value from 32.9 in well irrigated to 37.1 in 25% of irrigation. The highest SCMR was in Kadiri 9 (44.5) and the lowest in VRI 2 (30.1) The irrigation treatment has significantly reduced the pod yield from 232.9 g m^{-2} in well irrigated to 212.0 g m^{-2} in 50% irrigation and 148.6 g m^{-2} in 25% irrigation treatment. The pod yield in g m^{-2} was highest in ICGV 86590 (292.5 g m^{-2}) which was statistically at par with JAL 42 (275.6 g m^{-2}) and the lowest in LGN 1 (97.3 g m^{-2}). The highest pod yield under 25% irrigation was in JAL 42 (222.4 g m^{-2}) which was statistically at par with Girmar 3 (212.9 g m^{-2}).

Studies on chlorophyll fluorescence in 12 groundnut cultivars contrasting in yield under water deficit stress.

Three different irrigation regimes, Viz., T₁ control (irrigation as per the requirement of crop through drip) T₂ 50% irrigation (drip) and T₃ 25 % irrigation (drip) has significant effects Net Photosynthetic Rate (P_N). The P_N significantly higher in T₂ (29.6 $\mu\text{mol m}^{-2} \text{s}^{-1}$) which was statistically at par with T₁ (28.6 $\mu\text{mol m}^{-2} \text{s}^{-1}$) as compared to T₃ (24.3 $\mu\text{mol m}^{-2} \text{s}^{-1}$) at 75 DAS. Variety ICGV 91114 registered the highest photosynthesis rate (30.9 $\mu\text{mol m}^{-2} \text{s}^{-1}$) which was statistically at par with GG 20, ICGV 86590, TAG 24 and TPG 41. The interaction was significant



with the highest P_n ($34.5 \mu \text{ mol m}^{-2} \text{ s}^{-1}$) in ICGV 9114 in T_1 . The maximum quantum yield of PS II (F_v/F_m) was significantly highest in T_1 (0.839) and lowest in T_3 (0.831). Varieties also differed significantly with the highest in TMV 2 (0.844) and the lowest in TAG 24 (0.822). The interaction for F_v/F_m was significant with the highest value in TMV 2 (0.847) in T_1 and the lowest in TAG 24 (0.799) in T_3 . Interestingly, the actual efficiency of photosynthesis (F_v'/F_m') was significantly highest in T_2 as compared to T_1 and T_3 . Among the varieties, the highest F_v'/F_m' was in ICGV 86590 which was statistically at par with JL 24, SG 99 and TAG 24. However, the interaction was significant not significant for F_v'/F_m' . The quantum yield of PS II or the proportion of absorbed energy utilised for photochemistry (Φ_{PSII}) was not significantly affected due to limited water supply. However, varieties differed significantly for the proportion of absorbed energy utilised for photochemistry and the highest Φ_{PSII} was in GG 20 (0.283) and the lowest in JL 24 (0.191). The interaction was significant for Φ_{PSII} with the highest in Girnar 3 (0.320) in T_1 and the lowest in JL 24 (0.181) in T_3 . The NPQ increased due to irrigation treatment and just opposite to the actual efficiency of photosynthesis, the non-photochemical quenching was lowest in T_2 and the highest in T_3 . Among the varieties, the capacity to disseminate the extra absorbed energy in terms of NPQ was highest in Girnar 3 (1.88) and the lowest in JL 24 (1.1).

Effect of salicylic acid on amelioration of water deficit stress in groundnut

In an experiment in summer 2013, effect of salicylic acid and abscisic acid to ameliorate water deficit stress was studied with six cultivar viz., SG 99, TAG 24, ICGV 86031, AK 159, DRG 1 and ICGS 44 with following treatment details (T_1 control; T_2 Water deficit stress (WS); T_3 WS + 2 ppm salicylic acid spray; T_4 WS + 1 ppm ABA spray; T_5 WS + 2 ppm salicylic acid + 1 ppm ABA spray). Imposition of water deficit stress resulted in 35% yield loss on an average in all the cultivars with highest reduction observed in ICGS 44 (39%) and least in TAG 24 (27%). Application of combination of salicylic acid @ 2.0 ppm and abscisic acid @ 1.0 ppm can reduce the average yield loss from 35 to 15%. Production of ROS and membrane lipid peroxidation was highest under T_2 , while application of plant growth regulators in combination reduced the oxidative stress in all the cultivars. Activity of SOD was increased with imposition of water deficit stress and it showed increasing pattern even up to 16th day after imposition of stress, but higher activity was observed in TAG 24 and ICGS 44.

D. Screening groundnut varieties for drought tolerance

Study was carried out among 35 Spanish and 25 Virginia varieties of groundnut during *Kharif* 2013 to evaluate effect of drought during 40-70 DAS on various physiological parameters. The



RWC, SCMR SLA and pod yield decreased significantly due to water deficit stress in both Spanish as well as Virginia group. The highest SCMR was in Kadiri 9 among the Spanish group whereas it was highest in the GG 11 among the Virginia group. The Pod yield decreased from 276 g/m² in protected crop to 257 g/m² in due to water deficit stress in Spanish group with the highest yield under water deficit stress. In Virginia group the yield was 143 and 156 g/m² in protected and water deficit plots.

Screening groundnut varieties for mid-season drought tolerance

In another experiment, a total 36 varieties of Spanish and Virginia group were screened for water deficit stress tolerance. The SCMR value has increased from 35.7 in protected to 40.0 due to natural water deficit stress occurred during mid-season. The yield has reduced from 152 g/m² to 132 g/m² due to water deficit stress.

Screening groundnut varieties for late season drought tolerance

Sixty genotypes comprising 40 varieties and 20 advance breeding material were evaluated for drought tolerance at late stage. At 65 DAS there was no significant difference in SCMR value among the genotypes. The SLA was highest in Chicko and the lowest in Kadiri 9. The highest yield PBS 12185 (275 g/m²) and the lowest in PBS 12090.

Table 1. Mean, maximum and minimum values of SCMR and Net photosynthetic rate in 36 groundnut varieties under different soil moisture regimes

Varieties	SCMR			PN ($\mu\text{mol m}^{-2}\text{s}^{-1}$)		
	100% irrigation	50% Irrigatio	25% Irrigatio	100% irrigatio	50% Irrigation	25% Irrigation
Mean	33	36	37	28	28	25
Max	45	47	47	35	38	34
Variety	Kadiri 9	Kadiri 9	SG 99	ICGV 91114	Kadiri 6	JAL 42
Min	27	27	31	20	22	19
Variety	VR1 2	Gangapuri	JL 24	TMV 13	GG 2	LGN 1

Table 2: Mean fodder yield and pod yield of 36 groundnut varieties grown under different soil moisture regimes

Varieties	FY gm ⁻²			PY gm ⁻²		
	100% irrigation	50% Irrigatio	25% Irrigatio	100% irrigatio	50% Irrigation	25% Irrigation
Mean	734	758	515	233	212	149
Max	1158	1298	875	338	376	242
Min	383	346	295	109	106	77



PROJECT 25 : STUDIES ON MICROORGANISMS IN RELATION TO SOIL HEALTH AND PLANT NUTRITION IN GROUNDNUT

(R. DEY AND K.K. PAL)

Evaluation of DAPG-producing fluorescent pseudomonads (summer and *kharif*, 2013)

DAPG-producing fluorescent pseudomonads having multiple plant growth promoting traits (production of IAA and siderophore; P-solubilization, ammonification and ACC deaminase activity, etc.) besides suppressing soil-borne fungal pathogens like *A. niger*, *A. flavus* and *S. rolfii* were selected for field trial after initial screening in pots. Seven such DAPG-producing fluorescent pseudomonads were selected for evaluating their effect on the growth and yield of groundnut in field conditions.

Application of *P. fluorescens* FP93, *P. fluorescens* FP94 and *Pseudomonas* sp. FP20 significantly enhanced the root length, biomass, pod and haulm yield and shelling out-turn over un-inoculated control. The maximum enhancement in pod and haulm yield was achieved with the inoculation of *P. fluorescens* FP93 (2248 kg ha⁻¹) and *P. fluorescens* FP94 (4895 kg ha⁻¹), respectively over un-inoculated control (Table 1). In *kharif* season, application of *P. putida* DAPG7, *P. fluorescens* FP94 and *Pseudomonas* sp. FP20 significantly enhanced the pod and haulm yield of groundnut cultivar TG37A over un-inoculated control.

Table 1. Evaluation of the effect of DAPG-producing fluorescent pseudomonads on the growth and yield of groundnut cultivar TG 37A (summer & *kharif* 2013)

Treatment	Summer 2013 PY (kg/ha)	HY (kg/ha)	<i>Kharif</i> 2013 PY (kg/ha)	HY (kg/ha)
Un-inoculated Control	2052	4367	1973	4397
FP93	2248	4672	1932	4593
FP94	2170	4895	2357	4823
DAPG7	2197	4565	2166	4717
FP20	2245	4560	2178	4577
FP46	2141	4715	2162	4993
FP133	2173	4295	2165	4687
FP86	2204	4752	2037	4230
CD (0.05)	144	251	189	307

Evaluation of competitive strains of groundnut rhizobia

Newly identified strains of highly competitive and efficiently nodulating groundnut rhizobia were evaluated in a field trial during *kharif* 2013. 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. The inoculation with the newly isolated strains of groundnut rhizobia RH11, SRR7, and PAS17-2 significantly enhanced the pod yield of cultivar TG 37A over un-inoculated control and NC92 (Table 2). Besides, plant growth, haulm yield, nodule number and biomass, shelling out-turn, etc. also improved with the application of these new strains.

Table 2. Evaluation of the effect of newly isolated groundnut rhizobia on growth and yield of cultivar TG37A, kharif 2013

Treatments	PY (kg ha ⁻¹)	HY (kg ha ⁻¹)	HSM (g)
Control	1463	4180	41.3
RH29	1547	4677	40.8
SRR7	1705	4057	44.8
RH17	1675	4053	42.6
RH11	1677	4847	45.1
RH20	1552	4333	40.1
NC92	1477	4607	42.4
PAS17-2	1681	4617	45.2
CD (0.05)	138	309	1.4

Application of DAPG-producing fluorescent pseudomonads for suppression of collar rot of groundnut (kharif 2013)

Some 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 for fungal pathogens, twelve DAPG-producing fluorescent pseudomonads, highly antagonistic to *A. niger* were evaluated in field condition for their potential in development of suppressive soils for management of *A. niger*. In case of *Aspergillus niger*, the incidence of collar rot was less than 10% in pathogen control and therefore no comparison was made. However, there was reduction in disease incidence from 10% in pathogen control to 2-6% in different treatments with DAPG-producing fluorescent pseudomonads. Moreover, there was significant improvement in the yield of groundnut due to application of different DAPG-producing fluorescent pseudomonads (Table 3). Application of *P. putida* DAPG2, *P. putida* DAPG4 and *P. putida* FP86 significantly enhanced the pod and haulm yield and shelling out-turn of cultivar GG 20. In addition, there was significant improvement in the pod yield of groundnut due to inoculation of *P. putida* strains FP20, FP98 and FP93. Haulm yield also improved significantly due to inoculation of *P. putida* DAPG7.



Table 3. Evaluation of the effect of DAPG-producing fluorescent pseudomonads on the growth and yield of cultivar GG 20, kharif 2013 in presence of *Aspergillus niger*

Treatments	PY(kg/ha)	HY(kg/ha)	SOT(%)	HKM (g)
Control	3394	6912	65.19	50.83
Patho. (P)	3144	6972	64.52	48.77
P+DAPG2	4098	7607	67.40	51.88
P+DAPG3	3507	7341	66.45	50.25
P+DAPG4	3823	7658	67.22	53.93
P+DAPG7	3234	7956	69.71	51.71
P+FP20	3983	7429	68.56	53.18
P+FP46	3393	7293	66.14	53.68
P+FP86	4051	7800	68.30	54.12
P+FP93	3817	6910	66.33	51.78
P+FP94	3703	7217	66.73	50.68
P+FP121	3978	7250	65.77	54.03
P+FP133	3681	7355	66.57	53.76
P+FP98	3887	7467	65.45	51.32
CD(0.05)	337	585	2.03	NS

Isolation and characterisation of endophytic bacteria and fungi of groundnut

Seventy-six bacterial and twenty fungal endophytes were isolated and characterised from seeds, roots and stems of groundnut. The bacterial endophytes include *Acinetobacter radioresistens*, *Staphylococcus* sp., *Kytococcus* sp., *Pseudomonas fluorescens*, *Enterobacter* sp., *Alcaligenes faecalis*, *Brevundimonas* sp., *Pantoea agglomerans*, *Pseudomonas aeruginosa*, *Enterobacter ludwigii*, *Enterobacter cloacae*, *Staphylococcus* sp., *Bacillus subtilis*, *Bacillus firmus*, *Pseudomonas* sp., *Bacillus tenquimensis*, etc. and a number of isolates of *Bacillus* and *Bacillus* derived genera. Majority of fungal endophytes were identified as *Aspergillus terreus*.



PROJECT 26: APPLICATION OF MICROORGANISMS FOR MANAGEMENT OF BIOTIC AND ABIOTIC STRESSES IN GROUNDNUT

(K.K. PAL, R. DEY AND NATARAJA M.V.)

Isolation and characterization of microbes insecticidal to *Helicoverpa* and *Spodoptera*

Different bacterial isolates (non-Bt) were obtained from the naturally dead larvae (Figure 1) of *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fabricus) following standard techniques. Twenty-one bacilli (non-Bt) were obtained from *Helicoverpa* and 27 from dead larvae of *Spodoptera*. Initial evaluation of twenty-two non-Bt bacilli (LS1, LS2, LS4, LS5, LS6, LSH1, LSH2, LS13, LS14, etc.) in leaf bioassay for control of *Spodoptera* resulted in larval mortality of ~100% as compared to 10% mortality obtained in control. Among the isolates, LS13 and LS14 were found most effective in causing 100 per cent mortality in 72 hours of inoculation in 3rd instar larvae of *S. litura*. So far, promising non-Bt bacilli could not be obtained against *Helicoverpa*.



Figure 1. Naturally dead larva of *Helicoverpa* and *Spodoptera*

Isolation and characterization of rhizobia and endophytes tolerant to salinity and moisture deficit stress

From the nodule samples collected from salinity affected groundnut growing areas of Bhuj, 31 isolates of groundnut-rhizobia were obtained, purified, characterized and will be tested in pots for further evaluation. All the isolates can tolerate 5% of NaCl concentration and 7 of them can grow upto 10% of NaCl concentration in medium. Out of 76 bacterial endophytes isolated so far from groundnut, ten were found to tolerate 45°C temperature and 5% of NaCl and can colonize different tissues of groundnut (root, stem and seeds).

Comparative genomics to understand the mechanisms of osmotolerance and for isolating relevant genes

To understand the mechanisms of osmotolerance in evolutionary perspective and to try to trace stable traits across domains of life i.e., archaea, bacteria and eukaryotes (like fungi), genomes of nine bacteria, one archaebacteria (novel haloarchaeon 3A1-DGR) and one fungus (*Aspergillus*



sydowii BF5), which grow differentially upto saturated level of NaCl (Table 1), were analyzed. The genomes include *Salinibacillus aidingensis* MSP4 (growth:10-20% NaCl; genome:7.38-Mbp; CDSs:7,663; stress response:201 genes); *Bacillus* sp. NSP2.1 (Sensitive to salinity; genome:5.42-Mbp; CDSs:5,558; stress response:103 genes); *Bacillus* sp. NSP9.1 (growth:~15% NaCl; genome:4.51-Mbp; CDSs:4,887; stress response:101 genes); *Bacillus* sp. SB47 (growth:5%-35% NaCl; genome:4.46-Mbp; CDSs:4,684; stress response:105 genes), *Thalassobacillus devorans* MSP14 (growth:5-15% NaCl; genome:3.93-Mbp; CDSs:4,011; stress response:123 genes), *Sediminibacillus halophilus* NSP9.3 (growth:~20% NaCl; genome:3.98-Mbp; CDSs:4,232; stress response:109 genes), *Bacillus* sp. SB49 (growth:~30% NaCl; genome:3.72-Mbp; CDSs:3,907; stress response:96 genes), *Bacillus megaterium* MSP20.1 (growth:~27.5% NaCl; genome:4.45-Mbp; CDSs:4,255; stress response:110 genes), *Bacillus* sp. NSP22.2 (growth:4-22.5% NaCl; genome:4.03-Mbp; CDSs:4,251; stress response:105 genes), haloarchaeon 3A1-DGR (growth:8-35% NaCl; genome:2.88-Mbp; CDSs:2,894; stress response:43), and *Aspergillus sydowii* BF5 (growth:~35% NaCl; genome:86.6 Mbp; 8 chromosomes).

