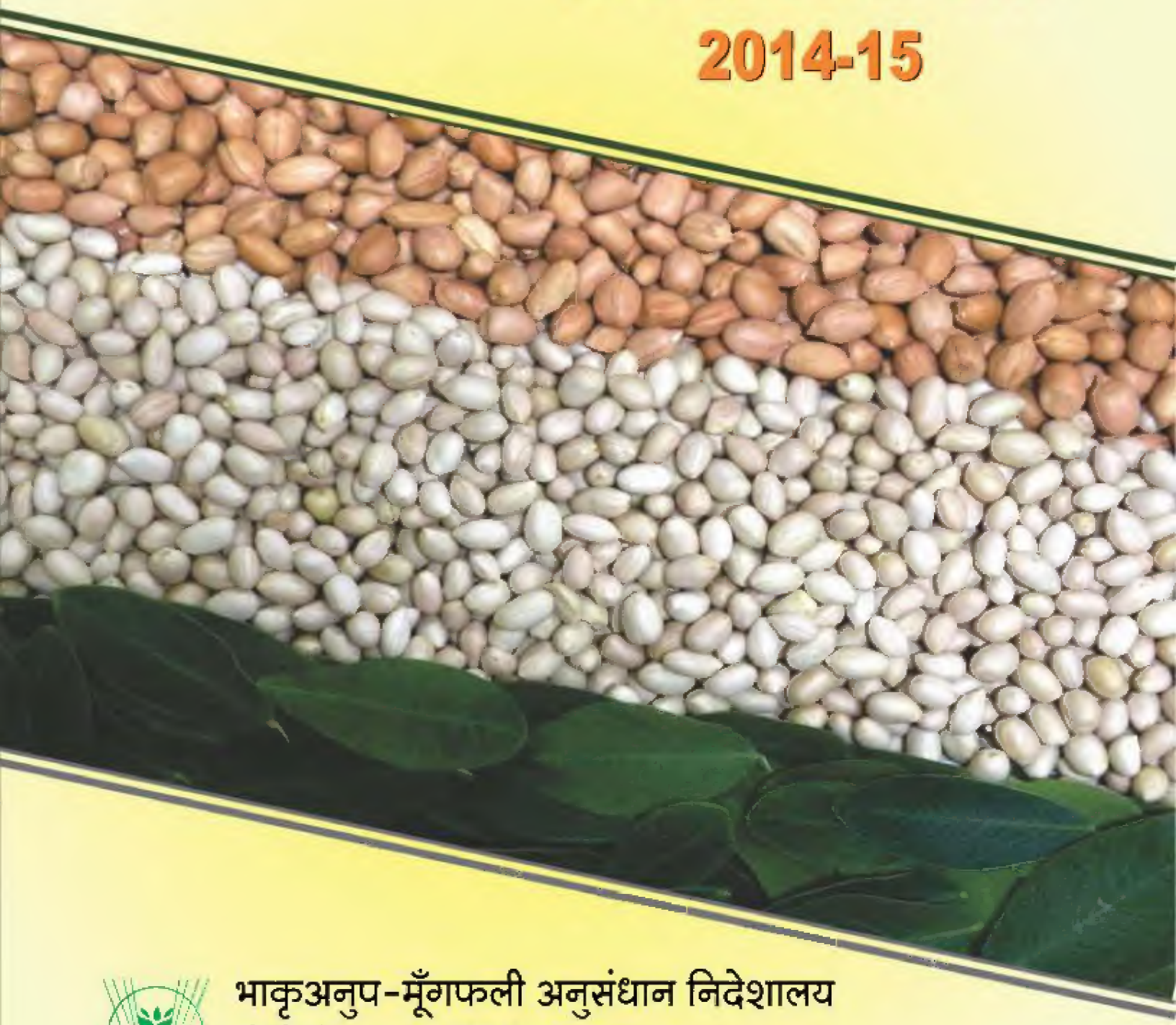
वार्षिक प्रतिवेदन
ANNUAL REPORT
2014-15



भाकृअनुप-मूँगफली अनुसंधान निदेशालय
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ICAR-Directorate of Groundnut Research

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Citation:
Annual Report 2014-15, ICAR-Directorate of Groundnut Research, Junagadh- 362001, Gujarat, India

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Cover Illustration:
Tricolor of groundnut

Published By:
Director, ICAR-Directorate of Groundnut Research
Post Box 05, Ivnagar Road,
Junagadh- 362001, Gujarat, India

Printed At:
Moon Graphics, Junagadh
8, City Point, Opp. Sahyog Chember, Talav Gate, Junagadh. - 362 001.
Phone : 0285 2650625

PREFACE

Groundnut production and productivity has seen wide fluctuations in the recent years, mainly due to changing rainfall patterns and stiff competition from other cash crops and availability and preference for cheaper edible oils. During the year 2014-15, there was a production of 6.68 million tons of groundnut from an area of 4.19 million ha with a yield of 1591 kg/ha. The decline in area and production as compared to previous year was mainly due to the delayed onset of monsoon in the groundnut growing areas of the country which reduced the *kharif* output of groundnut.

During the year, a total of 10,458.91 q breeder seed comprising 47 varieties was produced. Seven hundred and thirty-two front line demonstrations were conducted across the country to demonstrate the new and improved production technologies for groundnut.

During 2014-15, the DGR maintained its status as an ISO 9001-2008 certified institution. A DGR Vision-2050 and RFD document was also prepared.

The DGR organized a three-day (6-8 December, 2014) Group Meeting of the All India Network Project on Soil Biodiversity-Biofertilizers (AINP-SBBF) at Junagadh. About 70 participants presented and discussed their research work in the areas of soil and agricultural microbiology and biofertilizers. An Industries Interface meeting was held at this Directorate on 15 December, 2014 bringing all the stakeholders in groundnut cultivation and industry on a common platform to facilitate their interactions for identifying issues of mutual interest and formulating strategy for research, extension and trade and also addressing the policy issues.Two technologies developed by scientists of DGR, for the production of enzymes cellulase and protease, utilizing groundnut shell and de-oiled groundnut cake, respectively, were transferred to entrepreneurs.

Utilization of the grants was to the tune of Rs. 381.93 lakhs under head 'Plan' and Rs. 1056.73under the head 'Non-plan' for DGR and Rs. 697.97 lakhs for AICRP-Groundnut, a nearly cent per cent utilization. The funds received through the externally funded projects were also utilized effectively. During 2014-15, four 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 the report. 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.

Radhakrishnan T.
Director

CONTENTS

SUMMARY

Crop Improvement

- One advanced breeding line PBS 15044 registered significantly superior pod yield (2530 kg ha^{-1}) in *kharif* season. Three advanced breeding lines namely, PBS 15044, PBS 16038 and PBS 15028 were found to possess fresh seed dormancy for 15, 22 and 35 days respectively, consistently in *kharif* and summer seasons and both under irrigated and drought stress conditions.
- Nine new advanced high yielding breeding lines (three of Spanish and six of Virginia group) were developed during *kharif* 2014 and an elite advanced breeding line PBS-22080 was proposed for testing in AICRP-G trials for ensuing *kharif* 2015. Based on two year screening, an advanced breeding lines PBS-12169 and PBS-12190 identified as tolerant (<4.7 on 1-9 scale) to *Alternaria* leaf spot. Pooled analysis revealed that three genotypes *viz*., PBS-12009, PBS-18037, PBS-18038 and PBS-18045 recorded lower number of leafhoppers (<4 leafhoppers/5 sweeps) at 45, 60, 75 and 90 DAS whereas the groundnut genotypes NRCGCS-85 and NRCGCS-349 recorded lower number of thrips (<3.6 thrips /5 sweeps).
- Three varieties (GG-14, ICGV-86590 and TG-37A); two germplasm (NRCG-2615, ICG-1697 (NCAc 17090) and one advanced breeding line (PBS-12009) were found moderately resistant to root knot nematode. High yielding genotypes PBS 12196 was identified based on two year yield evaluation and proposed for testing at multi-location for yield and other component traits under AICRPG trials.
- Among the Spanish bunch germplasm lines, 27 genotypes have been identified for high shelling outturn (>70%), 32 genotypes have round kernels that have not more than 1.5 kernel length width ratio, and 34 genotypes have high protein content (>30%). The genotype NRCG 14407, and NRCG 14472 identified for high harvest index (>35%).
- Among the Valencia germplasm lines, NRCG 14379 identified for high harvest index (36%) and high shelling outturn (72%), NRCG 14507 has longest kernel (16.1mm), and NRCG 14332 has the widest kernel (8.6mm), and NRCG 14369 and NRCG 14379 has the 1.5 ratio for kernel length/width it shows roundness of the genotypes. The genotypes NRCG 14332, NRCG 14451, and NRCG 14499 identified for high protein content (>33%).
- One advanced breeding line PBS 29132 identified for low oil content (45.7%), high protein content (33.9%) and high sugar content (5.3%), and also has high pod number per plant (>20). Two advanced breeding lines PBS 29146 and PBS 29148 have been identified with low oil content (44.3% and 44%), high protein content (35.9% and 36.2%) and high sugar content (5.6% in each).
- Identified five accessions, NRCG 10922 (98 days), NRCG 14451 (98 days), NRCG 11346 (98 days), NRCG 11532 (98 days) and NRCG 11275 (99 days) which matured early (<100 days). Identified five high oil containing accessions NRCGs 7040 (55.6%), 6999 (55.0%), 1476 (54.9%), 12328 (54.9%), and 3817 (54.8%) and one accession Ah 347/5 containing low oil content (44.4%).

- Three accessions, NRCGs 7063 (34.6% and 6.5%), 7128 (35.6% and 6.4%), and 5239 (34.3% and 6.3%), recorded both high protein and sugar contents respectively. Identified nine accessions, NRCGs 14367 (FST), 14403 (FST), 14419 (FST), 14450 (FST), 14481 (FST), 14484 (FST), 14360 (HYB) 14341 (HYR), and 14383 (VUL) exhibited 100% germination under 12°C day-night temperature; 60% RH and germinated after 10 days of incubation. Identified eight GG 20 mutants (<10%); one AICRP-G genotype JSP 59 (9.1%), and seven released varieties, BG 2, ICGS 76, RS 138, VRI 3 (<5%), Karad 4-11 (5.6%), and TMV 1 (7.1%) and TMV 3 (7.7%) which recorded less than 10% incidence of the stem rot during kharif
- Salinity stress tolerance analysis groundnut transgenic having *mtlD* gene exhibited enhanced *mtlD* activity, antioxidant response, RWC, sugar accumulation and growth parameters and reduced H_2O_2 and MDA content, compared to WT. The expression of *mtlD* gene has participated in scavenging of ROS and stabilized the macromolecular structures and shown improved salt stress tolerance in transgenic lines.
- Characterization of groundnut lines having *AtDREB1A* gene showed improved tolerance to both drought and salinity stresses over WT, as observed by delayed and less severe wilting of leaves and by improved growth parameters that were correlated with physio-biochemical parameters such as proline content, total chlorophyll content, osmotic potential, electrolytic leakage and RWC.
- From the publically available *Arachis hypogaea* EST sequences, 2456 EST-SSR primer pairs were designed; of which 366 having relevance to various stresses and other functional unigenes were PCR validated using 11 diverse groundnut genotypes.
- Interspecific breeding lines: (i) 25-5-32-sel: with higher pod yield and resistant to stem rot; (ii) NRCGCS-574: highly resistant to Rust and Late leaf spot diseases; (iii) NRCGCS-281-21-1, (iv) NRCGCS-281-21-2 and (v) NRCGCS-281-40-2 with large kernel size with higher pod yield were identified.

Crop Protection

- *Trichoderma* (T-170 and Dharwad) significantly reduced the per cent stem rot incidence when applied as seed treatment @ 10 g/kg seed and furrow application @ 4 kg/ha enriched with 250 kg FYM. The lowest severity of Alternaria leaf spot/blight in groundnut variety JL42 and GG2 (3.0 and 2.7 respectively) was recorded using modified 1-9 scale in single spray of Cabrio^{Top} (pyraclostrobin 5% + metiram 55%) @ 0.12% at 40 DAS.
- The severity of ELS, LLS and rust was less when sowing was done on the 1st of April and May of both the year i.e. 2013 and 2014 and severity of Alternaria blight and spot was less when sowing was done on the 1st of January of 2014 and 1st of February of both the year i.e. 2013 and 2014. The lowest severity of foliar diseases in groundnut variety JL42 and GG2 (ELS-4.0 and 3.7), (LLS-3.7 and 4.3), and (Rust-6.7 and 6.0), respectively was recorded using modified 1-9 scale in two spray of difenoconazole @ 1ml/lt at 40 and 60 DAS.
- The varieties, Chitra, CSMG-884, RS-138, CSMG-9510, M-548, and ICGV000348 showed resistance (<4) against the LLS, however, none recorded resistant to ELS and Rust.

- In summer, the population of *A. flavus* was smaller compared to *kharif*. The decrease in soil population of *A. flavus* in summer could be attributed to rise in soil temperature and rotation with crops or fallow, soil amendments, bioagents, botanicals and fungicide. 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.
- In the summer groundnut as well as in the *kharif* groundnut, *A. flavus* infection in freshly stripped pods was lower than the left over pods collected from soil. Aflatoxin contamination was detected in almost all the gleaned pod samples. The rainfed groundnuts grown during *kharif* acquire high *A. flavus* infection and subsequent contamination with aflatoxin than the groundnut grown in summer under irrigated condition.
- Pods stored upto 6 months at room temperature (28±2 degree C) in high density polythene lined gunny bags has lesser *A. flavus* infection and aflatoxin contamination compared to pods stored in gunny bags (jute bags), nonetheless no difference was observed when pods stored either in gunny bags or in high density polythene lined gunny bags at 15±2 degree C.
- Nearly cent per cent mortality was observed in all stages of bruchid, by aromatic hydrocarbons (naphthalene and camphor) and >95% of germination was recorded in treated pods and kernels. Genotypes, TPG 41 and GPBD 4 recorded lowest number of eggs laid (17 and 19, respectively), adults emerged (14 and 13, respectively), damage (21% and 13%, respectively) and weight loss (25% and 13%, respectively).
- Amongst six intercrops tested, combination of bajra with groundnut (3:1) harbored lowest population of thrips, hoppers and aphids as compared to other tested intercrop combinations.
- Amongst three bio-pesticides tested for their efficacy in managing sucking pests, the treatments of Ponneem @ 6ml/L, Azadirachtin 1.5% @ 7.5 ml/L and standard check of monocrotophos 36 SL @ 1.2ml/L were found effective in reducing leafhopper population. However, Azadirachtin 1.5% @ 7.5 ml/L and standard check of monocrotophos 36 SL @ 1.2ml/L treatments were found effective for checking thrips population.
- Soil drenching with Pf1 and Pf3 strains of fluorescent pseudomonads resulted in significant reduction in number of gall/plant in groundnut roots due to root-knot nematode by 51.8 % and 46.1 % respectively. Number of egg masses was also significantly reduced in Pf1 (61.7 % reduction) and Pf3 (68.7 % reduction) strains of fluorescent pseudomonads treated plants compared to control.
- The levels of peroxidase (POD), catalase (CAT), polyphenol oxidase (PPO) and phenol activities in the treatment with Pf1 strain of fluorescent pseudomonads as a seed treatment followed by soil application is significantly higher at 24, 48 and 72 h after post-inoculation of nematodes as compared with the untreated control and seed treatment or soil application alone.
- Higher content of pyrocatachol, ascorbic acid 2,6-dihexadecanoate and linoleic acid were observed in genotypes showing low stem rot disease incidence(CS19 and CS319). Higher content of cinnamic, coumaric, caffeic and

salicylic acid were observed in genotypes showing low stem rot disease incidence. Glucose and sucrose content was increased in late leaf spot resistant genotypes whereas decreased in susceptible genotypes after infection. Higher constitutive and induced level of salicylic acid was observed in LLS resistant genotypes

Crop Production

- Minimum tillage was found to increase pod yield and net returns as compared to conventional tillage. Whereas wheat stubble retention+*Cassia tora* mulch increased pod yield and net returns as compared to no residue application.
- Significantly higher groundnut-pod equivalent yield was recorded from groundnut-wheat-*Sesbania* green manuring cropping system over groundnut monoculture, groundnut based cropping systems involving green manuring and groundnut+pigeonpea intercropping systems.
- At different salinity levels (0.5 to 6 dS m^{-1}) in groundnut–cluster bean rotation (2014-15), 2-3 dS m^{-1} salinity was found to be the threshold salinity level. But the yield of dry fodder of cluster bean was significantly lower at all the saline water irrigation levels compared to control (0.5 dS m^{-1}). Significantly higher pod yield was recorded with the application of 2 dS/m saline irrigation water but it was at par with control (0.5 dS m^{-1}). Application of potassium @ 60 kg ha^{-1} ameliorated the effect of water salinity by countering the effect of salinity.
- Significantly higher pod and haulm yield with 24.6% and 30.7% were recorded under polythene mulch as compare to no mulch, respectively. Use of polythene mulch was beneficial for soil enzymes such as dehydrogenase, acid and alkaline phosphatase and urease activities by overcoming the salinity stress imposed through varied levels of saline irrigation; which is further assured by the application of potassium. Moreover, the increased soil enzyme activities was observed at later crop growth stage (100 DAS).
- Both summer as well as *kharif* season groundnut significantly responded to use of phosphatic fertilizers. However, the response was found inconsistent with graded dose of phosphorus application in these soils.
- Use of polythene mulch under drip and resource conservation management practices were found promising for creating congenial conditions to solubilize and/or mobilize the soil phosphorus in to different conceptual pools as well as uptake by the plants.
- The area, production and productivity of different groundnut growing districts of six major and nine minor groundnut growing states was analyzed based on average of three years' data. Further categorization was made into high and low productive districts based on the defined threshold productivity values for *rabi*-summer and *kharif* seasons. Apart from state-wise classification, groundnut productivity was also categorized based on the agro-ecological zones of the country.

Basic Sciences

- Application of Ca, K, B and Zn nutrients are important for pod-filling in groundnut and hence essential for obtaining proper pod and seed sizes and quality seeds. The responsiveness of Zn and Fe in 190 groundnut cultivars varied

- Ten high Fe and 15 high Zn density groundnut cultivars identified. Among Zn fertilizers soil and foliar application of zinc sulphate was best, though all beneficial, and increased Zn content of groundnut seed.
- Crop growth in different temperature regime resulted in 10-15 days differences in total degree days required to the crop to obtain maturity. Early sowing also prolonged the period to attain 50% flowering in groundnut. High temperature stress created by late planting of the crop resulted in reduction in both 100-seed weight as well shelling percentage in all the cultivars.
- Higher oxidative stress was observed under temperature stress in all the cultivars with increase in H_2O_2 and superoxide radical content and lipid peroxidation. However, the genotype TPG 41 and GG 7 were least affected in terms of oxidative stress. High temperature stress resulted in yield loss in all the cultivars with drastic reduction in pollen viability from 76% to 43% due to increase in 3.5°C mean day temperature.
- The stomatal density (SD) in WD treatments decreased by 19% and among the various chemicals highest reduction in SD was due to application ABA. Among genotypes under WD the SD was highest in variety Kadiri 9 in combination with foliar spray of succinic acid.
- In 36 varieties, the mean photosynthesis was 27.7 µmol CO_2 m^{-2} Sec^{-1} in control which has reduced to 19.2 µmol CO_2 m^{-2} Sec^{-1} due to water deficit stress given during 40-85 DAS. The stomatal conductance decreased from 0.484 to 0.309 mmol m^{-2} Sec^{-1}. The total number of sink was 48.0 in control and 13.4 in water deficit SB genotypes. In case of the 25 VB genotypes, the mean total sink number was 47.8 in control and only 13.5 in stressed plants.
- Inoculation with the newly isolated competitive strains of groundnut rhizobia Rh17 and Rh20 significantly enhanced the pod yield of cultivar TG 37A over un-inoculated control and NC92, a standard culture.
- The application of DAPG-producing fluorescent pseudomonads (identified for having antifungal activities against the major soil-borne fungal pathogens) enhanced the growth and improved the pod yield of cultivar TG37A by 12-15% during summer and 11-18% during *kharif*.
- Among one hundred fifty-three groundnut endophytes screened, in vitro, for antifungal activities against *Aspergillus niger* and *Sclerotium rolfsii*, 10 isolates showed antifungal activities against *S. rolfsii*, while eight isolates showed strong inhibition against *A. niger*.
- Under moisture deficit stress condition, inoculation of endophytes like *Acinetobacter junii* J20, *B. subtilis* REN51N and *B. firmus* J22N reduced the stomatal aperture as compared to uninoculated control. Significant differences in pod and haulm yield, plant biomass, etc. was noticed in different treatments with endophytes *Pseudomonas pseudoalcaligens* SEN29, *Pseudomonas mexicana* REN47, and *Pseudomonas aeruginosa* REN24 as compared to control.

Social Sciences

- In all the major groundnut growing states, cost of cultivation has shown less growth in compare to value of produce. In all the state value of produce has shown higher instability may be due to higher rainfed cultivation. Out of fifteen years losses in ten or more years over cost C2 except in Gujarat, pointed out towards higher efficient cultivation and better support prices for groundnut.

PROJECT 01. BREEDING FOR TOLERANCE TO ABIOTIC STRESSES IN GROUNDNUT

(Chunilal, Narender Kumar and Anita Man)

Hybridization, selection and generation advancement in segregating generations, development of new advanced breeding lines

Ten fresh crosses were attempted in *kharif* 2014 to enhance thermo-stability, uniform maturity, shelling out turn, and tolerance to drought stress and yield attributes. In summer 2014 the probable hybrid pods from ten crosses attempted in *kharif* 2013 were raised and total of 60 F_1 hybrids were harvested as single plants. Two crosses were rejected in F_4generation, and 146 single plant progenies (spp) were selected from the remaining crosses. One cross each in F_5 and F_6 generations was rejected. In F_5generation 28spp were selected. In F_6generation28 new non-segregating advanced breeding lines were selected.

Maintenance breeding and seed enhancement

Twenty-nine new advanced breeding lines (5 Spanish and 24 Virginia) were sown for seed enhancement in summer 2014 for evaluation in different yield trials. Seed of other 11 advanced breeding lines was multiplied for their evaluation in AICRPG trials.

Advanced breeding lines in AICRP-G trails

The advanced breeding line PBS 25053 was evaluated in the initial varietal trial stage–I of Virginia groundnut (IVT-I) in *Kharif*2014, and PBS 16038 line under initial varietal trial stage–I of Spanish groundnut (IVT-I) in the AICRP G trials in summer2015.

Station trials for yield evaluation

Fifty-five advanced breeding lines (test entries) developed under the project were evaluated under five 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 (DFI) and 50% plants to flower (DF_{50}) on plot basis; WUE-traits (SCMR and SLA, $cm^2\ g^{-1}$), pod (PY, kg ha^{-1}) and kernel (KY, kg ha^{-1}) yields, shelling (%), 100-kernels weight (HKW, g), 100-seleceted mature kernels weight (HSMK, g), proportion of sound mature kernels (SMK, %), protein content (%) and oil content (%)in preliminary trials. In case of advanced trials, additional observations on HI (%) and dry fodder yields (FY, t ha^{-1}) were also taken.

Three and fifteen advanced breeding lines (test entries) were evaluated under *Preliminary Yield Evaluation Trials of Spanish and Virginia groundnut,* respectively. Likewise, twelve and thirteen advanced breeding lines were evaluated under *Advanced Yield Evaluation Trials of Spanish and Virginia groundnut*, respectively. The Advanced Yield Evaluation included six test entries each in Spanish and Virginia trials which were in second year of their evaluation. Evaluation trials of GG 7, JL 501, SG 99 and TG 37A, were used as checks in Spanish whereas Virginia trials had GG 20, Somnath and Kaushal as checks.

Preliminary yield evaluation trials

In *Preliminary Yield Evaluation Trial of Virginia groundnut* the test entries (PBS 21118, 1528 kg; PBS 24148, 1993 kg; PBS 24149, 1725 kg; PBS 25118, 1809 kg and PBS 26047, 1919 kg) which have yield potential at par with the best check variety Somnath (1632 kg) shall be re-evaluated in *kharif* 2015.

Advanced yield evaluation trials

In *Advanced Yield Evaluation Trial for Spanish* groundnut, of the 12-entries evaluated, six were in

the first year of testing. One of the test entry PBS 15044 (2530 kg ha^{-1}) has recorded significantly higher pod yield over the best check variety SG 99. This genotype has also registered significantly higher harvest index. These six entries will be tested in *kharif* 2015 also so that higher yielding ability of PBS 15044 (2530 kg ha^{-1}) is revalidated.

Six advanced breeding lines of Spanish groundnut were evaluated over two seasons (*kharif* 2013 and 2014) along with four check varieties. ANOVA was performed over two years' replication wise mean data for different traits. Interactions between seasons and genotypes was significant for traits namely, PY, KY, HSMK, HI, protein content and oil content. In general the test entries which had higher oil content had poor yields. Test entries like PBS 15022 and PBS 15028, which had higher protein contents had yield potential (1734 and 1650 kg ha^{-1}) which was, though not significant, but comparable to the check variety SG 99 (1644 kg ha^{-1}. These entries will be re-evaluated for one more year.

In *Advanced Yield Evaluation Trial for Virginia groundnut* thirteen advanced breeding lines (test entries) were evaluated in *kharif* 2014. ANOVA indicated highly significant differences due to genotypes for all the traits studied except for SCMR, PY, SMK and FY. Two test entries PBS 25075 and PBS 25076 were significantly early in days to flowering. Likewise four test entries, PBS 25041, PBS 25070, PBS 25075 and PBS 25076 registered significantly higher protein content.

Of the above thirteen advanced breeding lines, six were evaluated over two seasons i.e. *kharif* 2013 and 2014. ANOVA over pooled means indicated genotypic differences for all the traits except DF_{50}. Test entries PBS 25070, PBS 25075, PBS 25076 and PBS 25080 registered significantly superior protein content (30.5 to 32.9%). Significantly superior oil content (51.0%) was found in one test entry PBS 21093. In general genotypes that showed higher oil content were poor in yield. However, ones with higher protein contents their yielding ability was also at par with the best check variety, if not significantly higher yielder. Contribution of years was significant for yields as in *kharif* 2013, yields obtained were much lesser. Therefore, these six genotypes will be given one more chance for evaluation.

Drought screening nurseries

Three hundred fifteen advanced breeding lines were raised in augmented design in three drought screening nurseries with 105 lines in each nursery. Three known drought tolerant checks (Girnar 3, ICGS 44 and ICG76) were repeated thrice in each nursery. Except one irrigation provided at the time of sowing, these nurseries were grown under solely rain-fed conditions. As uniform and continuous rains were received during the crop season, meaningful screening for drought could not be concluded

Field evaluation of advanced breeding lines of Spanish groundnut for yield traits and fresh seed dormancy

Thirteen advanced breeding lines evaluated for yield and its related traits were also evaluated for fresh seed dormancy along with four check varieties both in summer 2014 (both under irrigated and drought stress) as well as in *kharif* 2014. As at harvest all the seeds are not at same physiological stage, the time taken for 50% of the seeds to germinate was considered as the dormancy period (in days).

In summer 2014 it was observed that in general drought has reduced duration of fresh dormancy with few exceptions (may be due to different maturity group of genotypes). It is possible because drought, particular terminal drought, may lead to forced early maturity depending up on the phenological stage of the plant. Period of fresh seed dormancy was different in most of the genotypes in *kharif* season compared to summerseason. However, three advanced breeding lines (PBS 15028, PBS 15044 and PBS 16038) were consistent in duration

of fresh seed dormancy both in seasons as well as under drought and irrigated conditions of cultivation (Fig.1, 2). Therefore, these lines possess genetic potential for fresh seed dormancy, a valuable trait in Spanish groundnut. These lines took15 (PBS 15044), 22(PBS 16038) and 35 (PBS 15028) days for 50% of the freshly harvested seeds to germinate compared to the known check variety TG 26 for fresh seed dormancy in Spanish groundnut which took 6 days in *kharif* and 15 days in summer (irrigated) growing conditions and TG 37A the check variety known to have no fresh seed dormancy took only 2 to 5 days for germination. In summer 2014 these lines have also exhibited significantly higher SCMR, a surrogate for high water-use efficiency and have recorded pod yield comparable to the best check variety TG 37A in *kharif* 2014. PBS 16068 has already been identified as higher yielding genotypes and is presently under National Yield Evaluation trials of AICRP-G in summer season. These three advanced breeding lines shall be registered with NBPGR for this trait.

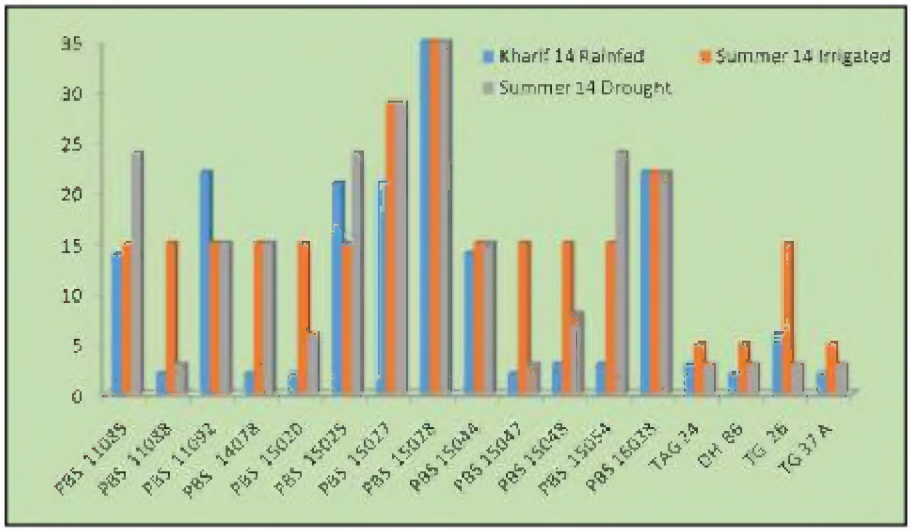
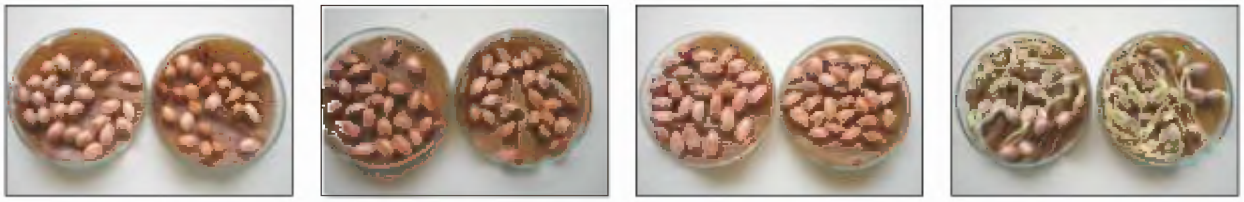


Fig.1. Fresh Seed Dormancy in Spanish Groundnut



PBS 15028 PBS 15044 PBS 16038 TG 37A(No FSD)

Fig.2. Non-germinating seeds of lines PBS 15028, PBS 15044 andPBS 16038 with fresh seed dormancy, and germinating seeds of variety TG 37A lacking fresh seed dormancy

PROJECT 02. BREEDING FOR RESISTANCE TO MAJOR DISEASES AND INSECT PESTS IN GROUNDNUT

(Narendra Kumar, A. L. Rathnakumar, Chuni Lal, M.C. Dagla, K. S. Jadon, M. V. Nataraja, and P. Holajjer*)

*Associated till 15th November 2014 (Transferred to Directorate of Floricultural Research, Pune)

1. Crosses effected: Thirteen crosses were made in *kharif* 2014 to develop improved varieties resistant/tolerantto foliar diseases, stem rot, *Alternaria* leaf spot, *Spodoptera* and sucking pest. The number of harvested crossed pods varied from 8 to 76. The mean success rate (%) of the entire hybridisation programme was 29.4, which ranged from 3.4% to 76%.

2. Identification hybrids: Probalbe hybrid pods from nine different crosses for developing resistant genotypes to stem rot, foliar diseases, seed coat resistance to aflatoxin, and insect-pests were raised in summer 2014 to identify true hybrids and recovered 48 hybrids. The maximum number (13) of hybrids was in the cross TAG 24 × CS 349 followed by eight and seven in the crosses CTMG 6 × BG 2 and TG 37A × CS 319 respectively and lowest number (1) in the cross of GG 20 X CS 319.

3. Advancement of different filial generations: The breeding materials generated earlier were advanced to next higher filial generation in *kharif* 2014. Progenies of 42 crosses were advanced to different filial generations (F_2-F_6). Among them 27 crosses in early generations (up to F_4) and 15 in advanced generation. In F_6 generation, individual plant progenies of six crosses were raised to identify high yielding stable genotypes, among these crosses nine new advanced high yielding breeding lines were identified and given number according to objective of their parents.