Enormous diversity in G+C content, genome size, CDSs (around 30% codes for hypothetical proteins), genes involved in stress and other related responses and pathways, etc. have been noticed. Attempt to study the co-linearity among the differentially expressed proteins to their transcripts and eventually to their coding sequences, including those of hypothetical proteins, and studying their variability structurally and functionally would lead to identification and isolation of stable osmotolerant genes. Moreover, twelve genomic islands have been identified in *Bacillus* sp. NSP9.1 ranging from 5.4 KB to 71.0 KB. Further studies of these genomic islands are underway to ascertain their role in imparting moderate halophilism in *Bacillus* sp. NSP9.1

Isolate	Accession Number	Identity on the basis of nearest match	Tolerance level (%NaCl in growth media)							
			0	5	10	15	20	25	30	35
NSP2.1	JF802192	<i>Bacillus</i> sp. NSP2.1	+	-	-	-	-	-	-	-
NSP9.1	JF802181	<i>Bacillus</i> sp. NSP9.1	+	+	+	+	+	+	+	+
MSP20.1	JF802191	<i>Bacillus megaterium</i> MSP20.1	+	+	+	+	+	+	+	+
SB49	JF802167	<i>Bacillus</i> sp. SB49	+	+	+	+	+	+	+	+
MSP22.2	JF802172	<i>Bacillus</i> sp. NSP22.2	-	+	+	+	+	+	+	+
SB47	JF802185	<i>Bacillus</i> sp. SB47	-	+	+	+	+	+	+	+
NSP9.3	JX518263	<i>S. halophilus</i>	+	+	+	+	+	+	+	+
MSP14	JX518269	<i>T. thermophilus</i>	-	+	+	+	+	+	+	+
3A1-DGR	JF802160	Haloarchaeon	-	-	+	+	+	+	+	+
BF5	-	<i>Aspergillus sydowii</i>	+	+	+	+	+	+	+	+



**PROJECT 27: IDENTIFICATION OF FACTORS RESPONSIBLE FOR YIELD GAPS
IN MAJOR GROUNDNUT GROWING REGIONS OF INDIA
(NARAYANAN G. AND MURLIDHAR MEENA)**

Component wise analysis of yield gap I in AICRP – G FLD centers (2009-2012)

An analysis was done to know the existing yield gap I (The yield difference between improved technology and farmers practice) among the components of FLD for three years 2009-2012. The result (Table I) showed that there are seven components followed to demonstrate the improved technologies by the implementing centers. They are improved variety, IPDM, IPM, IDM, INM, IWM, PGPR under *Kharif* and *Rabi/Summer* seasons. The improved variety, IPDM, INM components recorded 23 per cent yield gap I in *Kharif* season.

Table I. Component wise analysis of yield gap I in AICRP – G FLD centers (2009-2012)

FLD components	No. FLDs.	<i>Kharif</i> Gap- (%)	No. FLDs	<i>Rabi/Summer</i> Gap-I (%)
Improved Variety	1105	23	640	21
IPDM	15	23	19	16
IPM	44	18	10	12
IDM	46	19	-	-
INM	50	23	72	17
IWM	45	13	59	17
PGPR	-	-	44	20

In *Rabi/Summer*, improved variety component followed by PGPR component recorded 20 per cent yield gap I. When compare to the varietal component the PGPR component was more economical and fetched high net returns. Thus for *Kharif* improved variety, IPDM, INM components may be recommended to bridge the yield gap I. For *Rabi/Summer* again varietal component and PGPR component may be recommended for bridging the yield gap I. Further analysis was made on the existing of yield gap I with respect to varietal performance in particular to AICRP-G FLD centers of major groundnut growing states for the year 2009-2012. Table No.2

The result showed that in Andhra Pradesh there are two centers namely Kadiri and Jagtial and followed improved variety components with Kadiri 6 and kadiri 9. The Jagtial center carried out the improved variety Kadiri 6 against old varieties TMV2. The new variety recorded the 10 per cent yield gap against these varieties in this area. In Kadiri center ie. Anantapur district among the varieties demonstrated the Kadiri 6 recorded the highest yield gap I at 32 per cent followed by Kadiri Harithandra (30 per cent).



Table 2. Analysis of yield gap- I with respect to varietal performance in AICRP-G FLD centers of major groundnut growing states (2009-12)

State: Andhra Pradesh					
Variety	Components	Kharif (2009-12) Gap-I (%)		Rabi/Summer (2009-12) Gap-I (%)	
Kadiri 6	Varietal	32		10	
Kadiri 6	INM	36			
Kadiri 9	Varietal	22			
KadiriHarithandra	Varietal	30			
Farmers practicing variety: TMV-2					
Variety	Compo- nents	Kharif (2009-12) Gap-I (%)	Variety	Compo- nents	Rabi/Summer (2009-12) Gap-I(%)
State: Gujarat					
GG-5*	Improved Variety (IV)	15	TPG-41***	(IV)	13
GJG HPS-1	(IV)	12	GJG-31**	(IV)	6
GJG-9	(IV)	9			
Farmers practicing varieties: * GG 20 in Kharif; ** TG 37 A ; *** GG-2					
State: Karnataka					
ICGV-91114	(IV)	22	DH-101	(IV)	26
GPBD-4*	(IV)	36	R-2001-2*	(IV)	42
DH-101	(IV)	21	GPBD-5	(IV)	37
JSP-39	(IV)	25			
R-2001-2	(IV)	22			
Farmers practicing variety: *JL 24					
State: Maharashtra					
JL-501	(IV)	21	JL-501	(IV)	19
JL-501*	INM	22	JL-501	IWM	22
Farmers practicing variety:*SB-11					
State: Rajasthan					
Girnar-2	(IV)	28	Farmers practicing variety:*Samrala		
State: Tamil Nadu					
ALR-3	(IV)	44	ALR-3*	(IV)	33
VRI-6*	IPDM	27	VRI-6	(IV)	23
VRI-6	(IV)	20	Farmers practicing variety: *TMV 2		



In Gujarat there are two centers namely Vyara and Junagadh. The two centers in *kharif*, demonstrated GG5, GJG HPS – 1, GJG – 9 against the age old variety and ruling variety GG20. The yield difference recorded for the three years was minimal. It was ranged between 12-15 percentages. This difference would not bring visible difference in the farmer's field at larger level. In *Rabi/Summer* TPG 41, GJG-31, TG 37 A was demonstrated as new technology against GG2. There also the yield difference was 6-15 percentages. The newly released variety GJG-31 recorded very low yield difference between TG 37 A. Thus bridging the yield gap I is difficult with GJG-31 variety. In general, in Gujarat there observed low yield gap I.

In Karnataka there were three centers demonstrated the improved varieties, IPDM, and IWM components. Among these in *Kharif* the variety GPDB 4 recorded highest yield gap I (36 %) against old variety JL 24. In *Rabi/Summer* GPBD 5 (37 %) and R-2001-2 (42 %) recorded the highest yield gap I against JL 24. In Maharashtra Jalgaon center has demonstrated JL 501, the newly developed variety in different components against local variety SB-11. Among the components, this variety recorded the highest yield gap I in whole package and INM components. Thus to bridge the yield gap I the JL 501 has to be promoted to bridge the yield gap existed in the locality. In Manipur and Punjab in *Kharif* the yield gap I recorded between 21-26 per centages. In Rajasthan, in *Kharif* the Gimar 2 variety recorded yield gap of 28 % against the local variety *Samrala*. In Tamil Nadu there are two centers with two varieties viz., ALR3 and VRI 6. Among the two, ALR 3 recorded the yield gap I to the range of 44 % in *Kharif* and 33% in *Rabi/Summer*.

Survey on factors responsible for high and low productivity areas in Tamil Nadu

Tamil Nadu State groundnut productivity scenario: 7% of crop sown area under groundnut (385612 ha) (2011-12), Annual average productivity: 2031kgs/ha (2011-12), Average productivity: 1948 Kg/ha (2001-2012), Minimum average: 1429 Kg/ha (2001-12), Maximum average: 2751 Kg/ha (2001-12).

Agro-climatic profile: Soil types in major groundnut growing districts:

Red sandy soil - Kancheepuram, Tiruvannamalai, Tiruvallur and Vellore
 Red loam - Erode, Namakkal, and Salem
 Laterite soil - Dharmapuri, Kancheepuram, Tiruvannamalai, Thiruvallur and Vellore
 Brown soil - Villupuram, Vellore and Tiruvannamalai

Particularly, coastal taluks gets more rain than interior regions in addition to that having sandy coastal alluvium type soil make the following taluks viz., Tirur, Tirukalukundram, Tindivanam, Marakanam, Vanur and Alngudi to record 3000 to 4200 Kg pods/ha.



Rainfall pattern	: (Avg.) by seasons (2000-2012) (in mm.)
South west monsoon	: 300-360; North east monsoon: 400-550
Winter season	: 15-35; Hot weather season: 100-150
Temperature (°C)	Maximum : Summer-36.6; Winter-28.7;
	Minimum : Summer-21.1; Winter-19.8

Source: IMD, Chennai.

Seed replacement rate: (2010-11) percentage to total cropped area

State department - 6; Private agro-service - 9; Total - 15

Source: Commissioner of Agriculture, Chennai.

Micronutrients application:

Micronutrients mixture distribution (2011-12): 8331 tonnes covering 6.60 lac ha.

For groundnut- Groundnut rich (TNAU product)

Index number of groundnut production and productivity for 2010-2011

(Base year: Triennium ending 1993-94=100) Production: 52.18; Productivity: 155.51

Source: Dept. of Economics and Statistics, Chennai.

Rank based on area sown % to State	District Name	Average Productivity (Kg/ha.)
1	Tiruvannamalai	1780
2	Vellore	1946
3	Villupuram	2897
4	Namakkal	1951
5	Salem	1875
6	Erode	1861
7	Pudukkottai	2500
8	Kancheepuram	1800
9	Dharmapuri	2028
10	Ariyalur	1673

Source: Joint Director of Agriculture, & KVKs of each district.

Success story: Transformation of village cropping pattern through Front Line Demonstrations on groundnut among the tribal farmers in Junagadh district (Gujarat)

Shri Alad Lakha Parmar, who belongs to *Siddhi* community (an African migrant tribe covered under Schedule Tribes) resides at *Jambur*- a village in *Talala Taluka* of Junagadh district. He is a 55-year old traditional farmer with seven members in his family. Agricultural farming is his livelihood. Earlier he used to raises millets and certain other crops with traditional methods using low cost inputs, which would not fetch him good yields and hence he could not produce enough grains to meet his family needs and thus prone to food insecurity by suffering poverty. In a joint



attempt, DGR and KVK Kodinar, introduced technological interventions in *Talala Taluka* through FLDs. Initially, only 11 farmers were trained to raise groundnut crop on their own fields by following improved technologies and using groundnut variety TG-37 A. Other inputs were also provided free of cost. *Shri Alad Lakha Parmar* was one of the trainees.

Due to this intervention, the farmers realized good yields (2050 to 2373 kg/ha) in summer groundnut and they could earn a profit of at least ₹ 39,000/ha land. This success in groundnut crop spread like wild fire among tribal community and groundnut has now established itself as a favored crop in this area.

Conclusions : Performance of Kadiri-6 in INM component better (36% more yield) in Kharif against TMV-2. In Gujarat, GG-5 makes visible impact than GG-20 and TPG 41 against GG-2. GBPD-4 and R-2001-2 performed better (36% and 42%) against JL-24 in Kharif and Rabi/Summer respectively. In Maharashtra, JL-501 showed high potential to bridge yield gap-I while demonstrated with INM and IWM components in Kharif and Rabi/Summer respectively. ALR-3 is best performing variety and had high potential to bridge yield gap in Tamil Nadu. To bridge YG-I in Kharif, improved variety along with IPDM and INM has to be promoted. For Rabi/Summer, PGPR component with improved variety will bring high productivity. If all the new technologies adopted by all the farmers, the EYR estimation revealed that, about 2.3 MT production groundnuts can be achieved from existing 1.6 MT in Rabi/Summer and 7.9 MT from existing 3.1 MT groundnut productions in Kharif. The general agro-climatic factors responsible for minimum yield in groundnut and in areas closer to big cities technological gap is more than extension gap. In rural and remote areas both technological and extension gap is more. Among tribal areas, critical input and capacity building is needed to secure livelihood through groundnut crop.

Visit of farmers

This year (2013-14), a total of 655 farmers in 18 different groups and 46 students belonging different agricultural universities visited DGR. Thus during the year altogether 701 visitors from various states viz. Gujarat, Maharashtra, Odisha, Madhya Pradesh, New Delhi, Rajasthan and Goa visited the DGR. The visits were sponsored by State Departments of Agriculture or State Agricultural universities concerned. These visitor-groups were taken round field experiments; technology Park, laboratories, museum, library etc. and interaction meetings with the scientists were also arranged.

Training programmes organized for farmers and extension officers

During year (2013-2014) 4 trainings were conducted at DGR. Two three day training programmes organized on a common title "Improved groundnut production technologies for tribal farmers of Odisha". The first batch of 27 farmers from Odisha was imparted training on



18-20 January 2014, the second batch of 35 was imparted on 25-27 January 2014 and third batch of 37 famers from Navsary, Gujarat on 22-24 January 2014 and the fourth batch consisting of extension officers from Uttar Pradesh was given “Technologies for summer groundnut production in Uttar Pradesh” from 18-22 February 2014. First three day training was coordinated by Shri Murlidhar Meena and subsequent all three trainings were coordinated by Dr. Narayanan G., while Dr. Ram Dutta and Dr. Poonam Jasrotia had worked as course director and co-coordinator for the fourth training. Topics covered in training were improved agronomic practices for groundnut production, polythene mulch technique for enhancing groundnut production, major groundnut pest and Diseases and their management, minimizing risk of aflatoxin contamination in groundnut, application of micro-nutrients and its benefit to groundnut, prospects of value addition in groundnut, mechanization of groundnut production, post-harvest management: drying and storage technique for groundnut, Groundnut marketing: opportunities and challenges. A training manual prepared in Gujarati and Hindi was given to each of the trainees.

FACTORS	VILLUPURAM (High productivity area)	ARIYALUR (Low productivity area)
Farming system/ Enterprise	Groundnut(June- Sept)Groundnut(Oct-Jan) Sesamum(Feb-March)	Rice-Rice-Groundnut, Groundnut-Sesame-Coriander
Agro-climatic characteristics	The mean annual rainfall: 1120 mm (in 63 rainy days). The north east monsoon: 601 mm (in 29 rainy days) Southwest monsoon: 294 mm (in 24 rainy days). The major soil types are red loam and clay loam. The average maximum temperature varies from 19.5° C to 24.8 ° C. It has a wet period of 7 months and dry period of 5 months in a year.	Average annual rainfall of 909.18 mm. The soil pH is ranging from 6.5 to 8.0. Ferruginous red loam occurs. The maximum precipitation is contributed by North East Monsoon. Red Soil- Rich source of Fe, Mn, High P fixation capacity. Low organic matter & clay. Black Soil- More than 30% clay.
Crop management constraints	Lack of availability of certified seeds Lack of knowledge on foliar application of nutrients and growth regulators Poor organic matter in soil Lack of awareness on IPM in Groundnut Labor Shortage Drought Helicoverpa problem in groundnut Lack of seed treatment Lack of knowledge on drought management techniques Moisture stress at critical stages of crop due to erratic monsoon Run-off problem during peak monsoon period Lack of awareness on adopting bio-fertilizers	Usage of age old variety-VR12 Unaware of seed treatment methods Lack of knowledge about gypsum application Heavy root rot incidence Occurrence of leaf rust, leaf spot and verticillium wilt Bore holes in pods Poor grain formation Yellowing and stunted growth Heavy seed rate



PROJECT 28 : ASSESSMENT OF ECONOMIC SUSTAINABILITY OF GROUNDNUT CULTIVATION IN MAJOR GROWING AREAS

(MURLIDHAR MEENA, NARAYANAN G. AND A.P. MISHRA*)

*TILL 31ST NOVEMBER, 2013.