4. Development and generation advancement of mapping populations

A. Summer 2014: A mapping population (GG 20 × JSP 39) of 344 recombinant inbred lines (RILs) generated earlier were mass multiplied to get sufficient seed for screening under sick plot for resistance to stem rot.

B. *Kharif* 2014: The mapping populations developed earlier were advanced to next filial generation in *kharif* 2014. A total five mapping populations were in F_5 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*. Two mapping populations were in F_6 generation, in which one (JL 24 × VG 9816) meant for foliar diseases resistance and one (GG 20 × CS 19) for tolerance to stem rot. One mapping population (GG 20 × JSP39) was raised to identify stable genotypes, among these a total 304 RILs were obtained to study tolerance/resistance of stem rot.

5. Yield evaluation of advanced breeding lines

A. Summer 2014: A total 45 Spanish advanced breeding lines with two checks (TAG 24 and Dh86) were evaluated in RBD with three replications in two row trials for yield and its other traits during summer 2014. Due to iron chlorosis and termite damage the yield was very poor in mostly genotypes including

checks resulting high variation in data. Hence same trial will be repeated in next year.

B. *Kharif* 2014:

First year evaluation: Eleven genotypes of Virginia bunch along with checks *viz*. GG 20, Somnath and Kaushal were evaluated in five rows of 5m length for yield and its component traits in RBD with three replications. The differences due to genotypes were highly significant for pod and kernel yield. 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 but only one genotype PBS 22093 (1944 kg of pod and 1325.8 kg kernel/ha) was found at par with best check variety Somnath (1535.4 kg of pod and 1043 kg kernel/ha).

Eleven genotypes of Spanish bunch along with checks *viz*. GG-7 and TG-37A were evaluated in five rows of 5m length for yield and its component traits in RBD with three replications. Analysis of variance indicated highly significant differences due to genotypes for pod and kernel yield, shelling outturn and harvest index. The results showed that none of the genotype significantly superior over best check for pod and kernel yield (kg/ha), shelling outturn and harvest index. Two genotype PBS-12200 (2013.8 kg of pod and 1394.3 kg kernel/ha) and PBS-12201 (2175.3 kg of pod and 1504.4 kg kernel/ha) were found at par with best check variety TG-37A (1794.7 kg of pod and 1198.8 kg kernel/ha).

Second year evaluation: Fourteen Spanish bunch genotypes along with two high yielding checks *viz*. GG-7 and TG-37A were evaluated in five rows of 5m row length for yield and its component traits in a RBD with three replications during *kharif* 2013 and *kharif* 2014. Analysis of variance indicated highly significant differences due to genotypes for pod and kernel yield, shelling outturn and harvest index. The results revealed that none of the genotype significantly superior over best check for all the traits except one genotype PBS 12196 (2149.4 kg of pod and 1524.8 kg kernel/ha), which was found at par with best check variety TG-37A (1920.4 kg of pod and 1292.5 kg kernel/ha). Hence, this elite breeding genotype was identified as high yielding and further it need to be tested at multi-location for yield and other component traits under AICRPG trials.

Another experiment comprising nine Virginia bunch genotypes along with two high yielding checks *viz*. GG-20 and Somnath were evaluated in five rows of 5m row length for yield and its component traits in a RBD with three replications during *kharif* 2013 and *kharif* 2014. Analysis of variance indicated highly significant differences due to genotypes for pod and kernel yield, number of pods per plant and shelling outturn. The results revealed that none of the genotype significantly superior over best check for all the traits except two genotypes PBS-22098 (11.7 pods/plant) and PBS-22103 (11.2 pods/plant) was found at par with best check variety Somnath (8.5 pods/plant). Hence, based on pod and kernel yield none of the genotypes found significantly high yielding over best check.

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

I. Development of new advanced breeding lines: A total 09 new advanced high yielding breeding lines were developed during *kharif* 2014, of which three lines (PBS-12212, PBS-12213, PBS-12214) belonged to Spanish and six lines (PBS-22117, PBS-22118, PBS-22119, PBS-22120, PBS-22121, PBS-22122) belongs to Virginia group.

II. Multiplication of breeding materials

A. Summer 2014: Twelve new (developed during *kharif* 2013) were mass multiplied to get sufficient seed for yield evaluation and screening for different biotic stresses. Besides that 10 of Spanish bunch and 03 of Virginia bunch advanced breeding lines were mass multiplied to get sufficient seed for conducting yield trials and screening for resistance to biotic stresses.

B. *Kharif* 2014: Twelve new advanced breeding lines, of which 03 belonged to Spanish bunch and 9 belonged to Virginia bunch lines were mass multiplied to get sufficient seed for conducting yield trials as well as screening for different biotic stresses.

III. Maintenance of breeding materials

A. Summer 2014: Fifteen maintenance advanced breeding lines and 17 groundnut genotypes have resistance/tolerance to different biotic stresses were mass multiplied to get sufficient seed for screening against different biotic stresses.

B. *Kharif* 2014: A total 30 groundnut genotypes have resistance/tolerance to different biotic stresses were mass multiplied to get sufficient seed for screening against different biotic stresses.

IV. Multiplication of AICRP-G lines:

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

B. *Kharif* 2014: Seeds of six elite advanced breeding lines PBS-22059, PBS-22062, PBS-22063 (under testing from *kharif* 2013), PBS-22066, PBS-22067 (under testing from *kharif* 2014) and PBS-22080 (proposed for testing in *kharif* 2015) were mass multiplied in to get sufficient quantity of seeds for yield evaluation under AICRP-G trials.

V. Distribution of breeding materials to different AICRP-G centres

The breeding material of seven different crosses from two segregating generations (F_3 to F_4 generation) was selected and supplied to two AICRP-G centres (RRRS, Vyara and RCA, Udaipur) to effect location specific selections for different biotic stresses during *kharif* 2015.

7. Screening of genotypes for tolerance of stem rot under sick plot

A. Summer 2014: Forty-six 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 and summer 2014. Data were recorded on per cent infection at the time of harvesting. The maximum disease incidence was 58.1% (PBS-22065) and 55.8% (PBS-12032) in 2013 and 2014 respectively. Results revealed that five genotypes (PBS-12029, PBS-12038, PBS-18037, PBS-18057 and PBS-18062) recorded less than 20% disease incidence as compared to the resistant genotype CS-19 recorded 32.4% and 25.9% during 2013 and 2014 respectively. Hence, these genotypes are identified as promising for stem rot.

B. *Kharif* 2014: Forty-six 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* 2014. Data were recorded on per cent plant mortality and disease infected plants at the time of harvesting then calculated total disease incidence. The disease incidence varied between 6.3 to 57.7% among the genotypes. Results revealed that eight genotypes (PBS- 12067, 12172, 12180, 18006,

18037, 18038, 18062, 22063) recorded less than 20% disease incidence as compared to the resistant genotype CS 19 (26.1%). Results on durability and stability of resistance to stem rot will be screen one or more year for confirmation under sick plot.

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

Forty-six groundnut genotypes screened for *in vitro* colonization by *A. flavus* at pod as well as kernel levels during kharif 2014 using modified progressive 1-4 scale suggested by Thakur et al., 2003. The seed infection ranged from 1.0 to 2.2 scale while pod infection ranged from 1.0 to 2.1 scale. 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 0.7 to 133.5ppb. 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.

9. Screening of advanced breeding lines for foliar disease resistance

A. Summer 2014: Forty-five advanced breeding lines were screened for resistant to *Alternaria* leaf spot with resistant check *viz*., CS 349 (4.3 and 3.7 on 1-9 scale in 2013 and 2014 respectively). The experiment was conducted under natural field condition in RBD with three replications and disease was score using modified 1-9 scale. Maximum disease severity was observed in genotype PBS 18037 (8 on 1-9 scale) in both the years summer 2013 and 2014. Based on the two year screening results it indicated that two genotypes PBS-12169 and PBS-12190 showed resistance or tolerant reaction (<4.7 on 1-9 scale) to *Alternaria* leaf spot. These can be used as new sources of resistance to *Alternaria* leaf spot.

Another e16 genotypes screened for *Alternaria* leaf spot under irrigated and drought conditions during summer 2013 revealed that under drought condition, disease incidence was increased in all the genotypes and maximum in the cultivar TG37A (4.0 to 6.3 on 1-9 scale) while the few genotypes JUN-27, PBS-16038, PBS-15031 and PBS-30055 do not showed any per cent changes in disease incidence under drought condition. Similarly disease incidence under drought was also observed in 16 genotypes during summer 2014 but disease incidence was very low in all the genotypes (4.0 on 1-9 scale). The maximum increase per cent disease was in genotype PBS-15020 (2.3 to 3.7) while genotypes PBS-15047, PBS-15054 and TAG-24 did not show changes in disease incidence under drought condition. Based on two year study it was observed that *Alternaria* leaf spot incidence was increased under drought conditions.

B. *Kharif* 2014: A total 142 genotypes along with resistant check *viz*., GPBD 4 (high yielding leaf spot and rust resistant variety) were screened in replicated trial under natural condition for resistance of foliar diseases (late leaf spot and rust) during *kharif*, 2014. The maximum disease pressure for late leaf spot and rust was 8.3 and 6.3 respectively on modified 1- 9 point scale while 3.0 and 3.0 for leaf spot and rust respectively in the cultivar GPBD 4. Rust disease severity, however, was not enough for screening rust resistant genotypes in all the trials.

In Virginia row trial, a total 54 genotypes were screened for leaf spot and rust. None of the genotype found resistant to leaf spot. Among them eighteen genotypes (PBS- 22050, 22057, 22061, 22068,

22082, 22028, 22040, 22070, 22078, 22079, 22087, 22089, 22090, 23034, ICGV-86325, VRI-5, KDG-123, KDG-128) identified as tolerant (disease score ≤ 6 on 1-9 point scale) to leaf spot. In Spanish row trial, a total 46 genotypes were screened for leaf spot and rust. Two genotypes (GPBD-4, JL-776) found resistant to leaf spot while one genotype (PBS-12200B) was found tolerant to leaf spot.

In Spanish yield evaluation trial; a total 24 genotypes were screened for leaf spot and rust. None of the genotype found resistant to leaf spot similarly in Virginia yield evaluation trial, a total 18 genotypes were screened for leaf spot and rust. Among them three genotypes (PBS-22095, PBS-22098, PBS-22107) identified as tolerant (disease score ≤ 6 on 1-9 point scale) to leaf spot while three genotypes (PBS-22098, PBS-22099, PBS-22107) recorded a disease score ≤ 3 on 1-9 point scale rust. Durability of resistance/tolerance of genotypes will be confirmed for one or more year of testing under high disease pressure.

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

A. Summer 2014: Fifty two groundnut genotypes were screened for resistance to sucking-pests such as, leafhoppers and thrips during summer-2013 and 2014. Significant differences in the mean population of leafhoppers between genotypes were observed at 45, 60, 75 and 90 days after sowing (DAS) whereas significant difference in the mean thrips population showed only at 45 DAS. Based on pooled analysis it was found that three genotypes *viz*.,PBS-12009, PBS-18037, PBS-18038 and PBS-18045 recorded lower number of leafhoppers (<4 leafhoppers/5 sweeps) at 45, 60, 75 and 90 DAS whereas the groundnut genotypes NRCGCS-85 and NRCGCS-349 recorded lower number of thrips (<3.6 thrips /5 sweeps). These genotypes can be used for intensive screening for their mechanism of resistance/tolerance.

B. *Kharif* 2014: Twenty-four groundnut genotypes in BYET-SB, 16 in BYET-VB, 46 in BIST-SB and 54 in BIST-VB were screened for resistance to sucking-pests (leafhoppers and thrips) at 30DAS. None of the genotypes were significantly differing with respect to both the mean leafhopper and thrips populations at 30 days after sowing (DAS) in all the trials except thrips populations in BYET-VB. The lowest thrips population (1.0 thrips/5 sweeps) was recorded in genotype PBS-22104 which was at par with genotype PBS-22099 (2.3 thrips/5 sweeps). These two promising genotypes need to be test one and two for their resistance reaction.

11. Screening of advanced breeding lines for resistance of root knot nematode

Sixteen groundnut genotypes were screened for root knot nematode (*M. arenaria*) in sick concrete blocks during *kharif* 2014. Disease reactions of these genotypes were recorded on number of root galls in each genotype per plant. The root galling in all the genotypes ranged from 15.6 (ICGV-86590) to 45.8 (PBS-12038) and found that all the genotypes were susceptible based on root-gall index. It was found that groundnut varieties (GG-14, ICGV-86590 and TG-37A); germplasm (NRCG-2615, ICG-1697 (NCAc 17090) and advanced breeding line (PBS-12009) found moderately resistant to root knot nematode based on the root-gall index. These groundnut genotypes can be used in breeding programmes.

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

(M.C. Dagla, M.K. Mahatma, Narendra Kumar and Ajay B.C.)

Hybridization (*Kharif*-14)

During *kharif*-2014, ten crosses were attempted to incorporate large kernel size coupled with high yield and other confectionery traits. A total of 1555 buds were pollinated and 399 probable hybrid pods were harvested with average 25% success rate. It was lowest in BAU 13 x NRCG 14492 (15%) and highest in PBS 29148 x CS 281 (31%).

Table 1 : Effected crosses, traits and success rate in *Kharif* -2014

S. No.	Crosses	Traits	Bud pollinated	F_1 pods	Success (%)
1	BAU 13 x NRCG 14492	Large seed and high protein	92	14	15
2	NRCG 14492 x BAU 13	High protein and large seed	107	24	22
3	Gangapuri x NRCG 14492	High sugar and high protein	132	36	27
4	NRCG 14492 x Gangapuri	High protein and high sugar	94	19	20
5	Mallika x NRCG 14422	High yield and large seed	191	49	26
6	PBS 29079A x NRCG 14452	Large seed and high yield	128	39	30
7	TG 51 x PBS 19022	High sugar and large seed	281	77	27
8	NRCG 9036 x Mallika	Large seed and high yield	151	31	21
9	PBS 29148 x CS 281	Large seed and high protein, low oil	123	38	31
10	GG 7 x PBS 29079B	Large and round seed	256	72	28
		Total	1555	399	24.7

Identification of true hybrid plants

Eight crosses generated during *kharif* -2013, among these five crosses were raised along with their parents during summer-14 and four crosses along with their parents during *kharif*-14 and total 72 hybrid plants were identified and pods were harvested individually for further advancement.

Table 2 : Identified hybrid plants and harvested as individual plants in F_1 generation

S.No.	Crosses	Season	Hybrid Plants
1	TPG 41 x S 230	Summer-14	18
2	ICGV 97079 x Dh 3-30	Summer-14	5
3	GPBD 4 x Dh 3-30	Summer-14	4
4	ICGV 97079 x MH 4	Summer-14	17
5	BAU 13 x NRCG 14492	Summer-14	5
6	BAU 13 x NRCG 14492	*Kharif*-14	1
7	NRCG 14492 x BAU 13	*Kharif*-14	5
8	Gangapuri x NRCG 14492	*Kharif*-14	9
9	NRCG 14492 x Gangapuri	*Kharif*-14	8
		Total	72

Generation advancement

Summer-14: Two crosses in F_4 generation were raised and 52 individual plants were selected. Twelve crosses in F_5 generation were raised, and 3 crosses were rejected, from remaining 9 crosses, 95 individual plants were selected. Six crosses in F_6 generation were raised and 19 individual plants were selected.

***Kharif*-14:** The F_2 generations of 8 crosses were sown and true F_2s (segregating) lines were identified and advanced. The selected crosses were cross-wise bulk-harvested for advancing to next generation. Three crosses in F_3 were sown and in each cross individual plants were selected and forwarded. Nine crosses in F_4 were sown and in each cross individual plants were selected and advanced. Similarly, eighteen crosses were sown and one cross was rejected and individual plants were selected in remaining 17 crosses and advanced.

New Advanced Breeding Lines from F_6 Generation (*kharif*-14)

In F_6 generation, seven crosses were sown, and ten large-seeded advanced breeding lines (eight belong to Virginia bunch PBS 29212, PBS 29213, PBS 29214, PBS 29215, , PBS 29216, PBS 29217, PBS 29218, PBS 29219, and two belong to Spanish bunch habit group PBS 19031 and PBS 19032) were selected as individual plants on the basis of their phenotypic performance. These individual plants will be multiplied in the next season for making sufficient seeds to conduct their evaluation trial.

Mutagenesis of variety GG 20 (*Kharif*-14)

For enhancing oleic acid content and Oleic/Linoleic ratio in groundnut, chemical mutagen EMS was used to mutate seeds of variety GG 20. GG 20 is the variety which is grown in large area of Gujarat in *kharif* season. The M_1 generation was grown in *Kharif*-14 and harvested as individual plants.

Multiplication and maintenance

Two Spanish bunch advanced breeding lines PBS 19018 and PBS 19022 multiplied in Summer-14 and Kharif-14 to make sufficient seed to enter in the AICRP-G for multi-location testing. In summer-14, seven newly developed large-seeded advanced breeding lines (Virginia bunch) multiplied for making sufficient seeds to conduct preliminary yield trial. Sixty one Virginia germplasm lines multiplied to make sufficient seed to evaluate for yield attributes and confectionery traits. Forty one Virginia and 14 Spanish bunch large-seeded advanced breeding lines multiplied in *Kharif*-14 for testing in advanced yield evaluation trial. Seventy three Virginia large-seeded advanced breeding lines have been maintained and inferior plants rejected at the time of harvest within the each line.

Evaluation of Spanish bunch genotypes for yield attributes 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 over *kharif*-12, summer-13, *kharif*-13, summer-14 and *kharif*-14 seasons. The pooled range was observed for pod yield per plant 2.4g (NRCG 14498) to 7.3g (TG 37A), pods per plant 6 (NRCG 14498) to 14 (NRCG 14377)), harvest index 17% (NRCG 14498) to 42% (TG 37A), shelling outturn 63% (NRCG 14362, and TKG 19A) to 74% (NRCG 14498), hundred kernel weight 20g (NRCG 14425) to 44g (TKG 19A), hundred selected mature kernel weight 30g (NRCG 14425) to 65g (TKG 19A), sound mature kernel 41% (NRCG

14425) to 66% (NRCG 14477), Kernel length width ratio 1.3 (NRCG 14380) to 1.8(TKG 19A), oil content 47.7% (NRCG 14383) to 51.5% (NRCG 14329), protein content 27.2% (NRCG 14329) to 31.6% (NRCG 14383), and sugar content 4.3% (NRCG 14329) to 5.5% (NRCG 14383).

Thirty six genotypes produced more than 10 pods per plant, and 27 genotypes have more than 70% shelling outturn, 32 genotypes have round kernels that have not more than 1.5 kernel length width ratio, and 34 genotypes have high protein content (>30%). Genotype NRCG 14407, and NRCG 14472 have the high harvest index (>35%).

Evaluation of Valencia genotypes for yield attributes and confectionery quality traits

Twenty eight Valencia germplasm lines with 2 checks (Gangapuri and MH4) were evaluated in randomized block design over *kharif*-12, summer-13, *kharif*-13, summer-14 and *kharif*-14 seasons. The pooled range was observed for pod yield per plant 1.8g (MH 4) to 5.8g (NRCG 14452), pods per plant 4 (NRCG 14507) to 9 (NRCG 14379), harvest index 14% (NRCG 14499) to 36% (NRCG 14379), shelling outturn 58% (NRCG 14444)) to 72% (NRCG 14379), hundred kernel weight 26g (NRCG 14451) to 46g (NRCG 14496), hundred selected mature kernel weight 34g (NRCG 14369) to 59g (NRCG 14496), sound mature kernel 36% (NRCG 14444) to 60% (NRCG 14496), kernel length 10.8mm (NRCG 14369) to 16.1mm (NRCG 14507), kernel width 7.1mm (NRCG 14499) to 8.6mm (NRCG 14332), Kernel length width ratio 1.5 (NRCG 14328, NRCG 14369, NRCG 14379, and NRCG 14429) to 2.1 (NRCG 14507), oil content 46.5% (NRCG 14499) to 50.2% (NRCG 14468), protein content 27.6% (NRCG 14468) to 33.4% (NRCG 14499), and sugar content 4.6% (NRCG 14468) to 5.7% (NRCG 14332 and NRCG 14451).

Genotypes have been identified for yield attributes and quality traits, such as NRCG 14379 for high harvest index (36%) and high shelling outturn (72%), NRCG 14507 has longest kernel (16.1mm), and NRCG 14332 has the widest kernel (8.6mm), and NRCG 14369 and NRCG 14379 has the 1.5 ratio for kernel length/width it shows roundness of the genotypes. Oil content was in the normal range ( ) but protein content was >30% in most of the studied Valencia genotypes; however NRCG 14332, NRCG 14451, and NRCG 14499 have more than 33% protein content.

Evaluation of Virginia genotypes for yield attributes and confectionery quality traits

Twenty six Virginia advanced breeding lines developed at ICAR-DGR, Junagadh with 4 checks (BAU 13, GG 20, M 13 and Somnath) were evaluated in randomized block design over *kharif*-12 (Junagadh), *kharif*-13 (Junagadh and Bikaner) and *kharif*-14 (Junagadh). The pooled range was observed for pod yield per plant 5g (PBS 29172) to 20g (PBS 29098, PBS 29114 and GG20), pods per plant 10 (PBS 29172) to 26 (PBS 29098), harvest index 21% (PBS 29114) to 44% (PBS 29162), shelling outturn 59% (PBS 29136) to 74% (PBS 29162), hundred kernel weight 45g (PBS 29171 and PBS 29172) to 64g (PBS 29166), hundred selected mature kernel weight 72g (PBS 29171) to 101g (PBS 29145), sound mature kernel 36% (PBS 29120) to 51% (PBS 29171 and BAU 13), kernel length 15.5mm (GG 20) to 18.2mm (PBS 29168), kernel width 8.4mm (PBS 29171) to 9.9mm (PBS 29144), oil content 45.7% (PBS 29132) to 51.9% (GG 20), protein content 26.3% (GG 20) to 33.9%(PBS

29132), and sugar content 3.6% (GG 20) to 5.3% (PBS 29132).

Genotypes have been identified for yield attributes and quality traits, such as PBS 29098, PBS 29120, PBS 29132, PBS 29161, PBS 29162, and PBS 29164 have >20pods per plant, PBS 29136, PBS 29160, PBS 29162, PBS 29166, PBS 29167, and PBS 29168 have high harvest index (>40%), PBS 29162 and PBS 29168 have the high shelling outturn (>70%), PBS 29144, PBS 29145, PBS 29157, PBS 29165, PBS 29166 and PBS 29168 have >60g hundred kernel weight. One advanced breeding line PBS 29132 has the lowest oil content (45.7%), highest protein content (33.9%) and highest sugar content (5.3%) among the studied 30 genotypes.

These identified genotypes in three groups Valencia, Spanish bunch and Virginia can be used as parents in further breeding programme for improvement in groundnut for their respective identified traits.

Large-seeded Virginia advanced yield evaluation trial

One advanced yield evaluation trial was conducted during *kharif*-13 and *kharif*-14. There were fifteen Virginia ABLs and three checks GG 20, BAU 13 and M 13. For pod yield, BAU 13 was the best check, and no advanced breeding line surpassed this check. For confectionery type groundnut, two advanced breeding lines PBS 29146 and PBS 29148 have been identified with low oil content (44.3% and 44%), high protein content (35.9% and 36.2%) and high sugar content (5.6% in each). Pod yield and pods per plant are 7g and 8 in each of both advanced breeding lines. Highest pod yield per plant is 8g in PBS 29087 and PBS 29137. PBS 29087 produced highest pods (11), highest harvest index (48%), highest shelling outturn (71%), but lowest hundred kernel weight (46g) and lowest hundred selected mature kernels weight (68g), lowest kernel length (15.2mm) and lowest kernel width (9.1mm). These identified advanced breeding lines can be used as parents/donor in further breeding programme for improvement of groundnut for their identified respective traits.

Supply of breeding materials to different AICRP-G centers

The breeding material of twelve different crosses in F_4, F_5 and F_6 generations was supplied to AICRP-G centers. Pods of 5 crosses were sent to JAU, Junagadh, and pods of 12 crosses to each following centers; CAU Imphal, SKRAU Hanumangarh, Dr. PDKV Akola, MPKV Jalgaon, and PAU Ludhiana for site specific selections.

PROJECT 04 BREEDING GROUNDNUT VARIETIES FOR HIGH YIELD UNDER LOW INPUT CONDITIONS

(Ajay B.C., M.C. Dagla, K.A. Kalariya, H.N. Meena and R.S. Yadav)

Hybridization, selection and generation advancement

In *kharif* 2014 ten crosses were attempted in field using P-efficient (SP 250A, ICGV 86590 and FDRS 10) and P-inefficient (NRCG 7320 and NRCG 162). On an average success rate under field condition was 48%. Five crosses effected during kharif 2013 were raised during summer 2014 and 27 F_1hybrids were identified. In the cross GG 20 x NRCG 1308 no hybrids were identified. Six crosses were advanced from F_2 to F_3 generation and 132 breeding lines were selected. Five crosses were advanced from F_1 to F_2 and 257 breeding lines were selected which later would be advanced to next generations by plant to progeny row method. Two crosses namely Girnar 3 x FDRS 10 and TG 37A x FDRS 10 were advanced from F_5 to F_6 generations and eight elite genotypes were identified based on pods per plant. Eight crosses involving GG 20, TPG 41, TG 37A and Girnar 3 as female and FDRS 10 and NRCG 7320 as males were advanced from F_4 to F_5 generation by single seed descent method.

Generation advancement of promising breeding materials.

Promising breeding lines which were initially identified during summer 2013 and further selected during kharif 2013 were raised in a plant to row progeny method. At the time of harvest single superior plant is selected from each line for forwarding it to next generation. Four breeding lines in $F_4 - F_5$ generation from cross Girnar 3 x FDRS 10 were rejected based on pod number. Two additional plants with good pod number which were a segregants from their parental generations were identified and selected from $F_3 - F_4$ generations of a cross TG 37A x FDRS 10 and Girnar-3 x FDRS 10 and similarly one additional segregant was also selected in $F_3 - F_4$ generation of cross TPG 41 x NRCG 7320.

Screening of germplasm forP use efficiency

During summer 2014 a study involving 158 germplasm accessions with four check genotypes (ICGV 86590, SP 250A, VRI 3 and NRCG 162) was undertaken under two treatment with (HP) and without (LP) external phosphorus application to study P use efficiency among germplasm accessions. Significant genotypic differences were observed among check genotypes for yield parameters under both HP and LP. Significant genotypic differences was also observed among germplasm for pod yield per plant, 100 kernel weight and biomass per plant under both HP and LP conditions (Table 4). Pod yield, 100 kernel weight and biomass weight reduced from HP to LP. For pod yield none of the germplasm accessions could surpass best check VRI 3 (under HP) and ICGV 86590 (LP). Although germplasm accessions with high 100 kernel weight under HP (NRCG 12138) and LP (NRCG 14428) and high biomass yield under HP (NRCG 12455) and LP (NRCG 14443) were identified.

In *Kharif* 2014,48 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 having Nitrogen (50 kgha^{-1}), Phosphorous (50 kgha^{-1}) and Potassium (60 kg ha^{-1}) (T1); (ii) Without P Nitrogen (50 kgha^{-1}), Phosphorous (0 kg ha^{-1}) and Potassium (60 kg ha^{-1}) (T2). Analysis of variance indicated significant genotypic differences for pod yield per plant, biomass yield per plant, shelling per cent and 100 seed weight. Pod yield per plant reduced under low-P compared to normal-P. Under low-P, pod yield per plant of genotypes PBS 22080 and PBS 22088 were on par to best check (ICGV 86590). Among advanced breeding lines screened PBS 29145, PBS 29080 and PBS 29169 had low pod yield under low-P. Biomass yield of genotype PBS 29125 was superior to best check (ICGV 86590).

Screening of promising breeding lines for yield under two P levels

In *Kharif* 2014, 91 promising breeding lines were evaluated in comparison to five check varieties (Somnath, GG 20, GG 2, GG 7 and TG 37A) under two phosphorous levels (i) With P having Nitrogen (50 kgha^{-1}), Phosphorous (50 kgha^{-1}) and Potassium (60 kg ha^{-1}) (T1); (ii) Without P having Nitrogen (50 kgha^{-1}), Phosphorous (0 kg ha^{-1}) and Potassium (60 kg ha^{-1}) (T2). Analysis of variance (ANOVA) was performed by augmented design–I separately for two P levels. ANOVA indicated significant genotypic differences for pod yield per plant, pods per plant, shelling per cent and 100 seed weight. Thirteen promising breeding lines had significantly higher pod yield per plant compared to superior check (GG 20) under treatment without P application whereas under treatment having P application three promising lines were superior to best check.

Development of P deficient plot

During *kharif* 2014 plots with three P gradients i.e. deficient-P, normal-P and high-P have been created with each plot measuring 600m^2. Deficient-P plots are being developed by cultivating maize crop by applying zero phosphorus and with recommended doses of nitrogen and potash. In normal and high-P plots no crops were cultivated but in high-P plots recommended doses of DAP was applied to facilitate phosphorus build up in soils. Soil samples were collected before sowing and after harvest in all three plots to determine P levels.

PROJECT 05. ENHANCEMENT AND MANAGEMENT OF GROUNDNUT GENETIC RESOURCES

(A.L. Rathnakumar, S.K. Bera, M.K. Mahatma, G.P. Mishra and M.C. Dagla)

Field maintenance of Wild *Arachis* germplasm

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

Acquisition, distribution and utilization of germplasm accessions

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

Multiplication and conservation of germplasm accessions

Multiplication: A total of 87 accessions (Registered genetic stocks; 17 interspecific derivatives; and 31 other accessions) were multiplied in summer 2014. Two thousand and twenty one accessions received from NBPGR, New Delhi under Svalbard Gene Bank (Global Seed Vault, Norway) programme have been rejuvenated through five AICRP-G centres (JAU- Junagadh, MPKV-Rahuri, UAS- Dharwad, ANGRAU- Kadiri and TNAU-Vridhachalam) during *kharif* and *rabi*-summer 2014. Of these 1642 accessions have been rejuvenated and seed enhancement is in progress. One thousand germplasm accessions of base collections received from NBPGR under Consortium Research Platform on Agro-Biodiversity (CRP-AB) of ICAR have been rejuvenated and seed enhanced at DGR-Junagadh (350 accessions), ANGRAU-Kadiri (325 accessions) and TNAU-Vridhachalam (325 accessions). Out of these 345 accessions multiplied at DGR Junagadh have been submitted for long term conservation at NBPGR.

For seed enhancement, distribution and conservation 10 diverse set of 942 accessions have been multiplied in *kharif* 2014. They are: Composite Collection of Water Use Efficient/drought tolerant accessions (189 accessions); release varieties of India (195 Nos.); Mini-core collection (184 accessions); a sub-set of DGR working collection (167 accessions); interspecific derivatives (17 Nos.); large seeded Virginia accessions (30 Nos.); morphological variants (45 accessions); elite genotypes of AICRP-G (53 nos.); promising mutants of GG 20 (12 Nos.) and others (49 accessions). Four hundred and eighty three accessions of working collection have been rejuvenated and seed enhanced in *kharif* 2014. In addition, 30 DUS reference varieties have been multiplied for seed enhancement in kharif 2014.

Morphological characterization and evaluations

Summer 2014: Characterisation of composite collection for drought tolerance

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

Evaluation of Spanish bunch large seeded accessions for summer season

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

Evaluation of Valencia accessions for table purpose

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

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

***Kharif* 2014: Evaluation of large seeded Virginia (spreading/semi-spreading) accessions**

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

Evaluation of Valencia accessions for table purpose

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

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

One thousand accessions of the working collection have been evaluated for oil, protein and sugar. These accessions belonged to 62 countries. The botanical group of these accessions were: 226 Valencia; 442 Spanish bunch; 193 Virginia bunch; 117 Virginia Runner; and 3 intermediate types. The oil content in 987 accessions ranged from 44.4%-55.6%; protein content ranged from 21.3%-35.6%; and the sugar content ranged from 2.9%-6.6%. Out of 1000 accessions, 105 accessions oil content having more than 52%. Of these 16 accessions recorded more than the benchmark variety TMV 10 which was so far the highest oil containing genotype i.e 52.8%. 407

accessions recorded more than 30% protein content of which eight accessions recorded >34% protein; and 425 accessions recorded more than 6% sugar content of which 24 accessions had >6% sugar content. The top five accessions in each of these categories are provided below.

Table 1. Promising accessions identified for quality traits

S. No.	Traits	Top five accessions (NRCGs)	Value (%)
1	High oil	7040	55.60
		6999	55.00
		1476	54.90
		12328	54.90
		3817	54.80
2	High protein	7128	35.60
		12523	35.20
		5239	34.70
		7063	34.60
		12666	34.40
3	High sugar	7063	6.58
		12317	6.53
		7128	6.39
		1632	6.35
		5239	6.33

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

Screening for low temperature tolerance at germination under lab conditions

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

Altogether 39 varieties have shown germination up to 80% under incubation at 12°C after 10 days. Of which 15 varieties exhibited 100% germination under the above conditions. The popular varieties grown during rabi-summer and which exhibited 100% germination were MH 2, MH 4, Kopergaon 3, ICGV 00350, OG 52-1 and TAG 24, TG 26, Dh 86, TG 37A etc. Among the accessions of working collection, 40 accessions exhibited germination up to 80% under incubation at 12°C of which nine accessions viz. NRCGs 14367 (FST), 14403 (FST), The accessions NFCGs14419 (FST), 14450 (FST), 14481 (FST), 14484 (FST), 14360 (HYB) 14341 (HYR), and 14383 (VUL) exhibited 100% germination under the above conditions. These accessions will be grown under field conditions to validate the results.

Screening for resistance to stem rot under sick plot conditions

Four hundred and thirty five genotypes comprising 195 released varieties; 144 GG 20 M5 mutants; 84 AICRP-G genotypes; 12 advanced breeding lines were screened for resistance to stem rot under sick plot conditions. Altogether 32 genotypes (12 GG 20 mutants; 6 AICRP-G genotypes; 14 released varieties have been found promising with <20% stem rot incidence. Of these promising genotypes, eight GG 20 mutants (<10%); one AICRP-G genotype JSP 59 (9.1%), and seven released varieties, BG 2, ICGS 76, RS 138, VRI 3 (<5%), Karad 4-11 (5.6%), and TMV 1 (7.1%) and TMV 3 (7.7%) recorded less than 10% incidence of the disease.

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

Evaluation of transgenic expressing a bacterial *mtlD* gene under salinity stress

The four groundnut transgenic (T) events namely MTD1, MTD2, MTD3 and MTD4 in T_4 generation, having single copy transgene insertion and confirmed with Southern blot analysis were used for salt stress tolerance analysis. Wild type (WT) (cv. GG20) and T events were sown in concrete rings (in triplicate) under salinity stress and controlled conditions. The *mtlD* gene transgenic groundnut (cv. GG 20) was assessed for the effects of salt stress in near field conditions at flowering, pegging and pod formation stages. Various growth and physio-biochemical factors like *mtlD* enzyme activity, mannitol and other sugar accumulation, ROS accumulation and antioxidant response in transgenic lines compared to WT under different salt stress treatments (1, 2 and 3 dS/m) were analysed. The transgenic lines recorded significant higher mannitol dehydrogenase enzyme activity and mannitol accumulation than wild type.

During salt stress, all the transgenic lines showed significant higher level of superoxide dismutase, catalase, guaiacol peroxidise, ascorbate peroxidase, glutathione reductase activity, while significant lower level of hydrogen peroxide and malondialdehyde content was recorded when compare to wild type plants. Among studied antioxidant enzymes activity, at higher salt treatment (3 dS m^{-1}), activity of POD and APX increased remarkably in transgenic lines. Histochemical *in situ* localization has shown lower accumulation of H_2O_2 and O_2^- in T lines compared to WT. H_2O_2 (visualized as deep brown products) and O_2^- (visualized as dark blue products) under different salt stress condition.

Fig.1. In situ localization of hydrogen peroxide (H_2O_2) and superoxide radical (O_2^-) and measurement of H_2O_2 content in WT and T lines under different salt treatments

Similarly, significantly higher ascorbic acid and relative water content was recorded in transgenic lines. The study revealed that the transgenic lines has exhibited enhanced mtlD activity, antioxidant response, RWC, sugar accumulation and growth parameters and reduced H_2O_2 and MDA content as compared to WT plants. The expression of *mtlD* gene has participated in scavenging of ROS and stabilized the macromolecular structures and shown improved salt stress tolerance.

Expression of *AtDREB1A* gene in transgenic groundnut-conferred tolerance to drought and salinity stresses

Research on genetic transformation in various crop plants using the *DREB1A* transcription factor has shown better abiotic stress tolerance in transgenic crops. The *AtDREB1A* transgenic groundnut (cv. GG 20), which was previously developed, was characterized in terms of its physio-biochemical, molecular and growth parameters. The tolerance of

this transgenic groundnut to drought and salinity stresses was evaluated at the seedling (18 days old) and maturity stages. Transgenic groundnut lines showed improved tolerance to both stresses over wild-type, as observed by delayed and less severe wilting of leaves and by improved growth parameters that were correlated with physio-biochemical parameters such as proline content, total chlorophyll content, osmotic potential, electrolytic leakage and relative water content. The expression pattern of the *AtDREB1A* gene evaluated using qPCR at different time points demonstrated that transgene expression was induced within two hours of stress imposition. The better performance of transgenic *AtDREB1A* groundnut at the seedling stage and the improved growth parameters were due to the expression of the transgene, which is a transcription factor, and the possible up-regulation of various stress-inducible, downstream genes in the signal transduction pathway under abiotic stress.

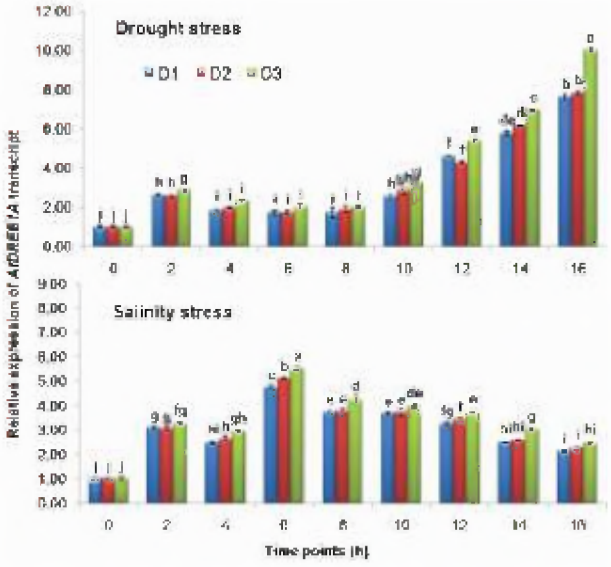


Fig.2. Relative expression of AtDREB1A transcript during drought and salinity stresses.

Characterization of TSV-CP and PBNV-NC dual construct groundnut transgenic

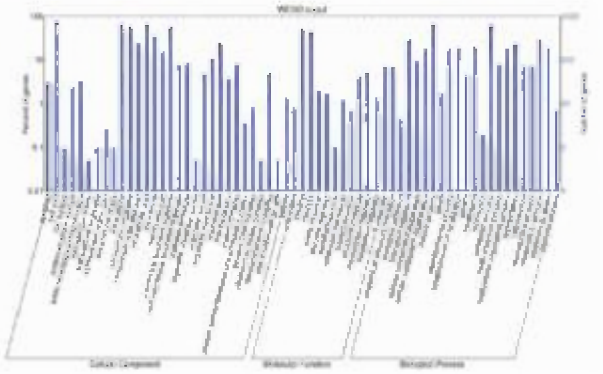
- Initially total 222 plants in T1 and T2 generations were PCR screened and 106 plants found positive for 9 events. All events were brought to T3 generation and 374 plants (T3) from 7 events were PCR screened and 192 plants were found positive for 5 events (DCV- 191, 304, 485, 492 and 547). These events were used for further molecular characterization.
- The presence of *transgene* (*TSV-CP and PBNV-NC*) in T3 generation was confirmed by *dot blot* analysis, using PBNC-NC gene as the probe in five events.
- RT-PCR results showed that five events of transgenic plants were expressing for *TSV-CP and PBNV-NC* gene in significant quantity of mRNA.
- q-PCR results indicates that five events where showing differential fold mRNA expression in dual construct plants.

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. Bera, Narendra Kumar and Abhay Kumar*)
*On study leave

Development and validation of novel, stress relevant EST-SSR markers

Large number of expressed sequence tag (EST) sequences is available for groundnut in the public databases. These ESTs can be employed for the development of simple sequence repeat markers aptly called EST derived SSR markers or functional markers. In the present study, all the publically available *Arachis hypogaea* EST sequences were employed for the development of novel, functional markers in groundnut. From 16424 unigenes, 2784 (16.95%) SSR containing unigenes having 3373 SSR motifs were identified. Of these, 2027 (72.81%) sequences were annotated and assigned 4124 gene ontology terms. Among different SSR motif-classes, tri-nucleotide repeats (33.86%) were the most abundant followed by di-nucleotide repeats (27.51%) while, AG/CT (20.7%) and AAG/CTT (13.25%) were the most abundant repeat-motifs. A total of 2456 EST-SSR primer pairs were designed; of which 366 having relevance to various stresses and other functional unigenes were PCR validated using 11 diverse groundnut genotypes. Of these, 340 (92.62%) primer pairs yielded clear and scorable PCR products and 39 (10.66%) exhibited polymorphisms. Overall, the number of alleles per marker ranged from 1-12 with an average of 3.77 and the PIC ranged from 0.028 to 0.375 with an average of 0.325. The identified EST-SSRs not only enriched the existing molecular markers kitty, but would also facilitate targeted research in marker-trait association for various stresses, inter-specific studies and genetic diversity analysis in groundnut.



Distribution of most abundant Gene ontology (GO) terms assigned to 2027 annotated SSR containing sequences

Marker assisted selection for foliar disease resistance (Cross: GJG 17 x GPBD 4)

Parental polymorphism screening and identification of hybrids

The hybridization programme was started in June 2013. GPBD 4 is a highly resistant variety to rust and LLS was selected as a donor parent in the MABC programme, as it was used for identify the QTL regions and RIL mapping for foliar disease resistance in various molecular breeding studies, while GJG 17 used as recurrent parent which is a newly released high yielding variety having stem rot tolerance. The parental polymorphism was done for linked and newly designed primers. Among 30 linked makers 10 were found polymorphic which

include seq8D9, PM 384, PM137, TC11H06, GM2009, GM2079, Ah4-26, seq16F10, IPAHM103 and PM 50.

The true hybrids were selected by using foliar diseases using linked polymorphic markers in summer 2014 season. A total 90 plants were obtained in F_1 generation with seq8D9 primer contributes up to 62.3% phenotypic variation. All the plants were screened with 4 primers including seq8D9, PM 384, PM137 and TC11H06. Those F_1 hybrids common in all the primers were used as male parent to make first backcross. The foreground selection of BC_1F_1 and BC_2F_1 plants was done and 3rd backcross with recurrent parents is under progress.

Identification of F1 hybrids on PAGE using seq8D9 primer [P1- GJG 17(130bp), P2- GPBD 4 (140bp), hybrid both showing both (130bp and 140bp)]

F_2 mapping

A total of 1700 F_2 seeds were planted in kharif season 2014. This F_2 population was screened for foliar disease resistance through artificial inoculation of rust and LLS spore at one day interval. Disease score for both was recorded at time of harvesting. Morphological as well as post harvest and observation of 1000 plants were also recorded. DNA was isolated from 1000 F_2 plants using lab protocol and 374 F_2 were screened with seq8D9 marker while 93 F_2 s were analysed with all 10 linked and 4 new polymorphic makers. Out of 8 linked and 1 new marker showed co dominant nature and 1:2:1 segregation ratio while reaming segregated in 3: 1 ratio. In summer 2015, 1550 F_3 seeds were sown for advancement of RIL using single seed decent method.

Cross: TMV2 X CS 196

'TMV 2' (the national susceptible check for both rust and rust) crossed with interspecific derivative CS 196 having resistance to both diseases in kharif 2015. A total of 130 seeds were obtained and true F_1 will be confirmed with molecular markers.

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

(S.K. Bera, Chunilal, P.P. Thirumalaisami and Ajay B.C.)

Advanced yield evaluation of promising genotypes

Advanced yield evaluation of selected promising Virginia bunch genotypes was done during *kharif,* 2014. Nine genotypes, selected from progenies of a cross between GG-20 x CS-19 for improving resistance to stem rot, were evaluated along with five checks in RBD with three replications. Each genotype was shown in four lines on a three meter bed with a spacing of 45 cm between lines and 10 cm between plants. Recommended crop management practices were followed for raising a healthy crop. Observations on days to 50% flowering, pod yield (PY), shelling out turn (SOT), hundred kernel mass (HKM), and sound mature kernel (SMK) per cent were recorded. Single genotype 25-5-32-sel out of nine tested, was found significantly superior in terms of pod yield per plot (2417 g) over best check, GG 20 (1897 g) with a CD (at 5%) value of 419.5. Besides, genotype 25-5-32-sel recorded 67% SOT and 44 g HKM in comparison to 69% SOT and 50 g HKM observed in GG-20 with CD (at 5%) value of 6.87 and 12.11, respectively. Performance of these genotypes will further be compared for additional two more years prior final recommendation.

Advanced yield evaluation of promising genotypes with high kernel mass

Advanced yield evaluation of selected promising Virginia bunch genotypes with high hundred kernel mass was done during *kharif,* 2014. Thirty-three genotypes, developed by chemical mutagenesis of genotype GG-2 for increasing yield as well as hundred kernel mass, were evaluated along with five checks in RBD with three replications. Each genotype was shown in two lines on a three meter bed with a spacing of 45 cm between lines and 10 cm between plants. Recommended crop management practices were followed for raising a healthy crop. Observations on days to 50% flowering, pod yield (PY), shelling out turn (SOT), hundred kernel mass (HKM), sound mature kernel (SMK) per cent were recorded. Four genotypes NRCGCS-281-21-1 (434.4 g), NRCGCS-281-21-2 (385.1 g), NRCGCS-281-40-2 (400.7 g) and NRCGCS-281-40-4 (402.3 g) were found significantly superior in terms of pod yield per plot over best check Girnar-2 (307.1 g). On the other hand, HKM and SMK % of these four genotypes was statistically at per with best check GG-20 (51 g). Out of these, three genotypes viz, NRCGCS-281-21/1 (VR), NRCGCS-281-21/2 (SB) and NRCGCS-281-40/2 (VR), recorded significantly higher pod yield over the checks during *kharif*2013.

Initial yield evaluation of Virginia bunch genotypes

Initial yield evaluation of selected promising Virginia bunch genotypes was done during *kharif,* 2014. Thirty-three genotypes were evaluated along with five checks in RBD with three replications. Each genotype was shown in two line on a three meter bed with spacing of 45 cm between lines and 10 cm between plants. Recommended crop management practices were followed for raising a healthy crop. Observations on days to 50% flowering, pod yield (PY), shelling out turn (SOT), hundred kernel mass (HKM), sound mature kernel (SMK) per cent were recorded. None of the genotypes was found significantly superior in terms

of pod yield per plot over best check variety GG-20. Performance of these genotypes will further be compared for additional two more years prior final recommendation.

Confirmation of resistance to major foliar diseases in Pre-breeding lines

Interspecific advanced breeding lines were screened at Coconut Research Station, Alliyarnagar, TNAU, a natural hot spot for foliar diseases during *rabi*/ Summer season. Hundred and twenty two breeding lines were screened for Rust and Late Leaf Spot diseases along with susceptible (TMV-7, JL-24 and, Co-2) as well as resistant (GPBD-4, VRI(Gn)6, ALG-06-320) checks. Each breeding lines as well as checks were sown in single line on five meter bed. Standard crop management practices were followed to raise healthy crop. Susceptible and resistant checks were sown after every 15 rows of test lines. Disease scoring for Rust and LLS ranged from 6-8 and 7-9, respectively in 1-9 standard disease scale among susceptible checks. High disease scores among susceptible checks indicated presence of sufficient disease pressure under natural field conditions. GPBD-4, a resistant check recorded minimum disease score (one) for both rust and LLS. Nine breeding lines (NRCGCS numbers 476, 517, 527, 534, 537, 541, 548, 566 and 574) recorded rust score of one, while single breeding line (NRCGCS-574) recorded LLS score of two. The elite breeding line NRCGCS-574, also recorded similar low disease scoring for Rust as well as LLS during *kharif* 2013,is afresh source for both rust and LLS diseases and could be used as donor in future groundnut breeding programme.

Characterization of Pre-breeding lines under imposed drought conditions

Interspecific advanced breeding lines were screened at DGR, Junagadh for tolerance to drought during *rabi*/ summer season. Fifty four breeding lines were sown in augmented design in three blocks. Each breeding line was sown in single line on five meter bed. Standard crop management practices were followed to raise healthy crop. Normal irrigation was provided to the crop up to 40 days. After 40 days, irrigation was skipped alternately from normal schedule till harvest of the crop. Observations on two surrogate traits of drought viz, SLA and SCMR were recorded at 60 days after sowing. TG37A recorded highest SCMR value (41.4), while TAG24 recorded lowest SLA value (163.5) among checks used. NRCGCS numbers 512, 515, 518, 519, 451, 452, 455, 467, and 469 recorded significantly higher SCMR value than best check (GG-20). Significantly lower SLA value over best check (TAG-24) was recorded in 26 breeding lines (253, 268, 456, 465, 439, 440, 445, 441, 505, 443,464, 459, 469, 516, 455, 454, 442, 463, 514, 462, 450, 449, 436, 444, 513, 506). These advanced breeding lines could be promising donor for SLA and SMR in future breeding programme.

Evaluation of RILs for tolerance to drought

Recombinant Inbred Lines (RIL) were developed using ICG-4747 and TMV 2 NLM. RILs were evaluated under both irrigated and imposed drought conditions at DGR during *rabi*/ summer season. Sixty seven RILs along with two parents were sown in RBD with three replications. Each genotype was sown in single line on five meter bed and recommended crop management practices were followed to raise healthy crop. For irrigated condition, regular irrigation as per requirement was provided to the crop. While for drought condition, irrigation was skipped alternately from normal schedule after 40 days of sowing to impose drought

stress to the crop. Significant genotypic variation was observed among 67 RILs for pod weight (g), biological yield (g), SCMR, SLA, shelling percent, hundred kernel weight, harvest index (%) and root diameter (mm) in both irrigated and drought conditions. However, population mean values of all the characters decreased under drought conditions except SLA, harvest index and root diameter. SLA and harvest index were almost equal in both drought and irrigated conditions while root diameter increased under drought conditions. Both SLA and harvest index were less affected due to drought stress and can be targeted in selecting genotypes for tolerance to drought in these population. Further, promising RILs with less SLA, high harvest index and high SCMR values were identified.

Screening for resistance to stem rot

Two hundred and eighty breeding lines along with checks were screened for confirming resistance to stem rot in sick soil under field conditions during *kharif* season. Each line was sown in one line of three meter bed following recommended management practices. Inoculum was added in the soil at 35 as well as 65 days to maintain optimum disease pressure throughout the crop stages. Plant population was recorded prior adding inoculum and at the time of harvest. Mortality ranged from 0-86%among RILs indicating high disease pressure in screening plot. A total of 116 lines recorded less than 20% mortality. Out of these RIL 25-5-31 was found promising with low mortality along with low pod infection during *kharif* 2013. In a separate experiment, 120 interspecific pre-breeding lines were also evaluated for resistance to stem rot in sick soil under field conditions during *kharif* season. Each line was sown in one line of three meter bed following recommended management practices. Inoculums were added in the soil at 35 as well as 65 days to maintain optimum disease pressure throughout the crop stages. Plant population was recorded prior adding inoculums and at the time of harvest. Mortality ranged from 0-57% and a total of 72 lines recorded less than 20% mortality.

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 cultivated varieties for resistance to stem rot: The experiment was conducted during summer 2014 and *Kharif* 2014.

Altogether, 53 cultivated varieties were screened for resistance to stem rot disease during summer-2014, where minimum (18.07%) stem rot was recorded with variety R-9251 followed by DRG-12 (20.69%) and the maximum (62.79%) disease was recorded with HNG-10. The maximum (133.33 g) pod yield was recordedwith SG-84 followed by SG-99 (108.33 g) while the minimum pod yield of 18.33 g was recorded with Tirupati-3 in three meter row.

During *Kharif*-2014, 60 cultivated varieties were screened for resistance to stem rot disease, where minimum (2.78%) stem rot was recorded with variety M-522 followed by CSMG-84-1 (6.67%) and the maximum (46.11%) disease was recorded with DH-8 and Girnar-3 (44.97%). The maximum (124.67 g) pod yield was recorded with JL-501 followed by ICGV-86235 (92.33 g) in three meter row while the minimum pod yield of 12.67 g was recorded with CSMG-84-1in three meter row.

Evaluation of bio-control agent for growth promotion of groundnut and management stem rot: The field bio-efficacy of seven *Trichoderma* spp./isolates, namely *Trichoderma harzianumS1, T. koningiopsis, T. bravicompactum, T. longibrachiiatum, T. virens, T. harzianum-T-170 isolate* and *T.harzianumdharwad isolate* was tested for management of *Sclerotiumrolfsii* during summer 2014, and all seven *Trichoderma* and one PGPR during Kharif-2014.

The maximum (25.67%) inhibition of stem rot was achieved by *Trichoderma harzianum S1* followed by *T. bravicompactum* (20.82%) against control. However, *T. harzianum* dharwad isolate could inhibit only 12.35% over control. Whereas, the maximum (883.56 kg/ha) pod yield was supported by *T. longibrachiatum* followed by T. *bravicompactum* (870.00 kg/ha) during summer-2014.

During Kharif-2014, the maximum (58%) inhibition of stem rot was achieved by *Trichoderma longibrachiatum* followed by *T. harzianum S1* (50%) against control. However, *T. coningiopsis* could inhibit only 7% over control. Also, maximum (1120 kg/ha) pod yield was supported by *T. longibrachiatum*, which was followed by *T. bravicompactum* (1176 kg/ha). However, the maximum (5556 kg/ha) fodder yield was supported by *T. harzianum*-T-170 isolate followed by *T. virens* (5278 kg/ha) at par with *T. koningiopsis.*

Effect of ridge, raised and flat bed for management of soil borne diseases: The experiment was conducted with four treatments namely on ridge bed (single row), raised bed (two rows side by side), raised bed (with three rows), flatbed (with four rows) against farmers' practice as control (without seed treatment) on flatbed (with four rows).

The minimum (5.20%) stem rot was recorded in treatment with raised bed (with three rows) as compared to farmers' practice, the control. It was noted that maximum (14.09%) stem rot was recorded in the treatment which was on ridge bed (with single row). The maximum stem rot on ridge bed (with single row) could be attributed to the availability of more moisture content for the longer period during summer-2014.

During *Kharif*-2014, the minimum (3.1%) stem rot was recorded in treatment with raised bed (with three rows) as compared to farmers' practice, the control. It was noted that maximum (10.5%) stem rot was recorded in the treatment which was on ridge bed (with single row). The maximum stem rot on ridge bed (with single row) could be attributed to the availability of more moisture content for the longer period.

Testing of different modules for stem rot disease

Altogether, 9 modules were identified and tested for soil borne diseases with farmers' practice and absolute control during *Kharif*-2014. There

were two sets of experiment, one for stem rot and another for collar rot.

Effect of modules on stem rot and yield:
Stem rot: The maximum (60%) inhibition of stem rot was achieved by Module-M15 *i.e.* deep summer ploughing with mould board plough+seed of variety GG-20+seed treatment with PGPR @625g/ for per ha of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS (days after sowing) and third at 80 DAS, followed by Module M-17 *i.e.* deep summer ploughing with mould board plough+seed of variety GG-20+seed treatment with tebuconazole @ 1.5 g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS (days after sowing) and third at 80 DAS over absolute control at par with farmers' practice. However, Module-M9 *i.e.* deep summer ploughing with mould board plough+seed of variety GG-20+ seed treatment with PGPR @625g/ for per ha of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS (days after sowing) received maximum stem rot (16% inhibition) over absolute control at par with farmers' practice.

Pod and fodder yield: The maximum pod (1574 kg/ha) and fodder (3333 kg/ha) yield was supported by Module-M11 *i.e.* deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with Tebuconazole @ 1.5 g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS followed by Module-M5 *i.e.* deep summer ploughing with mould board plough+seed of variety GG-20+seed treatment with Tebuconazole @ 1.5 g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM at the time of sowing, which supported pod and fodder yield of 1558 kg/ha and 3333 kg/ha, respectively. It was noted that Module-M11 and M5 were superior in supported both pod and fodder yield in-spite of having moderate amount of stem rot incidence (~15%).

Effect of modules against collar rot and yield: In case of collar rot experiment, the disease incidence was not up the level of satisfaction, therefore diseases data was not considered for report/presentation. However, yield data were recorded which are presented:

Pod yield and fodder yield: The maximum pod yield (1797 kg/ha) i.e. 53% over control was supported by Module-M16 *i.e.* deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with *Trichoderma* @ 10g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS (days after sowing) and third at 80 DAS at par with Module-M11 (1786 kg/ha) *i.e.* deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with Tebuconazole @ 1.5 g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS over control. The maximum fodder yield (4306 kg/ha) *i.e.* 72% over control was supported by Module-M11 *i.e.* deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with Tebuconazole @ 1.5 g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS followed by Module- M10 (4167 kg/ha) *i.e.* deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with *Trichoderma* @ 10g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS at par with M16 (Deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with *Trichoderma* @ 10g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS (days after sowing) and third at 80 DAS) and M17 *i.e.* deep summer ploughing with mould board plough+ seed of variety GG-20+ seed treatment with Tebuconazole @ 1.5 g/ kg of seed+soil application of *Trichoderma* @ 4 kg/ ha enriched in FYM first at the time of sowing, second at 35 DAS (days after sowing) and third at 80 DAS over control.

PROJECT 10. DEVELOPMENT OF MANAGEMENT PRACTICES FOR FOLIAR DISEASES IN GROUNDNUT

(Kuldeep S. Jadon, P.P. Thirumalaisamy, Ram Dutta and Prasanna Holajjer*)
(*Transferred to ICAR-DFR, Pune since Nov. 2014)

***Rabi*-summer**

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

For the management of *Sclerotium* stem rot, isolates of *Trichoderma sp.* (T-170 and Dharwad), *Pseudomonas fluorescens* (DGR) and there combinations [T1: *Trichoderma sp.* (DGR T-170); T2: *Trichoderma sp.* (Dharwad isolate); T3: T1+T2; T4: *P. fluorescens* (DGR); T5: T1+T2+ T4 (Seed treatment); T6: Control (untreated)] were applied. *Trichoderma sp.* (T-170 and Dharwad) used as seed treatment @ 10 g/kg seed and furrow application @ 4 kg/ha enriched with 250 kg FYM in all the treatments except T5 where only furrow treatment of *Trichoderma sp.* applied with seed treatment with *P. fluorescens* (DGR) @ 10 ml/kg seed. *P. fluorescens* (DGR) applied as seed treatment @ 10 ml/kg seed. Inoculum of *Sclerotium rolfsii* enriched with sorghum (≈2 g sorghum grains/plant). Incidence of stem rot was recorded in the range of 29.1% to 42.8%. All the treatments were at par, however, *Trichoderma* (T-170 and Dharwad) significantly reduced the per cent stem rot incidence over control (untreated).

Management of foliar diseases in groundnut using fungicides

Among six fungicides (T1: Tebuconazole@ 1ml/L; T2: Difenoconazole @ 1ml/L; T3: Cabrio @ 2g/L, T4: Nativo @ 1.32g/L; T5: Seed treatment of Carbendazim @ 2g/kg seed+Spray of Mancozeb 2.66g/L; T6: Ergone @ 0.22ml/ltL; T7: Control (Water Spray)) were applied to manage the Alternaria leaf spot/blight and to avoid losses due to soil borne diseases seed treatment with tebuconazole @ 1.5 g/kg seed were also applied in TI, T2, T3, T4 and T6. The lowest severity of Alternaria leaf spot/blight in groundnut variety JL42 and GG2 (3.0 and 2.7 respectively) was recorded using modified 1-9 scale in single spray of Cabrio^{Top} (pyraclostrobin 5%+metiram 55%) @ 0.12% at 40 DAS.

Survey on major diseases of groundnut

The survey of major diseases in groundnut was carried out in Gujarat (districts: Junagadh, Rajkot, Amreli, Jamnagar and Gir-Somnath), in summer 2014. Alternaria leaf blight was observed in all the surveyed area (2-10%). Groundnut bud necrosis disease was present in farmers' field at Junagadh, Jamnagar, Rajkot and Amreli (1-5%). The incidence of stem rot, collar rot, and aflaroot was also observed in patches 12-34% at 2-8%, 2-5%, 2%, respectively. A bacterial disease was also observed in Gir-Somnath district ranging from 2-5%. During survey it was also observed that farmers were taking keen interest to adopt new varieties like TG-37A, TPG-41 and TPG-45 rather than traditional variety GG-2.

Kharif

Effect of climate change on disease incidence (epidemiology of foliar diseases)

An experiment was started in February, 2013 to record the effect of climatic factors on incidence of foliar diseases. For this purpose first of each month, sowing of groundnut variety GG-2 was also started. Observations on the severity of foliar diseases were

recorded on 1-9 scale. The data indicated that severity of ELS, LLS and rust was less when sowing was done on the 1st of April and May of both the years *i.e.* 2013 and 2014 and severity of Alternaria blight and spot was less when sowing was done on the 1st of January of 2014 and 1st of February of both the years *i.e.* 2013 and 2014.

Evaluation of six fungicides against foliar diseases (ELS, LLS and rust)

Among six fungicides (T1: tebuconazole@ 1ml/t; T2: Difenoconazole @ 1ml/L; T3: Cabrio @ 2g/L, T4: nativo @ 1.32g/L; T5: Seed treatment of Carbendazim @ 2g/kg seed+Spray of Mancozeb 2.66g/L; T6: Ergone @ 0.22ml/L; T7: Seed treatment of Tebuconazole @ 1.5 g/kg seed and water spray; T8: Control (untreated seed and water Spray)) were applied to manage the foliar diseases and to avoid losses due to soil borne diseases, seed treatment with Tebuconazole @ 1.5 g/kg seed were also applied in TI, T2, T3, T4 and T6. The lowest severity of foliar diseases in groundnut variety JL42 and GG2 (ELS-4.0 and 3.7), (LLS-3.7 and 4.3), and (Rust-6.7 and 6.0), respectively was recorded using modified 1-9 scale in two spray of Difenoconazole @ 1ml/L at 40 and 60 DAS.

Evaluation of bio-control agents (*Trichoderma* sp. and *Pseudomonas fluorescens*), and botanicals (neem oil and NSKE) for management of foliar diseases (ELS, LLS and rust)

Ten bio-control agents including botanicals [T1, (T2 Seed treatment *Trichoderma harzianum* S1 10g/kg); T2, (T3 Seed treatment *Trichoderma koningiopsis* 10g/kg); T3, (T4 Seed treatment *Trichoderma bravicompactum* 10g/kg); T4, (T5 Seed treatment *Trichoderma longibrachiiatum* 10g/kg); T5, (T6 Seed treatment *Trichoderma Virens* 10g/kg); T6, (Seed treatment *Trichoderma T-170 Isolate* 10g/kg); T7, (Seed treatment *Trichoderma* dharwad isolate 10g/kg); T8, (PGPR Seed treatment 625g/ha); T9, (Neem oil Spray); T10, (NSKE Neem seed Kernel extract spray); T11, Control (without and seed and spray treatment)] were applied to manage the foliar diseases. All the treatments were superior to control, however, found at par with each other.

Screening of varieties (50-60) for resistance to foliar diseases (ELS, LLS and rust)

Sixty groundnut varieties were evaluated for resistance to foliar diseases under natural conditions. The severity of foliar diseases was recorded on 1-9 scale. The severity of ELS LLS and Rust were found in the range of 4.3-6.7, 3.7-5.7, 4.0-7.3, respectively. The varieties, Chitra, CSMG-884, RS-138, CSMG-9510, M-548, and ICGV000348 were showed resistance (<4) against the LLS, however, none of the variety recorded resistant to ELS and Rust.

Analysis of data on survey of major foliar diseases of groundnut in the major groundnut producing states, conducted through AICRP-G

In Pollachi tract rust incidence was up to grade 8 and late leaf spot incidence was higher (7-8 grade). Collar rot incidence was 1-5% only whereas stem rot incidence was higher (10-25%). At Dharwad, early leaf spot score ranged from 2-4, late leaf spot ranged from 4-9 while rust score ranged from 3-6. Stem rot incidence ranged between 4-10% in different places surveyed. At Bhubaneswar, root rot and stem rot appeared in the farmers' field to an extent of 18% and 15% respectively. The severity of the disease varied from 3 to 7 and rust was much low (3-5). At

Hanumangarh, collar rot incidence of12-14% at 20-40 DAS and root rot incidence 12-14% a week before harvest were recorded. Foliar fungal disease ELS a score of 3-4 and for late leaf spot the score 1-2 was reached at a week before harvest. PBND also appeared and maximum incidence of 5-6% observed at the time of harvest. In Jalgaon, collar rot and stem rot were in range of 1 to 4% and 1 to 8% respectively while, LLS and rust intensity were 4-7 and 1-6 respectively and PBND was noticed 0-3%. At Junagadh, LLS was observed in most of the fields in a score of 1-5, whereas a most of the fields were free from rust or with maximum severity of 1-2 score. Most of the fields were infected with stem rot and the incidence ranged from 0.0 to 15%.