Comparative economics of groundnut with cotton in Gujarat

The study was based on data from commission for agricultural costs and prices (CACP) for the year 2010-11. In Gujarat, total and operational cost was found higher in cotton (54726 and 34951 ₹ ha⁻¹) than groundnut (33908 and 24564 ₹ ha⁻¹) respectively. Total value of produce was found more than double in cotton (103352 ₹ ha⁻¹) than groundnut (48563 ₹ ha⁻¹) resulted in higher net return (48626 ₹ ha⁻¹) in cotton against groundnut (14655 ₹ ha⁻¹) was calculated. The cost of production was also higher in cotton (2674 ₹ qtl⁻¹) as compared to groundnut (2240 ₹ qtl⁻¹). The higher operation cost in cotton was because of higher fertilizer and human labour cost (2910 ₹ ha⁻¹ and 16332 ₹ ha⁻¹) in cotton than in groundnut cultivation (1575 ₹ ha⁻¹ and 7282 ₹ ha⁻¹). In both the crops, major share of operational cost goes to the human labour (30% in groundnut and 47% in cotton), clearly indicated the urgent need of mechanization in groundnut as well as in cotton crops. Because of high seed rate in groundnut, seed cost (6699 ₹ ha⁻¹) is two and half times higher than cotton (2496 ₹ ha⁻¹). Irrigation charges in cotton (3075 ₹ ha⁻¹) are five times higher than groundnut (609 ₹ ha⁻¹) as of more irrigation application in cotton crop. Farmers are using more fertilizer and insecticides in cotton in compare to groundnut, which pointed out that cotton cultivation was more input intensive than groundnut cultivation, may be one of the reasons for low return in groundnut.

Comparative economics groundnut with maize in Tamil Nadu

Comparative economics of groundnut with maize was studied in TN based on the data of CACP, 2010-11. Per hectare cost of cultivation was found higher in maize (43461 ₹ ha⁻¹) than groundnut (38250 ₹ ha⁻¹). Total value of produce was higher in maize cultivation (58907 ₹ ha⁻¹) than groundnut (36330 ₹ ha⁻¹). Due to less value of produce than cost of cultivation in case of groundnut resulted in negative net returns while the net return of 15447 ₹ ha⁻¹ was recorded in maize crop. Per quintal cost of production was more than three times in groundnut (2895 ₹ qtl⁻¹) than maize (923 ₹ qtl⁻¹). Per hectare higher seed, manure, human labour and animal labour costs (5962, 1740, 16222 and 1350) were recorded in groundnut than maize (3227, 1468, 15271, 107) respectively. Whereas in case of maize cultivation, fertilizer, machine laborer, insecticide and irrigation (3184, 4770, 383 and 1068 ₹ ha⁻¹) costs were found higher than groundnut cultivation (1194, 1712, 232 and 657 ₹ ha⁻¹). It means low input application in groundnut i.e. fertilizer,



mechanization, insecticide, irrigation etc. may be one of the important reasons for negative returns. More than fifty per cent of operational cost goes to human laborer costs points out the urgent need of mechanization in both the crops in TN. Farmers are growing groundnut in resource poor condition, so good farm management is very much needed from farmer's side to get better return in groundnut crop in the state.

Resource use efficiency (RUE) in groundnut and cotton cultivation in Gujarat

In Gujarat higher TE (78%) was observed at cotton farms than groundnut farms (74%). In groundnut crop, fifteen per cent farmers were operating at less than fifty per cent TE as compared to eight per cent farmers in cotton. While, seventeen per cent groundnut farms are operating between 90 to 100% TE against fifteen per cent in cotton. More farmers were found hundred per cent technically efficient in groundnut (26 out of 150 farmers) against cotton (21 out of 150 farmers). Farmer to farmer efficiency variation is higher in groundnut crop than cotton. There was inefficiency of 26 per cent in groundnut and 22 per cent in cotton because of inefficient use of resources at farmer's field.

Understanding the district-wise performance of groundnut area, production and productivity in major groundnut growing states of India

District-wise data on groundnut area, production and productivity were collected from 1998-99 to 2009-10 for all the districts of Andhra Pradesh, Gujarat, Maharashtra, Rajasthan, Karnataka and Tamil Nadu, to identify the major groundnut growing and highly productive districts in each state. To analyze the performance of these districts over the period growth rate was estimated for each district in all the major groundnut growing states mentioned above.

Anantpur, Kurnool, Chittoor, Cuddapah and Mahabubnagar in AP; Junagadh, Jamnagar, Rajkot, Amreli and Bhavnagar in Gujarat; Kolhapur, Satara, Pune, Dhule and Nasik in Maharashtra; Tumkur, Chitradurga, Bellary, Belgaum and Gulbarga in Karnataka; Jaipur, Bikaner, Chittorgadh, Sikar and Tonk in Rajasthan; Tiruvanamalai, Villupuram, Vellore, Namakkal and Erode are top five groundnut growing districts in respective major growing states contributes more than fifty per cent of state's total area.

Nellore, Guntur, West Godavari, Krishna and Nizamabad in AP; Vadodara, Junagadh, Surendranagar, Kutch and Bharuch in Gujarat; Ratnagiri, Sindhudurg, Kolhapur, Akola and Satara in Maharashtra; Udupi, Uttarakannada, Shimoga, Bagalkot and Bangalore rural in Karnataka; Churu, Sikar, Jaipur, Bikaner and Jodhpur in Rajasthan; Thiruvallur, Kancheepuram, Perumbalur, Cuddalore and Thiruvannamalai are top five groundnut yielding districts in respective major growing states.



Research Highlights of AICRP on Groundnut- 2013-14

RABI-SUMMER 2012-13

CROP IMPROVEMENT

Germplasm enhancement

Multiplication of groundnut germplasm

A total of 2021 germplasm accessions received from NBPGR, New Delhi, under Svalbard Gene Bank programme were multiplied at five different AICRP centres viz. ARS, Kadiri, UAS, Dharwad, TNAU, Vridhachalam, JAU, Junagadh and MPKV, Rahuri. Of these a total of 1642 accessions have been rejuvenated and seeds of 219 accessions having sufficient quantity were deposited with NBPGR, New Delhi for long term conservation.

Germplasm evaluation

At Vridhachalam centres, 100 different germplasm accessions have been evaluated and out of which a few promising germplasm and advanced breeding lines have been identified for specific traits viz. earliness (AH 30, WC 190, AH 143 tolerance to mid season drought (ICG 3806), resistance to rust (AH 7272, K 437, ICG 1519) and LLS (NRCG 237, EC 225, CS 279)

Hybridization programme undertaken during rabi-summer 2012-13

For developing high-yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses which limit yield in rabi-summer season, hybridization programme was undertaken at 11 AICRP-G centers.

Altogether, 143 crosses using different cultivars/advanced breeding lines, germplasm accessions were made. Of the parents used in these crosses, few were germplasm accessions, and the rest were advanced breeding lines or recently released varieties.

Advancement of generations and selections made in inter and intra varietal crosses

Different segregating generations of objective specific inter and intra varietal crosses effected at 12 AICRP-G centers earlier, were advanced to their respective next higher filial generations during rabi-summer 2012-13. A large number of single plants/line or progeny bulks were selected from these crosses at different filial generations.

During rabi-summer season, progenies of 594 crosses were advanced to their respective next filial generation from which, a very large number of (8411) selections were made at 12 AICRP-G centres. The selections comprised mostly (7083) of single plants and 126 progeny bulks. Of the total crosses, which were advanced to different filial generations 369 crosses were in early



generations (F_1 - F_3) and 225 crosses in advanced generations (F_4 onwards). A vast majority number (7209) of single plant selections made during the last season were in early generations and the rest (1202) in advanced generations.

Interspecific hybridization and generation advancement

To develop novel sources of resistance/tolerance to foliar diseases (ELS, rust, LLS) and tolerance to drought 16 crosses have been attempted by RRS Vridhachalam centre. This involved crosses with amphidiploids; crosses involving cultivated types and derivative of *A. hypogaea* x autotetraploids; crosses involving cultivated types and diploids and crosses involving cultivated types and inter specific derivatives. The crossed seeds obtained will be sown in the next season for identification of true hybrids and further evaluation.

From the interspecific crosses effected earlier the promising selections made were advanced to next higher filial generation in RRS Vridhachalam (F_2 through F_5). In F_2 generation the number of crosses advanced was 17; in F_3 six crosses; in F_4 eight crosses and in BC_1F_5 four crosses have been advanced. The total number of selections made were 79 in F_2 ; and 102 in F_4 and 43 in BC_1F_5 stage. These selections will be further evaluated in the ensuing rabi-summer season. In addition a total of 33 stable interspecific derivatives developed earlier were also evaluated in different trials by the centre during rabi-summer 2012-13. Three of them viz., VG 0430 (State level multilocal trial), VG 0107 and VG 0104 (Adaptive Research Trial) are in advanced stages of evaluation.

Varietal Evaluation at Multilocations

A three tier system of evaluation of groundnut entries under the nomenclature of Initial Varietal Trial, Stage I (IVT I) and Initial Varietal Trial, Stage II (IVT II) was adopted and the trials were allotted to different centers located in five eco-geographical zones across the country.

Initial Varietal Trial (Stage-I)

Nine entries were tested in all the five zones against TAG 24 as the national check (NC), and the respective zonal check varieties at 23 centres and all of them except for Raichur have conducted the trial. As this trial is to be repeated as such at all the centres in *rabi*-summer, 2013-14, by using the produce of IVT I harvested at each centre as seed for IVT II.

Initial Varietal Trial (Stage-II)

Seventeen entries and three checks, one national and two zonal checks were tested at 24 locations spread over the five agro-climatic zones of groundnut. Over two years, in Zone IIb comprising Tamil Nadu and Andhra Pradesh, two entries in order of merit viz., JL 776 (3502 and 2445 kg/ha



of pod and kernel yield respectively) and KDG 160 (3041 and 2022 kg/ha of pod and kernel yield respectively) were found significantly superior over best zonal check variety, R 8808 (ZC) for both pod and kernel yield. Hence, these two entries were promoted to Advanced Varietal Trial (AVT).

CROPPRODUCTION

Survey of agronomic management practices in farmer's fields

A survey of 824 farmers was conducted by 11 AICRP-G centres during *rabi*-summer 2012-13 to study adoption of improved agronomic management practices and also to find out the constraints faced by them. Majority of the farmers were not adopting good agricultural practices like optimum seed rate, balanced use of fertilizers including gypsum and micronutrients like Fe, Zn and B, seed treatment with bio-fertilizers/fungicides, herbicides for weed control, high yielding and disease resistant/tolerant cultivars. Non-availability of good quality seeds of high yielding/improved cultivars in sufficient quantity as well as high cost of seed at the time of sowing were observed to be major constraints.

Integrated nutrient management in rice-groundnut cropping system

At Bhubaneswar, significantly higher total groundnut equivalent yield (3281 kg ha^{-1}), net returns ($\text{₹}44258 \text{ ha}^{-1}$) and B:C ratio (2.48) were obtained with the nutrient management practices involving application of recommended dose of nitrogen @ 60 kg ha^{-1} to rice and recommended dose of phosphorus (@ $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$) to the succeeding groundnut crop in rice-groundnut cropping system.

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

At Jalgaon, application of 80% of average daily transpiration rate by drip at alternate days gave significantly higher pod yield (3825 kg ha^{-1}) and net returns ($\text{₹}100073 \text{ ha}^{-1}$) over border strip irrigation at 1.0 IW/CPE ratio with 5 cm irrigation water depth (2767 kg ha^{-1} and $\text{₹}74166 \text{ ha}^{-1}$, respectively). For pod yield this treatment was at par with other drip irrigation management practices. However, haulm yield was not significantly affected due to different irrigation management practices. Maximum dry pod yield and net returns were recorded in 60 cm lateral spacing. At Vriddhachalam, irrigating groundnut at 100% average daily transpiration rate (Td) by drip at alternate day with one lateral between two pairs produced significantly higher pod yield (2584 kg ha^{-1}).



Evaluation of commercially available multi-micronutrients fertilizers and their economic viability in groundnut production during rabi-summer (Soil application)

At Akola, Multinelf 16 @ 60 kg ha⁻¹ recorded significantly higher pod yield (3677 kg ha⁻¹) over remaining treatments except Vasundhara (3532 kg ha⁻¹), Zinc High (3505 kg ha⁻¹), Easy mix (3485 kg ha⁻¹), Boracal 12 (3452 kg ha⁻¹) @60 kg ha⁻¹. This treatment also registered maximum net returns (₹106441 ha⁻¹). At Jalgaon, application of Multiplex @ 40 kg ha⁻¹ in soil at the time of sowing significantly enhanced dry pod yield, gross and net returns as well as benefit cost ratio over lower dose of any multi-micro-nutrients and was at par with same and higher levels of multi-micro-nutrients.

Evaluation of commercially available multi-micronutrients fertilizers and their economic viability in groundnut production during rabi/summer (Foliar application)

At Akola, foliar spray of Microlla @ 5.0 L ha⁻¹ at 30 DAS was found better whereas at Jalgaon, foliar application of Stanes Micro Food/Rich combi F @ 5 L ha⁻¹ at 30 days after sowing showed superiority. At Kadiri, foliar application of Growth or Mahaphal @ 2.5 L ha⁻¹ at 30 days after sowing was found to be optimum for higher productivity and economic returns.

Studies on the effect of water soluble foliar grade fertilizers (WSFGF) on the growth and yield of groundnut

The experiment was initiated in *rabi*-summer 2011-12 with twelve different treatments including organic, inorganic and water soluble fertilizer combinations at ten different centres. The groundnut productivity was highest with application of 7.5 t FYM ha⁻¹+100% RDF along with foliar application of water soluble grade fertilizer @ 2% as starter dose (11:36:24 + trace element) at 30 DAS and booster dose (8:16:39) at 45 and 60 DAS at all the centres.

Fertigation in groundnut production

At Aliyarnagar, application of drip irrigation once at 60% pan evaporation along with 50% RDF through fertigation recorded significantly highest pod, haulm and kernel yields (3007, 4096 and 2078 kg ha⁻¹, respectively) and it remained at par with drip once at 80% pan evaporation+50% RDF through fertigation (2887, 1953 and 4370 kg ha⁻¹, respectively). At Jalgaon, application of drip irrigation at 100% of ETc with 100% RDF through water soluble fertilizers in 9 equal splits) recorded significantly highest dry pod yield (5633 kg ha⁻¹), gross monetary returns (₹260500 ha⁻¹) net monetary returns (₹189124 ha⁻¹). However, it was at par with drip irrigation 80% of ETc with 80% of RDF through water soluble fertilizers in 9 equal splits where savings of water and fertilizers was 20%.



CROPPROTECTION

Pathology

Disease Situation

Report on disease situation in farmers' fields

The diseases like collar rot, stem rot, dry root rot, early leaf spot, late leaf spot, rust, *Alternaria* blight and bud necrosis were reported from different locations. Peanut stem necrosis was recorded at Kadiri. Late leaf spot was severe at Aliyarnagar (6-8 of 1-9 scale), Vriddhachalam (6-9 of 1-9 scale), and Kadiri (7-9 of 1-9 scale). Rust was severe at Aliyarnagar (6-7 of 1-9 scale) and Kadiri (4-7 of 1-9 scale). Dry root rot was severe at Kadiri (16-28%) and stem rot was recorded more than 10% at Dharwad and Kadiri. The bud necrosis incidence was severe at Raichur (13%) and Kadiri (8%) in the farmers' field.