At Kadiri, incidence of collar rot ranged from 3.0 to 10.0% at 30 DAS. At harvest stage, incidence of stem rot ranged from 7.0 to 12.0% and dry root rot ranged from 8.0 to 22.0% among different villages surveyed. Similarly, incidence of PSND recorded from 3.0 to 8.0% and PBND incidence ranged from 0.0 to 2.0%. Intensity of early leaf spot ELS and LLS were ranged from 1.0 to 3.0 scale and 5.0 to 8.0 scale respectively. At Latur, stem rot incidence was in traces. Late leaf spot severity was in the range of 30 to 40% and rust severity was in the range of 15 to 20% and PBND was noticed in traces. In Raichur, late leaf spot ranging from 4 to 7 and rust range of 3 to 5 in Yalburga taluka. The incidence of PBND was found maximum on TMV-2 (15-18%) compared to spreading type. The stem rot ranged from 3 to 10%. At Vriddhachalam, foliar fungal diseases *viz.*, Alternaria leaf spot incidence was moderate level (Grade 4-6) at 45-65 DAS and the incidence of late leaf spot was high up to grade 9 at the time of harvest in VRI-2 and TMV-13 groundnut varieties.

Regarding soil borne diseases, incidence of collar rot was recorded to the extent of 4-10% in the early stage of the crop at 25-30 DAS. Root rot incidence was recorded to the extent of 2-7% and stem rot incidence was noticed to the level of 1-5% at 45-65 DAS. Scattered incidence of peanut bud necrosis disease was recorded. At Tumkur, the collar rot was noticed to an extent of 4%. However, only 2% incidence of stem rot and PBNV were recorded, no other diseases were noticed when the crop was at the age of 30 days. Incidence of stem rot was noticed to a tune of 12% and PBNV was about 11% and the foliar diseases like early and late leaf spot was higher, early leaf spot was up to 6 grade, late leaf spot was up to a score of 7 and in case of rust, highest disease score recorded was 3 at the one week before harvesting.

PROJECT 11. MANAGEMENT OF AFLATOXIN CONTAMINATION IN GROUNDNUT

(P. P. Thirumalaisamy and Kuldeep Singh Jadon)

Effects of crop rotation, bioagents, botanicals, salts and fungicides on soil population of *Aspergillus flavus*, pod and kernel infection and aflatoxin contamination

Soil population of *A. flavus,* infection on pods and kernels, and subsequent aflatoxin contamination in kernels were estimated in various treatments namely i. Rotation system of *kharif* groundnut with onion, garlic, pearl millet, sesame, groundnut and fallow in summer, ii. Soil application of bioagents *viz., Trichoderma harzianum* - T 170 and *T. viride* Dharwad isolate, and *Pseudomonas florescence* as seed treatment and soil application iii. Soil application of sodium chloride, sodium bicarbonate and rock salt, and iv. Carbendazim application as seed treatment and soil application. In summer, the population of *A. flavus* was smaller in soil at harvest compared to that of before sowing and vice-versa in *kharif*. The decrease in soil population of *A. flavus* in summer could be attributed to rise in soil temperature and rotation with crops or fallow, soil amendments, bioagents, botanicals and fungicide. 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.

Table 1. Aflatoxin contamination in freshly stripped and gleaned pods

Sample	Population (x10-3 cfu/g soil)	Pod infection (%)		Kernel infection (%)		Aflatoxin (B1+B2+ G1+G2)(ppb)	
		Stripped pods	Gleaned pods	Stripped pods	Gleaned pods	Stripped pods	Gleaned pods
Summer 2014							
Jetpur, Rajkot-1	1.5	5.7	15.0	0.8	5.6	1.2	1.9
Jetpur, Rajkot-2	0.2	4.2	44.5	1.2	18.0	0.0	0.5
Vadiya	1.0	5.4	80.0	0.5	56.4	1.7	1.5
Rajkot -1	2.5	0.0	53.3	0.2	12.8	0.0	0.7
Rajkot -2	1.2	0.0	0.0	0.0	1.8	0.0	1.7
Navagam, Jamvada Savarkundala-1	1.0	0.0	42.0	1.0	8.9	0.0	2.1
Navagam, Jamvada Savarkundala-2	1.3	4.0	24.0	1.8	14.0	0.0	1.3
Nava Asrana -1	0.8	4.0	58.1	0.0	32.5	0.0	3.5
Nava Asrana -2	0.5	4.5	31.3	3.2	24.2	0.0	14.6
Mota Asrana -1	0.2	0.0	8.0	0.0	1.8	1.0	4.3
Mota Asrana -2	1.0	5.2	80.0	2.0	22.0	1.2	1.9
Nesavada	1.5	3.4	26.6	0.6	4.8	0.0	0.5
Mahuva	0.7	0.0	6.8	0.4	2.6	1.7	2.6

***Kharif* 2014**							
Borvav-1	2.8	32.8	40.0	3.0	33.3	0.6	480
Borvav-2	7.8	30.0	36.6	15.0	33.3	17	1.2
Kharediya	10.5	18.0	20.0	5.0	13.3	310	850
Vadal-1	13.0	23.5	46.7	0.0	3.3	7.7	29
Mendrada	2.2	16.7	26.7	3.3	3.1	1.9	5.9
Navagam	4.3	10.0	40.0	0.5	3.3	6.2	9.2
Doraji	3.4	42.5	43.3	3.0	30.0	3.1	95
Vadal-2	3.2	30.9	25.0	5.5	10.0	0.3	5.7
Bhesan	1.5	35.0	46.7	2.8	20.0	1.9	6.2
Mitadi	2.0	30.0	31.0	0.0	30.0	0.0	560

Aflatoxin contamination in stripped and gleaned pods

Freshly stripped and gleaned pods were collected from farmers field for analysis of aflatoxin contamination in groundnut kernels

In the summer groundnut, *A. flavus* infection in freshly stripped pods was in the range of 0.0 to 5.7% and kernel infection was 0.0 to 3.2%. In the left over pods collected from soil, *A. flavus* infection was in the range 0.0 to 80.0% and 1.8 to 56.4% in the kernel. Aflatoxin contamination was detected in all the gleaned pod samples and 38.5% of freshly harvested samples. Above 4 ppb was detected in 15.4% gleaned pod samples and none in freshly harvested samples. Aflatoxin contamination of was in the range of 0.0 to 1.7 ppb 0.5 to 14.6ppb in freshly harvested pods and in gleaned pods, respectively.

In the *kharif* groundnut, *A. flavus* infection in freshly stripped pods was in the range of 10.0 to 42.5% and kernel infection was 0.0 to 15.0%. In the left over pods collected from soil, *A. flavus* infection was in the range 20.0 to 46.7% and 3.1 to 33.3% in the kernel. Aflatoxin contamination was detected in all the gleaned pod samples and 90.0% of freshly harvested samples. Above 4ppb was detected in 90.0% gleaned pod samples and 40.0% in freshly harvested samples. Aflatoxin contamination of was in the range of 0.0 to 310ppb 1.2 to 850ppb in freshly harvested pods and in gleaned pods, respectively.

Table 2. Aflatoxin contamination in freshly stripped and gleaned pods

S. No.	Details	Stripped pods	Gleaned pods
Summer 2014			
1	Samples got aflatoxin contamination	38.5%	100%
2	Samples got above 4ppb aflatoxin contamination	0.0%	15.4%
3	Range of aflatoxin contamination	0.0 – 1.7 ppb	0.5 – 14.6 ppb
***Kharif* 2014**			
1	Samples got aflatoxin contamination	90%	100%
2	Samples got above 4ppb aflatoxin contamination	40%	90%
3	Maximum level of aflatoxin contamination	0.0 - 310 ppb	1.2 - 850 ppb

The rainfed groundnut grown during *kharif* acquires high *A. flavus* infection and subsequent contamination with aflatoxin than the groundnut grown in summer under irrigated condition.

Storage conditions and aflatoxin contamination

Pods stored upto 6 months at room temperature (28±2 °C) in high density polythene lined gunny bags has lesser *A. flavus* infection and aflatoxin contamination compared to pods stored in gunny bags (jute bags). No difference was observed in terms of *A. flavus* infection and aflatoxin contamination when pods stored either in gunny bags or in high density polythene lined gunny bags at 15±2 °C.

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

Evaluation of storage bins and botanical oils on infestation of bruchid (*Kharif*, 2014)

The experiment was not materialized during this period due to the failure in timely availability of bruchid adults as well as the groundnut produce. However the same has been taken up in Rabi, 2015.

Survey, collection and identification of bruchid populations collected from storage and processing industries in Saurashtra (*Kharif*, 2014)

Bruchids were collected from the farm stores and processing industries located in the four districts of Saurashtra (Junagadh, Porbandar, Gir-Somnath and Rajkot). All the collected specimens belong to the *Caryedon serratus* only.

Screening groundnut genotypes against bruchid (*Rabi*, 2014)

Among the eighteen genotypes were screened for resistance to groundnut bruchid none showed significant differences for number of eggs laid, number of adults emerged, damage and weigh losses in pods. However, the genotypes, TPG 41 and GPBD 4 recorded lowest number of eggs laid (17 and 19, respectively), adults emerged (14 and 13, respectively), damage (21% and 13%, respectively) and weight loss (25% and 13%, respectively).

Evaluation of aromatic hydrocarbons for managing bruchid (*Rabi*, 2014)

Both the Naphthalene and Camphor @ 1.0 g/50.0 g kernels were found to be effective against four developmental stages (egg, grub, pupae and adult) of bruchid. Nearly cent per cent mortality was caused by both Naphthalene and Camphor in egg, grub, pupal and adult stages under airtight conditions whereas under partially aerated condition they caused mortality ranging from 89 to 99%. The germination (%) was found to be more than 95% in both the treatments at both conditions.

PROJECT 13. MANAGEMENT OF INSECT-PESTS OF GROUNDNUT

(Poonam Jasrotia, Nataraja, M.V. and Prasanna Holajjer*)
*Relieved from DGR w.e.f 15.11.2014 to join at ICAR-DFR, Pune

Influence of inter-crops on population dynamics of groundnut insect-pests *Kharif*, 2014)

Six intercrops *viz.*, pigeon pea, cotton, bajra, maize, sesame, and castor were tried as intercrop with groundnut to determine their impact on population dynamics of groundnut insect-pests. Pigeon pea, cotton, sesame and castor were planted in ratio of 3:1 while maize and bajra were planted at 2:1 ratio with groundnut. The population recorded with sticky traps revealed that the population of thrips and aphids were comparatively lower in crop combination of groundnut with Bajra. However, the leafhopper population in all the treatments was comparatively similar. During the *Kharif*-2014, a total rainfall of 978.5 mm was recorded during three months period from July to September (27th to 40th standard weeks) which may be the reason for lower pest population counts.

Evaluation of bio-pesticides against insect pests of groundnut (*Kharif*, 2014)

The efficacy of three bio-pesticides *viz.*, Azadirachtin, Ponneem and *Beauveria bassiana* were tested at three different doses against sucking pests (leafhopper and thrips) of groundnut. After the first spray the treatment, Monocrotophos 36 SL @ 1.2ml/L was proved to be most effective followed by Ponneem @ 6ml/L and Azadirachtin 1.5% @ 2.5 ml/L. These recorded leafhopper populations of 3.3, 7.8, 10.0 hoppers/ 5 sweeps, respectively. After second spray, Azadirachtin 1.5% @ 2.5 ml/L and Monocrotophos 36 SL @ 1.2ml/L were equally effective in reducing hopper population and recorded population of 13.7 and 13.8 hoppers/ 5 sweeps, respectively whereas efficacy of Ponneem @ 6ml/L reduced (16.0 hoppers/5 sweeps). In case of thrips, after first spray the lowest population was recorded in Monocrotophos 36 SL @ 1.2ml/L (4.1 thrips/5 sweeps) followed by Ponneem @ 6ml/L (5.5 thrips/5 sweeps) and Azadirachtin 1.5% @ 7.5 ml/L (6.4 thrips/5 sweeps).After second spray, Azadirachtin 1.5% @ 7.5 ml/L (4.3 thrips/5 sweeps) recorded lowest thrips population followed by Ponneem @ 6ml/L (5.1 thrips/5 sweeps) Monocrotophos 36 SL @ 1.2ml/L (5.5 thrips/5 sweeps). There were no significant differences between the yields obtained from each treatment however the highest (2569 kg ha-1) yield was recorded in treatment Chlorpyriphos @ 2.5ml/L.

Influence of nitrogen and potassium fertilization on the incidence of sucking pests of groundnut (*Rabi*-summer, 2015)

This experiment has been out during *Rabi*-summer, 2015 in split-plot design to evaluate the impact of three levels of N (25.0, 37.5 and 50.0 kg/ha) and K (0.0, 30.0 and 60.0 kg/ha) fertilizations on population dynamics of insect-pests of groundnut. The treatments were imposed at the beginning of the experiment and weekly observations on insect-pests are being recorded by using the yellow and blue sticky traps. The post-harvest observations will also be recorded after the harvest.

Effect of trap colour and height on sucking pest incidence in popular groundnut varieties of Saurashtra region (*Rabi*-summer, 2015)

A new study was initiated during *Rabi*-summer-2015 season to evaluate two colored sticky traps i.e yellow and blue. The traps were placed at

three heights 15, 45, 75 cm from the ground on poles made by PVC pipes. Four populate varieties of Saurashtra region were chosen; TAG 37, GG2, TG24 and GJG 31.The observations are being recorded on number of insects caught on these traps at fortnightly interval. The post-harvest observations on yield, shelling out (%) and insect damage on pods will be taken after the harvest.

Effect of seed rate on insect pest population of groundnut (*Rabi*-summer, 2015)

An experiment has been laid out using groundnut variety TAG 37A to study the effect of seed-rate on population of insect-pests of groundnut. The four treatments were planned *i.e.* T1: recommended seed rate: 120 kg/ha, T2: Half of the recommended seed rate: 60 kg/ha, T3: Double the recommended seed rate: 240kg/ha and T4. Farmers' practice: 180 kg /ha. The observations are being recorded on number of insects caught in each treatment using sticky traps at fortnightly interval. The post-harvest observations will be taken after the harvest.

Identification of entomopathogenic nematode

EPN specific primers from 18S ribosomal RNA gene, partial sequence internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence were used to amplify the ITS region of the nematode isolated. The sequences generated were compared with EPN sequences available in public database through BLAST. BLAST results showed 99% similarity with the ITS region of *Steinernema* sp. from all over India and Pakistan with 100% query coverage.

In-vitro screening of entomopathogenic nematodes for their virulence against *Spodoptera litura*

Two entomopathogenic nematodes (*Steinernema* sp and *Heterorhabditis* sp) isolated from groundnut production were evaluated for their pathogenicity was assessed against larvae of *S. litura*. The 3rd and 4th instar larvae of *S. litura* were exposed to infective juveniles (IJs) of EPNs@ 2, 5, 10, 20 and 40 IJs cm^{-2} under laboratory condition. After 48, 72 and 96 h of inoculation, LC_{50} (no. of IJs per cm^{-2} for 50% larval mortality) of *Steinernema* sp strain for 3rd instar larvae was 55, 8 and 6 cm^{-2}; and for 4th instar was 214, 10, 4 cm^{-2}; respectively. However, the LC_{50} of *Heterorhabditis* sp. for 3rd instar larvae was 61, 7 and 2 cm^{-2}; and for 4th instar larvae was 65, 9, 6 respectively, after 48, 72 and 96 h of inoculation.

PROJECT 14. DEVELOPMENT OF MANAGEMENT OPTIONS FOR NEMATODES IN GROUNDNUT

(Prasanna Holajjer, Rinku Dey and Poonam Jasrotia)

Survey for plant parasitic nematodes in groundnut production system in Junagadh and surrounding areas.

Diagnostic survey was taken to know the infestation of root-knot nematodes in groundnut growing areas of Rajkot and Junagadh. There is no infestation of root-knot nematode detected in groundnut areas of Rajkot. Information on crop history revealed that in Rajkot area, formers are taking cotton as a rotational crop for one or two year after taking groundnut which may act as non-host for root-knot nematode, *Meloidogyne areneria*. Survey in Junagadh area revealed the presence of root-knot nematodes in a single field, however infestation is not serious.

Evaluation of effect of two PGPRs on nematode reproduction, and also galling and plant growth.

Effect of two strains (Pf1 and Pf3) of fluorescent pseudomonads on nematode reproduction and galling in groundnut was studied. The cups (200 cm^3) 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 60 days after nematode inoculation and root systems were evaluated for number of egg masses and number of galls. Soil drenching with Pf1 and Pf3 strains of fluorescent pseudomonads resulted in significant reduction in number of gall/plant in groundnut roots by 51.8 % and 46.1 % respectively. Number of egg masses was also significantly reduced in Pf1 (61.7 % reduction) and Pf3 (68.7 % reduction) strains of fluorescent pseudomonads treated plants compared to control. However, the numbers of eggs per egg mass did not differ significantly.

Studies on induction of systemic resistance against root-knot nematodes

Two strains (Pf1 and Pf3) of fluorescent pseudomonads were evaluated for their ability to induce systemic resistance in groundnut against root-knot nematode, *M. areneria*. The several plant defence related enzymes were monitored in the leaves of groundnut treated with fluorescent pseudomonads strains and control. The levels of peroxidase (POD), catalase (CAT), polyphenol oxidase (PPO) and phenol activities in the treatment with Pf1 strain of fluorescent pseudomonads as a seed treatment followed by soil application is significantly higher at 24, 48 and 72 h after post-inoculation of nematodes as compared with the untreated control and seed treatment or soil application alone.

PROJECT 15. INFLUENCE OF FUNGAL PATHOGENS ON METABOLOMES OF GROUNDNUT

(M.K. Mahatma, K.S. Jadon and Anita Mann)

Analysis of various metabolites from the stem of *Sclerotium rolfsii* infected and healthy groundnut genotypes

Groundnut genotypes showing high (GG20, TG37A and GG16) and low disease incidence (CS19 and CS319) were grown in greenhouse condition in two sets. Stem samples from both sets (30 DAS and 60 DAS) were taken as control (non-infected) and infected at three time interval (24, 48 and 96 hours after infection). Various metabolites form the stems of groundnut genotypes were extracted in ethyl acetate and methanol (1:1) and derivatized with N-Methyl-N-(trimethylsilyl) trifluoroacetamide (MSTFA). Derivatized samples were analysed by GC-MS for identification of metabolites. In a single run analysis various carbohydrates, organic acids, fatty acids, sterols and phenolics were detected in groundnut genotypes. After infection per cent area was increased for some metabolites. Interestingly, higher per cent area of pyrocatachol, 2-furancarboxaldehyde 5-(hydroxymethyl) and ascorbic acid 2,6-dihexadecanoate were observed in non-infected genotypes showing low disease incidence(CS19 and CS319). Linoleic acid a substrate of lipoxygenase enzyme was not detected in GG16,GG20 and TG37Awhile increased in CS19 at 48 and 96 h.a.i. Thus results revealed that constitutive level of higher content of pyrocatachol, a substrate of polyphenol oxidase and ascorbic acid an antioxidant may provide resistance to stem rot infection. Moreover, linoleic acid a signal molecule in defense reaction and substrate of lipoxygenase enzyme also plays important role in disease resistance.

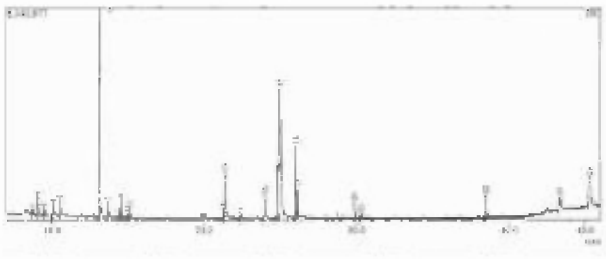


Fig1: Metabolites of TG37A at 30 DAS (non-infected).Line no. 4: Pyrocatechol,6: 2-Furancarboxaldehyde 5-(hydroxymethyl), 18: l-(+)-Ascorbic acid 2,6-dihexadecanoate

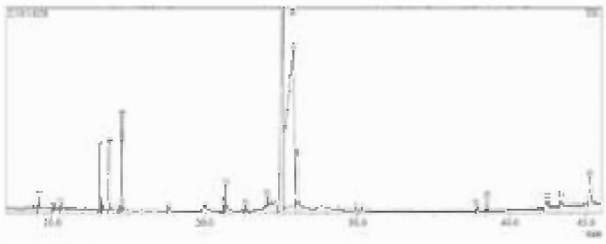


Fig 2: Metabolites of TG37A at 30 DAS (non-infected).Line no. 2: Pyrocatechol,4: 2-Furancarboxaldehyde 5-(hydroxymethyl), 16: l-(+)-Ascorbic acid 2,6-dihexadecanoate

Changes in Phenol profiles of groundnut genotypes during stem rot disease

Phenols were extracted from *Sclerotium rolfsii* infected and non-infected stems in 80% methanol. Experimental and sampling conditions were same as for metabolites (described above). Total nine phenolic acid standards (gallic acid, catachol, chlorogenic acid, caffeic acid, syringic acid, cinnamic acid,

coumaric acid, ferulic acid and salicylic acid) were used for identification of phenols from groundnut genotypes.

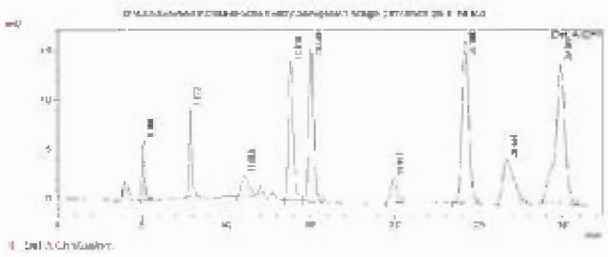


Fig 3: Chromatogram of standard phenolic on HPLC. Retention time of gallic acid (5.06) gallic acid (7.83), 2: catechol (11.08), 3: chlorogenic acid (13.82), 4: caffeic acid (15.04), 5: syringic acid (19.91), 6: cinnamic acid (24.17) , 7: coumaric acid, 8: ferulic acid, and 9: salicylic acid

At 30 DAS, chlorogenic acid content was higher in CS19, CS319 and GG16 during control and 24 h.a.i. While caffeic acid, cinnamic acid and coumaric acid was higher at 30 and 60 DAS. Constitutive level of higher cinnamic acid observed in CS19 and CS319 genotypes 30 and 60 DAS and it was also increased after infection. However, constitutive higher level of coumaric acid and ferulic acid was observed only at 60 DAS. Salicylic acid, which induces systemic acquired resistance, observed higher in non-infected stems of CS19, CS319 and GG16 at 30 DAS and during 24 and 48 h.a.i. at 60 DAS. These results confirm the role of phenolics in disease resistance. Cinnamic acid, coumaric acid and caffeic acid are important products of phenylpropanoid pathway and derivatives of lignin biosynthesis.

Changes in various sugars and enzymes during Groundnut- *Cercosporidium personatum* interaction

Late leaf spot disease resistant (AK-265, ICGV-86590, FDRS-10, GPBD-4 and Cs-186) and susceptible (JL-24, JL-42, GG 20, GG-7 and TG37A) were sown in the pots and leaf samples were taken from control and infected plants at 90 DAS. Sugars were separated by Ion chromatography. Glucose and sucrose content was increased in resistant genotypes whereas decreased in susceptible genotypes after infection. Inositol content was increased in all genotypes after infection. Phenolic acids were separated and analysed using LC-MS/MS and identified with nine phenolics as described in above. Higher constitutive and induced level of salicylic acid was observed in resistant genotypes. Resistant genotypes had about 2-3 times higher constitutive level of salicylic acid. Moreover, resistant genotypes also had higher content of coumaric acid than that of susceptible genotypes at non-infected stage. Thus results revealed that higher content of salicylic acid and coumaric acid in resistant genotypes at pre-infection stage confers disease resistant.

SERVICES

Oil, protein and moisture content of 1500 groundnut samples from different section of DGR and 300 samples from different AICRP-G centers were measured 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 and M.D. Meena)

Response of summer groundnut to plant population and fertilizer doses under drip and check basin methods of irrigation

A field experiment was conducted during summer, 2014 to know the effect of irrigation methods, plant stand, and fertilizer doses in summer groundnut. The treatments consisting of two irrigation methods *viz.* check basin irrigation and drip irrigation, three plant population densities *viz.* 100 plant population, 125% plant population and 150% plant population and three fertilize doses viz. 75% RDF (recommended dose of fertilizer), 100% RDF and 125% RDF were tested in split-split plot design with three replications.

Even though drip irrigation increased pod and haulm yields by 15.4 and 2.8% over check basin method of irrigation but differences were not significant at 5% probability. Protein and oil contents were not significantly affected by irrigation methods. Drip irrigation significantly improved net returns and B:C ratio over check basin method of irrigation ($P<0.05$). Increasing plant population density and fertilizer doses improved pod and haulm yields, and net returns but differences were not significant at 5% probability. Protein and oil contents, and B:C ratio were also not significantly affected by plant stand and fertilizer doses.

Effect of mulching, sowing time and seed priming on productivity of summer groundnut

A field experiment was initiated during summer 2014 to study the effect of mulching, sowing time and seed priming on productivity of summer groundnut. The experiment, consisting of two mulching treatments (No mulch and biodegradable mulch) allotted to main plots, three sowing time (Second fortnight of January, first and second fortnight of February) allotted to sub-plots and three seed priming media (control, hydro-priming and 2% KCl priming) allotted to sub-sub plots, was laid out in split-split plot design with three replications.

Use of biodegradable mulch film significantly enhanced the pod and haulm yields of groundnut by 19.8 and 6.9% over non-mulched groundnut, respectively and initiated germination earlier compared to non-mulched groundnut. It also registered 6.3 kg/day higher pod yield than the non-mulched groundnut (25.3 kg pods/day). On the other hand, time of sowing and seed priming did not bring out any significant variation in pod and haulm yields. There was no significant effects of mulching, sowing time and seed priming on activities of soil enzymes (DHA, acid and alkaline phosphatases) measured at 30, 60 and 90 DAS and at harvest except significantly higher activities of acid and alkaline phosphatases were recorded in control and 2% KCl seed priming media at harvest and 30 DAS, respectively over other treatments.

Effect of water soluble fertilizers on productivity of summer groundnut

A field experiment was initiated during summer 2014 to study the effect of water soluble fertilizers (specialty fertilizers) on productivity of summer groundnut grown under raised bed with biodegradable mulch. The experiment, consisting of 10 treatments namely, control (100% NF with surface irrigation), 100% RDF soil application at

sowing (NF with drip irrigation), 100% WSF fertigation (At sowing), 100% WSF fertigation [sowing(1/2), 20 DAS (1/4) and 40 DAS (1/4)], 100% WSF fertigation [sowing(1/4), 20 DAS (1/4), 40 DAS (1/4) and 60 DAS (1/4)], 75% WSF fertigation (At sowing), 75% WSF fertigation [sowing(1/2), 20 DAS (1/4) and 40 DAS (1/4)], 75% WSF fertigation [sowing(1/4), 20 DAS (1/4), 40 DAS (1/4) and 60 DAS (1/4)], 50% soil [sowing (1/2 furrow)] + 50% fertigation [20 DAS (1/4) and 40 DAS (1/4)] and NF fertigation (At sowing), was laid out in randomized block design with three replications.

There were no significant differences in pod and haulm yields of groundnut obtained under drip irrigation with soil application of fertilizers and surface irrigation with soil application of fertilizers, and between drip irrigation and 100% WSF fertigation. Also levels of drip fertigation with water soluble fertilizers did not significantly improved the pod yield but caused significant reduction in haulm yield at 75% rate WSF fertigation over 100% rate WSF fertigation irrespective of time of application. Further, fertigation with normal fertilizers could not bring significant change in pod and haulm yields compared to fertigation with water soluble fertilizers (100% rate). Methods of fertilizer application also could not bring significant difference in pod yield but haulm yield was significantly lower in 50% soil [sowing (1/2 furrow)]+50% fertigation treatment compared to 100% WSF fertigation, normal fertilizer fertigation and normal fertilizer with surface irrigation treatments. Thus, 25% fertilizers could be saved through drip fertigation with water soluble fertilizers. There was no significant effect of water soluble fertilizers on activities of soil enzymes (DHA, acid and alkaline phosphatases) measured at 30, 60 and 90 DAS and at harvest.

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

A field experiment was initiated during *kharif* 2014 to study the effect of land configuration and mulching on resource use efficiency and productivity of *kharif* groundnut. The experiment, consisting of three land configurations/planting methods (Conventional, ridge and furrow and, raised bed and furrow systems) allotted to main plots and three mulching treatments [Control, organic mulch (ex-situ) and biodegradable mulch] allotted to sub-plots, was laid out in split plot design with four replications. Land configuration did not have any significant influence on pod and haulm yields of groundnut. However, higher yield levels were recorded in raised bed and furrow method of planting. Among the mulching treatments, significantly higher pod yield was recorded with the use of biodegradable mulch film which was 12.9 and 6.5% higher over control and organic mulch, respectively. However, no significant difference was observed in haulm yield due to mulching.

Integrated nutrient management studies in groundnut-wheat cropping system

A field experiment was initiated during *kharif* 2014 to study the effect of integrated nutrient management practices on system productivity of groundnut-wheat cropping system. The experiment was laid out in randomized block design with 12 treatments, replicated three times. The treatments comprised T_1, Absolute control (No fertilizers and organic manures); T_2, 50% recommended dose of fertilizers (RDF)-100% RDF; T_3, 75% RDF-75% RDF; T_4, 100% RDF-100% RDF; T_5, 75% RDF+5 t FYM/ha-75% RDF; T_6, 75% RDF+2.5 t FYM/ha-

100% RDF; T_7, 75% RDF+2.5 t GM/ha(dhaincha)-75% RDF; T_8, 50% RDF+5 t GM/ha(dhaincha)--100% RDF; T_9, 100% RDF+biofertilizers(BF)-100% RDF+BF; T_{10}, 100% RDF+5 t FYM/ha+BF-75% RDF; T_{11}, 75% RDF+5 t FYM/ha+BF-100% RDF and T_{12}, farmers' practice for groundnut and wheat, respectively.

Significantly higher pod yield was obtained with the application of 100% RDF in groundnut over rest of the treatments. However, haulm yield did not differ significantly due to various INM practices. On the other hand, maximum grain yield of wheat was recorded in the treatment receiving 100% RDF (wheat) preceded by 75% RDF+5 t FYM/ha+BF (groundnut), which was significantly superior over control, 50% RDF, 100% RDF+BF and farmers' practice only. Whereas, maximum straw yield of wheat was registered in the treatment receiving 75% RDF (wheat) preceded by 100% RDF+5 t FYM/ha+BF (groundnut), and was significantly higher over control, 50 and 75% RDF, and farmers' practice only. Significantly highest system productivity (groundnut equivalent yield) of groundnut-wheat cropping system was recorded under treatment receiving 100% RDF in groundnut and 100% RDF in wheat over rest of the treatments.

Standardization of periodicity of sulphur fertilization in groundnut–based cropping systems

A field experiment was initiated during *kharif* 2014 to standardize the time and dose of application of sulphur for obtaining higher system productivity of groundnut-based cropping systems. The experiment, consisting of two cropping systems (Groundnut-wheat and groundnut-chickpea) allotted to main plots, three periodicity of sulphur fertilization (Every year, once in two years and once in three years) allotted to sub-plots and three doses of sulphur application (100% in both crops, 100% in groundnut, 100% in wheat and 50% in both crops) allotted to sub-sub plots, was laid out in split-split plot design with three replications.

There was no significant difference in pod and haulm yields of groundnut and grain/seed and straw yields of wheat and chickpea due to cropping systems, periodicity of fertilization and dose of sulphur application as complete set of treatments had not been imposed in both the cropping systems. Further, higher system productivity (groundnut equivalent yield) was obtained in groundnut-chickpea cropping system.

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 2014-15 to know the effects of three tillage practices viz. conventional tillage, minimum tillage and zero tillage, and three residue management practices viz. no residue application, wheat stubble retention, and wheat stubble retention+*Cassia tora* mulch in groundnut-wheat cropping system. The experiment was laid out in split plot design with three replications. Minimum tillage improved groundnut pod yield by 21.70% as compared to CT however, differences were not significant at 5% probability. Minimum tillage could improve haulm yield marginally as compared to CT. Wheat stubble retention increased pod yield significantly as compared to no residue application ($P<0.05$). Both tillage and residue management practices could not significantly affect oil and protein content in groundnut.

Minimum tillage improved net returns by 37.18% as compared to conventional tillage but differences were not significant at 5% probability. Similarly, minimum tillage improved B:C ratio as compared to minimum tillage. Wheat stubble retention increased net returns and B:C ratio as compared to no residue application ($P<0.05$). Both minimum tillage and zero tillage improved wheat grain yield, net returns, and B:C ratio as compared to conventional tillage but differences were not significant at 5% probability. Wheat stubble retention increased grain yield, net returns, and B:C ratio as compared to no residue application however, differences were not significant at 5% probability.

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 2014-15. The experiment, consisted of 14 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 in wheat), groundnut-wheat (zero tillage in wheat)-*Sesbania* green manuring, groundnut-wheat (zero tillage in wheat)-greengram green manuring, groundnut-wheat (zero tillage in wheat and 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.

Maximum pod yield of groundnut was obtained from groundnut-wheat-*Sesbania green manuring* cropping system which was significantly superior over groundnut-wheat-greengram green manuring, groundnut-wheat (zero tillage in wheat), groundnut-wheat(zero tillage in wheat)-greengram

green manuring, groundnut+pigeonpea, groundnut+pigeonpea-*Sesbania* green manuring and groundnut+pigeonpea-greengram green manuring. However, haulm yield was maximum in groundnut-*Sesbania green manuring* cropping system which was significantly higher over rest of the cropping systems except groundnut-wheat. Seed and stalk yields of pigeonpea did not differ significantly under various groundnut-based intercropping systems. Further, grain and straw yields of wheat also did not influence significantly due to various tillage practices carried out in wheat, residue incorporation and green manuring treatments. However, significantly higher groundnut-pod equivalent yield was recorded from groundnut-wheat-*Sesbania* green manuring cropping system over groundnut monoculture, groundnut-*Sesbania* green manuring, groundnut-greengram green manuring, groundnut-wheat-*Sesbania* green manuring, groundnut-wheat-greengram green manuring, groundnut-wheat (zero tillage in wheat)-*Sesbania* green manuring, groundnut-wheat (zero tillage in wheat)-greengram green manuring, groundnut+pigeonpea, groundnut+pigeonpea-*Sesbania* green manuring and groundnut+pigeonpea-greengram green manuring systems.

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 2013, 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 build-up in soil at harvest of cluster bean with use of different irrigation water salinity levels was 2.40, 2.86, 4.00 and 6.39 dS m^{-1}, respectively. A decreasing trend was observed in fresh pod and dry fodder yield of cluster bean with increasing level of soil (2.40 to 6.39 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 2.86 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.

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

The experiment was conducted during summer 2014 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 34.5% as compare to 2 dS/m saline irrigation water. The haulm yield of groundnut was also showed non-significant results up to 2dS/m as compared to those of fresh irrigation water (i.e., control). Further, significantly higher pod and haulm yield with 24.6% and 30.7% 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 5.40% and 11.6% respectively indicating ameliorative effect of potassium on salinity stress.

The effect of soil enzymes by combined application of potassium and polythene mulching under saline irrigation was studied during the active crop growth stages (50 DAS and 100 DAS) in groundnut. Dehydrogenase activity was found more at 100 DAS of crop growth than 50 DAS, irrespective of treatments. Effect of potassium was not found under polythene mulched soil under varied irrigation levels; however without mulching potassium application seemed to have beneficial effect (34.3 µg TPF g^{-1} h^{-1}). Without polythene mulch the dehydrogenase activity declined more than that with mulching under saline irrigations at both 50 DAS and 100 DAS. Alkaline phosphatase (Alk-PA) and acid phosphatase (Ac-PA) activities showed contrasting changes over two crop growth stages. Alk-PA was observed more at 100 DAS than at 50 DAS; non-saline irrigation with polythene mulch treatment showed significantly higher activity (32.8 µg PNP g^{-1} h^{-1}) under zero potassium. But without polythene mulching when received 60 kg ha^{-1} K, maintained higher Alk-PA under non-saline irrigation. Saline irrigation invariably reduced Alk-PA across mulching and potassium application. On the other hand, Ac-PA recorded more activity at 50 DAS which gradually reduced at 100 DAS across the treatments. Moderately saline irrigation (2.0 dS m^{1})

under polythene mulching obtained higher Ac-PA (28.4 µg PNP g^{-1} h^{-1}) even under no potassium application; however without mulching, 30 kg ha^{-1} K at higher salinity (4.0 dS m^{1}) retained the significantly higher Ac-PA value over rest of the treatments. Urease activity also followed the same trend of maintaining higher values at 100 DAS than 50 DAS irrespective of the treatments. Combination of polythene mulching and 30 kg ha^{-1} K helped to reclaim the salinity stress to the maximum extent (95.0 µg urea-N g^{-1} h^{-1}); however without mulching the same effect could not be found. The behaviour of soil enzymes can be summarized as: use of polythene mulch is beneficial to overcome the salinity stress imposed through varied levels of saline irrigation; which is further assured by the application of potassium. Again without polythene mulch, application of potassium showed a positive effect to resume the activities soil enzymes under saline irrigations. Moreover, the enhanced enzyme activities could be found with progression of crop growth stage (100 DAS).

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

Kharif groundnut was taken in 2014 to test the performance of two released varieties namely TG 37A and GG 2 using normal/fresh 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 salinity induced seeds) were sown in this experiment. It was observed that the pod 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 6 dS/m in comparison to water salinity of 0.5 dS m^{-1} control. The haulm yield of groundnut was significantly lower in all the treatments as compared to those of fresh irrigation water (i.e., control). Further, the non-significant difference in pod and significant difference in haulm yield were recorded within the varieties with higher pod yield in TG 37A (976 kg ha^{-1}) over GG 2 (968 kg ha^{-1}) while haulm yield in GG 2 (2414 kg ha^{-1}) over TG 37A (1550 kg ha^{-1}). The reduction in haulm yield of TG 37A was 55.74%, as compare to GG 2. However, significant difference was also observed between fresh seeds and salinity induced groundnut seeds with higher pod and haulm yield in fresh seed (1090 and 2205 kg ha^{-1}) over salinity induced groundnut seeds (854 and 1759 kg ha^{-1}) respectively. The reduction in pod and haulm yield of salinity induced groundnut seeds as compare to fresh seeds were 27.63 and 25.35%, respectively. Almost a similar trend was observed for other yield contributing characters also.

PROJECT 19. STUDIES ON DYNAMICS OF SOIL PHOSPHORUS UNDER VARIOUS MANAGEMENT PRACTICES IN GROUNDNUT CULTIVATION

(R.S. Yadav, H.N. Meena, D. Badhuri and Ajay B.C.)

Optimum phosphorus requirement for groundnut in calcareous soil

Summer 2014: 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* 2014. Fresh and dry shoot weight at 80 DAS and hundred pod weight, grain and haulm yield of groundnut were significantly (p=0.05) differed among different phosphorus levels. However, other plant growth and yield parameters were found non-significant. The highest grain as well as haulm yield of groundnut was observed with application of 70 kg phosphorus per hectare which was at par to other levels of P application. The phosphorus content in the plants was decreased with plant growth which was significantly altered among different P levels at 40 and 60 DAS (i.e., vegetative to flowering stage) only suggested the highest P requirement of the crop at these stages. The soil phosphatases enzyme activities were also varied with plant growth and the maximum activities were observed at 30 and 60 DAS for alkaline and acid phosphatase, respectively. However, the effect of different phosphorus levels on soil phosphatases activities were found inconsistent.

***Kharif* 2014:** 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* 2014. There was no application of phosphorus in control plot. The growth and yield of groundnut was significantly (p=0.05) differed among phosphorus levels. Among P-fertilizers sources, supply of phosphorus through di-ammonium phosphate (DAP) was found to be better than single superphosphate (SSP) in terms of groundnut yield. The highest yield of groundnut pods was observed with application of 60 kg phosphorus per hectare as DAP. The phosphorus fertilizer use efficiency was also higher for use of DAP as compared to SSP for both in terms of pod and haulm yield of groundnut.

Control (No- P_2O_5)

60 Kg P_2O_5 ha^{-1}

Study on soil phosphorus fractions under different management practices in groundnut

Soils having three different management practices namely i) polythene drip (PD); cultivation of groundnut on raised beds using polythene mulch and drip irrigation, ii) resource conservation (RC); groundnut followed by wheat in zero tillage with green manuring and iii) conventional system (CS); cultivation on flat bed with conventional nutrient and water management practices were used and characterized for different P-fractions. The availability of soil phosphorus was highest under polythene drip followed by resource conservation and least under conventional systems depending on inputs used. The highest soil inorganic-P was recovered from PD in water soluble and mineralizable pools, CS in labile pool and RC in stable pool. Similarly the soil organic-P were recovered in the order of CS>RC>PD for soluble and labile pools and PD>RC>CS for mineralizable and stable pools. Use of PD and RC practices enhanced the inorganic-P pools except labile pool under RC whereas organic-P pools were deceased except mineralizable pool (Fig. 1). Overall the polythene drip and resource conservation management practices were found promising for creating congenial conditions to solubilize and mobilize the soil phosphorus in to different conceptual pools in the soil.

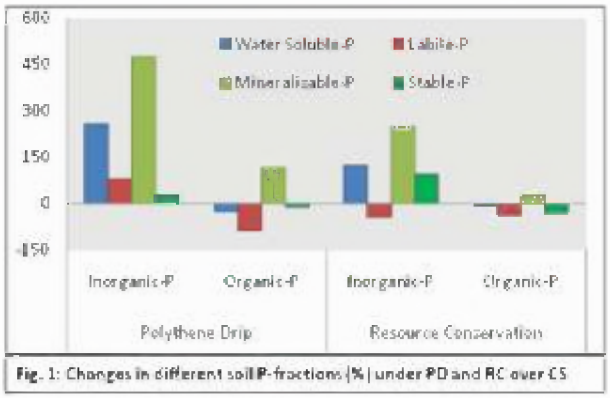


Fig. 1: Changes in different soil P-fractions (%) under PD and RC over CS

Mobilization of soil phosphorus as influenced by nutrient management in groundnut-wheat cropping systems

Groundnut crop (cv. TG 37 A) was grown in calcareous *vertisols* having four different phosphorus (P) gradients viz., native soil phosphorus, 50% RDP, 100% RDP and 150% RDP as main plots. Four different phosphorus solubilizers namely citric acid @ 2.5kgha-1, FYM @ 1% w/w, Haem-compost @ 1% w/w and PGPR consortia with one control (i.e., no P-solubilizer) were applied in sub-plots during *Kharif* 2014. The groundnut yield was inconsistently differed among different soil phosphorus gradients as well as among different phosphorus solubilizers. Comparatively application of citric acid and FYM was found better than other phosphorus solubilizers.

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

(Debarati Bhaduri, R.S. Yadav and Narayanan G.*)
*Associated since January, 2015

The area, productivity and production of different groundnut growing districts of all the minor groundnut growing states (Orissa, West Bengal, Chattishgarh, Uttar Pradesh, Haryana, Himachal Pradesh, Punjab, Uttarakhand, Nagaland) was analyzed over three years. 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. Few districts such as Malkangiri, Sonepur, Khurda (Orissa), Narsimpur (Madhya Pradesh), West Midnapore, Purulia (West Bengal) were identified as highly productive among the minor groundnut growing states. Highly productive districts (>2.0 t $ha^{-1}$and >2.5 t ha^{-1}) of all states were categorized for *rabi*-summer and *kharif* seasons based on the mean productivity values of three consecutive years. Districts like Kancheepuram, Thiruvallur, Thiruvarur, Dindigul in Tamil Nadu and Chittoor, Prakasam, Nellore, Cuddapah, Guntur, Krishna in Andhra Pradesh accounted with average groundnut productivity of more than 2.5 t ha^{-1}.

Changing scenario of district-wise contribution of production and area covered (in terms of percentage) for groundnut crop for all major and minor states was also accounted. Groundnut productivity was also classified on the basis of fifteen agro-ecological zonesof the country. Among all zones, 'East coast plains and hills region' (covering parts of Andhra Pradesh, Tamil Nadu and Orissa) was identified as the most productive zone over the years. Proforma on soil-related information was prepared and circulated among the AICRP-Groundnut centers. Collection of information on various soil fertility parameters is in progress and separate database is being maintained.

Geographical database (latitude, longitude, elevation) was maintained for all districts of major and minor groundnut growing states to generate GIS-based maps.

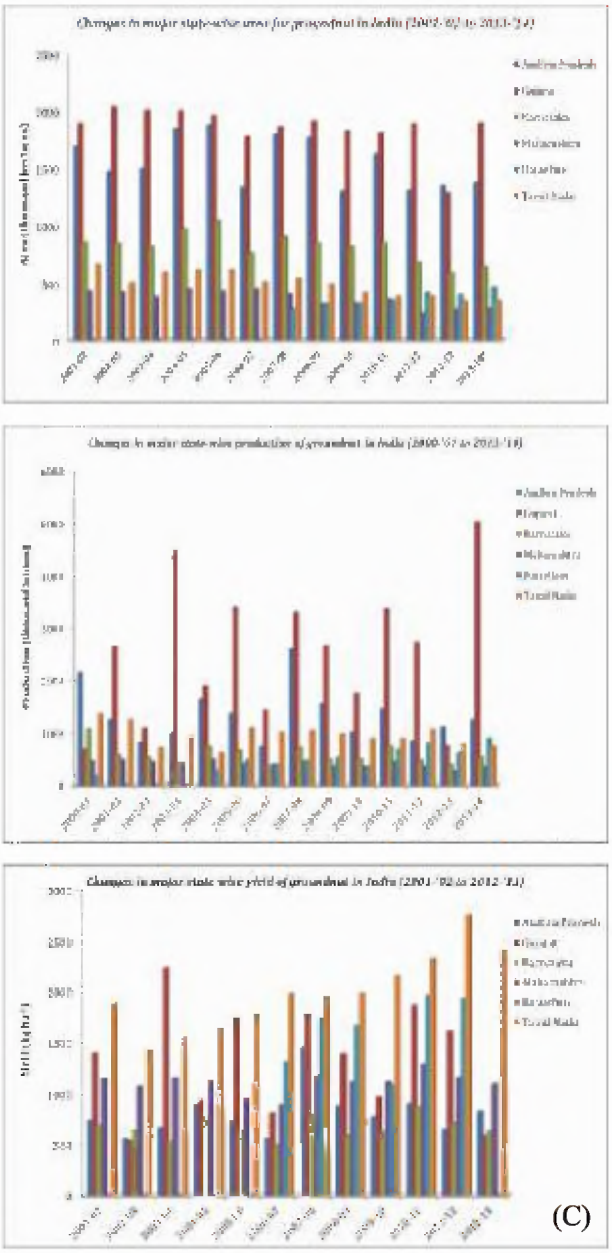
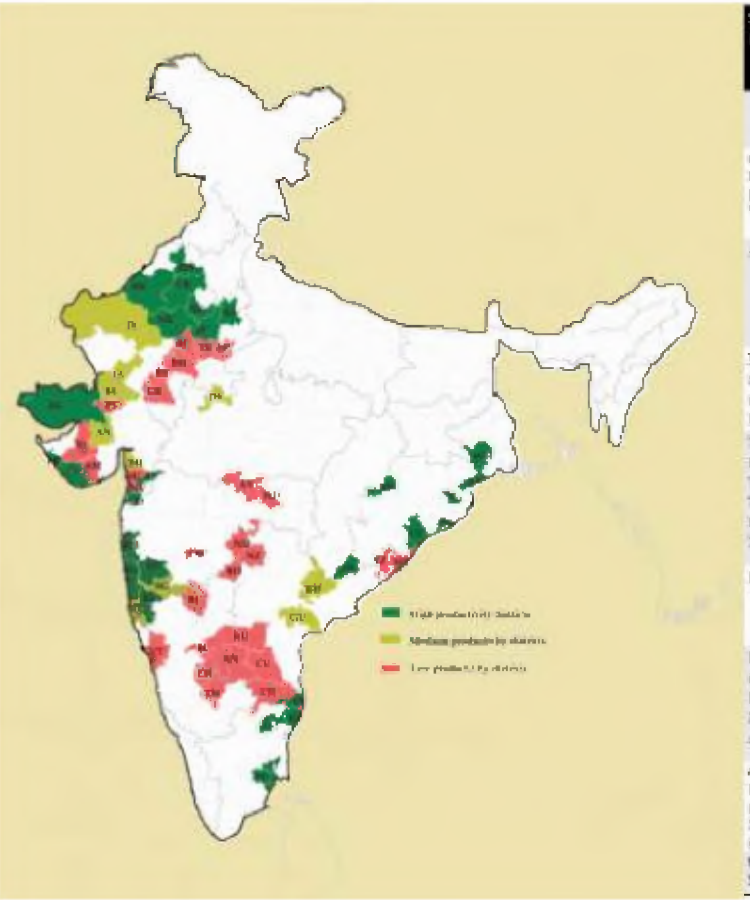


Figure 1. Changing scenario of (A) area, (B) production and (C) yield of major groundnut growing states in India over last decade



State wise classification of districts on the basis of average yield (the abbreviation used in the map above for naming the districts are indicated within the parenthesis after the name of the district)

High (>1500 kg/ha)	Medium (1200-1500 kg/ha)	Low (<1200 kg/ha)
GUJARAT: Kutch (KC), Porbandar (PB), Junagadh (JN), Tapi (TP), Valsad (VL)	Banaskantha (BS), Bharuch (BH), Surendranagar (SN)	Amreli (AM), Rajkot (RJ), Patan (PT), Surat (SU), Navsari (NV)
ANDHRA PRADESH:	Guntur (GU), Khammam (KH)	Anantapur (AN), Nizamabad (NZ), Cuddapah (CU), Kurnool (KU), Srikakulam (SH), Chittoor (CH), Vizianagaram (VZ)
MAHARASHTRA: Satara (ST), Kolhapur (KL), Raigad (RD)	Sangli (SG), Sindhudurg (SD)	Wardha (WH), Nanded (ND), Amravati (AV), Osmanabad (OS)
TAMIL NADU: Kanchevpuram (KP), Tiruvannamalai (TM), Thiruvallur (TR), Pudukkottai (PD), Thanjavur (TT)	–	–
KARNATAKA:	–	Bidar (BD), Bellary (BL), Bijapur (BJ), Tumkur (TM), Uttarakannada (UT), Chitradurga (CH)
RAJASTHAN: Bikaner (BK), Churu (CR), Hanumangarh (HN), Nagaur (NG), Sikar (SK), Alwar (AW), Jaipur (JP)	Jalore (JA), Jaisalmer (JS), Jhalawar (JW)	Udaipur (UR), Bhilwara (BH), Ajmer (AJ), Tonk (TN), Rajsamand (RS), Sawaimadhopur (SW)
ORISSA: Balasore (BA), Bolangir (BK), Ganjam (GJ), Jajpur (JJ), Malkangiri (MG), Puri (PU)	–	–
WEST BENGAL: West Midnapore (WM)		

Figure 2. High, medium and low productivity districts of major groundnut growing states in India; Classification is based on the average productivity of three years (2009-2012)[Source: Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India]

PROJECT 21. IRON AND ZINC BIO-FORTIFICATION IN GROUNDNUT

(A.L. Singh, K. Chakraborty, K.A. Kalariya and Ajay B.C.)

Fe and Zn responses and their densities in groundnut cultivars

A total of 190 groundnut cultivars were grown in field under unfertilized (control) and fertilized with Zn (2 kg/ha, 50% soil and 50% foliar) or foliar application of iron sulphate (0.5%) to study their response on pod yield and micronutrient enrichment in kernels. There was a large variation in yield varying from 1050-2700 kg pod yield/ha and all the cultivars did not respond to theseFe and Zn fertilizers. The pod yield increased substantially with application of Fe and Zn. As we are growing all the 190 cultivars at a time, efforts were made to study the photosynthetic rates, SCMR and VCR readings which showed large variation among cultivars with the growth stages.

Screening of these cultivars for their reaction to lime-induced iron-chlorosis (LICC), 25 were tolerant and several others moderately tolerant, besides 20 were very sensitive to iron chlorosis. The tolerant cultivars were: R8808, S230, Kadiri 7, 8, and 9, Tirupati 3, TG 42, Kadiri gold, HNG 69, M 145, M 197, M522, GJG 22, Champawat, LGN 2, BG1, Mallika, RSB 87, RG 510, RG 425, DH4-3, ICGV87846.

The seed of these 190 groundnut cultivars are being analysed for Fe and Zn contents and other nutrients. From the previous year experiments seeds of 187 groundnut cultivars were analyzed for Zn and Fe, as well as many other nutrients. Of these:

- High Zn containing groundnut cultivars in seed (more than 51 ppm) are : GG 7, GG 20, Tirupati 1, Tirupati 3, Tirupati 4, CO 2, GG 13, ICGS 76, CSMG 884, TAG 24, DH 8, KRG 1, Gangapuri.
- High Fe (more than 125 ppm): M 145, M 13, DSG 1, AK12-24, TAG 24, ALR 3, JSP 19, MH 4, Somnath, ICGV 86031, ICGV 86325, Tirupati 3, GG 2

The study conclude that, there are certain high Zn and Fe density groundnut cultivars which need extensive cultivation and consumptions as food to combat the Fe and Zn malnutrition in India.

Zinc biofortification in groundnut

In two different field experiments, during Kharif and summer seasons, the soil and foliar application of various sources of zinc at 2kg Zn/ha were studied in 20 groundnut cultivars, where zinc sulphate was better than Zn-EDTA in influencing the yield as well as the seed nutrient contents. In standing cropsthreefoliar spray of aqueous solution of 0.2 % zinc sulphateat 40, 55 and 70 days after emergence, influenced yield attributes, and increased the seed Zn contentand hence recommended. However foliar application of Zinc chloride showed scorching on groundnut leaves, and hence not recommended. The mean Zn concentrations in seeds ranged from 21-61 ppm which with spray of Zn increased to 35-60 ppm.

Macronutrients and Zn and B nutrition of various seed-sizes groundnuts

Our earlier studies revealed that the large seed-sized groundnut required more nutrients particularly of P, Ca and K for their pod filling than the small and medium size seed, the pod nutrition of various seeds size groundnut was studied for Zn and B in a field with 50 groundnut genotypes varying in pod structure and sizes and

grown at various combination with fertilizers (T1-control, T2-Ca_{100}+K_{100}+ 1 kg ha^{-1} B, T3-T2 + 2 kg Zn,) where a large variation in the response depending upon the seed size was observed. The average pod yields under unfertilized condition was 1100 kg ha^{-1}which with application of Ca,K and B increased to 1860 kg ha^{-1} and to 2100 with further application of Zn. The seeds of these produce are being analysed to see the effect of B and Zn and their contents in seed.

Screening mini-core germplasm for high Fe and Zn densities and response to these micronutrient applications

The 179 mini-core ICRISAT germplasm when evaluated in field for Fe and Zn fertilizers responses and seed micronutrient densities, the pod yield ranged from 70-410 g m^{-2} with an average yield of 210 g/m^2 without micronutrients and 240 g/m^2 with micronutrients. Majority of these genotypes responded to Fe and Zn fertilizers, however there were a number of nonresponsive genotypes mainly due to their poor yielding or utilization capacitiesand hence low requirement. The mini-core genotypes, showed SCMR 29-46 with mean of 40. The seed of these lines are being analysed for fe and Zn, however from previous yearsamples some of the high seed Zn containing accessions with >53 ppm Zn were: NRCG, 14331, 14332, 14420, 14450, 14460, 14470, 14471, 14480, 14484, 14485, 14499.

B and Z interactions in relation to their content in seed

In India most of the groundnut is grown on the light texture soils deficient in both B and Zn and there is recommendation to apply both of these micronutrients through their available salts. However there may be some interaction effect of these on yields. Thus, to observe the effect of these in 20 cultivars were conducted through field trials with three treatments, *i.e.* control, 1 kg ha^{-1} B, 1 kg ha^{-1} B + 2 kg ha^{-1}Zn. The data clearly showed synergestic effects of these micronutrients and both of these were important for pod development and high yields.

Fe-biofortification through seed dressing

Five iron sources ($FeSO_4$, $FeCl_3$, Ferric Citrate, FeEDDHA, Fe-EDTA) were tested as a seed dressing to see the effect of these on pod yield and Fe content in seed taking 12 groundnut cultivars, where all these Fe sources increased yield except FeEDTA. The seed of these produce when analysed showed mild increase in both Fe and Zn contents.

Basic studies on Nutrient efficient lines

Twenty six groundnut varieties representing both of the nutrientefficient and inefficient one with high yield potentials when grown in the field during summer season, wide variation in the cation and anion contents of root exudates and leaf sap of these cultivarswas recorded. The study reveals that the high cation contents both in leaf sap and root exudates were related with the high yield. On the contrary, the inefficient cultivars showed less cation/anion concentrations in leaf than the efficient cultivars. High Potassium content was major element responsible for high harvest index.

PROJECT 22. IONOMICS FOR IMPROVEMENT OF GROUNDNUT PRODUCTIVITY

(Anita Mann, A.L. Singh, Koushik Chakraborty and M.K. Mahatma*)
*Since December 2014

To study the correlation of Fe with other micronutrients at pegging and pod setting stages.

Fe-efficient genotypes had more active Fe content in leaves with a range of 40-65 mg Fe^{+2}/g fw than inefficient genotypes having 15-42 mg Fe^{+2}/g fw with the exceptional higher active Fe content in Tirupati-4 and MH-1 to 57.4 and 58.8 mg Fe^{+2}/g fw after iron application respectively.

Fe deficiency markedly decreased the active Fe content in roots and leaves. However with application of Fe, the active Fe content was increased in both roots and leaves which was even greater than the control conditions where no nutrients were applied. In efficient genotype, TG 37A, active Fe content (mg Fe^{+2}/g fw) was 54.42 under control conditions which reduced to 30.38 under Fe-deficiency and a more than double fold increase was obtained to 74.42 with iron application. Similarly, in inefficient genotype, NRCG 7472 the active Fe content decreased to 20.78 without iron source from 28.43 under control conditions which increased to 42.43 with iron source.

Fe deficiency also led to decreased elemental concentrations of Zn, Mn, Cu but Ca and Mg concentration were higher. The concentration of K was not affectedby Fe-deficiency in dry matter. On an average, Zn concentration (µmol g^{-1}dw) was decreased from 0.49 to 0.46 andMn from 0.63-0.58 in Fe-inefficient genotypes.

The active Fe content along with the other mineral nutrients was approximately 30% more at peg formation than the pod setting stage.

To study the physiological mechanism of organic acids accumulation in root and leaves under iron deficiency

The organic acids of tri-carboxylic (TCA) cycle malic acid, succininc acid, glutaric acid, oxaloacetic acid and citric acid were standardized and separated on Ion Chromatograph using AG11-HC column.

Regardless of the genotypes, the concentration of malic acid and citric acid increased significantly in root extracts with Fe-deficiency. Oxalic acid was found to be increased approximately three fold from 327.9 ppm at control conditions to 941.11 ppm under Fe-deficiency.

In Fe^{-} and Fe^{+} treatments, both Fe-efficient and inefficient plants, the predominant was oxalic acid with malic acid followed by citric acid. On an average, concentration of malic acid and citric acid showed threefold increase.

In leaf extracts, the concentration of citric acid and succinic acid did not differ much between genotypes with Fe deficiency. Citric acid was more in root extracts while malic acid was more in leaf extracts. Iron supply caused gradual decrease in organic acid concentration.

The increased PEP carboxylase activity was responsible for the increased organic acid concentration under Fe deficiency. Two-three fold increase in PEP carboxylase activity was observed in Fe-deficient roots in comparison to the leaves.

Pot Experiment: To study the effect of salinity on ionomics of Fe absorption and translocation

To study the correlation of Fe with other micronutrients at pegging and pod setting stages under saline conditions (Salinity levels: 50 mM and 75 mM)

- Two groundnut genotypes, GG-20 and TG 37 were taken for the studies and the experiment was conducted in pots. At peg formation as well as at pod formation, the concentrations of Fe, Zn, Mn and Ca decreased with increasing levels of salinity from 50 mM to 75mM. Cu, K and Mg concentration decreased to 13-15 % with 50 and 75 mMNaCl.
- The concentration of Fe was more in roots than leaves at stage I while at stage II, concentration of Fe was more in leaves than roots. With saline treatment, the Fe concentration decreased significantly in both leaves and roots.
- With salinity, there is decreased uptake of Fe.

To study the physiological mechanism of organic acids accumulation in root and leaves due to iron deficiency under saline conditions.

- The organic acids of tri-carboxylic (TCA) cycle malic acid, succininc acid, glutaric acid, oxaloacetic acid and citric acid were separated on Ion Chromatograph using AG11-HC column.
- The concentration of malic acid and citric acid increased significantly in root extracts with Fe-deficiency which decreased with salinity in leaves. The accumulation of malic acid and citric acid was more in Fe-inefficient plants.
- Iron supply caused gradual decrease in organic acid concentration.

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

(Koushik Chakraborty, A.L. Singh, K.L. Kalariya, M.K. Mahatma and R.A. Jat)

Effect of temperature stress on crop phenology and pollen viability

To study the effect of high temperature stress on different physiological and biochemical parameters an experiment was conducted in summer 2014 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 (D_1, D_2 and D_3) 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 34.5/18.0, 37.5/21.5 and 39.0/24.0 °C respectively for D_1, D_2 and D_3 condition. This situation simulates three different temperature regimes for the plants at a particular growth stage.

The difference is sowing time resulted in differences in total degree days required to the crop to obtain maturity. In total there was 10-15 days difference observed in total maturity period in different cultivars as a result of differences in temperature regime they were grown. High temperature stress created by late planting of the crop resulted in reduction in both 100-seed weight as well shelling percentage in all the cultivars. High temperature stress also resulted in yield loss in all the cultivars. On an average pod yield reduced from 185 g m^{-2} in early sown crop to 143 g m^{-2} in late sown crop. Severe reduction in pollen viability from 76% to 43% was observed due to increase in 3.5 °C mean day temperature.

Effect on membrane stability, oxidative stress and antioxidant enzyme activities

Membrane stability reduced in all the cultivars with increase in mean day/night temperature. On an average MSI reduced from 85% to 65% with increase in 4.0 °C mean day temperature. Under high temperature stress total chlorophyll content of the leaf dropped significantly, while the carotenoid content increased across the cultivars. Membrane lipid peroxidation measured in terms of TBARs content also showed partial destabilization of membrane. Accumulation of H_2O_2increased under temperature stress in all the cultivars with an average increase from 108 to 136 µmol g^{-1} FW. However, the genotype TPG 41 and GG 7 showed least increase in H_2O_2 content. Accumulation of osmolyte *viz.*proline, was more with increase in mean day/night temperature. Activity of different antioxidant enzymes like superoxide dismutase, catalase increased in almost all the cultivars under high temperature stress. Some of the cultivars like GG 7 and SG 99 showed increased antioxidant enzyme activities under high temperature stress compared to other cultivars.

Effect of temperature stress on kernel quality

High temperature stress as a result of late sown condition leads to significant alteration of important kernel quality parameters like oil, protein and sugar content. Due to late sowing, all the 10 cultivars used in the present study showed significant reduction in oil yield compared to early or normal sown plants. On the other hand, the protein and sugar content in the seed showed slight to moderate increase when calculated on percentage basis. The stability of the oil measured in terms of oleic acid to linoleic acid ratio, showed considerable decrease under late sown condition.

PROJECT 24. PHYSIOLOGICAL TRAITS ASSOCIATED WITH WATER DEFICIT STRESS TOLERANCE IN GROUNDNUT

(K.A. Kalariya, K. Chakraborty, A. L. Singh and M. K. Mahatma)

Response of growth regulators on stomatalbehaviour, water relations and yield in four groundnut cultivars under deficit soil moisture

Adaxial stomatal behavior and gaseous exchange capacity were studied in four Spanish varieties of groundnut raised at two soil moisture regimes. Control irrigated at PAN evaporative demand and water deficit (WD) with foliar sprays of distilled water along with six different chemicals/growth regulators applied at 45 and 60 DAS. The chemicals/growth regulators used were two stomatal closures namely ABA @50 µM and PMA @100 ppm, two growth retardants namely Ethrel @1000 ppm and 8-HQ@10 ppm and one known secondary electron accepter of ETR, succinic acid @ 150 ppm. At 75 days after sowing (DAS) the mean soil moisture content (SMC) in absolute control plots were 16.2 and 18.0% at 0-15 and 15-30 cm soil depth whereas the mean SMC in deficit soil moisture plots were 8.4 and 9.8% in 0-15 and 15-30 cm soil depth, respectively. The WD reduced RWC and water potential of all peanut cultivars and stomatal closures and growth retardants helped maintained higher RWC under WD. Among genotypes under WD the SD was highest in variety Kadiri 9 in combination with foliar spray of succinic acid. The stomatal aperture size was lowest in plants sprayed with growth retardants ethrel and 8-HQ whereas the effect of stomatal closures ABA and PMA was evident from maximum reduction in stomatal pore size. The stomatal clustering pattern was analysed and found that type Astomatal clustering is reported in peanuts. The per cent incidence of stomatal clustering was only 3.3% in control plants. All WD treatments have increased incidence of the stomatal clustering however, the per cent incidence of stomata clustering increased to the highest of 47% by foliar ethrel application and to 45% by 8-HQ application. The conductance was highest in unstressed plant whereas is it was lowest in WD plants sprayed with PMA and ABA. The transpiration reduced in all WD combinations with the maximum reduction under the influence of stomatal closures. The net photosynthetic rate (PN) decreased due to WD however, the foliar spray of succinic acid @150 PPM has helped to achieve high PN.