Disease Resistance

Screening of germplasm entries against major diseases

At Aliyarnagar, two entries viz., VG 1008 and VG 1016 have shown resistance to late leaf spot and rust, and five entries viz., VG 0517, VG 0706, VG 1007, VG 1012, and VG 1015 have shown resistance to rust alone. Among the 15 ICRISAT entries evaluated, ICGV 00241 shown resistance to late leaf spot and rust and six entries viz., ICGV 99072, ICGV 00162, ICGV 00189, ICGV 00191, ICGV 00211 and ICGV 00247 shown resistance to rust alone. At Vriddhachalam, eight entries viz., VG0502, VG0505, VG0507, VG0517, VG0519, VG0707, VG1002 and VG1003 showed moderately resistant reaction against LLS with grade of 3-4 in 1-9 scale. Disease pressure of stem rot was not high as majority of genotypes were free from infection. At Jalgaon, none of the entries were found promising against stem rot while, four entries viz., JL-903 (6.4%), JL-777 (7.2%), WRGS-1 (7.7%) and RHRG-861 (8.6%) were recorded below 10% incidence of stem rot and two entry JL-777 (4.4%) and JL-903 (4.3%) recorded collar rot incidence below 5%.

Disease Management

Management of aflatoxin contamination in groundnut

At Raichur, the population of *Aspergillus flavus* in soil ranges from 9.7×10^3 to 16.3×10^3 cfu/g soil and $\times 10^3$ to 17.3×10^3 cfu/g soil before sowing and after the harvest of crop, respectively. Rotation of crops and fallow reduces the population of *A. flavus* except in groundnut-groundnut rotation. At JAU, Junagadh there was no *A. flavus* colonies observed in the soil before sowing *rabi* crops and summer groundnut as well as after harvesting *rabi* and summer crops. There was no colonization and infection of *A. flavus* in pods/seeds collected at the time of harvesting of summer groundnut.



Management of Alternaria blight in groundnut

At JAU, Junagadh, the fungicides, mancozeb, propiconazole and difenconazole were found effective in reducing *Alternaria* leaf blight in groundnut. At DGR, Junagadh, the lowest severity of *Alternaria* blight was recorded in two spray of difenoconazole @ 0.025% at 45 & 60 DAS followed by mancozeb @ 0.2% in groundnut.

Development of sick plot for the stem rot (Sclerotium rolfsii) and periodical monitoring of the pathogen population dynamics

At Aliyarnagar, sick plot has been maintained continuously with addition of inoculums through infected debris and growing susceptible variety TMV 7. At Dharwad, the sick plot for *Sclerotium* stem rot (20 x 30 m) was developed and screening of entries is being done for last five seasons both in *kharif* and *rabi*-summer. The population of *S. rolfsii* appeared to be high in soil of the plot. At Kadiri, permanent sick plot has been developed with virulent isolate. Periodical estimation of pathogen inoculum load is being done.

Integrated Management of PBNB in groundnut

At Jalgaon, and Kadiri module-III [Border crop with Jowar (4 rows) + Seed rate @ 200 kg/ha + Seed treatment with Gaucho 600 FS @ 1 ml/kg seed + Foliar spray using Thiocloprid 480 SC @ 150 ml/ha at 20 DAS followed by Acetamiprid 20 SP @ 100 g/ha at 35-40 DAS]. At Raichur, Module II [Border crop with bajra (4 rows) + Seed rate @ 200 kg/ha + Seed treatment with Imidacloprid @ 2 ml/kg seed + Foliar sprays using Dimethoate @ 1 lit / ha at 20-25 DAS followed by Imidacloprid @ 200 ml / ha at 35-40 DAS] was found significantly superior over module I and module III.

ENTOMOLOGY

Incidence of major pests and diseases at different centres

The incidence of thrips and leafhoppers was high during vegetative stage of crop at Dharwad, Jagtial, Kadiri and Raichur centres whereas, the incidence of aphids, leaf miner and tobacco caterpillar was high at both Dharwad and Jagtial centres during pod formation stage.

Reaction of groundnut entries and genotypes against the major pests of groundnut

The groundnut entries which recorded lower thrips population than check varieties were: INS-II-2011-4, 5, 6, 8, 9, 11, 12, 30, 36, 37 and INS-I-2012-1, 3, 4, 5, 6, 7, 8, 16, 19, 20, 21, 22, 23, 24, 25, 26, 27; AIS-II-2010-4, AIS-II-2011-2 and 3; VG-0437, 094406, 0401, 0439 and 0430; ALSVT-



II-11-2 and 6 and PBS-12171, 1266, 18035, 12181 and 12163). The groundnut entries which recorded lesser foliage damage due to tobacco caterpillar were; INS-I-2012- 1 to 27, INS-II-2011- 3, 5, 8, 12, 29, 37, 38 and 39, AIS-II-2010- 4, VG-0437 and PBS -12171, 1266, 18035 and 12181.

Monitoring of tobacco caterpillar and leaf miner using pheromone traps

The occurrence of tobacco caterpillar (*Spodoptera litura*) and leaf miner (*Proarema modicella*) were monitored at seven AICRP-G centres (Dharwad, Jagtial, Jalgaon, Junagadh, Kadiri, Raichur and Vriddhachalam). In the summer crop, the population of *S. litura* peaked during 9th standard week (Jagtial and Kadiri); 12th standard week (Vriddhachalam); 15th standard week (Jalgaon and Junagadh); 17th standard week in Dharwad and 51st standard week at Raichur. The population of leaf miner exhibited its peak during 11th standard week in at Kadiri centre.

Evaluation of IPM modules

IPM module for managing tobacco caterpillar (basal application of castor cake @ 500 kg/ha, seed treatment with *Trichoderma* spp. @ 4g/kg, intercropping with castor (3:1) or growing border crop of castor, installing bird perches @ 50 and pheromone traps @ 2/ha as well as need based application of crude neem oil @ 2% was evaluated at four centres viz., Dharwad, Jagtial, Jalgaon and Vriddhachalam. In all the centres this module was found effective in controlling *S. litura* damage and gave higher yields as compared to farmer's practice.

Evaluation of new molecules for the control of major insect pests of groundnut

Several new insecticidal molecules were tested for their efficacy on sucking pests as well as defoliators at five centres (Dharwad, Jagtial, Junagadh, Kadiri and Vriddhachalam). The molecule thiamethoxam exhibited higher insecticidal efficacy in managing thrips. Whereas for managing defoliators like, tobacco caterpillar, gram-pod borer and leaf miner, the insecticide flubendiamide, was found most effective followed by chlorantraniliprole and spinosad.

Front Line Demonstrations

In rabi-summer 2012-13, a total of 476 FLDs were allotted to 24 AICRP-G centers located in ten different states. The FLDs under Improved Variety (IV) component recorded an average pod yield of 2322 kg/ha compared to 1967 kg/ha under old varieties, an increase of 18 per cent over old varieties. The average haulm yield was 2859 kg/ha as compared to 2460 kg/ha with farmers practices. The average cost of cultivation of new varieties was ₹37942/ha as compared to



₹35073/ha for old varieties. Thus through The net return increased to as much as 33% through adoption of new varieties.

The FLDs under Whole Package (WP) component recorded an average pod yield of 2409 kg/ha when compared with farmer's practice (1942 kg/ha pod yield). The increase in pod yield due to WP was 23 per cent over old practices.

The FLDs under Integrated Pest Management (IPM) component recorded an average pod yield of 1533 kg/ha as compared to 1370 kg/ha of pod yield realised under farmers practice. The increase in pod yield due to IPM was 11 per cent over farmers practice. The FLDs under Integrated Nutrient Management (INM) component recorded an average pod yield of 2338 kg/ha as compared to 1875 kg/ha of pod yield obtained under farmers practices. The pod yield was increased by 24 per cent over farmers practice. The net returns realized was ₹40863/ha as compared with ₹31882/ha with farmers practice.

KHARIF- 2013

CROP IMPROVEMENT

Maintenance and multiplication of groundnut germplasm

Five thousand one hundred and forty one germplasm accessions have been maintained at ten centres during *kharif* 2013. A set of 1000 germplasm received from NBPGR under Svalbard Global Seed Vault, Norway have been multiplied during *kharif* 2012 by seven centres. During *kharif* 2013, the same set was multiplied again for seed increase in these centres.

Evaluation of germplasm and pre-breeding lines

At Chinthamani, few promising germplasm, advanced breeding lines and released varieties have been identified for specific traits (earliness, high oil content, high shelling,; synchronous maturity and tolerance of drought, large seeds, fresh seed dormancy, resistance to rust and LLS. At Dharwad, two interspecific hybrid populations (pre-bred) comprising 97 and 84 lines have been screened for tolerance of *Sclerotium rolfsii*. Of the 181 lines screened eight breeding lines and 26 promising lines from the second population were found promising against *S. rolfsii*.

Hybridization

For developing high-yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses which limit yield in *kharif* season, a of hybridization programme was undertaken at 15 AICRP-G centers. Altogether, 201 single-crosses using different cultivars/advanced



breeding lines, germplasm accessions were made.

During *kharif* season-2013, progenies of 1390 crosses were advanced to their respective next filial generation from which, a very large number of (18451) selections were made. The selections comprised of large number (12859) of single plants and 5592 progeny bulks. Of the total crosses (1390), which were advanced to different filial generations 565 crosses were in early generations (F_1 - F_3) and 825 crosses in advanced generations (F_4 onwards). A vast majority number of single plant selections made during the last season were in early generations (9779) and the rest (3080) in advanced generations. In addition, few selections were also made from the six crosses that were made in M_1 generation and from three multiple crosses in advanced generation.

Interspecific hybridization

Maintenance of wild germplasm

At RRS Vridhachalam centre, 22 wild species; 4 auto triploids; 27 triploids obtained from crosses involving either of tetraploid cultivated types crossed with diploid wild species or cross combinations involving tetraploid cultivated types with amphidiploid cross combinations; 15 hexaploids obtained from cross combination involving tetraploid cultivated types with diploid wild species and 11 amphidiploids derived from crosses made using different wild species have been maintained.

New interspecific crosses made

Thirteen new interspecific crosses were made by the centre between different cultivated types with wild species season with an objective of introgressing the novel genes for tolerance reaction to major foliar diseases and drought. The crossed pods harvested will be sown during the next *kharif* season for establishment.

Varietal Evaluation

Of 84 genotypes, 27 Spanish bunch types and 18 Virginia types were evaluated in Initial Varietal Trial (stage-I); 18 Spanish types and 14 Virginia types in Initial Varietal Trial (stage-II); 7 large seeded types; 1 in Advanced Varietal Trial (SB) and 7 in Advanced Varietal Trial (VG) were evaluated at different groundnut zones in *kharif* 2013. One genotype each in Virginia type (RG 559-3) and large seeded type (K 1641) have been promoted to Advanced Varietal Trial.

In zone II (comprising Gujarat and southern Rajasthan), two Virginia genotypes, in order of merit, KDG 128 (2394 kg of pod and 1579 kg of kernel/ha) and KDG 123 (2170 kg of pod and 1509 kg of kernel/ha) which exhibited significant higher pod and kernel yields over the check



variety of this zone, GG 20 (1788 kg of pod and are being proposed for identification.

Similarly in Zone IV (comprising Jharkhand, Odisha, and West Bengal), two Virginia genotypes, JSP 51 (1914 kg of pod and 1330 kg of kernel per ha) and KDG 123 (1773 kg of pod and 1218 kg of kernel per ha) which exhibited significant higher pod and kernel yields over the check variety of the zone, Kaushal (1535 kg of pod and 1072 kg of kernel per ha), across different stages of testing and over three years have been proposed for identification.

In zone V, a large zone comprising ten locations in Tamil Nadu, Andhra Pradesh, and Karnataka, across different stages of testing and over three years, one Virginia genotype, KDG 123 (1914 kg of pod and 1330 kg of kernel per ha) exhibited significant higher pod and kernel yields over the best check variety of the zone, GG 16 (1743 kg of pod and 1162 kg of kernel per ha) and is being proposed for identification.

Breeder seed production

During *kharif* 2013, DAC indents to the tune of 12486.95q were received for 55 groundnut varieties. However, based on the availability of nucleus/breeder seed stage I, a production target of 11026.85q was assigned for 51 groundnut varieties to 23 breeder seed producing centres. During *kharif* 2013, against this allocation, a total quantity of 5302.82q breeder seed could be produced. To mitigate the short fall, a compensatory programme was undertaken during *rabi*-summer 2013-14 and the anticipated production is around 7693.00. Thus, the expected total production during 2013-14 would be 12995.82q.

CROPPRODUCTION

Optimization of *kharif* groundnut production under resource constraints

Application of full package gave significantly higher pod yield (2297 kg ha⁻¹) over all other treatments. Among the individual factors, lack of weeding caused highest loss in pod yield (38.0%) followed by no fertilizer application (21.5%) and lack of plant protection measures (18.2%) over full package of practices. Application of full package minus (fertilizer+plant protection+weeding) gave 138.2 per cent less pod yield as compared to full package.

Yield maximization in groundnut through nutrient management practices during *kharif* under rainfed situations

Application of FYM @ 7.5 t ha⁻¹ + RDNPK + critical micronutrient gave significantly higher pod yield (2213 kg ha⁻¹) over all other treatments. Further, foliar spray of 2% urea at 30 and 60 DAS sowing produced significantly higher pod yield over remaining treatments.



Productivity of groundnut as influenced by application of nitrogen and phosphorus in different ratios

Application of N and P in N/P_2O_5 ratio of 0.40 produced significantly higher pod yield (2533 kg ha^{-1}) as compared to other N/P_2O_5 ratios except 0.33(0.75), 0.42 and 0.50 ratios.

Effect of irrigation levels and hydrogel on productivity of *kharif* groundnut

Application of irrigation water at 0.8 IW/CPE ratio significantly improved pod yield (2300 kg ha^{-1}) over 0.6 IW/CPE ratio and was at par with higher ratios. Further, application of hydrogel @ 3.50 kg ha^{-1} produced significantly higher pod yield (2483 kg ha^{-1}) over other rates of application.

Effect of land configuration and mulching on productivity and resource use efficiency of *kharif* groundnut

Groundnut crop grown on raised-bed and furrow method (60 cm width and 30 cm furrow), being at par with broad-bed and furrow method, registered significantly higher pod yield (1993 kg/ha) as compared to other land configuration. Further, biodegradable mulch significantly produced higher pod yield of 2043 kg/ha as compared to other mulches.

Effect of paclobutrazol on growth and yield of *kharif* groundnut

Application of paclobutrazol @ 200 ppm recorded significantly higher pod yield over other levels and was comparable with 150 and 100 ppm. Mean pod yield due to time of application did not vary significantly, however numerically higher pod yield was recorded with application at 30 and 50 DAS.

CROPPROTECTION

Plant Pathology

Disease management

Integrated Management of late leaf spot and rust diseases

Seed treatment of Tebuconazole @ 1.5 g/kg + furrow application of *T. viride* @ 4kg enriched in 50 kg FYM/ha + Broadcasting *T. viride* @ 4kg enriched in 50 kg FYM/ha at 40 DAS + two spray of Tebuconazole @ 1ml/L, starting from initiation of foliar diseases and 2nd spray at 15 days was found to be the best in reducing rust and LLS as compared to control at Aliyarnagar and Dharwad.

Seed treatment with Tebuconazole @ 1.5 g/kg + furrow application of *T. viride* @ 4.0 kg enriched with FYM @ 50kg/ha + broadcasting of *T. viride* @ 4kg enriched with FYM @ 50kg/ha + two foliar spray of Tebuconazole @ 1ml/L starting from initiation of foliar diseases and second spray at 15 days intervals resulted in minimum collar rot incidence, minimum PDI of early leaf spot, highest pod and haulm yield



Management of soil borne diseases through organic practices

At Hanumangarh, a hot spot centre for collar rot, seed treatment with *T. viride* @ 10g/kg + furrow application of *T. viride* @ 4kg enriched with FYM @ 250kg/ha + foliar application of neem seed kernel extract @ 5% at 30 and 45 DAS gave less collar rot incidence and highest pod yield closely followed by seed treatment with *T. viride* @ 10g/kg + furrow application of *T. viride* @ 4kg enriched with FYM @ 250kg/ha + foliar application of *T. viride* @ 2.5 kg/ha at 30 and 45 DAS.