Screening of 12 groundnut cultivars for biochemical traits under water deficit stress

In another experiment in which water deficit stress was given during 30 to 70 DAS in twelve groundnut varieties the mean SLA reduced from 162 to 145. Number of mature pods per plant was 10.8 in control and 9.5 in water deficit stress whereas pod dry weight per plant was 8.9 g in control and 6.5 g in water deficit stress. The mean pod yield has reduced from 136 g m-2 to 88 g m-2

Amelioration of water deficit stress with salicylic acid application

In an experiment in summer 2014, effect of salicylic acid to ameliorate water deficit stress was studied in two contrasting groundnut cultivar viz., DRG 1 (susceptible) and ICGS 44 (tolerant), and five levels viz. 0 ppm (T3), 125 ppm (T4), 250 ppm (T5), 375 ppm (T6) and 500 ppm (T7) of salicylic acid treatment along with a set of control (T1) and water deficit treatment (T2) plants. Imposition of water deficit stress resulted in 15% yield loss in tolerant

cultivar (ICGS 44), while the loss was almost 30% in the susceptible one (DRG 1). Application of salicylic acid @ 500 ppm resulted in significant reduction in yield loss in case of both the cultivars. Salicylic application @ 500 ppm can offset the yield loss up to the magnitude of 50% in both ICGS 44 and DRG 1, however the ameliorative effect seems to be more in case of susceptible cultivar.

Screening 60 groundnut varieties under protected and water deficit stress (in ROS)

In *Kharif* 2014, 35 Spanish and 25 Virginia varieties were evaluated for their photosynthetic rate, transpiration rate, stomatal conductance and internal CO_2 concentration. At 60-65 DAS, the mean P_N,g_s and E were 28.1µmol CO_2 m^{-2} Sec^{-1}, 0.426 $mmolm^{-2}$ Sec^{-1}, 224 ppm and 8.6 molH_2O m^{-2} Sec^{-} respectively in control plants. The values of these parameters in WD plants in ROS were 24.8 µmol CO_2 m^{-2} Sec^{-1}, 0.41mmol m^{-2} Sec^{-1}, 245 ppm and 6.7mol H_2O m^{-2} $Sec^{-1.}$ At this stage number of immature pods were 31.9 in control whereas it was only 6.0 in stressed plots in 35 SB genotypes. The total number of sink was 48.0 in control and 13.4 in water deficit SB genotypes. In case of the 25 VB genotypes, the mean total sink number was 47.8 in control and only 13.5 in stressed plants.

Physiological characterization of 36 groundnut cultivars under water deficit stress

In 36 varieties, the mean photosynthesis was 27.7 µmol CO_2m^{-2} Sec^{-1} in control which has reduced to 19.2 µmol CO_2m^{-2} Sec^{-1} due to water deficit stress given during 40-85 DAS. The stomatal conductance decreased from 0.484 to 0.309 mmol m^{-2} Sec^{-1}.

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

(R. Dey, K.K. Pal, Thirumalaisamy P.P. and D. Bhaduri)

Evaluation of DAPG-producing fluorescent pseudomonads (summer and *kharif*, 2014)

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. rolfsii* 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. Inoculation of DAPG-producing fluorescent pseudomonads improved plant growth and biomass in most of the cases significantly over uninoculated control at harvest. Application of *P. putida* DAPG6 and *P. fluorescens* FP98 enhanced the pod (15%) and haulm yield, shelling out turn, nodule number, root and shoot length, plant biomass at 45 and 90 DAS, and HSM significantly over uninoculated control at harvest.

In case of second set of seven DAPG-producing fluorescent pseudomonads, application of *Pseudomonas* sp. FP 20, *P. putida* FP86 and *P. monteilii* FP133 significantly enhanced the root length, biomass, pod (8% to 12%) and haulm yield and shelling out-turn over uninoculated control, during summer 2014. During *kharif* 2014, inoculation with *Pseudomonas* sp. FP46, *Pseudomonas putida* FP86, and *Pseudomonas fluorescens* FP93 resulted in significant increase in pod yield (9.5 – 18%) of groundnut, cultivar TG37A. The maximum pod yield was obtained in treatment with FP86. Inoculation with these isolates also resulted in significant enhancement of haulm yield, shelling out-turn and hundred kernel mass.

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* 2014. 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 NC92. The inoculation with the newly isolated strains of groundnut rhizobia Rh17 and Rh20 significantly enhanced the pod yield of cultivar TG 37A over un-inoculated control and NC92, a standard culture. Inoculation with culture SRR7 resulted in yield at par with NC92. Besides, plant growth, haulm yield, nodule number and biomass, shelling out-turn, etc. also improved with the application of these new strains.

Application of DAPG-producing fluorescent pseudomonads for suppression of collar rot of groundnut (*kharif* 2014)

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 14% in pathogen control and there was reduction in disease incidence to 5-8% 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. Application of *P. putida* DAPG4, *P. putida* DAPG7, *Pseudomonas* sp. FP46, *P. putida* FP86, *P. monteilii* FP133, and *P. fluorescens* FP98 significantly enhanced the pod and haulm yield and shelling out-turn of cultivar GG 20. The yield enhancement ranged from 9 to 20%, the maximum enhancement was obtained with FP98.

16S rRNA sequencing of important cultures (custom sequencing)

Some of the DAPG-producing fluorescent pseudomonads were identified by 16S rRNA sequencing and identities are as follows:

Sr. No.	Isolate	Identity
1	FP46	*Pseudomonas* sp.
2	FP82	*Pseudomonas aeruginosa*
3	FP86	*Pseudomonas putida*
4	FP121	*Pseudomonas putida*
5	FP133	*Pseudomonas monteilii*

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*, *Spodoptera* and groundnut bruchid

Bacterial isolates (non-Bt) were obtained from the dead larva of *Helicoverpa armigera* (Hubner) and *Spodoptera litura* (Fabricus) following standard techniques. So far 47 non-Bt bacilli were obtained from *Helicoverpa* and 53 were obtained from dead larva of *Spodoptera*. In *in vitro* bioassay, repeated evaluation of the two non-Bt isolates LS13 and LS14 showed 100% mortality against *Spodoptera*. Against groundnut bruchid, 37 isolates of Bt (isolated previously) are being evaluated for mortality.

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

From the nodule samples collected from groundnut growing areas of Bhuj affected by salinity, 57 isolates of groundnut-rhizobia were obtained, purified, and characterized. All of the isolates can tolerate 5% of NaCl whereas 17 of them can grow upto 10% of NaCl, 5 could tolerate 15% of NaCl, *in vitro*. Out of 153 bacterial endophytes isolated so far from groundnut (cultivars and germplasm accessions), 25 were found to tolerate 45°C and ~10% of NaCl in growth medium. Thirty-one rhizobia were also isolated from nodule samples collected from groundnut grown without supplementary irrigation after germination.

Characterisation of endophytes for antifungal activities against fungal pathogens

One hundred fifty-three groundnut endophytes (isolated from root, stem and seed of groundnut) were screened, in vitro, for antifungal activities against *Aspergillus niger* and *Sclerotium rolfsii*. While 10 isolates showed antifungal activities against *S. rolfsii*, eight isolates showed strong inhibition against *A. niger* (Table 1). One isolates (L14) was inhibitory to both *S. rolfsii* and *A. niger*. Maximum inhibition zone of 55 mm was obtained with R76 against *A. niger* while against *S. rolfsii*, it was 22 mm by REN35.

Table 1. Evaluation of endophytes of groundnut for in vitro inhibition of soil-borne fungal pathogens of groundnut

Isolate	Diameter of inhibition zone (mm)	
	S. rolfsii	A. niger
L14	15 (±1.76)	25 (±1.95)
L23	-ve	20 (±1.47)
REN35	22 (±2.16)	-ve
REN40	16 (±1.41)	-ve
REN45	20 (±2.25)	-ve
REN58	20 (±1.92)	-ve
R76	-ve	55 (±2.76)
R77	-ve	22 (±2.16)
R81	12 (±0.89)	-ve
R85	-ve	12 (±0.95)
SEN11	-ve	45 (±1.43)
S35	-ve	28 (±0.56)
S41	16 (±0.36)	-ve
S50	18 (±2.11)	-ve
S52	-ve	32 (±2.25)
SD3	12 (±1.65)	-ve
SD5	10 (±0.65)	-ve

Selection and identification of endophytes for alleviation of moisture-deficit stress in groundnut

Nine endophytes comprising root, stem and seed endophytes were evaluated in field conditions to study the alleviation of moisture-deficit stress in groundnut by application of endophytic bacteria.

The experiment was conducted to select the ones which can enhance yield and alleviate/modulate the stress tolerant traits in groundnut, cultivar TG37A. The crop was sown on 27th January 2014 with flood irrigation and no further irrigation was applied till the harvest. Results indicated that inoculation of endophytes like *Acinetobacter junii* J20, *B. subtilis* REN51N and *B. firmus* J22N reduced the stomatal aperture as compared to uninoculated control and other endophytes. It was also found that there was probably no influence of endophytes on the stomatal size, stomatal density and SCMR. However, significant difference in pod and haulm yield, plant biomass, etc. was noticed in different treatments with endophytes as compared to control. While maximum pod yield of 903 kg/ha was noticed with the application of *Pseudomonas pseudoalcaligens* SEN29, it was 877 kg/ha and 847 kg/ha, respectively with the inoculation of *Pseudomonas mexicana* REN47 and *Pseudomonas aeruginosa* REN24 as compared to control (553 kg/ha). Application of other endophytes like *Bacillus subtilis* REN51N, *Bacillus firmus* J22 and *Acinetobacter junii* J20 also improved the yield significantly over uninoculated control.

Understanding the mechanisms of osmotolerance in extremophiles for isolating relevant genes

To establish co-linearity among the solute accumulated, proteins differentially expressed, and the transcripts over-expressed in extreme halophilic archaea, the intracellular solutes of *Haloferax volcanii* H1-DGR were subjected to XRD- and HPLC-analysis. HPLC analysis of solutes for major sugars, ectoins, hydroxyl ectoins and amino acids revealed that there was no significant accumulation of any sugars or sugar alcohols that could be detected by HPLC. Accumulation of ectoines and hydroxyl ectoines was not detected. Results of the analysis of amino acid revealed that there was a significant change in the amino acid composition with respect to salinity. The results indicated that at 10% NaCl concentration there was accumulation of tyrosine and leucine at much more higher concentration than other amino acids. For isolation of the full complement of the genes responsible for production of over-expressed proteins (hypothetical and known), primers have been designed and full complement of glycerol kinase (glpk), 2-oxo-3-methyl valerate dehydrogenase, three other hypothetical proteins have been amplified for further studies.

PROJECT 27. INNOVATIVE APPROACHES TO BRIDGING YIELD GAPS IN GROUNDNUT THROUGH TECHNOLOGY DISSEMINATION AND CAPACITY BUILDING

(Narayanan G. and Murlidhar Meena*)
*on study leave from 01.08.2014

District wise analysis of yield gaps exists during 2007-08 to 2011-12

There exists wider yield gap in oil seed crops of India. Groundnut crop yield gap is very wide. If ranges from 19 per cent to 136 per centwith an average of 77 per cent. Basically yield gap means the achieved yield difference between research station and farmers yield. Accordingly, secondary data were collected from the AICRP-G centre from major groundnut growing state. Apart from accessing for while state an attempt has been made to know district wise and variety wise exists during 2007-08 to 2011-12. In Andhra Pradesh, the largest groundnut growing district Anantapuramu been found to have 29% yield gap I and without much difference between experimental yields, whereas in *Rabi*-summer season it was found that FLD yield was more than experimental station yield. The yield gap II was 32%. The yield gap in Karimnagar district was in *Kharif* was 28% and in *Rabi*-summer 20% respectively in the further analysis among varieties grown (during five years), it was found that the variety Kadiri-6 performed better both in *Kharif* (1825kg/ha) and in *Rabi*-summer (2962kg/ha). The yield gap II observed was 19 and 32 percentages respectively.

In Karnataka, it was found that in Raichur district yield gap I is highest (122%) followed by Dharwad district (69 %). There was much yield difference between experimental station and FLD yields. In *Rabi*-summer the yield gap II was found to be more in Raichur district (41%). There is no much variation from the results of experimental station and FLD yield. As far as the varietal performance is concerned in *Kharif,* variety DH 101 recorded high experimental station yield (4764 kg/ha) followed by GPBD-4 (4079 kg/ha). It was followed by JSP-39 (3574 kg/ha). In yield Gap-I analysis these varieties performed very low in FLD plots. As much as 186% yield gap recorded by JSP-39 followed by DH-101 (88%) and GPBD-4 (68%). In *Rabi*- summer, there was no much variation among varieties performance in yield. The best performing varieties were Chintamani -2, ICGV-91114 and R-2001-2 with 3029, 2823, and 2735 kgs/ha pod yields respectively. The highest yield gap II was found in varieties R-2001-2 and R-8808.

Assessing economic sustainability of groundnut in Tamil Nadu

A study on assessing economic sustainability of groundnut in Tamil Nadu was undertaken with the assumption that there was declining area of groundnut due to higher cost of cultivation and lower net returns. The presumed economic unsustainability was studied with structured interview schedule among the 30 groundnut growers of Villupuram and Vellore districts of Tamil Nadu. The respondents were selected randomly. The average productivity recorded was 2252kg pod/ha. The study found out that the total cost of cultivation in *rabi* groundnut was Rs.70203/ha and net returns earned was Rs.34137. The cost benefit ratio was 1:1.4 only. A bulk of production cost shared by labour costs in inter-culture operations and harvesting, indicating the dire need of mechanization and herbicide applications to make groundnut cultivation sustainable.

Documenting case on high productivity achievement in Groundnut

Mr. Kumaraguru is a groundnut grower since 1990s. He resides in the village Karuppanachavadi, Cuddalore district, Tamil Nadu. He cultivates groundnut, paddy, sugarcane, and amla in his 10 hectare land. He is one of the leading farmers in the village in realizing groundnut pod yield, more than 6000kgs/ha in every season. The Cropping system he followed was Groundnut-Sesame – Bajra. Every year he was very particular about sowing date i.e. 17th November. Source of irrigating is bore well and soil type is sandy clay loam. As part of field preparation he plough land once with disc followed by twice harrows and rotavator once thereby getting desired tilth. As basal application he applied FYM 5t/ac, 100 kg of Gypsum followed by micro-nutrient mix 5 kg/ac. then formed 3M2 beds after levelling. He has used 48 kg of seed for one acre land. As seed treatment he treated the seeds with *Trichoderma viridi* @4gm/kg of seed followed by rhizobium 800 gm for 1acre seed, using rice gruel and dried in shade for 30 minutes. He used Varieties G-9 and VRI – 2 followed spacing 30 X 10 cms and maintained plant population @ 33 plants/m^2Followed soil test based recommendation: Urea 15 kg; SSP 80 kg, Potash 15 kg and again rhizobium 800 gm as field application. After sowing, life Irrigation on 3 DAS after that once in week, totally 5 irrigations through mobile sprinklers and used water efficiently. As part of weed management he applied Imazethapyr herbicide on 15 DAS after sowing in the presence of adequate soil moisture @ 250 ml/ acre and carried out one hand weeding on 35 DAS. He followed combined nutrient spray on 25DAS and 35DAS to boost the flowering and peg formation. For this he made a dilution consist of DAP 1 kg and Ammonium Sulphate 400 gm and Borax 200gm and kept overnight in 15 litre of water, in the next day filtered it added 187 litres of water to the filtrate. At the time of hand spray he added 140 ml of Planofix thereby increasing, according to him, about 30% flowering and the formation of peg was good.

Further, as part of top dressing, after hand weeding applied 10-26-26 complex @50 kg/acre on 35 DAS and applied Gypsum @150 kg/acre on 45DAS and carried out earthing up and on 75DAS sprayed growth promoter Hamla @250 ml/ac. As part of pest and disease management practice he had set up light traps @5/acre, raised bund cropping castor and cow pea sprayed Azadirachtin @250 ml – on 30 DAS, sprayed Chlorpyriphos 20% EC @250 ml/acre on 40 DAS for *Spodoptera* control and applied Acephate @250gm/acre to control Jassids, Tricyclazole 75% WP fungicide @200 gm/acre for controlling Tikka Leaf spot. He says that he has achieved 60-70 pods/plant by extending flowering up to 60 DAS, increasing about 30 per cent flowering, and maintained green cover till harvest on 110th day. In *rabi*-summer 2014-15 the pod yield/ha achieved with variety ICGS 86590 (ASHA) was 6700 kgs and in 2013-14 *rabi*-summer with varieties GJG-9 and VRI-2 were 8227 kgs/ha and 7940 kgs/ha respectively.

A comparative study on cost of cultivation, resource use management behaviour and training needs of groundnut growers of Andhra Pradesh

A survey was conducted in the Kharif 2014 among the three different areas of ground growers of Ananthpuramu and Nellore districts of Andhra Pradesh both known as high and low productivity areas respectively. In Ananthapuramu district 100 farmers randomly selected and based on irrigation availability they were grouped into *viz.*, 1. Tank/bore well irrigated (32) and 2. Rain-fed farmers (68). In Nellore 70 farmers were surveyed and all are using bore well for irrigation. The general social profile as follows: In Ananthapuramu district it was found

about one-third of the farmers belonged to young age group and mostly found to be in illiterate and primary educated category. The land holding among irrigated group was that 69% farmers having medium land holding (1.1-2 ha) and reports cost of cultivation Rs. 63135/ha whereas the rain dependent farmers, the small land holders (<2 ha.) spends Rs.53176/ha. and the medium land holder (2-4 ha.) spends Rs.46430/ha. The situation in Nellore district was that majority (60%) of the farmers belongs to middle aged category and 61% went up to primary and secondary education, has (53% of farmers) medium (2-4 ha.) land holdings and reports cost of cultivation Rs.95898/ha.

The reasons for wider yield gap in groundnut and groundnut production constraints can be overcome through efficient RUM behaviour. Thus there is a need to assess the existing level resource use management behaviour of Ananthapuramu and Nellore district farmers. As far as irrigated farmers of Anathapuramus is concerned, most of the groundnut growers had medium RUM behaviour in cropping systems management and had high level of RUM behaviour in soil-moisture management. There were low levels of RUM behaviour among them on weeds, pests and disease management systems. As far as Nellore farmers was concerned, except seeds management, in all other RUM indicators they were observed with low level management behaviours. In rain-fed situation, most of the farmers surveyed it was found that there was low to medium RUM behaviour in most of the indicators. As far as training is concerned among the farmers survey, most of them rated training on ICM practices as most important training need followed by storage and marketing.

Visit of farmers

This year (2014-15), a total of 666 farmers in 3 different States, 179 students and 45 officers belonging different agriculture universities visited DGR. Thus during the year altogether 890 visitors from various states viz.Gujarat, Madhya Pradesh and Rajasthan visited the DGR. The visits were sponsored by State Departments of Agriculture or State Agricultural universities concerned. These visitor-groups were taken demonstration fields, provided with Hindi, Gujarati and English literatures; shown field experiments, technology park, laboratories, museum, library etc. and interaction meetings with the scientists were also arranged.

Model Training Course (MTC)

The eight days model training course conducted on "Update on Low-cost Production Technologies and Post-Harvest Operations for Sustainable High Productivity of Groundnut" for state agricultural extension officers (17-24 September 2014).This training was sponsored by the Directorate of Extension, Ministry of Agriculture and cooperation, New Delhi in which 22 Agricultural extension officers from 11 states have participated. The course was conducted with both class rooms teaching by using case studies as well as field level orientations on low-cost production technologies and post-harvest operations in groundnut. The pre and post training evaluation showed that from existing knowledge about 42 per cent knowledge improvement had happened on the subject taught. In total 22 experts, including four experts from SAU and one from state department of agriculture acted as resource persons. Relevant literatures has been distributed for future reference and easy use of attending officers.

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

(Murlidhar Meena* and Narayanan G.)
*on study leave w.e.f. 1st August, 2014

Cost and returns in groundnut cultivation in India

Profit is the key livelihood to farmers and is the decisive goal in crop cultivation. Many reports pointed out poor and negative returns in agriculture have become more common in current period. These underprivileged, irregular and insufficient returns led to enlarged indebtedness and diminished reinvestment in agriculture. An inadequate return in crop cultivation is the main reason for the present agrarian crises. The sharp rise agricultural input prices led increasing cost of cultivation in recent past, is one of the main reasons for low or sometime even negative returns in crop cultivation. Profitability in groundnut in all major groundnut growing states *viz.* Andhra Pradesh, Gujarat, Maharashtra, Karnataka and Tamil Nadu from 1996-97 to 2010-11 was calculated. Data on different cost (A2 and C2) of cultivation (COC), family labour charges (FL), implicit price and value of produce (VOP) were taken from various CACP reports. Cost A2+FL and Cost C2 have been used to measure the profitability of groundnut cultivation. Growth and instability in COC and VOP have been compared in all the major states for the periods 1996-97 to 2010-11. Profit and loose over cost C2 and cost A2 with imputed family labour during studied fifteen was compared across the states.

All the states have shown upward trend in COC over the period. Among Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Tamil Nadu, the highest average cost of groundnut cultivation was observed in Tamil Nadu and least was observed in Karnataka (Figure1).

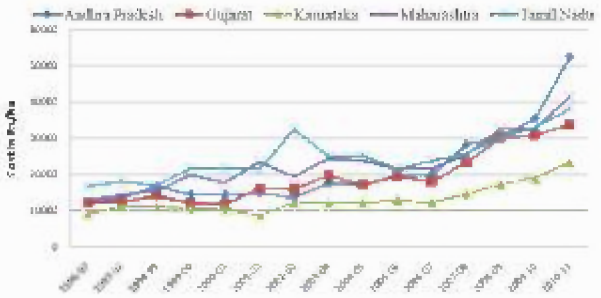


Figure 1. Groundnut cost of cultivation (C2) in major growing states

Maximum growth of 8.74% and 9.58% in COC (C2) and VOP respectively was observed in Andhra Pradesh followed by Gujarat. Least growth in C2 as well as in VOP was observed in Tamil Nadu. VOP have observed higher growth with higher instability than COC in all the states because of highly uncertain nature of groundnut production in rainfed cultivation condition in the country. Whereas COC has increased with less instability due to increased agricultural input prices with low fluctuation as compared to higher fluctuation in output and its prices. Least instability in COC and VOP in Tamil Nadu was observed due to relatively higher irrigated groundnut cultivation in the state in compare to other major states.

Table 1. Growth (in %) and instability index of cost (C2) and value of produce (VOP) during 1996-97 to 2010-11 in major groundnut growing states.

States	Andhra Pradesh		Gujarat		Karnataka		Maharashtra		Tamil Nadu	
	C2	VOP	C2	VOP	C2	VOP	C2	VOP	C2	VOP
Growth	8.74	9.58	7.74	7.83	5.32	6.07	6.76	7.67	4.77	4.91
Instability	0.48	0.59	0.35	0.64	0.33	0.49	0.39	0.53	0.30	0.35

Table 2. Number of times profit earned or losses incurred by groundnut farmers in each state during 1996-97 to 2010-11 period.

States	Cost Type	Profit	Loss	Total
Andhra Pradesh	Cost A2+FL	13	2	15
	Cost C2	4	11	15
Gujarat	Cost A2+FL	15	0	15
	Cost C2	13	2	15
Karnataka	Cost A2+FL	12	3	15
	Cost C2	4	11	15
Maharashtra	Cost A2+FL	12	3	15
	Cost C2	5	10	15
Tamil Nadu	Cost A2+FL	14	1	15
	Cost C2	4	11	15

Farmers earned profit over cost A2 including family labour (A2+FL) in twelve and more years in all the states. Groundnut farmers in Gujarat always earned profit over A2+FL in all the studied years, followed by Tamil Nadu (14 years) and Andhra Pradesh (13 years). But famers incurred losses in ten or more years over cost C2 except in Gujarat where in only two years farmers incurred losses. In Andhra Pradesh, Karnataka and Tamil Nadu farmers incurred losses over cost C2 in eleven years out of fifteen years.

RESEARCH HIGHLIGHTS: ALL INDIA COORDINATED RESEARCH PROJECT ON GROUNDNUT (AICRP-G)

Crop Improvement

1. Germplasm enhancement

Five thousand one hundred and forty-one germplasm accessions have been maintained at ten centres during *kharif* 2014. Three thousand and twenty one accessions supplied by NBPGR have been rejuvenated. Seven-hundred and thirty-six accessions have been multiplied in sufficient quantity and deposited with NBPGR for long term conservation. At Vridhachalam centre, 100 different germplasm accessions and 221 accessions at Shirgaon centre have been evaluated and out of which a few promising germplasm and advanced breeding lines have been identified for a few yield components. At Vridhachalam centre, a field gene bank comprising triploid interspecific hybrid derivatives, amphidiploids, auto tetraploids and allo-hexaploids have also been maintained. Few seeds that are set in each of these wild derivatives were conserved for further multiplication and use in crop improvement programme.

2. Interspecific hybridization and generation advancements

Six new crosses were made during rabi-summer 2013-14 at Vridhachalam centre involving six different wild 'A' genome species belonging to the section Arachis (Table D1). From the crosses made earlier the true hybrid plants of 12 interspecific crosses- all involving cultivated types and 12 wild 'A' genome species belonging to the section *Arachis*. Populations of interspecific crosses both in segregating and advanced generations viz 14 crosses in F2 generation; 3 crosses in F3 generation; 10 crosses in F4 generation and 11 crosses in F5 generation were raised. Of these crosses, 188 single plants and 30 progeny bulks were selected for further advancement at different generations.

At Dharwad, two interspecific hybrid populations (pre-bred) comprising 168 lines have been screened for resistance to rust and LLS under optimal disease pressure (disease score 7.0 for rust and 8.0 for LLS) on a 1.0 to 9.0 scale. Out of the 168 derivatives, 44 genotypes have been found immune to rust recording a disease score of 1.0 (immune) and 67 genotypes recording a disease score of 3.0 (resistant). Interestingly, seven genotypes exhibited immune reaction to rust and resistance reaction to LLS. The results of which will be confirmed upon further screening during *kharif* 2015. Another set of 168 germplasm accessions have been screened for rust and LLS during *kharif* 2014 at Dharwad. The disease pressure was high (9.0 both for rust and LLS) on a 1.0 to 9.0 scale. Of these thirteen genotypes exhibited resistance reaction to both rust and LLS. In the same centre, 20 marker aided back cross derivatives (MABC) were also screened along with suitable check varieties. The disease pressure was high for LLS (disease score 9.0 on a 1.0 to 9.0 scale) and low for rust (disease score 7.0 on a susceptible genotype, on a 1.0 to 9.0 scale). Three genotypes, ICGVs' 13193, 13200, and 13206 were promising for yield coupled with tolerance to rust.

3. Hybridization programme

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 during rabi-summer. In *kharif* 2014, 179 single-crosses using different cultivars/advanced breeding lines, germplasm accessions were made during *kharif* 2014. Of the parents used in these crosses, few were germplasm accessions, and the rest were advanced breeding lines or recently released varieties.

4. 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 11 AICRP-G centers earlier were advanced to their respective next higher filial generations during rabi-summer and kharif . 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 599 crosses were advanced to their respective next filial generation from which a very large number of (9968) selections were made at 11 AICRP-G centres. During *kharif* season, progenies of 1099 crosses were advanced to their respective next filial generation from which, a very large number of (17515) selections were made. The selections comprised of large number (13382) of single plants and 4133 progeny bulks..

5. Varietal Evaluation

Twenty-four Spanish bunch genotypes, 13 in Initial Varietal Trial (stage-I) and 9 in Initial Varietal Trial (stage-II); and 2 in Advanced Varietal Trial (SB) were evaluated at different groundnut zones in rabi-summer 2013-14. In zone IIIb (comprising Tamil Nadu, Andhra Pradesh) three genotypes, K 1719 (3056 kg of pod and 2164 kg of kernel yield per ha); TCGS 894 (2868 kg of pod and 1998 kg of kernel yield per ha); and ICGV 07240 (3056 kg of pod and 2164 kg of kernel yield per ha) which exhibited yield superiority over the check variety of this zone, ICGV 00350 were promoted to AVT.

Across the locations and different stages of testing the entry JL 776 exhibited yield superiority (3307 kg of and 2256 kg of kernel/ha) over the best check of this zone ICGV 00350. The increase in pod and kernel yields of this genotype over the best and recently released zonal check of this zone, ICGV 00350 was 42.4% and 52.2% respectively and over the other zonal check, R 88080 the increase was 41.4% and 40.2% for pod and kernel yields respectively. Over the national check, TAG 24 the test entry JL 776 recorded 48.4% and 52.1% increase in pod and kernel yield respectively. Hence JL 776 has been proposed for identification.

In kharif 2014, 111 genotypes, 17 Spanish bunch types and 9 Virginia types were in Initial Varietal Trial (stage-I); 21 Spanish types and 18 Virginia types in Initial Varietal Trial (stage-II); 2 in Advanced Varietal Trial (SB) and 2 in Advanced Varietal Trial (VG); and 1 Advanced Large Seeded Varietal Trial were evaluated at different groundnut zones. In zone V, a large zone comprising ten locations in Tamil Nadu, Andhra Pradesh, and Karnataka) three Spanish bunch genotypes, ICGV 05155 (2907 and 1955 kg/ha), ICGV 03043 (2857 and 1920 kg/ha), and ICGV 06420 (2877 and 1989 kg/ha) which exhibited yield superiority over the check variety of this zone R 2001-2 were promoted to AVT. In zone II (comprising Gujarat and southern Rajasthan), two Virginia genotypes, in order of merit, K 1715 (2932 and 1898 kg/ha) and K 1725 (2932 and 1898 kg/ha) which recorded significant higher pod and kernel yields over the best check, GG 20 were promoted to AVT.

In zone V in Virgina group, three genotypes JCG 1013 (2340 kg of pod and 1569 kg of kernel/ha) K 1725 (2218 kg of pod and 1537 kg of kernel/ha) and K 1715 (2143 kg of pod and 1488 kg of kernel/ha) which exhibited yield superiority over the check variety of this zone, ICGV 00348 were promoted to AVT. In zone I comprising four locations in Rajasthan, Uttar Pradesh and Punjab, one Virginia genotype, RG 559-3, a selection from ICAR-DGR breeding material, RG 559-3 maintained its yield superiority across different stage of testing and over seven checks both for pod (3173 kg/ha) as well as kernel (2201 kg/ha) yield. The increase in pod and kernel yields of this genotype over the best check of this zone, CSMG 2003-19 was 17.0% and 19.3% and over the next best check Raj Mungphali-1 this genotype recorded 17.4% and

19.4% increase in pod and kernel yield respectively and hence this genotype is proposed for identification.

6. Breeder seed production

For the year 2013-14, DAC indent for 12486.95q of groundnut breeder seeds was received for 55 varieties to be produced during kharif 2013. Based on the availability of nucleus/breeder seed of different varieties, a production target of 11026.85q was allocated for 51 groundnut varieties to 23 breeder seed producing centres/agencies. Against this allocation, however, a total of 5302.82q breeder seed has been produced during *kharif* 2013. To mitigate the shortfall, a compensatory programme was chalked out for rabi-summer 2013-14, through which a production of 7693.00q has been realised. Thus an overall quantity of 12995.82q groundnut breeder seed has been produced during the year 2013-14.

During kharif 2014, DAC indents to the tune of 11309.85q were received for 51 groundnut varieties. However, based on the availability of nucleus/breeder seed stage I, a production target of 10546.35q was assigned for 47 groundnut varieties to 22 breeder seed producing centres. During kharif 2014, against this allocation, a total quantity of 2338.71q breeder seed could be produced. To mitigate the short fall, a compensatory programme was undertaken during *rabi*-summer 2014-15 and the anticipated production is around 8120.20 Thus, the expected total production during 2014-15 would be 10458.91q.

Crop Production

Kharif 2014

1. Yield maximization in groundnut through nutrient management practices during kharif under rainfed situation

At Dharwad application of FYM @ 7.5 t ha^{-1} along with the recommended dose of fertilizers (25 kg N, 75 kg P_2O_5 and 25 kg K_2O ha^{-1}) and $FeSO_4$ @ 25 kg ha^{-1} produced significantly higher dry pod yield (3835 kg ha^{-1}) as compared to application of FYM @ 7.5 t ha^{-1} alone (3089 kg ha^{-1}), and application of recommended dose of fertilizers (25 kg N, 75 kg P_2O_5 and 25 kg K_2O ha^{-1}) alone (3430kg ha^{-1}). Foliar application of urea @ 2% at 30 and 60 days after sowing failed to exert significant influence on either dry pod yield or kernel yield of groundnut.