At Jalgaon, seed treatment with mixture of *Trichoderma* sp. and *P. fluorescens* @ 10 g each / kg seed + combined furrow application of *Trichoderma* sp. and *P. fluorescens* @ 2 kg each enriched with FYM @ 300 kg/ha + foliar application of neem seed kernel extract @ 5% at 30 and 45 DAS was recorded the least incidence of collar rot at 30 DAS, while significantly lowest stem rot incidence was recorded in seed treatment with mixture of *Trichoderma* sp. and *P. fluorescens* @ 10g each/kg seed + combined furrow application of *Trichoderma* sp. and *P. fluorescens* @ 2kg each enriched with FYM @ 300kg/ha + foliar application of mixture of both @ 2kg each/ha at 30 and 45 DAS.

Management of Aspergillus flavus and aflatoxin contamination through crop rotation/cropping sequence

At Kadiri, population of *A. flavus* was decreased in soil either by crop rotation with onion/jowar/maize or by keeping fallow the land. Less kernel and pod infection of *A. flavus* was recorded by crop rotation using onion in *rabi* when compared to other crops. Further, pod yield was increased by practicing crop rotation or by keeping land fallow either in *kharif* or *rabi*.

Entomology

- The major pests of groundnut during Kharif 2013 were Thrips, Leafhopper, *Spodoptera* and Leaf miner. *Helicoverpa*, hairy caterpillar, *Maruca vitrata*, bud borer, flower feeder blister beetle.
- The high incidence of *Spodoptera* and other defoliators was noticed at pod formation and maturity stage.
- The incidence of sucking pests; thrips and leafhopper was comparatively higher during vegetative stage as compared to maturity stage.
- At Jagtial centre, a very high damage due to thrips (70.0%), leaf hoppers (45.0%), by *Spodoptera litura*, and bihar hairy pillar (55.0%) was reported.
- Population dynamics of *Spodoptera* and leaf miner was recorded with pheromones traps. At most of the locations; the population of *Spodoptera* was peaked during 35th to 37th standard week.



- Population of leaf miner peaked during 36th to 37th standard week at Kadiri Vriddhachalam and at other locations the pest was not reported.
- Screening was carried at various AICRP centres to determine any resistant/tolerant lines mainly for thrips and *Spodoptera* by most of. Screening was done for leafhopper, leafminer and *Helicoverpa* at few centres where these pests are observed as higher numbers.
- Tolerant and resistant genotypes to pests have been identified based on scores obtained by measuring per damage inflicted by a particular pest.
- Among the insecticides tested for efficacy as seed treatment against sucking pests, at most of the locations Imidacloprid @ 2.0 ml/kg. At some locations, Imidacloprid @ 3.0 ml/kg or 1ml/kg gave best results. The next best treatment after Imidacloprid was of Thiamethoxam 35 FS (2 mL/kg)
- Amongst the insecticides tested against bruchid beetle Spinosad 45 SC @ 0.3 ml/l was effective followed by Deltamethrin 2.5 SC@ 0.5 ml/l in reducing bruchid beetle damage on groundnut pods in storage godown at Kadiri. The results are awaited from Dharwad and Jalgaon.

Front Line Demonstrations (FLDs)

- During Kharif 2013 a total of 465 FLDs were allotted of which 361 FLDs have been conducted. The FLDs were allotted on different components such as Improved Variety (IV), Whole Package (WP) and Integrated Nutrient Management (INM), and Integrated Disease Management (IPDM).
- The result showed of 277 FLDs with Improved Variety recorded a average pod yield of 2030 kg/ha compared to 1641 kg/ha with farmers practice. The pod yield increased by 24% with improved variety over local varieties. The average haulm yield was 2918 kg/ha with improved practice compared to 2547 kg/ha with farmers practice. Increase in the haulm yield with improved variety was 15% over local varieties.
- The average cost of cultivation and average gross returns with improved variety was ₹34680/ha and ₹83131/ha respectively. Whereas, in farmers practice it was ₹32318/ha and ₹65404/ha respectively. The gross returns increased by 27%.
- The results of 55 FLDs with whole package indicated that the average pod yield was 2024 kg/ha as compared to 1677 kg/ha realised with farmers practice. The pod yield increased by 21% with improved variety over local varieties. The average haulm yield was 4198 kg/ha with improved practice as compared to 3672 kg/ha with farmers practice. Increase in the haulm yield with improved variety was 14% over local varieties.

The average cost of cultivation and average gross returns with improved variety was ₹41243/ha and ₹92218/ha respectively whereas, in farmers practice it was ₹38832/ha and ₹76153/ha respectively. The gross returns increased by 21 per cent.



EXTERNALLY FUNDED PROJECTS

1. ALL INDIA NETWORK PROJECT ON SOIL BIODIVERSITY-BIOFERTILIZERS

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

Funding agency: ICAR

Duration: 01.04.2007-31.03.2014

Fund: ₹ 35.00 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:

- Application of *Pseudomonas putida* DAPG1, DAPG3, DAPG4 and *P. fluorescens* FP98 through seed treatment significantly enhanced pod and haulm yield, shelling out-turn and 100 kernel mass of groundnut, cultivar TG 37A during summer 2013. Besides, there was a significant improvement in root and shoot length, nodule number, plant biomass, etc. at 45 DAS by inoculation of most of the DAPG-producing fluorescent pseudomonads over un-inoculated control. In kharif season, pod yield enhanced significantly by application of *Pseudomonas putida* DAPG1, *P. putida* DAPG5, and *P. fluorescens* FP98. There was also significant improvement in haulm yield, root and shoot length, root and shoot dry weight, shelling out-turn, and 100 kernel mass by application of *P. putida* DAPG1 and *P. fluorescens* FP98 over un-inoculated control.
- To suppress the incidence of stem rot caused by *Sclerotium rolfsii*, a major soil-borne fungal pathogen of groundnut, DAPG-producing fluorescent pseudomonads were evaluated with the susceptible cultivar GG20. Application of the DAPG-producing fluorescent pseudomonads reduced the seedling mortality of groundnut, cultivar GG 20 from 60% in pathogen control to 25-40% in treatments inoculated with different DAPG-producing fluorescent pseudomonads. Moreover, besides reduction in disease incidence, maximum yield gain of 12.1% was achieved with the inoculation of DAPG-producing *P. putida* FP86 over uninoculated control.
- For studying the diversity of groundnut rhizobia, 75 samples each of *nifH* and *nodBC* (PCR amplified and cloned) and 16S rRNA were processed for sequencing.



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: 01.04.2007-31.03.2014

Fund: ₹ 58.70 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:

- Gene encoding 24 different proteins, expressed differentially at 20 and 35% of NaCl stress in *Haloferax volcanii* H5, 17 genes were amplified using custom designed primers and amplification nearest to the expected size of the amplicons was obtained (Figure 1). The amplified products were cloned to pUC18/pUC19 cloning vectors for studying the expression and validation in *E. coli*.

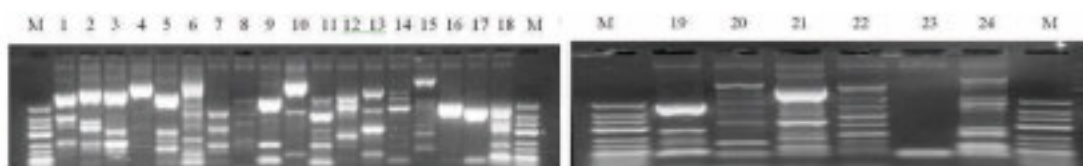


Figure 1. PCR amplification of 24 genes of *Haloferax volcanii* H5 which might be involved in osmotolerance



- [illegible]

- 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 *crv* and other insecticidal genes

Achievements:

- Genes of three differentially expressed proteins viz. glycerol kinase, hypothetical protein (137.4 KD), pyruvate dehydrogenase (40.6 KD), obtained from *Bacillus* sp. SB47 and expressed only at 20% of NaCl stress were cloned in expression vector. Validation of the role of these proteins in imparting osmotolerance in *Bacillus* sp. SB47 is underway.
- To understand the mechanisms of osmotolerance in extreme halophilic bacilli on evolutionary perspective by comparative genome analysis, two more bacterial whole genomes were sequenced in addition to four extreme halophilic bacilli sequenced earlier (*Salinibacillus aidingensis* MSP4; *Bacillus* sp. NSP2.1 (Sensitive to salinity); *Bacillus* sp. NSP9.1; and *Bacillus* sp. SB47). These were *Sediminibacillus halophilus* strain NSP9.3 and *Thalassobacillus devorans*. The sequence of the genomes of *Sediminibacillus*, *Thalassobacillus*, and *Salinibacillus* is being reported for the first time in the world. Further analysis is underway to understand the mechanism(s) of obligate and moderate halophilism in *Thalassobacillus devorans* MSP14 and moderate halophilism in *Sediminibacillus halophilus* NSP9.3.
- Circular genome map of *Bacillus* sp. NSP9.1 has been constructed with the location of ORFs, GC skew (+), GC skew (-), start and stop of each ORFs, etc.

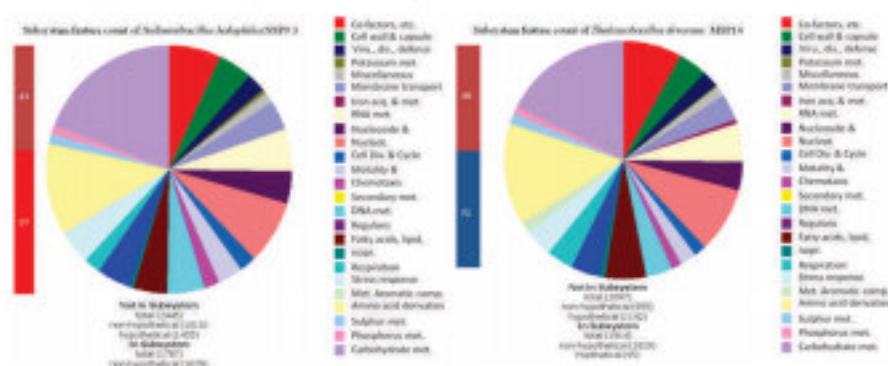


Figure 1. Subsystem feature count of the genome of *Sediminibacillus halophilus* NSP9.3 and *Thalassobacillus devorans* MSP14



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

(CCPIs: K.K. PALAND R. DEY)

Funding agency: NAIP

Duration: 04.05.2009-31.03.2014

Total fund: ₹ 97.59 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:

- 43 different proteins expressed differentially at 10, 20 and 35% NaCl stress against 0% NaCl as background were obtained from *Aspergillus sydowii* BF5. Identification and characterization of these proteins are underway by MALDI-TOF-MS.
- 25 differentially expressed transcripts coding conserved/predicted/ hypothetical proteins (S21, S28, S44, S62, S97, S101, S104, S105, S109, S112, S116, S117, S118, S131, S135, S136, S138, S144, S155(2), S156, S186, S192-1, S192-2, S200, S204) expressed only at 20% of NaCl as compared to that expressed without salt in *Aspergillus sydowii* BF5 were amplified by custom made primers. The amplicons varied from 410 bp to 3750 bp. Among these, five amplicons (450 bp, 900 bp, 1170bp, 1400bp and 1760 bp), all coding for hypothetical proteins, were successfully cloned to pUC18 for studying the expression and their validation, which would lead to elucidation of the role played by these differentially expressed hypothetical proteins in imparting extreme osmotolerance in to *Aspergillus sydowii* BF5, if any.
- As blast search of differentially expressed transcripts and proteins which might be involved in osmotolerance in extreme halophilic *Aspergillus sydowii* BF5, did not find match in the available NCBI databases, and as the genome database of *Aspergillus*



sydowii was not available, complete genome sequence of this unique fungus *Aspergillus sydowii* BF5 (Teleomorph *Eurotium* sp.) was undertaken employing multiple platforms. Eventually, *denovo* assembly of the sequence data lead to prediction of the genome size of 86.8 MB (against 35–40 MB of genome reported in the genus *Aspergillus*) with 18230 contigs (maximum contig length of 217649 bp with average contig length of 4766 bp and contig >10 KB 2402). Sequencing of mitochondrial DNA, scaffolding, gap filling, alignment to different chromosomes and bioinformatic analysis of the genome of *Aspergillus sydowii* BF5 is in process. Once complete genome sequences become available, the differentially expressed transcripts and proteins will be mapped in the genome of *Aspergillus sydowii* BF5 to isolate the candidate gene(s) imparting salinity tolerance.

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 NFBFSFARA

Duration: 01.06.2011-31.05.2016

Total fund: ₹ 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:

- Monitoring the population of endophytes revealed that while *B. firmus* (J22N) and *B. subtilis* (REN51N) colonized root, stem and seeds, *Bacillus tequilensis* SEN15N did not colonize seeds. However, REN15N was more aggressive in colonizing GG2 as compared to TG37A.
- Application of *B. firmus* (J22N) and *B. subtilis* (REN51N) increased contents of total carbohydrates, proline, total phenol, H₂O₂, etc. as compared to uninoculated control in



both the susceptible and tolerant cultivars. Besides, there was an enhancement in production of enzymes like SOD, GR, CAT, peroxidases, etc. when inoculated with J22N and REN51N as compared to control in both the cultivars.

- Maximum improvement in haulm yield of groundnut was achieved when inoculated with *B. subtilis* REN51N (normal and 6 EC water) and *B. firmus* J22N (3 and 9 EC water). In case of pod yield, there was improvement by 26% and 17% (normal and 3 EC) by inoculation with *B. subtilis* REN51N and by 17% and 13% (6 and 9 EC-irrigation water) by *B. firmus* J22N, respectively in summer 2013.
- In kharif 2013, pod and haulm yields significantly affected by salinity and seed treatments. Seed treatment with *Bacillus firmus* J22N and *Bacillus subtilis* REN51N enhanced pod yield by 15.89 and 16.82%, respectively over the control. The corresponding increase in haulm yield was 9.55 and 17.69% respectively, over the control.

6. ROLE OF ARCHAEABACTERIA IN ALLEVIATION OF SALINITY AND MOISTURE STRESS IN PLANTS

(CCPI: R. DEY; CI: K. K. PAL)

Funding agency: ICAR through NFBSFARA

Duration: 01.08.2012-31.07.2015

Total fund: ₹54.4743 lakh

Objectives:

- To compare the mechanism of action of archaea, eubacteria and fungi in alleviation of salinity and moisture deficit stress.
- To evaluate the feasibility of effective consortia based on microbes with complementary and supplementary mechanisms of alleviation for sustaining plant growth and nutrition under salinity and moisture stress.

Achievements:

- Seedling bioassays were conducted after standardizing the technique for *Sporobolous* spp. and *Dicanthium* spp. All the isolates of the archaea were evaluated with two grasses viz., *Dicanthium annulatum* and *Sporobolous marginata*. Results indicated that whereas application of archaeobacterial isolates like ARC2, ARC4, ARC5, ARC6, ARC7, ARC8, ARC11, ARC13, ARC16 and ARC25 enhanced both the root and shoot length of *Sporobolous marginata* as compared at 50 mM of NaCl, archaeobacterial isolates ARC9,



ARC29, ARC34, ARC36, ARC40 and ARC41 enhanced both root and shoot length of *Dicanthium annulatum* at 50 mM of NaCl. Common isolates enhancing the root and shoot length of both the grasses were not found indicating the possibility of host specificity of archaea so far as interaction with *Dicanthium* and *Sporobolous* are concerned.

- 16S rRNA of all the archaeobacteria obtained from the rhizosphere of naturally adapted plant species of Rann of Kutch has been sequenced for authentic identity and are being processed for submission to the NCBI genbank.

7. ICAR NETWORK PROJECT ON TRANSGENIC CROP

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

Funding Agency: ICAR, New Delhi

Duration: 2012-13 (Annual)

Total Fund: ₹06.94 Lakhs

Objectives :

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

Achievements :

- For incorporating tolerance of abiotic stresses, especially drought and salinity two gene constructs *ZAT12* TF and *AtDREB1a* were separately used for developing transgenic groundnut mediated through *Agrobacterium*.

AtDREB1a gene expression analysis

- Six transgenic events were evaluated for the quantitative expression of the gene using qPCR.
- It was observed that, within two h of imposition of drought (20% PEG) and salinity (200 mM NaCl) stress, *AtDREB1A* gene expression was more than two and three folds respectively. But, under drought stress, consistent increase in transgene expression was recorded from the 10th hours and maximum transgene expression was recorded at 16th hours (> 10 folds), while under salinity stress, it was maximum at 6th h (>5.52 fold), and thereafter a gradual reversal in the trends upto 16th h.



8. DEVELOPMENT AND PROMOTION OF PROMISING VARIETIES/ LINES WITH HIGH YIELD AND HIGH OIL CONTENT WITH ENHANCED O/L RATIO FOR ENHANCING PRODUCTION AND QUALITY OF GROUNDNUT OIL IN DROUGHT-PRONE ENVIRONMENTS TO BOOST THE INCOME OF SMALL AND MARGINAL GROUNDNUT FARMERS IN INDIA

(J.B. MISRA, T. RADHAKRISHNAN, S.K. BERA, S.K. BISHI AND K. CHAKRABORTY)

Funding Agency: ICRISAT, Patancheru, Hyderabad

Duration: 2011-2015

Total Fund: ₹40.50 Lakhs

Objectives :

- To evaluate high oil content groundnut varieties currently available at ICRISAT and other institutions in multilocation environments in the SAT of India (Andhra Pradesh, Gujarat and Tamil Nadu) for their local adaptation and stability of oil content
- To identify molecular markers associated with high oil content and O/L ratio traits
- To screen diverse 'reference set' and other germplasm lines with known gene(s)/molecular markers associated with oleic acid content for use in national breeding programs
- To develop and evaluate new elite groundnut lines possessing both high oleic acid and high oil content traits in multilocation environments in the SAT of India for their local adaptation and stability of oil traits
- To promote promising varieties/lines with high yield and high oil content with enhanced O/L ratio in state and national testing systems for their formal release

Achievements :

- Fifty-two groundnut lines with high oil or low oil content were evaluated under irrigated and imposed drought conditions during summer 2013.
- Three hundred and seventy six kg seed of eight groundnut genotypes with high oil content were produced for use in different trails.
- The oil, moisture and protein contents in the 384 samples from ICRISAT, 384 sample from TNAU, 256 samples from ANGRAU, 128 samples from JAU were determined in addition to the samples from the DGR.
- Back crossings were done in the crosses ICGV5141 x BC₁F₁ of (ICGV5141x



SunOleic95R) and ICGV6100 x BC₁F₁ of (ICGV6100 x SunOleic95R)

- The progeny of the crosses made for improving the oil content (ICGV 6188 x ICGV 7229 the ICGV 98432 x ICGV 7166) were advanced and genotyped
- CAPS analyses were done in 53 samples from DGR and 9 from JAU. Three and two plants, respectively from these samples were found to be homozygous for both the mutations ahFAD2A and ahFAD2B.

9. RELATIONSHIP BETWEEN *SCLEROTIUM ROLFII*, *RHIZOCTONIA SOLANI*, THE SOIL AND CLIMATIC VARIABLES IN THREE MAJOR CROPPING SYSTEM IN THE COUNTRY AND IDENTIFICATION OF MARKERS FOR RESISTANCE TO *SCLEROTIUM ROLFII*

(RADHAKRISHNAN T., A.L. RATHNAKUMAR, G.P. MISHRA, P.P. THIRUMALAISAMY AND NARENDRAKUMAR)

Funding Agency: National Fund for Basic, Strategic & Frontier Application Research in Agriculture, ICAR, New Delhi.

Duration: 1st April 2012-31st March 2017

Total Fund: ₹231.2228 Lakhs

Objectives:

- Study the nature of interaction of pathogen with crops, soil, temperature, and moisture in disease development
- Identification of QTLs governing genetic resistance of *S. rolfsii* in groundnut

Achievements :

- Five parents viz. JSP39, CS85, CS319 (resistant), GG20 and TG37A (susceptible) were used for parental polymorphism survey using >700 SSR primer pairs and the polymorphic primers were identified
- In a screening experiment in concrete blocks, the stem rot incidence was in the range of 15.4 to 100%.
- The incidence of stem-rot in genotypes ICGGV 86590, R 2002-2, K 134 and OG 52-1 were above 80%. In nine genotypes viz., BSR 1, Dh 101, ICG 1697, R 2002-3, R 8808, NRCG CS 85, NRCG CS 196, NRCG CS 327 and GG 20 the incidence was from 40 to 80%. Below 40% stem rot incidence was recorded in three genotypes viz., JSP 39, NRCG CS 19, and NRCG CS 319.



- Screening under controlled conditions with ensured disease pressure in glasshouse indicated that among the sixteen genotypes evaluated, an inter-specific derivative NRCG CS 319 had very low disease incidence (18.2%) compared to popular variety in *Saurashtra* region viz. GG 20 (80.0%). The highest incidence of stem rot was recorded in the genotype OG52-1 (85.0%)
- Three genotypes OG 52-1, K 134 and GG 20 recorded more than 80% stem rot incidence, nine genotypes viz., BSR 1, Dh 101, JSP 39, ICGV 86970, ICG 1697, R 2002-2, R 2002-3, R 8808, NRCG CS 196 and NRCG CS 327 recorded in the range of 40 to 80% and less than 40% incidence was recorded in three genotypes viz., JSP 19, NRCG CS 85, and NRCG CS 319.
- Survey was conducted in *kharif* 2013 to record stem rot incidence. The stem rot incidence was recorded more than 20% incidence of stem rot was recorded in two farmer's field where wheat was sown as previous crop and straw was used as mulch in the groundnut fields.
- Two crosses viz. TG37A x CS85 and TG37A x CS319 were attempted during *kharif* 2013 for F_1 mapping and also for the development of new RIL population.
- Cross between TG37A and CS85 was attempted and 121 putative F_1 s were harvested. On marker analysis of these F_1 's, 94 plants were found to be confirmed hybrids.
- Cross between TG37A and CS319 was attempted during *kharif* 2013 and 110 F_1 seeds were obtained. These seeds were sown during summer 2014 in field and identification of putative F_1 s using polymorphic SSR marker is under progress.

10. MAPPING OF THE STEM ROT RESISTANT GENE (S) IN GROUNDNUT AND ITS TRANSFER TO AN ELITE GROUNDNUT CULTIVAR

(PI: S.K. BERA, CO PI: AJAY B.C.)

Funding agency: DBT, New Delhi

Duration: 2013-2018

Total fund: ₹52.704 Lakhs

Objectives:

- Polymorphism survey of TMV 2, *Archis diogoi*, CS 19 and GG 20 with RAPD and SSR markers
- Development of F_1 mapping populations of GG 20 x CS 19
- Development of BC_1F_1 GG 20 x CS 19



- Screening of F_1 progenies for stem rot resistance under artificially inoculated condition
- RAPD and SSR analysis of F_2 progenies with polymorphic primers
- Identification of markers for resistance to stem rot
- MABC to transfer the resistance gene in to GG 20

Achievements:

- One hundred and eighty six fresh SSRs were synthesized from IDT.
- Resistant (CS-19 and NRCGCS-319) and susceptible parents (GG-20, TMV-2) and wild *Arachis* donor (*A. diogeni*) were screened with 1250 SSRs.
- Out of 1250 SSRs, 220 were found polymorphic between parents.
- Hybridization was made between GG-20 x CS-19 and GG-20 x NRCGCS319 and probable cross pod were harvested.
- Probable cross pods from the crosses GG-20 x CS-19 and GG-20 x NRCGCS-319 were sown and confirmation of F_1 is in progress.
- Protocol for screening of genotypes for resistance to stem-rot has been optimized.

11. GENETIC CHARACTERIZATION OF HIGH O/L GROUNDNUT GENOTYPES AND ORF ALLELE POLYMORPHISM OF AHFAD2 GENES OF SELECTED GROUNDNUT GENOTYPES

(PI: GYAN PRAKASH MISHRA)

Funding Agency: Science and Engineering Research Board, DST, New Delhi

Duration: 2013-2015

Total Funds: ₹18.90 Lakhs

Objectives:

- To do the identification and genetic characterization of high O/L genotypes using existing gene specific molecular markers.
- To do the sequencing of ORF region of $\Delta 12$ fatty acid desaturase (ahFAD2) cDNA from identified high O/L genotypes and find the relationship between FAD2 gene polymorphism (ORF) and O/L ratio.
- To identify any new SNP site in ahFAD2A and ahFAD2B gene if present.

Achievements:

- CAPS assay with RE *Hpy99I* digested the PCR product 826bp, 598bp and 228bp in 94 varieties predicting their wild type nature and remaining 78 varieties did not get digested. RE *Hpy188I* produced mutant allele specific banding pattern (bp)- 505, 263, 213, 171, 32, 12 only in SunOleic95R; and was absent in any of the released varieties.



- Among the Indian varieties analysed, 45.35% were found to have mutation in the *ahFAD2A* allele while none were found to have *ahFAD2B* mutant allele. This could be due to the fact that all the varieties were bred from very narrow genetic base. This however needs further confirmation.

12. EVALUATION OF BIO-EFFICACY, PHYTOTOXICITY AND COMPATIBILITY OF DICLOSULAM 84% WDG FOR WEED CONTROL IN GROUNDNUT (*ARACHIS HYPOGAEA* L.) AND EFFECT ON SUCCEEDING COTTON (*GOSSYPIUM* SPP.)

(PI: H.N. MEENA, COPIS: N.K. JAIN AND R.S. YADAV)

Funding agency: Dow Agro Science India PVT. Ltd., Mumbai

Duration: Two years

Total Fund: ₹05.84 Lakhs

Objectives:

- To find out the efficacy and compatibility of diclosulam 84% WDG for weed control in groundnut
- To study the phytotoxic effect of diclosulam 84% WDG on groundnut
- To find out an the optimum dose of diclosulam 84% WDG for weed control in groundnut
- To study the residual effect of diclosulam 84% WDG on succeeding cotton crop.

Achievements:

- The highest pod yield of groundnut was observed with application of Diclosulam 84% WDG @ 26g aī/ha + urea 2% with three times over control.
- Dry weed biomass was significantly less in plots with the application of Diclosulam 84% WDG as compared to oxyfluorfen, pendimethalin and control.
- There was no residual phytotoxicity and influence on cotton productivity.
-

13. DEVELOPMENT OF POST-HARVEST TECHNOLOGY FOR PRODUCTION OF AFLATOXIN FREE GROUNDNUTS BY THE PROCESSING UNITS IN INDIA

(PI: P.P. THIRUMALAISAMY, COPIS: K.S. JADON, S.K. BISHI* AND J. B. MISRA)

* On study leave from July 2012.

Funding agency: Agricultural & Processed Food Products Export Development Authority (Ministry of Commerce & Industry, Govt. of India), New Delhi

Duration: 1.1.2013 to 31.12.2015

Total Fund: ₹74.20 Lakhs



Objectives :**Research**

- To study the prevailing practices of handling, storing, and processing in groundnut processing units
- To identify the ambient factors responsible for promoting growth of *Aspergillus flavus* within the premises of processing units
- To develop alternative measures that would arrest the growth of *A. flavus* and production of aflatoxins within the processing units and thus reduce the chances of contamination
- To determine moisture level to be maintained in exportable groundnuts to minimize level of aflatoxin contamination and also split ratio of groundnut kernels at the same moisture level
- To integrate various measures identified for improving the shelling out of the feed stock without enhancing its vulnerability to aflatoxin contamination

Training

- To impart capacity building in sampling and analytical methods

Achievements:

- Fourteen peanut processing units engaged in the production of kernels, blanched peanuts, roasted kernels and peanut butter were studied for the production process and samples from each stage of the processing were taken for identification of the stages of operations that could promote growth of *A. flavus* and production of aflatoxin during pre-processing, storage, processing and packed products.
- The estimated moisture content in the pods collected from different processing units (dry processing) ranged from 3.1 to 6.7% and in kernels from 2.9 to 6.6%. None of the samples at these moisture content support the *A. flavus* growth when artificially spores were dusted on the pods and kernels, and incubated in controlled chamber at a temperature (29-32°C) and humidity (55-70%).
- In the laboratory experiment to determine the level of moisture content that support the *A. flavus* growth and subsequent aflatoxin contamination, pods of GG 2, GG 20, JAL 42 and TG 37 were sprinkled with water uniformly as it done during the wet processing. In the pods with moisture content above 7.1 and kernels with



moisture content above 6.9 supported the fungal growth that leads to aflatoxin contamination.

- Fourteen peanut processing units were surveyed and samples from each stages of the processing were collected for analysis of moisture content, *A. flavus* infection and aflatoxin contamination. Highest aflatoxin contamination was recorded from the discarded (rejected materials from manual or mechanical sortex) kernels in each stage of the processing.
- In wet processing, laboratory research was focused to identify food grade materials that prevent the growth of *A. flavus* without compromising the split in kernels during shelling. Sodium chloride, baking soda and rock salt were identified that prevents growth of *A. flavus*. In the optimization of concentration, salts at 1%, 2%, 5%, 10%, 15%, 20%, and 25% were tested. Adding of common salt (15%) or rock salt (10%) on pods adversely affected the germination of spores and also growth of colonies. Baking soda, however, proved to be equally effective even at much lower a concentration (2%).

14. AGRICULTURE FOR NUTRITION AND HEALTH (CRP4)

(Center PI: P.P. THIRUMALAISAMY)

Funding agency: International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT), Patancheru, Andhra Pradesh

Duration: 1.10.2012 to 30.09.2015

Total Fund: ₹10.00 Lakhs

Objectives:

- Integrated pre- and post harvest management strategies to mitigate aflatoxin contamination.
- Studies on factors influencing aflatoxin contamination, toxigenic profiling of *A. flavus* and mapping of the hot spot areas.
- Development of database of aflatoxin prevalence along the value chain and capacity building of stakeholders.

Achievements:

- Soil and pod samples were collected from 76 farmers field for analysis of *A. flavus*



population in soil, pod and kernel infection and aflatoxin contamination.

- The spacial distribution of *A. flavus* in soil ranged from 0 to 17×10^3 cfu/g soil in the district of Rajkot, Junagadh, Jamnagar, Amreli and Porbander.
- Infection of *A. flavus* on pods was more compared to kernels and aflatoxin contamination ranged from 0 to 1743ppb.

15. PEST DYNAMICS IN RELATION TO CLIMATE CHANGE (NICRA)

(Center PI: P.P. THIRUMALAISAMY, Center COPI: HARISH G. *)

* On study leave from July 2013.

Funding agency: Indian Council of Agricultural Research, New Delhi

Duration: From October 2011 to March, 2017

Total Fund: ₹5.0 Lakhs per year

Objectives:

- Pest and disease dynamics, changes in crop-pest/pathogen relationships, changed profile of insect pests and emergence of new biotypes due to climate change, and development of forewarning system

Achievements:

- Real time pest and disease dynamics was assessed in relation to climate change based on information collected from 20 fixed farmers field, and protected and unprotected fields from the research institute.
- In summer 2013, groundnut bud necrosis disease was present in farmers' field at Junagadh, Jamnagar, Rajkot and Amreli (2-16%) and stem rot and collar rot were present in most of the fields, with low incidence (below 10%). In the early stage of the crop, severe damage due to sucking pests was observed in most of the farmers' field.
- In *kharif* 2013, total rainfall received during the crop season (June 25th to October, 18th) was 1009 mm, distributed in 63 rainy days and maximum rain fall occurred in early stage of the crop (July third week, 76.6mm) and at maturity stage (4th week of September - 3rd week of October, 338 mm). Farmers of Junagadh, Rajkot, Porbander, Jamnagar and Amreli districts had sown GG 20 and TAG 37. Diseases viz., collar rot, stem rot, aflaroot, early and late leaf spots, rust, *Alternaria* leaf blight, groundnut bud necrosis disease and bacterial leaf spot were recorded in



groundnut during the season. The incidence of collar rot (20-30%) and stem rot (40-50%) were severe in 15-30 days old crop in few fixed fields. The severity of the foliar diseases viz., ELS, LLS and rust were low (ELS was 50 to 55%, LLS was 30 to 40% and rust upto 70%) compared to *kharif* 2012 (ELS upto 60%, LLS and rust upto 80%) in most of the farmers filed. The severity of rust was more at the stage of harvest and more than 80% in the fields were recorded during random survey in all the districts. Insect pest viz., aphids, thrips, jassids, *Spodoptera*, hairy caterpillars, semiloopers, ash weevil and white grub were recorded in the fields. However, infestation of aphids (25%), thrips (25% to 30%), jassids (25% to 35%), *Spodoptera* (45%) and *Helicoverpa* (25% to 30%) were more. Scattered incidence of white grub damage in Mendarda, Visavadar, Bilkha and Vanthli was noticed. At maturity stage of the groundnut, ash weevil and its damage was recorded in Rajkot, Jamnagar district and some area in Mendarda taluk. Ash weevil damage and adults were observed. Besides, natural enemies (Coccinellids) were observed. *Alternaria* blight was observed in the late sown crop.