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

At Akola, application of NPK @ 30:75:25 kg/ha recorded significantly higher dry pod yield (2744 $kgha^{-1}$) over remaining treatments under vertisol of Maharashtra. At Kadiri application of NPK @ 25:60:0 gave significantly higher pod yield (1254 $kgha^{-1}$) over no fertilizer application. At Mohanpur, pod yield of groundnut increased due to application of different ratios of NPK fertilizers and maximum pod yield was recorded when nitrogen @ 25-30kg/ha along with P_2O_5 @60-75 kg/ha was applied to *kharif* groundnut. At Shirgaonapplication of 30:75:00 NPK kg ha^{-1} recorded significantly higher pod yield (3706 kg ha^{-1}).

3. Effect of irrigation levels and hydrogel on productivity of kharif groundnut.

At Junagadh, application of irrigation water at 1.0-1.2 IW/CPE and hydrogel @ 2.5-3.5 $kgha^{-1}$were found better as compared to other treatments.

4. Nutrient management in prevalent groundnut-based cropping system

At Aliyarnagar application of 100% N+150% PK to groundnut and application of 100% RDF to *rabi* crop (cowpea) gave higher groundnut pod equivalent yield. Similarly, at Bhubaneshwar application of 100% N+150% PK to groundnut and 100% RDF to *rabi* crop (horsegram) produced significantly higher

groundnut equivalent yield and net monetary returns as compared to other nutrient management practices under groundnut-horsegram system. At Dharwad, application of FYM @ 7.5 t ha^{-1} along with 100% RDNPK (25 kg N, 75 kg P_2O_5 and 25 kg K_2O ha^{-1}) to groundnut during *kharif* + no fertilizers to wheat during succeeding *rabi* season produced higher groundnut pod equivalent yield and higher net monetary returns compared to other nutrient management practices. At Durgapura, application of 100% NPK to groundnut and 100% NPK to wheat gave significantly higher groundnut pod equivalent yield.

At Jalgaon, application of 100% N and 150% Pto groundnut crop during *kharif* season and 75% RDF to wheat produced significantly highest groundnut equivalent yield and net returns. At Junagadh, significantly highest groundnut equivalent was recorded under 100% N + 12 % P, which remained at par with 100% N + 150% P, to groundnut, and 100% RDF to wheat. At Shirgaon, application of 100% N + 150% PK to groundnut (*rabi*) and 100% RDF to rice (*kharif*) produced higher groundnut equivalent yield of groundnut-rice cropping system. At Vriddhachalam, application of 100% N + 150% PK (25:75:112.5 kg NPK/ha) to groundnut during *kharif* season followed by 100% RDF to blackgram had the highest pod yield of groundnut, net returns and BCR.

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

At Aliyarnagar, biodegradable mulch recorded the highest pod and haulm yields. At Bhubaneshwar, broad bed and furrow method recorded significantly higher pod yield and net returns compared to other methods. Similarly, application of organic mulch (7.5 t FYM/ha) produced significantly higher pod yield and net returns than other treatments. At Chintamani and Jalgaon,raised bed and furrow method and biodegradable mulch produced higher dry pod yield over rest of the treatments while at Vriddhachalam, raised bed and furrow method and plastic mulch produced higher pod yield over rest of the treatments. At Durgapura, Mohanpur and Shirgaon, broad bed and furrow method and biodegradable mulch produced maximum yield of groundnut. At Jagtial, raised bed and furrow method and organic mulch produced higher pod yield.

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

At Kadiri, mean higher pod yield was recorded with control which was comparable with 25 and 50 ppm and significantly superior over 100, 150 and 200 ppm, irrespective of time of application. At Mohanpur and Puducherry, pod yield increased with increasing concentrations of paclobutrazol and highest pod yield was recorded in the treatment with 200 ppm concentration. Double spraying at 30 and 50 DAE gave the highest pod yield as compared to single spraying either 30 or 50 DAE.

7. Evaluation of DAPG-producing fluorescent pseudomonads for enhancing nutrient use efficiency, biocontrol of soil-borne diseases and yield of groundnut

At Bhubaneshwar, FP 86 recorded significantly higher pod yield compared to otherpseudomonads. At Chintamani,application of DAPG 4 registered significantly higher yield and net returns and BCR, being at par with DAPG 2 and FP 86. Significantly least percent incidence of collar (6.13) and stem rot (5.06) was observed with *Trichodermaspp.* At Dharwad, higher dry pod yield of groundnut was obtained with DAPG 2. All the DAPG producing fluorescent pseudomonads were equally effective in controlling stem rot. At Jalgaon, application of DAPG 4produced significantly higher dry pod yield and lower incidence of collar rot (2.15) at 30 DAS,stem rot (2.96) at 30 DAS and stem rot (1.97) at

harvest. At Jagtial, DAPG-4 recorded significantly superior pod yield followed by FP 98. At Junagadh, seed inoculation of DAPG-4 producedmaximum pod and haulm yields Seed inoculation with DAPG-4, DAPG-2, DAPG-1, FP 86, FP 98 and *Trichoderma spp*. suppressed the soil-borne fungal diseases like collar rot and stem rot of groundnut. At Kadiri, DAPG 2 recorded significantly higher pod yield which was on par with FP-86, FP-98 and significantly superior over other treatments. Incidence of collar rot, dry root rot and stem rot were significantly lowest with DAPG 2 which were on par with FP-86 and FP-98 compared to other treatments. At Mohanpur, FP 86 either alone or in combination with *Trichoderma*spp showed the positive response to enhance pod yield of groundnut. At Shirgaon, application of FP 98 recorded higher pod yield which was at par with all other treatments except control. At Tirupati and Vriddhachalam, applicationof DAPG-4strain resulted in higher groundnut pod yield.

8. Studies on tank mix application of early post-emergence herbicides for efficient weed control in groundnut

At Kadiri, pod and haulm yields were higher with the application of Pendimethalin @ 1.5 kg ai/ha (PE)+ Imazethpyr (60%) + Quizalofop ethyl (40%) at 20-30 DAS. At Vriddhachalam, application of Pendimethalin @ 1.5 kg a.i/ha (PE) + one hand weeding at 25 DAS resulted in higher pod yield of groundnut.

9. Agronomic management of AVT Entries

At Dharwad, cultivar K 1641 responded to higher dose of nutrient application i.e. FYM @ 7.5 t ha^{-1}+150% RDNPK (37.5 kg N, 112.5 kg P_2O_5 and 37.5 kg K_2O ha^{-1}) and registered higher net monetary returns(` 103013 ha^{-1}) and B:C ratio(2.88). At Durgapura, genotype RG-559-3 gave significantly higher pod, haulm and kernel yields compared to genotype RG- 510 at the recommended plant spacing and fertilizer doses. At Junagadh, sowing of groundnut genotype KDG 123 or JSP 56 at 15 days prior to normal onset of monsoon with RDF produced higher pod yield.

Rabi/summer 2013-14

1. Studies on the effect of water soluble foliar grade fertilizers 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. Eight centres reported the results for rabi-summer 2013-14. 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 except Kadiri. Reduction in RDF doses from 85%, 60% and 35% recorded lower groundnut yield as compared to 100% RDF and FYM @ 7.5 t ha^{-1}.

2. Response of summer groundnut to fertilizer doses and plant population under drip fertigation and check basin methods

This experiment was initiated during *rabi*-summer 2013-14 with three different components like irrigation methods, plant density and fertilizer levels. Three centres conducted with drip irrigation, plant density and fertilizer levels whereas fourcentre reported results without drip irrigation. Plant population of 3.33 lakhs per ha (30 x 10 cm) along with application of 125% RDF proved its superiority over higher plant density and lower fertilizer levels at Aliyarnagar and Bhubaneswar while 4.00 lakh at Rahuri and 5.00 lakh at Shirgaoncentres. However cultivation of summer groundnut under drip irrigation with higher plant density (5.00 lakh/ha)

with 125% RDF and 75% RDF were found significantly superior over lower treatment levels at Jalgaon and Junagadh centres, respectively.In contrary, a non-significant difference was observed between check basin and drip irrigation methods with higher pod yield, net returns and B:C ratio under check basin method of irrigation at Vriddhachalam. Also the lower plant density (30 x 10 cm) with 125% RDF found superior over other levels for groundnut productivity.

3. Effect of mulching, hydrogel and nutrient management on productivity of summer groundnut

This experiment was also initiated *rabi*-summer 2013-14 with three major treatments namely biodegradable mulch as main treatment and application of hydrogel and fertilizer management as sub and sub-sub treatments. Total eight centres conducted the experiment during rabi-summer 2013-14. The use of biodegradable mulch (or polythene mulch) with hydrogel @ 5.0 kg ha^{-1} plus integrated nutrient management was found most effective treatment combination at all the centres with some exceptions. Like inorganic nutrient management was found better at Bhubaneswar, use of hydrogel exert non-significant effect at Jalgaon,Mohanpur, Shirgaon and Rahuri while Vriddhachalam reported higher net returns without hydrogel and use of inorganic fertilizers.

4. Fertigation in groundnut production

The experiment was initiated in *rabi*-summer 2011-12 having ten different treatment combinations including three drip-irrigation (100, 80 and 60% Etc) and three fertigation levels (100, 75 and 50% RDF at Aliyarnagar and 100, 80 and 60% RDF at Jalgaon) imposed at 1.2 m lateral spacing and 30 cm dripper distance and one control treatment of surface irrigation at 1.0 IW/CPE ratio having 5 cm irrigation depth. Application of drip irrigation once at 60% pan evaporation along with 50% RDF through fertigation was found superior and on par with drip once at 80% pan evaporation + 50% RDF through fertigation at Aliyarnagar. While application of drip irrigation at 100% of ETc with 100% RDF through water soluble fertilizers in 9 equal splits found superior at JALGAON in terms of groundnut productivity and economic return. However, the maximum WUE was recorded with drip irrigation at 60% Etc + 100% RDF through WSF in nine equal splits.

5. Evaluation of commercially available multi-micronutrient fertilizers and their economic viability in groundnut during *rabi*/summer (Soil application)

The experiment was started during *rabi*-summer 2011-12 with sixteen different treatments of different commercially available micronutrient mixtures (for soil application) including one control without micronutrient at Akola centre. Use of Multinelf 16 @ 60 kg ha^{-1} gave significantly higher pooled pod yield (3519 kg ha^{-1}) of three years over remaining micronutrient mixtures. This treatment also registered maximum net returns.

6. Evaluation of commercially available multi-micronutrient fertilizers and their economic availability in groundnut during *rabi*/summer (Foliar application)

The experiment was started during *rabi*-summer 2011-12 with sixteen different treatments of different commercially available micronutrient mixtures (for foliar application) including one control without micronutrient at Akola centre. Foliar application of Microlla @5.0 litre ha^{-1} at 30 DAS was found better in terms of groundnut productivity.

7. Agronomic management practices for advanced varietal trials (AVT) entries during *rabi*-summer

At Kadiri, JL-776 had recorded significantly higher pod yield compared to K-6. Irrigation scheduling and fertilization significantly affected the

pod yield of both the entries. Higher haulm yield was recorded with K-6 which was significantly superior over test entry. At Vriddhachalam, entry JL 776 had proved its superiority on yield attributes and yield (2438 kg/ha) over the check variety VRI 2 (2054 kg/ha).

Crop protection

Plant Pathology

Report on disease situation in farmers' fields

In *Rabi*-summer 2014 the major groundnut 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. Per cent incidences (soil-borne and virus diseases) and severity (foliar diseases) respectively were recorded. Peanut stem necrosis was recorded at Kadiri. Late leaf spot was severe at all the centers except Junagadh and Jalgaon. Rust was severe at Aliyarnagar followed by other centers except Jalgaon, Junagadh and Kadiri. Collar rot was recorded at all the centers however the disease incidence was low. Dry root rot was severe at Kadiri and incidence of stem rot was highest at Dharwad and Kadiri. The bud necrosis incidence was severe at Raichur and Kadiri in the farmers' field.

In *Kharif*2014 in *Pollachi* tract rust incidence was uptorating 8 and late leaf spot incidence was higher (7-8 rating). Collar rot incidence was 1-5% only whereas stem rot incidence was higher (10-25%).At Dharwad, foliar diseases were wide spread and noticed at all locations. Early leaf spot ranged from 2-4 ratings, late leaf spot ranged from 4-9rating while rust ranged from 3-6 rating. The variety GPBD-4 recorded low severity of foliar diseases. Stem rot incidence was ranged between 4-10% in different places surveyed. At Bhubaneswar, root rot and stem appeared in the farmers' field to an extent of 18% and 15% respectively. Late leaf spot appeared around 45-50 day after sowing. The severity of the disease varied from 3-7 and rust was much low (3-5) and it appeared around 60 day after sowing. At Hanumangarh, collar rot incidence appeared on 7th July, 2014 and maximum incidences 12-14% at 20-40 DAS, 6-8% at 40-60 DAS and 5-6% at 60-80 DAS were recorded. The root rot incidence 12-14% was observed a week before harvest of crop. Foliar fungal disease ELS 3-4 rating and late leaf spot 1-2 rating reached at a week before harvest. PBND also appeared and maximum incidence 5-6% observed at the time of harvest. In Jalgaon, the incidence of collar rot and stem rot were in range of 0 to 5% and 0 to 3% respectively at seedling stage, while LLS and rust intensity were 1-2 ratings. At pod formation stage collar rot and stem rot were in range of 1 to 4% and 1 to 8% respectively while, LLS and rust intensity were 4-7 and 1-6 rating respectively and PBND was noticed 0-2%. At pod maturity stage stem rot was in range of 0 to 6% while, LLS and rust intensity were 2-7 and 1-6 rating respectively.

At Juanagdh, LLS was observed in most of the fields in 1-5 rating, whereas a most of the fields were free from rust or with maximum severity of 1-2 rating. Most of the fields were infected with stem rot and the incidence ranged from 0.0 to 15%. At Kadiri, incidence of collar rot ranged from 3.0 to 10.0% at 30 DAS. At 60 DAS, incidence of peanut stem necrosis disease (PSND) and peanut bud necrosis disease ranged from 2.0 to 6.0% and from 0.0 to 2.0% respectively. At harvest stage, incidence of stem rot ranged from 7.0 to 12.0% and dry root rot ranged from 8.0 to 22.0% among different villages surveyed. Similarly, incidence of PSND recorded from 3.0 to 8.0 and PBND incidence ranged from 0.0 to 2.0%. Intensity of early leaf spot (ELS) and late leaf spot (LLS) were ranged from 1.0 to 3.0 rating and 5.0 to 8.0 rating respectively.At Latur, stem rot incidence was in traces. Late leaf spot severity was in the range of 30 to 40 percent and rust severity was in the range of 15 to 20 percent and PBND was noticed in traces. In Raichur, late leaf spot ranging from 4 to 7 and rust range of 3 - 5 in Yalburgataluka. The

incidence of PBND was found maximum on TMV-2 (15-18%) compared to spreading type. The stem rot ranged from 3 to 10%. At Vriddhachalam, foliar fungal diseases *viz.,Alternaria* leaf spot incidence was moderate level (Rating 4-6) at 45-65 DAS and the incidence of late leaf spot was high up to rating 9 at the time of harvest in VRI-2 and TMV-13 groundnut varieties. Rust incidence was generally low to moderate at maturity phase.

Integrated Management of late leaf spot and rust diseases

The experiment on refining integrated disease management in groundnut was conducted with eight treatments. In this experiment, *Trichoderma* was applied as seed treatment, soil application and broadcasting along with tebuconazole. At Aliyarnagar,Tebuconazole (ST) @ 1.5 g/kg + furrow application of *T. viride* @ 4kg enriched in 50 kg FYM/ha+ Broadcasting *T. viride* @ 4 kg 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 stem rot (4.1%), rust (PDI 28.9) and LLS (PDI 15.6) as compared to control (13.2%, PDI 63.7 and PDI 48.7 for stem rot, rust and LLS) respectively. At Dharwad,pooled data (over three years) indicated that the seed treatment with Tebuconazole (1.5 g / kg + three sprays of Tebuconazole (1.0 ml/L) (30, 45 and 60DAS) has resulted in significantly lowest PDI for LLS (22.97) and Rust (22.78 PDI). At Hanumangarh,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* @4.0 kg enriched with FYM @50kg/ha + Two foliar spray of Tebuconazole @1.0 ml/litre starting from initiation of foliar diseases and second spray at 15 days intervals reduced the soil borne and foliar diseases. At Jalgaonseed treatment with Tebuconazole @1.5 g/kg + furrow application of *T. viride* @4.0 kg enriched with FYM @50kg/ha + broadcasting of *T. viride* @4.0 kg enriched with FYM @50kg/ha + Two foliar spray of Tebuconazole @1.0 ml/litre starting from initiation of foliar diseases and second spray at 15 days intervals provided the effective results for management of soil borne and foliar diseases.

At Junagadh for control of collar rot and stem rot seed treatment of tebuconazole (T1, T5 & T7) was found superior in reducing collar rot as compared to the biocontrol agents. At Raichurseed treatment with *Tebuconazole* @ 1.5 g//kg seed + furrow application of *Trichoderma* sp.@ 4 kg enriched with 50kg FYM/ha + Broadcasting of *Trichoderma sp* @4 kg enriched in 50 kg FYM/ ha at 40 DAS + Two sprays of *Tebuconazole* @ 1ml/lit starting from initiation of foliar diseases and second spray at 15 days interval had significantly superior impact on reducing the soil bore, air born diseases and boosting pod yield, seed yield and shelling percentage. At Vridhachalam,seed treatment with Tebuconazole 1.5g/kg seed + furrow application of *T. viride* @4kg enriched in 50kg FYM /ha+ broadcasting *T.viride*4kgenriched in 50kg FYM/ha at 40DAS+ two spray of Tebuconazole @1ml/l was found to be the best in reducing the severity of collar rot, root rot, stem rot, foliar diseases *viz* LLS and rust. The maximum pod yield of 2035 kg/ha was obtained from the treatment (T7).

Disease Management through organic practices for organic groundnut cultivation

At Aliyarnagar, the highest income (Rs. 93202) and ICBR (1:11.48) was obtained where mancozeb was applied as seed treatment and hexaconazole as spray followed by *Trichoderma* as seed and soil treatments (Rs. 82801; ICBR 1: 4.26) for managing foliar diseases of groundnut.Based on the efficacy of fungicides, yield and ICBR, it is concluded that seed treatment with mancozeb followed by two sprays of hexaconazole along with the application of recommended fertilizers (12.5N:25P) was very

effective and economical in managing groundnut diseases, giving better yield as compared to the application of FYM and biological control agents (organic farming). However, those farmers who are interested in organic farming and organic management can apply FYM in place of NPK and *Trichoderma viride* as seed treatment @10 g/kg seed and in furrow @ 4.0 kg enriched in 250 kg FYM to realize higher income. But, for the better management of foliar diseases, fungicide hexaconazole is essential as it reduces the development of inoculum and further spreading of the diseases. Therefore, it is also concluded that although organic farming could reduce the soil borne diseases to some extent it could not manage the foliar diseases of groundnut.

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

In *Rabi*-summer 2014 at Junagadh, no *Aspergillus flavus* colonies observed in the soil before sowing of *rabi*crops and summer groundnut and after harvesting of *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. At Kadiri, presence of *A. flavus* was detected in the soil before sowing and after harvest of the crop and ranged from 0.8 X10^3 to 2.8 X 10^3 and from 0.5 X 10^3 to 2.5 X 10^3 colony forming units/gram soil before sowing and after harvest of the crop respectively. Lowest population of *A. flavus* was recorded by the treatment T1 (Groundnut in *kharif* and onion in *rabi*) and T2 (Groundnut in *kharif*and jowar in *rabi*) while incidence *of A. flavus* was very meagre both at 20 DAS and at harvest stage as it ranged from 0.6 to 2.2 % in the treatments T4 and T6. Per cent seed and pod infection of *A. flavus* ranged from 10.7 % to 14.7 % and from 10.3 % to 15.0 % in T4 (Groundnut in *kharif* followed by groundnut in *rabi*) and T6 (Fallow in *kharif* followed by groundnut in *rabi*) treatments respectively. At Raichur, maximum mean population of *Aspergillus* was 18.3X10^3 in treatment T4 (Groundnut – Groundnut) and T6 (Fallow- Groundnut). The least population 12.0X10^3 was found in treatment T3 (Groundnut – Maize) followed by 13.3X10^3 in treatment T2 (Groundnut – Sorghum). The estimation of *Aspergillus*after harvest of the crop showed minimum population in treatment T2 4.7X10^3 (Groundnut –Sorghum) followed by treatment T3 5.0X10^3 (Groundnut –Maize). Highest 15.3X10^3 was noted in treatment T4 (Groundnut – Groundnut). The results indicates that both sorghum and maize are effective in reducing *Aspergillus* population in soil and there after the aflatoxin contamination. In case of pod infection (1.83%) and seed infection (6.92%) it was again lowest in T3 and T2 (2.1 & 5.32% respectively).

In *Kharif* 2014 at Junagadhthere was no *Aspergillus flavus* colonies observed in the soil before sowing groundnut in *kharif.* However, after harvesting of groundnut crop, a very few colonies were observed in the soil where wheat - groundnut cropping sequence was followed. There was very few colonization and infection of *A. flavus* in pods/seeds collected at the time of harvesting in all the cropping sequence. At Kadiri,*A. flavus* was very meager as it ranged from 0.5 to 1.0% and from 0.2 to 0.5 % at 20 DAS and at harvest stage of the crop respectively. *A. flavus* population ranged from 3.0 X10 ^{3} to 5.0 X 10^3 and from 3.7 X10 ^{3} to 6.0 X 10^3 colony forming units /gram soil at before sowing and after harvest of the crop respectively. Lowest population of *A. flavus* in soil (3.7 X10 ^{3}) was recorded by the treatment T6 (fallow in *kharif* - groundnut in *rabi*). However, differences obtained in between treatments were non-significant. Per cent seed and pod infection of *A. flavus* ranged from 11.1 to 27.8% and 11.1 to 26.7% respectively. Less seed infection was recorded by the treatment T5 (groundnut in *kharif* followed by fallow in *rabi*).

But, at par with T1 and T6. Incidence of *Aspergillus flavus* is very meager in the fixed plot. However, presence of *A. flavus* in soil, pod and seed was detected in all the treatments. Soil population, seed and pod infection of *A. flavus* was decreased in soil by keeping fallow the land either in *kharif*or *rabi* or by crop rotation with onion/jowar/ maize. High pod yield was obtained by practicing groundnut in *kharif* followed by fallow in *rabi* (T5) and by crop rotation with onion (T1). At Raichur,The estimation of *Aspergillus* population before sowing by dilution plate count showed maximum mean population of $8.67X10^3$ in treatment T7 (Groundnut – rice/wheat). The least population $5.33X10^3$ was found in treatment T2 (Groundnut – Sorghum) followed by $6.67X10^3$ in treatment T3 (Groundnut – maize). The estimation of *Aspergillus*after harvest of the crop showed minimum population in treatment T3 $8.33X10^3$ (Groundnut – Maize) followed by treatment T2 $8.67X10^3$ (Groundnut –Sorghum). Highest $11.67X10^3$ was noted in treatment T4 (Groundnut – Groundnut). The results indicates that both sorghum and maize are effective in reducing *Aspergillus* population in soil and there after the aflatoxin contamination. In case of pod infection (2.0%) and seed infection (6.67%) it was again lowest in T2 followed by T3.

Management of *Alternaria* blight of groundnut

In *Rabi*-summer 2014 atJAU, Junagadh, The observation on disease intensity taken at harvest stage indicated that difenconazole was superior as compared to the other treatments in reducing Alternaria blight followed by mancozebalthough there was no significant difference between the fungicidal treatments. Though the overall development of Alternaria leaf blight was low in this trial, all the treatments were significantly superior in reducing Alternaria leaf blight as compared to the control.

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

In *Rabi*-summer 2014 atAliyarnagar, sick plot is maintained continuously with addition of inoculum through mass culturing of *S. rolfsii* (sand maize medium and sorghum grain) susceptible variety TMV 7 is being used for maintaining stem rot infection. At Junagadh, *S. rolfsii*culture multiplied in Sorghum Sand Media and was added in the plot during *kharif* and susceptible variety GG 6 is being used for maintaining stem rot infection. At Kadiri,sclerotial bodies of *S. rolfsii* were obtained using sterilized jowar grains and groundnut haulms and making the soil sick with *S. rolfsii* culture is in progress. Intensity of *S. rolfsii* was increased from 3.0×10^{-3} to 6×10^{-3} CFU/g soiltowards harvest stage.

Integrated management of PBND in groundnut

In *Rabi*-summer 2014, atJalgaon, the lowest thrips damage per cent was observed in module-III (6.98%) and the PBND incidence was observed in the range of 2.91 to 4.00 % among the modules. After spraying of respective insecticides the lowest PBND incidence was observed in module-III (1.46%). At Kadiri, both PBND and thrips damage were reduced significantly by adopting practices of module followed by module II and thrips damage per cent ranged from 13.2 to 38.0 % in all the modules at 20 DAS (before 1st spray). Significantly less per cent damage (13.2 %) was recorded in the module III followed by module II and module I. Pooled results (2011-13) showed significant reduction of both thrips damage and PBND was recorded by the module III with high ICBR of 2.5.AtRaichur,Module III had lowest incidence of PBND (7.52%) at 15 days after second spray, highest pod yield and haulm yield. The seed treatment with Gaucho helped to maintain more plant population than Imidacloprid treatment. The systemic insecticide with higher concentration acted for long time against the vectors of PBND compared to the lower dosage in MII.

Entomology

Insect pests and natural enemies recorded at various centers

- In Rabi- Summer, 2014, the major pests recorded were thrips, leafhoppers, *Spodoptera* and leafminer. The minor pests include aphids, whiteflies, *Anarsiaephippias* and red spider mites.
- *In Kharif*, 2014, the major sucking pests were thrips, leafhoppers, and occasionally aphidswere recorded. Amongst lepidopterous pests, *Spodoptera,* leafminer, *Helicoverpa* were observed.

Monitoring of *Spodoptera*, leafminer and sucking pests of groundnut using traps

In Rabi- Summer, 2014,The occurrence of *Spodoptera*, leafminer and sucking pests were monitored at Dharwad, Jagtial, Jalgaon, Junagadh, Kadiri, Latur, Mohanpur, Pavagada, Raichur, Tirupati and Vridhachalam. The peak incidence of sucking pests (thrips and leafhoppers)was observed during 16th and 17th standard weeks. The peak incidence of *Spodoptera*and leafminer was noticed at 43rd, 52nd, 5th, 9th, 10thand 17thand 14th and 17thstandard weeks, respectively.

In Kharif, 2014,The occurrence of *Spodoptera*, leafminer and sucking pests were monitored at Dharwad, Jagtial, Jalgaon, Junagadh, Kadiri, Latur, Mohanpur, Pavagada, Raichur, Tirupati and Vridhachalam.The peak incidence of *Spodoptera*at various locations was noticed from 32nd to 39th standard weeks. Leafminer peaks were only reported at Kadiri and Pavagada and these were observed during 44th& 45th and 41st& 43rd, respectively.

Evaluation of new seed treatment formulations in groundnut for managing sucking pests

In Rabi- Summer, 2014,New seed treatment formulations were evaluated for sucking pests at Dharwad, Jagtial, Jalgaon, Junagadh, Kadiri, Latur, Mohanpur, Pavagada, Raichur, Tirupati and Vridhachalam. In all the centers the seed treatments were found effective than the treated and untreated controls. Seed treatment with either imidacloprid 600 FS @ 2 ml/kg seed or thiamethoxam 30 FS @ 2 ml/kg seed were found effective in protecting the groundnut crop from sucking pests infestation.

In Kharif, 2014,Seed treatment with either imidacloprid 600 FS @ 2 ml/kg seed or thiamethoxam 30 FS @ 2 ml/kg seed were found effective in protecting the groundnut crop from sucking pests infestation.

Monitoring of groundnut Bruchid beetle, *Caryedonserratus* in storage using TNAU Two-in-one Model insect-trap

In Rabi- Summer, 2014,Bruchid populations were monitored in storage condition at Dharwad, Jalgaon, Junagadh, Kadiri, Latur, Pavagada, Raichur, Tirupati and Vridhachalam. TNAU two in one model insect trap was found effective in trapping adults followed by pupae and grubs

In Kharif, 2014,TNAU two in one model insect trap was found effective in trapping adults followed by pupae and grubs.

Evaluation of chemicals against the groundnut Bruchid beetle, *Caryedonserratus* in storage

In Rabi- Summer, 2014,Safe insecticides were evaluated for efficacy against groundnut bruchids at Dharwad, Jalgaon, Kadiri and Raichur. Among the various insecticides tested for efficacy against groundnut bruchids, spraying of deltamethrin2.5 SC@ 0.5 ml/1 ton the storage bags was found effective followed by spinosad 45 SC@ 0.3 ml/lt and malathion 50 EC @ 5 ml/lt.

Evaluation of different storage structures and bags against the groundnut Bruchid beetle, *Caryedonserratus* in storage

Storage structures/bags were evaluated for efficacy against groundnut bruchids at Jalgaon, Junagadh, Tirupati, Raichur and Vridhachalam. Among the different storage structures/bags, the high density polythene (HDPE) bags was found effective followed by polythene layered gunny bag and fertilizer bag in reducing the bruchid infestation and damage in stored groundnut.

Studies on virus vector relationship of thrips fauna and PSND/PBND incidence in groundnut

In Rabi- Summer, 2014,Population of *Scirtothripsdorsalis* and *Frakliniellaschultzei* was recorded at every 30, 40, 50, and 60 DAS and percentage pod damage and PBND and PSND was also recorded. *Scirtothripsdorsalis* population was more when compared to *Frakliniellaschultzei* population at Kadiri whereas at Pavagada, the thrips population ranged from 0.3 to 4.9 thrips per plant. However percent peanut bud necrosis plants ranged from 0.45 to 1.6.

EXTERNALLY FUNDED PROJECTS

1. ALL INDIA NETWORK PROJECT ON SOIL BIODIVERSITY-BIOFERTILIZERS (PI: K.K. PAL, CO-PI: R. DEY)

Funding agency: ICAR, New Delhi
Duration: 01.04.2014 till 31.03.2017
Fund: ₹ 31.00 Lakhs

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 multiple plant growth promoting and DAPG-producing fluorescent pseudomonads, besides capable of suppressing soil-borne fungal pathogens like *A. niger*, *A. flavus* and *S. rolfsii* improved plant growth and biomass in most of the cases significantly over uninoculated control at harvest during summer 2014. Application of *P. putida* DAPG6 and *P. fluorescens* FP98 enhanced the pod yield (15.6% by DAPG6, 2213 kg/ha; and 14.8% by FP98, 2198 kg/ha) and haulm yield, shelling out turn, nodule number, root and shoot length, plant biomass at 45 and 90 DAS, and HSM significantly over uninoculated control (pod yield of 1915 kg/ha) at harvest with cultivar TG37A. However, in *kharif* 2014 application of *P. putida* DAPG1, *P. putida* DAPG4, and *P. fluorescens* FP98 resulted in significant enhancement in pod yield (9.5 – 11%) of groundnut cultivar TG37A, the maximum pod yield being obtained in the treatment with FP98 (3283 kg/ha) as compared to uninoculated control (2957 kg/ha).
- To make soils naturally suppressive to soil-borne fungal pathogens like *Sclerotium rolfsii* causing stem rot in groundnut, DAPG-producing fluorescent pseudomonads, highly antagonistic to *S. rolfsii*, were applied and evaluated with the susceptible cultivar GG20. Application of the DAPG-producing fluorescent pseudomonads suppressed the seedling mortality of groundnut, cultivar GG20 from 82% in pathogen control to 23-31% in treatments inoculated with different DAPG-producing fluorescent pseudomonads. Moreover, application of *Pseudomonas* sp. FP46, *P. putida* FP86, *P. fluorescens* FP93, *P. putida* FP121, *P. monteilli* FP133 and *P. fluorescens* FP98 significantly improved the pod yield of groundnut, cultivar GG20 during *kharif* 2014. The enhancement in yield ranged from 10 to 16%, the maximum was with the inoculation of FP133 (2909 kg/ha as compared to uninoculated control, 2512 kg/ha). These DAPG-producing fluorescent pseudomonads have also been evaluated during *kharif* 2014 at different AICRP(G) centres throughout the country.