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

Nodal Officer : Dr Chuni Lal

Co-Nodal Officer : Dr Narendra Kumar (Since 20.03.2014)

Seed Committee : Dr Chuni Lal, Chairman; Dr. A.L. Rathana Kumar, Member; Dr. D.L. Parmar, Member ; Mr. B.M. Chikani, Member; Mr. V.K. Sojitra, Member Secretary

Funding Agency: ICAR, N. Delhi

Duration: Annual

Summary

- Seed production of DGR varieties 'Girnar 2' and 'Girnar 3' and BARC variety 'TG 37A' was taken up in summer 2013. In *kharif* 2013 seed production programme of DGR varieties only viz. 'Girnar 2' and 'Girnar 3' was taken up.
- To make up for the production deficits of *kharif* season, compensatory seed production was taken up in summer 2014 season.
- A total quantity of 61.25 q seed of different classes of three new generation groundnut varieties was sold for ₹397717/-.



- In summer 2013, an area of 1.85 ha was sown to produce breeder seed and nucleus seed of DGR varieties Girmar 2 and Girmar 3 and a production of 29.4 q seed was achieved. In addition, 1.85 ha was sown for production of TFL seed of variety TG 37A and 18.41 q twas produced (Table 1).
- In *kharif* 2013, seed production of 'Girmar 2' variety was taken up in 1.65 ha; and that of 'Girmar 3' in 1.55ha. The production realized was 3.75 q nucleus seed of 'Girmar 2' and 5.8 q breeder seed and 4.6 q nucleus seed of Girmar 3 (Table 1). In addition, production of TFL seed of different groundnut varieties was taken up in farmer's participatory mode. The farmers were provided with quality seed and technical know-how for groundnut seed production. Through this activity 230.0 q TFL seed was produced which includes 140 q seed produced by tribal farmers who were provided seed and inputs free of cost under TSP of scheme of DSR, Mau.
- Compensatory seed production programme of three varieties 'Girmar 2', 'Girmar 3' and 'TG 37A' was taken up in summer 2014 in 3.7 ha to produce seed of different classes (nucleus, breeder and truthfully labeled) of these varieties.
- A total 61.25 q seed of different classes of three new generation groundnut varieties was sold which generated a revenue of ₹3,97,717/-.
- An expenditure of ₹4,84,329.00/- was incurred under this project of annual budget of ₹7.5 lakhs received from the Directorate of Seed Research, Mau during the period under report (1.4.2012-31.3.2013). In addition the entire budget (₹3.0 lakhs) received under the Tribal Sub Plan was completely utilized.

Table 1: Seed of different classes and varieties produced in summer 2013 and *kharif* 2013 seasons

Variety	Breeder Seed	Nucleus Seed	TFL Seed at DGR Farm	Participatory TFL Seed Production
Summer 2013				
Girmar 2	17.1	8.1	-	-
Girmar 3	2.1	2.1	-	-
TG 37A	-	-	18.41	-
<i>Kharif</i> 2013				
Girmar 2	-	3.7	-	76.0
Girmar 3	5.8	54.6	-	14.0
TG 37A	-	-	-	140.0
Total	25.0	18.55	18.41	230.0



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

All Scientist

- National Conference of Plant Physiology-2013 on 'Current Trends in Plant Biology Research' at JAU, Junagadh from 13th-16th Dec, 2013.'
- *Seasonal Long Training Programme on IPM in Groundnut* by DPPQ&S and CIPMC, Vadodara at DGR, Junagadh from 16th Sep-15th Oct 2013.

Radhakrishnan T

- Third National Conference on Biotechnology, Bioinformatics and Bioengineering' held on 28-29 June 2013 at Tirupati, Andhra Pradesh
- International Conference on Biodiversity, Bioresources and Biotechnology, 30-31 January 2014 held at The Quorum Hotel, Mysore, Karnataka, India
- Expert lecture on molecular markers at Virani College, Feb 18, 2013
- Annual review meeting of project "Development and promotion of promising varieties / lines with high yield and high oil content with enhanced O/L ratio for enhancing production and quality of groundnut oil in drought-prone environments to boost the income of small and marginal groundnut farmers in India" at Junagadh Agricultural University, Junagadh
- Meeting on the ICAR-ICRISAT collaborative projects held at ICIRSAT, Patancheru (10 May 2013)
- The project meeting of National fund held at NIRJAF, Kolkata (23-25 June 2013)
- Meeting on the project proposals on genomics in groundnut held at ICIRSAT, Patancheru (5 June 2013)
- The project meeting of National fund held at NASc Complex, New Delhi (21-23 July 2013)
- IMC meeting at DOR, Hyderabad (2 Aug 2013 and 20 February 2014)
- IMC meeting at DGR, Junagadh (11 October 2013 and 15 March 2014)

Chuni Lal

- Delivered a lecture on 'Groundnut- a bird's eye view' on 27.4.2013 in XXVIII Group Meeting of National Seed Project, held at PAU, Ludhiana on 27 – 29 April, 2013.
- Visit to National Research Centre for Camel, Bikaner on 4-9 August, 2013 to monitor groundnut crop of DGR



- Attended annual review meeting of ICAR Seed Project held at NBPGR, New Delhi on 26-27 August 2013.
- Attended annual review meeting of Scientific Advisory Council (SAC) of KVK, Kodinar held at Kodinar on 28.1.2014.
- Attended Orientation Workshop for launching of National Mission on Oilseeds and Oil Palm (NMOOP) on 13-14 March, 2014 and delivered a lecture on Technologies for increasing yield of groundnut crop.

R DEY

- Review meeting of NFBSFARA project, "Role of archaeobacteria in alleviation of salinity and moisture stress in plants" at DOR, Hyderabad as CCPI on 13.4.13.

KK Pal

- Review meeting of NFBSFARA project "Deciphering molecular mechanism of induction of biotic stress tolerance by *Trichoderma* spp. in castor (*Ricinus communis* L.)" at DOR, Hyderabad as an external expert on 13.4.13.
- International Conference 'Biodiversity, Bioresource and Biotechnology' from 30-31 January 2013 at Mysore and made oral presentation of research paper.
- Review meeting of NFBSFARA project, "Unraveling biochemical and molecular basis of bacterial and fungal endo-symbiosis for management of abiotic stresses in plants" at DOR, Hyderabad and made presentation of the progress of work as CPI on 13.4.13.
- Annual workshop of NFBSFARA held at N. Delhi from 22-23 July 2013.

NK Jain

- Attended Annual Meeting of Groundnut Researchers, held at Junagadh Agricultural University, Junagadh during 15-17 April, 2013.
- Attended Review Meeting of Programme Advisory and Monitoring Committee of National Programme on Carbon Sequestration Research, held at Indian Institute of Technology, New Delhi 11-12 November, 2013.

R Dutta

- A lecture on "Diseases in wheat and potato fallow summer groundnut in Uttar Pradesh and their management" in training programme on "Technologies for summer groundnut production in Uttar Pradesh" from 18-22 February 2014 organized by DGR, Junagadh on 19.02.2014.
- Organized 5-days (18.02.2013 – 22.02.2014) training on "Technologies for summer groundnut production in Uttar Pradesh" sponsored by State Institute on Management of



Agriculture, Lucknow, Uttar Pradesh under ATMA scheme.

- Coordinated 30-days (16.09.2013 to 15.10.2013) "Season Long Training Programme" (SLTP) in Groundnut organized by Directorate of Plant Protection, Quarantine & Storage (DPPQ&S) through its CIPMC, Baroda at DGR, Junagadh

GPMishra

- 'Foundation Course Training- July 2013' at NAARM, Hyderabad, 15th-27th July, 2013
- 'RFD review meeting of Nodal and Co-nodal officers' at Krishi Bhawan, New Delhi on 29th Oct, 2013
- AICRPG workshop held at JAU, Junagadh during 15-17 April, 2013.
- International Conference on Biodiversity, Bioresources and Biotechnology, 30-31 January 2014 held at The Quorum Hotel, Mysore, Karnataka, India

MK Mahatma

- AICRPG workshop held at JAU, Junagadh during 15-17 April, 2013.
- Refresher Course for Agricultural Research Management held at NAARM, Hyderabad during 2-16 February, 2014.

Anita Mann

- Short Course on "Recent Advances in Proteomics for Biomarker Discovery" held at Animal Biotechnology Centre, National Dairy Research Institute, Karnal from July 08 – July 17, 2013.
- 21 days CAFT training programme on "Advanced Omics Techniques for Improvements in Plant and Human Health" held at Division of Biochemistry, IARI, New Delhi from Nov 15 - Dec 05, 2013.

Narendra Kumar

- Attended annual groundnut workshop at JAU, Junagadh from 15-17th April, 2013.

Ajay BC

- Training program on "Plant Genetic Resources and Genebank Managment" from 7th – 12th October 2013 at ICRISAT, Patancheru, Hyderabad, India

D Bhaduri

- National Seminar on Developments in Soil Science: 2013, 78th Annual Convention, Indian Society of Soil Science. 23-26th Oct, 2013. Central Arid Zone Research Institute, Jodhpur
- AICRP-Groundnut Annual Workshop. 15-17th April, 2013. Junagadh Agricultural University, Junagadh, Gujarat.



Dr MC Dagla

- Training on 'Pre-breeding and crop improvement in legumes" at ICRISAT from 09th-20th Dec, 2013.
- Organized the '*Hindi Chetna Maas-2013*' in which competitions were held for Essay Writing, General Hindi Knowledge, Extempore, Speech, Debate, Noting and Drafting, and *Antaaksharee*.
- Meeting held by Parliamentary Committee on Official Language on 18th April 2013 at New Delhi.
- Annual groundnut workshop at JAU, Junagadh from 15-17th April, 2013.

KS Jadon

- 2013 Norman E. Borlaug International Agricultural Science and Technology Fellowship Program, USDA at NC State University, USA during 24 September 2013 to 07 December 2013
- Attended the 65th Annual Crop Protection School and Annual Meeting of the Crop Protection Association of North Carolina Inc. on Wednesday, December 4, 2013 at the Embassy Suites near I-40 and Harrison Ave. in Cary, NC, USA

PPThirumalaisamy

- Participated in ICRISAT and the Oil Crops Research Institute (OCRI) of Chinese Academy of Agricultural Sciences (CAAS) jointly organized an International Training Workshop for Groundnut Soil-borne Diseases during 7-9 June 2013 in Wuhan, China.
- Project review and work planning meeting of CCIAR research program on CRP4: Agriculture for Nutrition and Health held on 7th May, 2013 at ICRISAT, Patancheru, Andhra Pradesh.
- Project review meeting of 'Pest Dynamics in Relation to Climate Change' under NICRA-Groundnut team held on August 2nd, 2013 at NCIPM, New Delhi.
- Delivered lecture "Good agriculture, storage and manufacturing practices for management of aflatoxin contamination in groundnuts" in the awareness workshop organized jointly by IOPEPC, Mumbai and APEDA, New Delhi at Hyderabad (5.9.2013), Chennai (6.9.2013), Chitradurga (7.9.2013), Bhuj (6.12.2013), Junagadh (6.11.2013), Rajkot (7.11.2013), Chitradurga (10.2.2014) and Trichi (9.3.2014).
- Delivered lecture 'Minimizing risk of aflatoxin contamination in groundnut' in the Season Long Training Programme (SLTP) organized by DAC and DPPQ&S (16.09. 2013 to 15.10.2013) and in the workshop 'Improved groundnut production technologies for tribal



farmers of Gujarat' at DGR, Junagadh from 25-27 January, 2014.

- Delivered lecture 'Minimizing risk of aflatoxin contamination in groundnut' and 'Major groundnut diseases and their management' in the workshop 'Improved groundnut production technologies for tribal farmers of Odisha' at DGR, Junagadh from 18 to 21th January, 2014.

K Chakraborty

- AICRP-G annual workshop on "Public purchase management for goods, works and consultancy" at Junagadh Agricultural University, Junagadh from 15-17 April, 2014.
- International Conference on "Biodiversity, Bioresources and Biotechnology organized by 'Association for Advancement of Biodiversity Science' at Mysore, Karnataka from 30-31 January, 2014.

Murlidhar Meena

- Attended summer school at NCAP, New Delhi on "Decision Support System in Agriculture using Quantitative Techniques" 2-22 August, 2013.
- Attended SAS installation training at MPAUT, Udaipur from 9-10 October, 2013.

SCIENTISTS ON DEPUTATION

- **Dr PP Thirumalaisamy**, Scientist, Plant Pathology attended 'International Training Workshop for Groundnut Soil-borne Diseases' during 7-10 June 2013 in Wuhan, China.



- **Dr AL Singh** (Principal Scientist, Plant Physiology) and **Dr Ajay BC** (Scientist, Plant Breeding) attended 17th International Plant Nutrition Colloquium (IPNC) which was held in Istanbul / Turkey, at the Istanbul Convention and Exhibition Center (ICEC), from 19-22 August, 2013. The main theme of this colloquium was "Plant nutrition for nutrient and food security".



- **Dr KS Jadon** (Scientist, Plant Pathology) visited USA for 12 weeks (September 23, 2013 to December 15, 2013) under Norman E. Borlaug International Agricultural Science and Technology Fellowship Program, funded by the USDA-Foreign Agricultural Service. He worked with Dr. Barbara B. Shew (Research Assistant Professor and Director, Department of Plant Pathology) at NC State University, Raleigh, NC on "Peanut Risk Management Decision Support System (DSS) and Weather based Diseased Advisories".



- **Dr GP Mishra** (Senior Scientist, Plant Breeding) attended an international training on "Application of Biometrics and Bioinformatics Tools in Crop Improvement Research" at Nairobi (Kenya) from November 04-09, 2013 which was fully funded by the ICRISAT, Patncheru, Hyderabad.



AWARDS / HONOURS / RECOGNITION

- **DGR** becomes an ISO 9001: 2008 certified institute

- **Dr K Chakraborty:** Received International Award funded by Australian Government Department of Education '**Endeavour Research Fellowship 2014**' for pursuing six-month post-doctoral research in Australian Universities.

- **Dr K Chakraborty, Dr Anita Mann and Dr Ajay BC:** Selected for USDA funded '**Borlaug International Fellowship**' for three-months advance exposure training to US Universities or research institutes.

- **Dr KK Pal along with Dr R Dey and Dr M Thomas:** Received the '**Best Paper Award**' for their paper, "*Studying the haloarchaeal diversity in the hypersaline environments of the Rann of Kutch, Gujarat, India*" presented at the International Conference "Biodiversity, Bioresource and Biotechnology" from 30-31 January 2013 at Mysore, India.

presented at the International Conference "Biodiversity, Bioresource and Biotechnology" from 30-31 January 2013 at Mysore, India.

- **Dr NK Jain** (Principal Scientist) is elected as '**Councilor from Gujarat**' for Indian Society of Agronomy for the biennium 2013-14.

- **Dr Radhakrishnan T** (Principal Scientist) received '**Award of Excellence in Plant Biotechnology**' by the Society for Applied Biotechnology during International Conference on Biotechnology, Bioinformatics and Bioengineering at Tirupati, Andhra Pradesh, India on 29 June 2013.



STAFF LIST ON 31.03.2014

1.	Dr. J.B. Misra	Director
2.	Dr. A.L. Singh	Pr. Scientist (Plant Physiology)
3.	Dr. T. Radhakrishnan	Pr. Scientist (Plant Breeding)
4.	Dr. A.L. Rathnakumar	Pr. Scientist (Plant Breeding)
5.	Dr. N.K. Jain	Pr. Scientist (Agronomy)
6.	Dr. S.K. Bera	Pr. Scientist (Genetics & Cytogenetics)
7.	Dr. Chuni Lal	Pr. Scientist (Plant Breeding)
8.	Dr. K.K. Pal	Pr. Scientist (Microbiology)
9.	Dr. Rinku Dey	Pr. Scientist (Microbiology)
10.	Dr. Ram Dutta	Pr. Scientist (Plant Pathology)
11.	Dr. R.S. Yadav	Sr. Scientist (Soil Science)
12.	Dr. R.A. Jat	Sr. Scientist (Agronomy)
13.	Dr. G.P. Mishra	Sr. Scientist (Plant Breeding)
14.	Dr. Anita Maan	Sr. Scientist (Plant Physiology)
15.	Dr. Poonam Jasrotia	Sr. Scientist (Entomology)
16.	Dr. M.K. Mahatama	Sr. Scientist (Biochemistry)
17.	Dr. H.N. Meena	Scientist (Agronomy)
18.	Dr. M.C. Dagla	Scientist (Plant Breeding)
19.	Sh. Abhay Kumar	Scientist (Plant Biotechnology)
20.	Sh. SK Bishi	Scientist (Biochemistry)
21.	Dr. P.P. Thirumalaisamy	Scientist (Plant Pathology)
22.	Shri Harish G.	Scientist (Agril. Entomology)
23.	Dr. Narendra Kumar	Scientist (Plant Breeding)
24.	Dr. Koushik Chakraborty	Scientist (Plant Physiology)
25.	Dr. Debarti Bhaduri	Scientist (Soil Science)
26.	Dr. K.S. Jadon	Scientist (Plant Pathology)
27.	Dr. Prasanna Holajjer	Scientist (Nematology)
28.	Dr. KA Kalariya	Scientist (Plant Physiology)
29.	Dr. Ajay B.C.	Scientist (Plant Breeding)
30.	Sh. Nataraja M.V.	Scientist (Entomology)
31.	Dr. Ajoy Saha	Scientist (Agril. Chemicals)
32.	Dr. Narayanan G.	Scientist (Agril. Extension)
33.	Sh. Murlidhar Meena	Scientist (Agril. Economics)
34.	Sh. V.K. Sojitra	Sr. Technical Officer
35.	Sh. H.B. Lalwani	ACTO
36.	Sh. D.M. Bhatt	ACTO
37.	Dr. D.L. Parmar	CTO
38.	Sh. H.M. Hingrajia	Sr. Technical Officer
39.	Sh. N.R. Ghetia	ACTO



40.	Sh. P.V. Zala	ACTO
41.	Sh. Ranvir Singh	Sr. Technical Officer
42.	Dr. S.D. Savaliya	Sr. Technical Officer
43.	Sh. V.G. Koradia	ACTO
44.	Sh. P.K. Bhalodia	ACTO
45.	Dr. H.K. Gor	ACTO
46.	Dr. J.R. Dobaria	ACTO
47.	Dr. M.V. Gedia	ACTO
48.	Sh. P.R. Naik	Sr. Technical Officer
49.	Mrs. V.S. Chaudhari	Sr. Technical Officer
50.	Sh. Virendra Singh	Sr. Technical Officer
51.	Sh. B.M. Chikani	Sr. Technical Officer
52.	Sh. D.R. Bhatt	Sr. Technical Officer
53.	Sh. R.D. Padvi	Technical Officer
54.	Sh. H.V. Patel	Technical Officer
55.	Sh. C.B. Patel	Technical Officer
56.	Sh. J.G. Kalariya	Tractor Driver (Technical Officer)
57.	Sh. K.H. Koradia	Driver (Technical Officer)
58.	Sh. A.M. Vakhariya	Photographer, (Technical Officer)
59.	Sh. G.J. Solanki	Sr. Tech. Asst.
60.	Sh. P.B. Garchar	Sr. Tech. Asst. (Electrician)
61.	Sh. N.M. Safi	Sr. Tech. Asst. (Driver)
62.	Sh. A.D. Makawana	Tech. Asst.
63.	Sh. Lokesh Kumar	Tech. Asst.
64.	Sh. A.K. Maurya	Tech. Asst.
65.	Sh. G.G. Bhalani	Tech. Asst. (Driver)
66.	Sh. B.M. Solanki	Tech. Asst. (Driver)
67.	Sh. Pitabas Das	Sr. Technician
68.	Sh. Darvesh Kumar	Administrative officer
69.	Sh. R.T. Thakar	AAO
70.	Mrs. Rosamma Joseph	PS
71.	Sh. Y.S. Kariya	PA
72.	Sh. L.V. Tilwani	PA
73.	Mrs. Santha Venugolan	Assistant
74.	Mrs. M.N. Vaghasia	Assistant
75.	Sh. M.B. Kher	Security Supervisor
76.	Sh. H.S. Mistry	UDC
77.	Sh. C.G. Makawan	UDC
78.	Sh. P.N. Solanki	LDC
79.	Sh. N.M. Pandya	SSS
80.	Sh. D.M. Sachaniya	SSS



81.	Sh. R.B. Chawada	SSS
82.	Sh. M.B. Shaikh	SSS
83.	Sh. K.T. Kapadia	SSS
84.	Sh. J.G. Agrawat	SSS
85.	Sh. V.N. Kodiatar	SSS
86.	Sh. R.P. Sondarwa	SSS
87.	Sh. G.S. Mori	SSS
88.	Sh. V.M. Chawada	SSS
89.	Mrs. D.S. Sarvaiya	SSS
90.	Sh. N.G. Vadher	SSS
91.	Sh. P.M. Solanki	SSS
92.	Sh. B.J. Dabhi	SSS
93.	Sh. C.G. Moradia	SSS
94.	Sh. D.A. Makwana	SSS
95.	Sh. J.R. Purohit	SSS

Sanctioned strength of employees on position and their category-wise distribution as on 31.03.2014

Category of staff	Sanctioned	Filled	General	SC	ST	OBC
Scientific	39+01RMP	33	20	04	03	06
Technical	40	34	19	03	05	07
Admn.	17	11	05	03	00	03
SSS	19	17	03	04	03	07
Total	115+01	95	47	14	11	23

Discipline and grade-wise sanctioned scientific positions

Discipline	Scientist	Sr. Scientist	Pr. Scientist	Total
Agril. Biotechnology	2	1	0	3
Agril. Economics	1	0	0	1
Agril. Entomology	2	1	0	3
Agril. Extension	1	0	0	1
Agril. Microbiology	1	1	0	2
Agril. Statistcs	0	1	0	1
Agromnomy	1	1	1	3
Genetics and Plant Breeding	7	3	1	11
Nematology	1	0	0	1
Plant Biochemistry	1	1	0	2
Plant Pathology	2	2	1	5
Plant Physiology	2	1	0	3
Seed Science & Technology	0	1	0	1
Soil Science	1	1	0	2
Total	22	14	3	39



Resignation:

- Dr. Sakkira Begum, Scientist (Plant Breeding) resigned from the service on 29.08.2013 on her selection to Indian Forest Service.
- Dr. R.S. Garwal, T-3, resigned from the service on 04.03.2014 on his selection as Asst. Prof at Sardarkrushinagar Dantiwada Agricultural University.

Financial Up gradation:

- DPC held on 28.06.2013 for Scientist staff, benefit 01 Employee RGP 6000/- to 7000/-
- DPC held on 14.15/10.2013 for Tech. staff, benefit 01 Employee category -I
- DPC held on 14.15/10.2013 for Tech. staff, benefit 01 Employee category -II
- DPC held on 22.06.2013, ACP Benefit one employee in Admn. Staff.

Probation Clearance:

- DPC held on 14.5.2013, Probation Clearance of one Pr. Scientist
- DPC held on 4.01.2014, Probation Clearance of two Scientist
- DPC held on 11.9.2013, Probation Clearance of one Admn. Staff

Retirement:	1. Dr. S.M. Chauhan, T-9	31.05.2013
	2. Dr. R.S. Tomar, F.S.	31.10.2013
	3. Dr. A.P. Mishra, Sr. Scientist	30.11.2013
	4. Shri R.D. Nagwadia, Assisiatnt	31.01.2014
	5. Shri C.N. Jethwa, SSS	28.02.2014



MEETINGS

Research Advisory Committee (RAC) Meeting

26-28 September 2013, Junagadh

The 15th meeting of Research Advisory Committee was held at DGR, Junagadh from 26th-28th September, 2013. Due to the poor health of Dr. S.K. Patil, Chairman (VC, Indira Gandhi Krishi Vishwavidyalaya, Raipur) he has nominated Dr. Masood Ali, (Ex-Director, IIPR, Kanpur) as the chairman. Other members who have participated in the meeting are Dr. M.B. Chetti (Dean, UAS, Dharwad), Dr. S.N.Gurha (Ex. PS, IIPR, Kanpur), Dr. A.M.Parakhia (Director of Extension Education, JAU), Dr. J.B. Misra (Director, DGR), Ms. Hirbaiben I. Lobi (Progressive Farmer, Jambur, Junagadh), Shri. J.K.B. Gunde (Progressive Farmer, Kolhapur, MH). Dr. S.K. Bera (PS, DGR, Junagadh) was the Member Secretary of 14th RAC meeting.

Presentations on ongoing research projects were made by the PIs or co-PIs which were discussed meticulously and the work plan was customized as per the remarks of the research advisory committee. In their concluding remarks, Chairman and the members of RAC appreciated the research work that has been done at DGR and pointed out the need for reorienting the research plan on certain areas.



A view of 14th RAC meeting

Institute Research Committee (IRC) meeting

The 61st and 62nd meetings of Institute Research Committee were held from 5-7, 10 June and 1 July 2013 and 6-8 January 2014, respectively under the Chairmanship of Dr JB Misra, Director to review the progress of research activities undertaken and to finalize the technical programme for ensuing seasons. The research projects for the 12th plan were finalized during these meetings. The PIs of different projects presented the highlights under the respective projects and the proposed technical programme. The house approved the activities to be undertaken after thorough discussions keeping in view the priority and availability of resources. The meetings ended with vote of thanks to the Chair by the Secretary.

IMC Meeting: Held on 11-12/10/2013 and 15/03/2014.



GENERAL INFORMATION

Institute Management Committee

Chairman:

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

Members:

- Director of Agril. (Gujarat) Krishi Bhavan, Sector-10A, Gandhinagar
- Director of Agril, Chepauk, Chennai-600 005, Tamil Nadu
- Dr. K.L. Dobariya, Research Scientist (Groundnut) JAU, Junagadh-362001, Gujarat
- Ms. Heerbai Ben Lobi, Jambur, Talala, Junagadh, Gujarat
- Sh. J.K.B. Gunde, Post Pattan Kodoli, Hatkanagle, Kolhapur-416 202, Maharashtra
- Dr. B.B. Singh, ADG (OP), ICAR, Krishi Bhavan, New Delhi- 110 001.
- F&AO, CIRCOT, Mumbai (ex-officio)
- Dr. A. Henry, Project Coordinator (NNRPL), CAZRI, Jodhpur- 342 003, Rajasthan
- Dr. Radhakrishnan T., Pr. Scientist, DGR, Junagadh
- Dr. S.R. Bhatt, Pr. Scientist, NRCPB, IARI, New Delhi- 110 012
- Dt. (Mrs.) M. Sujatha, Pr. Scientist, DOR, Hyderabad-500 030

Research Advisory Committee (RAC)

Validity: (i) Three years w.e.f 01.09.2012 for the members nominated at Sl. No. 1-4&6 (ii) up to 26th May 2014 for the members nominated at Sl. No. 5 (i&ii) Reference: Council Office Order F.No. 12(5)/09-IA.III dated 11th October 2012

Dr SK Patil, Chairman	Vice Chancellor, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur-492 006, Chhattisgarh
Dr Masood Ali, Member	Ex-Director, IIPR, Kanpur, Uttar Pradesh
Dr. VD Patil, Member	Ex. ADG (O&P), ICAR, New Delhi
Dr MB Chetti, Member	Dean, College of Agriculture, UAS, Yettineyudda Campus, Krishi Nagar, Dharwad-580 005, Karnataka
Dr SN Gurha, Member	Ex. Principal Scientist (Plant Pathology), IIPR, Kanpur, Uttar Pradesh
Dr. A.M. Parakhia, Member	Director of Extension Education, Junagadh Agricultural University, Junagadh – 362 001, Gujarat
Dr. J.B. Misra, Member	Director, Directorate of Groundnut Research (DGR), Junagadh– 362 001, Gujarat
Assistant Director General (O&P), Member	Indian Council of Agricultural Research, Krishi Bhavan, New Delhi – 110 114
Ms Hirbaiben I. Lobi, Member	Village-Jambur, Taluka-Talala, Junagadh-362 150, Gujarat
Shri J.K.B. Gunde, Member	Post Pattan Kodoli, Tal. Hatkanagle, Kolhapur, Pin-416 202, Maharashtra
Dr. S. K. Bera, Member Secretary	Principal Scientist, Directorate of Groundnut Research (DGR), Junagadh



Institute Joint Staff Council**Chairman**

- Dr. J.B. Misra, Director, DGR, Junagadh-362 001, Gujarat

Members: Staff side

- Shri Y.S. Karia, Secretary-IJSC and Member CJSC
- Shri G.G. Bhalani, Member
- Shri B.J. Dabhi, Member
- Smt. M.N. Vaghasia, Member
- Shri A.K. Maurya, Member
- Shri C.G. Moradia, Member

Members: Office side

- Dr. Chuni Lal, Pr. Scientist, DGR, Junagadh
- Dr. R. Day, Pr. Scientist, DGR, Junagadh
- FAO, DGR, Junagadh
- AO, DGR, Junagadh

Institute Research Committee**Chairman**

- Dr. J.B. Misra, Director, DGR, Junagadh-362 001, Gujarat

Members

- All scientists of DGR

Member Secretary

Dr R. Dey, Principal Scientist, DGR



FINANCE AND ACCOUNTS
Expenditure statement for the year 2013-14
DGR Main Unit (₹In Lakhs)

Budget Head	Non Plan			Plan		
	BE	RE	Expenditure	BE	RE	Expenditure
Establishment charges	630.00	675.00	667.1	0.00	0.00	0.00
Wages	50.40	50.00	48.90	0.00	0.00	0.00
Loans & Advances	6.00	3.50	3.23	0.00	0.00	0.00
Pensions	75.00	95.00	93.20	0.00	0.00	0.00
T.A	7.00	8.00	8.00	0.00	7.07	7.07
Recurring Contingencies	84.60	108.94	107.10	0.00	298.67	298.67
Works	0.00	0.00	0.00	0.00	0.00	0.00
Equipments	6.00	6.00	6.00	0.00	26.05	26.05
Furniture	0.00	5.00	5.00	0.00	14.67	14.67
IT	0.00	0.00	0.00	0.00	0.86	0.86
Books	0.00	0.00	0.00	0.00	8.42	8.42
HRD	0.00	1.00	1.00	0.00	5.26	5.26
Total	859.00	952.44	939.53	476.83	361.00	361.00

AICRP-G

Budget Head	RE 2013-14	Expenditure
Pay and Allowances	768.50	768.4
TA	6.90	6.90
Recurring contingency	48.45	48.45
Need Based Research	31.15	31.31
TSP	15.00	14.94
Total	870.00	870.00



Directorate of Groundnut Research

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

Phones

Director : 0285-2673382 (Office)
: 0285-2675831 (Residence)
EPABX : 0285-2672461/ 2673041
Administrative Officer : 0285-2672843
Guest House : 0285-2673629

FAX : 0285 2672550 (Fax)

E-mail : director@nrcg.res.in

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



हर कदम, हर डगर किसानों का हमसाफर

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