2. EXPLORING THE DIVERSITY OF EXTREME HALOPHILES BY FUNCTIONAL AND COMPARATIVE GENOMICS FOR ISOLATING NOVEL GENES AND ALLELES FOR AFFORDING SALINITY TOLERANCE TO CROP PLANTS (PI: K.K. PAL, CO-PI: R. DEY)

Funding agency: ICAR through AMAAS project
Duration: 01.04.2014 till 31.03.2017
Fund: ₹40.00 Lakhs

Objectives

- To understand the biochemical and molecular bases of osmoadaptation and osmoregulatory mechanisms of selected extreme halophilic bacilli, archaea and fungi on evolutionary perspective
- To identify candidate gene(s) having relevance to salinity tolerance for future exploitation in development of crops tolerant to salinity

Achievements

- To explore the diversity of the extreme halophiles of the Rann of Kutch for isolation of genes and alleles for affording salinity tolerance to crop plants, multi-pronged strategies have been adopted including clues from genomes, metagenomes, transcripts and differentially expressed proteins. From the three metagenome data, predominance of archaea was noticed along with the over expression of Serine-Glyoxalate cycle and or the intermediates and enzymes of it.
- Analysis of intra-cellular solutes indicated the enhanced level of production and accumulation of alanine and leucine at 20% NaCl concentration and histidine and tyrosine at 30% NaCl concentration in *Haloferax volcanii* H1-DGR against base level of 10% NaCl stress in growth medium.
- From differentially expressed transcripts and proteins, it was evident that many hypothetical proteins and or transcripts have been expressed while imparting osmotolerance in *Haloferax volcanii* H1-DGR.
- To understand the mechanisms of osmotolerance on evolutionary perspectives and isolation of relevant genes, genome of a novel haloarchaeon, 3A1-DGR (2890613 bp; tolerance to NaCl 10-35%), has been completely sequenced and annotated besides the first complete genome of the genus *Virgibacillus* sp. MSP4-1 (3333438 bp; tolerance to NaCl 8-23.5%).

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

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

Funding agency: ICAR through NFBSFARA
Duration: 01.06.2011-31.05.2016
Total fund: ₹ 249.2690 Lakhs

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

- Application of endophyte like *Bacillus endophyticus* REN51N resulted in 20.5% increase in pod yield at 3EC of irrigation water during *kharif* 2014. In a separate experiment, application of *Pseudoxanthomonas mexicana* REN47 resulted in enhancement of yield of groundnut by 17.5% over uninoculated control at 4 EC irrigation water.
- Genome of two bacterial endophytes, *Bacillus endophyticus* REN51N (NCBI Acc. No. JXAB01000000) and *Micrococcus luteus* SEN31 (NCBI Acc. No. JXAR01000000) have been sequenced to understand the evolution and interaction of these endophytes with groundnut/groundnut genome.

4. ROLE OF ARCHAEBACTERIA 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

- 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.
- In vitro seedling bioassay with groundnut (cultivar GG2) resulted in improved root length and secondary roots by inoculation of *Haloarcula* sp. ARC4, *Haloarcula* sp. ARC6 and Haloarchaeon ARC 16 at 25, 50 and 75 mM of NaCl.
- Majority of the archaebacterial isolates could tolerate NaCl (~12.5-23.5%) and 45-50°C and also produced siderophore, solubilize phosphates and IAA like substances.
- 20 fluorescent pseudomonads could tolerate 5-12.5% NaCl in growth medium and five of them improved the root and shoot length of *Sporobolous marginata* in in vitro seedling bioassay.

5. 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

I. Genotyping of BC_3 plants from MABC for High O/L content using allele specific markers to aid further backcrosses.

Cross: ICGV 06100 x SunOleic 95R

- Three plants were found to be homozygous positive for both mutations in BC_2F_1 generation.
- These lines were advanced to BC_2F_2 in which twenty lines were double mutants.
- BC_2F_1 backcrossed to derive BC_3F_1 plant population. Among 100 $BC_3F_{1:2}$ plants, 39 plants were found double mutants.
- Further, these plants will be analyzed by CAPS assay to screen homozygous double mutants.

Cross: ICGV-06420 xSunOleic95R

- One plant was found to be homozygous positive for both mutations in BC_2F_1 generation and was advance to BC_2F_2 generation.
- BC_2F_1 backcrossed to derive BC_3F_1 plant population. Among 28 $BC_3F_{1:2}$ plants, 10 plants

were found double mutants.

- Further, these plants will be analyzed by CAPS assay to screen homozygous double mutants.

Cross: ICGV-05155 x SunOleic95R

- One plant was found to be homozygous positive for both mutations in BC_2F_1 generation and was advance to BC_2F_2 generation.
- BC_2F_1 backcrossed to derive BC_3F_1 plant population. Among 29 $BC_3F_{1:2}$ plants, 14 plants were found double mutants.
- Further, these plants will be analyzed by CAPS assay to screen homozygous double mutants.

II. Marker polymorphism survey in the high oil genotypes

Cross 1: ICGV 98432 x ICGV 07166

- Lines of $F_{4:5}$ populations were assayed by SSR to Screen Male type progenies. Out of which 45 were found to be male type.

Cross 2: ICGV 06188 x ICGV 07229

- In $F_{3:4}$ population 23 lines were analyzed, out of which 6 line were found to be positive. These 6 lines were then individually analyzed in which 89 plants were screened and 48 male type progenies were found.
- Forty-eight lines of $F_{4:5}$ populations were assayed by SSR to screen Male type progenies. Out of which 45 were found to be male type.

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

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

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

Phenotying of Groundnut Genotypes for Resistance to Sclerotium Stem Rot

- Thirty groundnut genotypes *viz.*, inter-specific crosses, registered genotypes, and released varieties including highly susceptible genotype were selected for phenotyping to stem rot in the temperature and humidity controlled P II glass house. Among these, CS19, CS85 and CS319 were found resistant to stem rot. A positive correlation was found between the thickness of the stem and disease resistance.

Methods of inoculation for screening against *Sclerotium rolfsii*

- Among different methods of inoculation for screening against *S. rolfsii viz.*, inoculation sclerotia on the soil surface, mixing sclerotia with the soil @ 1 viable sclerotia/g soil, applying of *S. rolfsii* multiplied on sorghum grains on the top 5cm of the soil or mixing with the soil @ 2g/ kg soil, applying of the fungus multiplied on sorghum grains around stem region @ 0.5 g along with wheat straw as substrate at different growth stages of the groundnut, the later one was found effective for screening. Seed rot and seedling rot were not encounter in this method and all the genotypes got chances for the attachment with pathogen.

Screening of the primers for parental polymorphism

- Five parents *viz.*, JSP39, CS85, CS319

(resistant), GG20 and TG 37A (Susceptible) were used for parental polymorphism survey using >700 SSR primer pairs. Of which only 18, 16 and 13 primers were found polymorphic between GG20 and JSP39, TG37A and CS85, and TG37A and CS319 parental combinations respectively.

Genotyping and Phenotyping of the F_5 population of the RIL-1 (GG20 x JSP39)

- The plants were grown under controlled conditions in the greenhouse and DNA was isolated from 331 RILs (in two replications) and its parents. RILs in F_5 generation along with its parents were sown on 03 February, 2014 in the greenhouse and DNA is isolated for further screening. A total of 377 plants of RIL-1 along with the parents were used for the phenotyping and data on parameters like wilting (%), node symptoms, pot surface area covered with the mycelia (%), number of branches, stem-hairiness, stem-thickness, stem-damage, number of nodes were recorded. It was observed that almost 50% of the RILs were completely dead within seven days of the infection in both the replications. After 17 days of infection none of the RIL survived.

Anatomical analysis of the RILs and parents

- The mainstem thickness and thickness of the branches were measured in the 16 genotypes. It was assumed that stem thickness is responsible for imparting resistance to the disease. The resistant source, CS319 was having stem thickness of 2.1 to 2.6 mm compared to the susceptible cultivar, GG20 having stem thickness 0.7 to 1.6 mm at harvest. To establish a correlation, if any, several hand cut sections were prepared. However, we could not establish the mode of mycelial penetrations to the cells.

New crosses and *screening under Sick plot and P II glasshouse*

- Two crosses *viz*., TG 37A x CS85 and TG37A x CS319 were attempted during *kharif* 2013 for F_2 mapping and also for the development of new RIL population. During *kharif* 2014 a total of 331 RILs were grown both under PII glasshouse and in a sick plot for further screening. The inoculum load was maintained by adding *S. rolfsii* multiplied on autoclaved sorghum grains at regular interval of one month under field conditions. The data on disease incidence (in %) was recorded. Same RILs were also sent to IARI, New Delhi and BCKV, WB for multi-location testing. The inoculum load was recorded both before and after the harvest of crop in sick plot. Physiological characters like number of nodes, primary branches, secondary branches, main stem thickness, etc were recorded. A total of 121 putative F_1s derived from the cross (TG 37A x CS85) were first confirmed using polymorphic primers and 94 confirmed $F_{1's}$ were forwarded for the generation of $F_{2's}$. A total of 430 F_2s were planted in plastic cups under controlled conditions and were infected with *S. rolfsii* was multiplied on autoclaved sorghum grains for 15 days and used for inoculation @ 20g per pot on 40 days old plants. Genotyping of F_2 mapping population is underway using polymorphic SSR primers. Another set of 400 F_2s were planted under field conditions and seeds of individual plants were harvested ($F_{2:3}$) so as to develop RILs.

Survey of Bhuj district of Gujarat

- During October, 2014 survey of Bhuj district was conducted for assessing the disease severity of stem rot. While interacting with the local progressive farmers of that area, we found that the problem of stem-rot is not very alarming and are localized to some fields only. It was found that

GG 6 is the variety grown by most of the farmers. The disease severity was recorded to the tune of 1-2%. Both soil and plant samples were collected from both stem-rot infected and non-infected groundnut fields and further analysis is in progress. Other data like GPS, cropping pattern and variety grown were also recorded.

7. 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 Board, DST, New Delhi
Duration: 2013-2016
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 Δ12 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:

Fatty acid profiling of groundnut varieties

- Fatty profiling was done for the 176 released varieties, in which 8 major fatty acids palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2), arachidic acid (C20:0), gadoleic acid (C20:1), behenic acid (C22:0) and lignoceric acid (C24:0) were clearly detected. However, myristic acid (C14:0), linolenic acid (C18:3) and erucic acid (C22:1) were also detected in some varieties. Highest oleic acid content was recorded in TMV 10 (66.57%) while MH 1 had lowest 37.87%. In case of linoleic acid, GJG 22 has lowest 17.41% and ICGS1 highest 40.92%. Among the varieties carrying the *ahFAD2A* mutant allele, the oleic acid ranged from 41.16% to 66.57% with a mean of 55.91%. However, non mutant varieties had mean oleic acid content of 43.85%. The varieties having substitution mutation in *FAD2A* allele (81) and wild type *FAD2A* allele (93) had average O/L ratio of 2.20 and 1.26 respectively. This means even a single gene mutation can also lead to significant increase in the O/L ratio.

Identification of SNPs in the *ahFAD2* gene(s) in selected cultivars

PCR product sequencing (Primer designing and variety selection)

- Primers were designed to amplify full length *FAD2* gene. Accession >gi|307697073|gb|HM359250.1| *Arachis hypogaea* var. hirsuta oleate desaturase (FAD2A) gene, complete cds sequence and primer3 a online tool used to design and analyze primers for PCR. A total of 30 varieties representing high, medium and low O/L ratio were selected.

PCR Amplification and Purification of PCR Product from Agarose Gel

- PCR amplification was carried out in triplicates for each sample of total reaction volume 20ul. The PCR products were electrophoresed through a 1.2% agarose gel. Excised specific band (1148-bp) and purified using QIAquick gel extraction kits (QIAGEN) according to the manufacturer's protocol. About 50 ng/µl vaccum dried samples were sent to SciGenom Labs for sequencing.

Cloning and Sequencing of FAD2 gene

- The purified *FAD2* gene PCR products from all the 30 varieties were cloned using the pGEM®-T

Easy cloning kit (Promega). The PCR products were ligated to pGEM®-T easy vector with T_4 DNA ligase at 4 °C overnight. Transformations were carried out via conventional heat shock method into competent E. coli (X_1 blue) cloning cell. Selection for transformed cell was done on LB/ampicillin/IPTG/X-Gal plates. LB agar plates containing ampicillin (100 µg/ml LB agar) as a selection marker while, IPTG (50 µM) and X-gal (80 µg/ml) for blue/white screening of recombinant colonies were spread before plating of transformed mixture on LB agar plates containing ampicillin. Positive colonies identified with vector specific i.e. SP6 and T7 as well as gene specific primers. Positive colonies were grown overnight and plasmid DNA was isolated using QIAgene kit. Data analysis in under progress.

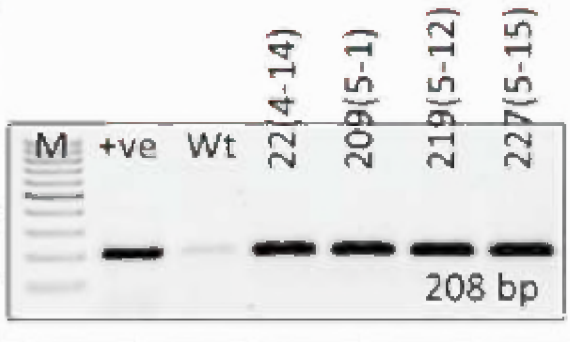


Fig. PCR amplification of TSV-CP gene from representative transgenic plants of all four events with primer pair 1900.IDT and 1901.IDT. Lane M contains 100 bp ladder, +ve lane have PCR amplified product from expression vector construct, Wt is the non-transformed plants and –ve lane represents PCR product without any template DNA.

Fig. Partial restriction digestion analysis of PCR product with HindIII restriction enzyme. After digestion, 208 bp PCR product produced two fragments of 135 and 73 bp, respectively

8. EVALUATION OF TRANSGENIC GROUNDNUT WITH RESISTANCE TO BUD AND STEM NECROSIS VIRUSES (PI: RADHAKRISHNAN T., CO-PI: PP THIRUMALAISAMY)

Funding Agency: DBT, New Delhi
Duration: 2014-2015 (Initially for one year)
Total Funds: ₹27.196 Lakhs

Objective

- Validation of the transgenic events with coat protein jnucleocapsid gene(s) of GBNV, TSV or both already produced by us for the expression of the transgene.

Achievements

- Four events of the *TSV-CP* transgenic groundnut plants (event no. 22, 209, 219 and 227) were were screened for the presence of *TSV-CP*gene through PCR. Genomic DNA was used for PCR reaction using gene specific primers:

Isolation of RNA, cDNA synthesis and Real-Time Quantitative PCR analysis

- Total RNA were isolated from transgenic plants of two events (227 and 209) and cDNA were prepared using First Strand cDNA synthesis kit (Thermo Scientific, USA). These cDNAs were used for Real Time Quantitative PCR. The 18s gene was used as internal control and the primers used in the experiments are IDT.1011 F and IDT.1011 R for *TSV-CP* (69 bp amplicon) and IDT.1043 F and IDT.1043 R for 18s (118 bp amplicon).

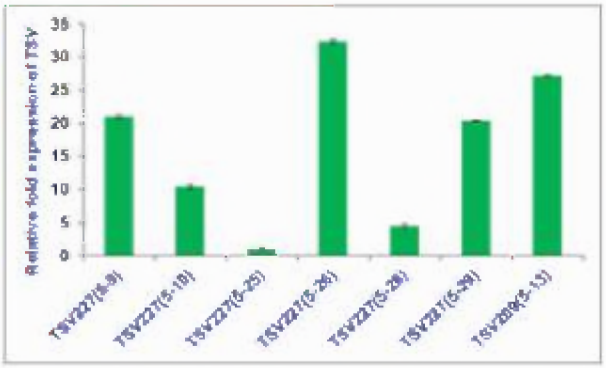


Fig. Relative fold expression of TSV-CP in transgenic plants. The 18s gene was used as internal control. Primer pairs used were IDT.1011 F and IDT.1011 R for TSV-CP (69 bp amplicon) and IDT.1043 F and IDT.1043 R for 18s (118 bp amplicon). The least expressing event TSV227(5-10) was considered as calibrator and level of TSV expression in other events were calculated relative to TSV227(5-10).

9. 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*, CS19 and GG20 with RAPD and SSR markers
- Development of F_1 mapping populations of GG 20 x CS 19
- Development of BCrFr GG 20 x CS 19
- Screening of Fl progenies for stem rot resistance under artificially inoculated condition
- RAPD and SSR analysis of Fz progenies with polymorphic primers
- Identification of markers for resistance to stem rot
- MABC to transfer the resistance gene in to GG 20

Achievements

- Resistant (CS-19 and NRCGCS-319) and susceptible parents (GG-20, TMV-2) and wild *Arachis* donor (*A. diogoi*) were screened with 2000 SSRs.
- Out of 2000 SSRs, 400 were found polymorphic between parents.
- True F_1 hybrids from the crosses GG-20 x CS-19 and GG-20 x NRCGCS-319 were confirmed with the help of polymorphic primers and single plant progenies were advanced to F_{2-3} generation.
- Phenotypying of F_{2-3} progenies has been done under artificially inoculated field conditions as per the protocols optimized by the PI.
- Genotyping of F_{2-3}progenies with 400 polymorphic SSRs is in progress.

10.SYNTHESIS, VALIDATION AND POPULARIZATION OF INTEGRATED PEST MANAGEMENT TECHNOLOGY FOR GROUNDNUT CROP

(CCPIS: K.S. JADON AND POONAM JASROTIA)

Funding Agency: ICAR-NCIPM, New Delhi
Duration: 2013-2018
Total Fund: ₹11.0 Lakhs

Objectives

- Development of location specific integrated pest management technology for groundnut crop. • Validation of integrated pest management technology for groundnut crop
- on the farmers' fields with farmers' participatory approach.
- Popularization of the IPM technology.

Activities and achievements

- A total of five different IPDM modules were synthesized for the management of pathogens and insect-pests in groundnut including farmer practices after reviewing the literature and available resources/ technologies.
- The IPDM modules comprised cultural,

biological and chemical practices for the management of pathogens and insect-pests in groundnut
- The validation trials were successfully conducted in *Kharif* 2013, *Rabi*-summer2014 and *Kharif* 2014. The *Rabi*-summer 2015 trial has already sown in January, 2015 and observations being taken on incidence of insect-pests and diseases.

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

(PI: P. P. THIRUMALAISAMY, COPIS: KULDEEP SINGH JADON, SUJIT KUMAR BISHI* AND J. B. MISRA)**

* Scientist on study leave from July 2012; ** Retired from August 2014

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

Fund: ₹74.2 Lakhs

Objectives
- 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
- To impart capacity building in sampling and analytical methods

Achievements
- Precleaning of farmers stock and storing in high density polythene bags in the processing industries reduce the chances of aflatoxin contamination and storage insect pests (Bruchid and Corcyra) damage.
- In the pods, moisture content above 7.1 and kernel moisture content above 6.9 supports the fungal growth that leads to aflatoxin contamination 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%).
- Two decorticator blades were designed and tested for its shelling efficiency and split ration. The blade having slightly curved and tilted edges have high shelling efficiency (90% and above) for the variety Girnar 2 and GG 20 and less than 4% split ratio.

12. AGRICULTURE FOR NUTRITION AND HEALTH (CRP 4)

(CCPI: P.P. THIRUMALAISAMY)

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

Duration: 1.10.2012 to 31.12.2015

Fund: ₹10 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 100 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 0.45 x10^3 cfu/g soil to 33.5 x10^3 cfu/g soil in the district of Rajkot, Junagadh, Jamnagar, Amreli and Porbander.
- In 2014 *kharif* groundnut, infection of *A. flavus* on pods was more compared to kernels.
- Primary survey was done for the collection of data regarding awareness of aflatoxin, good agricultural practices, adoption of crop rotation etc from 100 farmers in the district of Rajkot, Junagadh, Jamnagar, Amreli and Porbander.

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

(CCPI: P.P. THIRUMALAISAMY, COPIs: POONAM JASROTIA AND HARISH G*)

* Scientist on study leave from July 2013

Funding agency: Indian Council of Agricultural Research, New Delhi

Duration: From October 2011 to March, 2017

Fund: ₹5.00 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 2014, total of 1276mm rainfall was received 41 rainy days
- The pest situation *viz.*, aphids, jassids and defoliators in 2014 were similar to the occurrence in 2011 and 2013. The thrips damage occurred in early as well as at harvest stage of the crop. The rare occurrence of thrips damage in maturity period was due to prevalence of high temperature in day time and no rain in this period.
- The changes in disease situation was evidenced in rust where the disease severity was low (mean disease severity below 30%) compared to previous years (above 50%) due to low amount of rain fall in the maturity period (after 70 days) not supported the further development of rust.
- There were no changes in the occurrence and severity of *tikka* disease, and incidence of stem rot, collar rot diseases.

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

(NODAL OFFICER: DR CHUNI LAL; CO-NODAL OFFICER: DR NARENDRA KUMAR)

Summary

- Seed production of DGR varieties 'Girnar 2' and 'Girnar 3' and BARC variety 'TG 37A' was taken up in summer 2014 and *kharif* 2014.
- To make up for the production deficits of *kharif* season, compensatory seed production was taken up in summer 2015 season.
- A total 5.8 q breeder seed of 'Girnar 3' was sold to Odisha which generated a revenue of ` 58000/-

In summer 2014, an area of 3.6 ha was sown to produce breeder seed and nucleus seed of DGR varieties Girnar 2 and Girnar 3 and a production of 9.65 q seed was achieved. In addition, 0.40 ha was sown for production of TFL seed of variety TG 37A and 4.20 q seed was produced (Table 1). In *kharif* 2014, seed production of 'Girnar 2' variety was taken up in 3.0 ha; and that of 'Girnar 3' in 3.5 ha. The production realized was 4.85 q nucleus seed and 7.00 q breeder seed of 'Girnar 2', and 5.1 q nucleus seed and 18.0 q breeder seed of Girnar 3 (Table 1). In addition, production of TFL seed of TG 37A variety

was taken up in 0.4 ha which resulted in 3.6 q TFL seed. Compensatory seed production programme of three varieties 'Girnar 2', 'Girnar 3' and 'TG 37A' was taken up in summer 2015 in 3.0 ha to produce seed of different classes (nucleus, breeder and truthfully labeled) of these varieties.

A total 5.8 q breeder seed of 'Girnar 3' was sold to Odisha which generated a revenue of ₹ 58000/-. Two trainings for groundnut farmers comprising of 57 farmers were organized to provide technical knowhow to them for enhancing quality of farm saved groundnut seed (Fig. 1 and Fig.2). An expenditure of ₹ 400628.00/- was incurred under this project of annual budget of ₹ 4.5 lakhs received from the Directorate of Seed Research, Mau during the period under report (1.4.2012-31.3.2013) (Table 1). In addition the entire budget (₹ 3.0 lakhs) received under the Tribal Sub Plan was provided to ATMA NGO in Khargone region of Madhya Pradesh for its utilization for tribal farmers for seed production in groundnut crop.

Table 1: Seed of different classes and varieties produced in summer 2014 and *kharif* 2014 seasons

Variety	Seed Produced (q)		
	Breeder Seed	Nucleus Seed	TFL Seed
Summer 2014			
Girnar 2	-	4.70	-
Girnar 3	-	4.95	-
TG 37A	-		4.20
Kharif 2014			
Girnar 2	7.00	4.85	-
Girnar 3	18.0	5.10	3.60
TG 37A	-	-	-
Total	25.0	19.60	7.80

Certificate of participation being distributed in a 3-day Farmers' Training Programme at DGR

PUBLICATIONS

Research Articles

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નરેન્દ્ર કુમાર, એ.એલ. રત્નાકુમાર, ચુનીલાલ, જી.પી. મિશ્ર, એમ.સી. ડગલા અને બી.એમ. ચીકાણી (૨૦૧૫) ગુજરાત માટે ભલામણ કરેલ મગફળીની સુધારેલ જાતો. તાલીમ પત્રિકા, આઈએસપી/૨૦૧૫-૩. પીપી ૬.

TRAINING AND CAPACITY BUILDING

During 2014-15, fifteen scientists of this Directorate organized and or attended various kinds of trainings and capacity building programs in different national and international organizations. The details are as follows:

Radhakrishnan T

- Executive Development Programme (EDP) on Leadership Development held at NAARM, Hyderabad from 19-23 January 2015

R. Dey

- दो-दिवसीय कार्यशाला ' सरकारी कामकाज में राजभाषा कार्यान्वयन" during 25-26 July 2014.

Ram Dutta

- Organized 8-days (17.09.2014-24.09.2014) model training course on "Update on low-cost production technologies and postharvest operations for sustainable high-productivity of groundnut" sponsored by Ministry of Agriculture, Government of India.
- आत्मा, शिवपुरी (मध्य प्रदेश) द्वारा प्रायोजित " मूँगफली की उत्पादकता बढ़ाने के लिए उन्नत प्रौद्योगिकी" नामक 5-दिवसीय प्रसिक्षण कार्यक्रम (26.09.2014-30.09.2014) को भा.कृ.अनु.प.-मूँगफली अनुसंधान निदेशालय, जूनागढ़-362 001, गुजरात परिसर में आयोजित किया

G.P. Mishra

- दो- दिवसीय कार्यशाला ' सरकारी कामकाज में राजभाषा कार्यान्वयन at DGR, Junagadh (25-26 July 2014)
- 11th CEG Training course on 'Next Generation Sequencing Technologies for Crop Improvement' at ICRISAT, Telangana (24 Nov – 05 Dec, 2014)

M.K. Mahatma

- Hindi workshop at ICAR-Directorate of Groundnut Research, Junagadh during 25-26 July, 2014

P.P. Thirumalaisamy

- Delivered lecture on 'IPM in groundnut' in three day orientation course organized by ICAR-NCIPM, New Delhi at (a) NBAII, Bengaluru (23 to 25 July 2014); (b) RARI, Durgapura, Jaipur (16-18 October, 2014).
- Delivered lecture on 'aflatoxin problems in food industry' in the ICAR-DGR industrial interface meeting, 2014 at DGR, Junagadh on 15.12.2014.
- Delivered lecture on 'Integrated Pest Management in Groundnut' in the ICAR sponsored 21 days winter school on recent advances in integrated pest management' from 26 February to 18 March, 2015 at NCIPM, New Delhi.

H.N. Meena

- Attended Summer School on "Recent Innovations for Improving Nutrient Use Efficiency through Integrated Nutrient Management in Major Field Crops" from 06th -26th August, 2014 at Division of Agronomy IARI, New Delhi.

M.C. Dagla

- Coordinator of a three-day farmers training programme on "Improved technologies for groundnut seed production in Gujarat" during 22-24 December, 2014 at ICAR-DGR, Junagadh.
- Coordinator of a three-day farmers training programme on "Groundnut Seed Production by Scientific Techniques in Saurashtra" during 02-04 March, 2015 at ICAR-DGR, Junagadh.
- 'हिंदी चेतना पखवाड़ा-2014' का आयोजन दिनांक 8 से 20 सितम्बर 2014 के दौरान किया गया जिसमें निबंध लेखन, सामान्य हिंदी ज्ञान, आशुभाषण,

इत्यादि प्रतियोगिताओं का आयोजन किया गया|

- दो दिवसीय (25-26 जुलाई 2014) को "सरकारी कामकाज में राजभाषा कार्यान्वयन" विषय पर कार्यशाला का आयोजन किया गया, जिसमें समन्वयक के रूप में कार्य किया|
- दिनांक 28 मार्च 2015 को 'राजभाषा कार्यशाला' का आयोजन किया गया, जिसमें समन्वयक के रूप में कार्य किया|

Ajay B.C.

- "Re-defining priorities in the national action plan for genetic resources management in India" organized by ICAR-NBPGR at NASC complex New Delhi (23-24 Dec. 2014)
- Workshop on "Effective implementation of PME cells in ICAR institutes" on 23rd Feb 2015 at NASC complex, New Delhi.
- 2015 Norman E. Borlaug International Agricultural Science and Technology Fellowship Program, USDA at Florida A&M University, Tallahassee, USA during March 2015 to June 2015

Narendra Kumar

- Coordinated a five-day farmers training programme on "Improved technologies for increase groundnut productivity" from September 26-30, 2014 at ICAR-DGR, Junagadh.
- Coordinated a three-day farmers training programme on "Improved technologies for groundnut seed production in Gujarat" from 22-24 December, 2014 at ICAR-DGR, Junagadh.
- Coordinated a three-day farmers training programme on "Groundnut Seed Production by Scientific Techniques in Saurashtra" from 02-04 March, 2015 at ICAR-DGR, Junagadh.
- Organized a one day Hindi Workshop on 28 March, 2015 at ICAR-DGR, Junagadh.

K.S. Jadon

- International Summer School on Plant Disease Epidemiology (ISSPDE2015) organized by Department of Plant Pathology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur during March 30 to April 03, 2015.
- दो- दिवसीय कार्यशाला ' सरकारी कामकाज में राजभाषा कार्यान्वयन at DGR, Junagadh (25-26 July 2014)

K. Chakraborty

- Pursued post-doctoral research on salinity tolerance mechanism in oilseeds with special reference to ionic balance and movements under salinity stress using Micro-Electrode Ion Flux Estimation (MIFE) technology' under 'Endeavour Research Fellowship – 2014' by Department of Education, Govt. of Australia (2014) from 23 April – 22 October, 2014

Prasanna Holajjer

- 21 days training programme on "Forecast Modelling Analytics in Crops" from 30th May to 19th June, 2014 at IASRI, New Delhi.

K.A. Kalariya

- A five day short course international training programme on DSSAT "Cropping System Models Application in Land Recourse Management" held during 23-37 March, 2015 at ICRISAT, Patancheru 502 324, Telangana.

Debarati Bhaduri

- दो-दिवसीय हिंदी कार्यशाला 'सरकारी कामकाज मे राजभाषा कार्यानव्यन' at ICAR-DGR, Junagadh, July 25-26, 2014.

Nataraja M.V.

- International training programme on 'Pest Risk Analysis' at NIPHM, Hyderabad (01-05 Sept, 2014)

PARTICIPATION IN CONFERENCE/ WORKSHOP/ SEMINAR/ SYMPOSIA/ MEETINGS

Radhakrishnan T

- 21st ZREAC (Rabi-summer) meeting of South Saurashtra Agro-climatic zone held on 9-10 October 2014 at JAU, Junagadh
- Meeting for presentation of Vision 2050 and Institute Projects to be held under the Chairmanship of DG, ICAR on 10-11 November 2014 at Krishi Bhavan, New Delhi
- Brainstorming Session on Minimizing Aflatoxin Contamination in Groundnut to be chaired by the Agriculture Commissioner, MoA, DAC on 13.11.14 at Krishi Bhavan, New Delhi
- Annual Breeder Seed Review Meeting 2015 to be held at ICAR Research Complex for NEH Region, Umiam, Meghalaya on 7-8 January 2015
- Presented the collaborations in the oilseed networking, at IIOR, Hyderabad on 17 Jan 2015
- National Seminar on Technologies for Enhanced Oilseed Production through NMOOP, 18 Jan 2015
- National Seminar on Water Management and climatic smart agriculture' in collaboration ICAR, Govt. of Gujarat, NABARD, WASMO, GGRC, Gujarat Council of Science & Technology held on 13 February 2015 at JAU, Junagadh
- 5th International Conference on Next Generation Genomics and Integrated Breeding for Crop Improvement on 20.2.15 at ICRISAT, Hyderabad
- Review meeting of DUS Project he;d on 9-10th March 2015 at JAU, Junagadh

A.L. Rathnakumar

- 5th International Conference on Next Generation genomics and Integrated Breeding for Crop Improvement. February 18-20, ICRISAT, Patancheru, India,

Chuni Lal

- IX Annual Review Meeting of ICAR – Seed Project at ANGRAU, Hyderabad from 22-23 September, 2014
- Meeting of Commission for Agriculture Costs and Prices, MoA, GoI, in New Delhion 16th January 2015

K.K. Pal

- Joint Advisory Committee Meeting of NFBSFARA Projects "Deciphering molecular mechanism of induction of biotic stress tolerance by Trichoderma spp. in castor", and 'Unravelling the biochemical and molecular basis of bacterial and fungal endosymbiosis for management of abiotic stress tolerance in plants' on 12th May 2014 at DGR, Junagadh and made presentation of research work.
- Group meeting of All India Network Project on Soil Biodiversity – Biofertilizers at DGR from 6-8 December 2014.
- Annual workshop of AMAAS project and presented work done report of DGR centre at New Delhi, 22-23 January 2015.
- Annual Review Meeting of NFBSFARA project, NASC complex, New Delhi, 10-12 February 2015

R. Dey

- Joint Advisory Committee Meeting of NFBSFARA Projects on 12th May 2014 at DGR, Junagadh.
- NAIP-IFPRI workshop on Priority setting, Project management and Evaluation at NASC complex, Pusa, N. Delhi on 27th May 2014.
- RFD Mid-term achievements review meeting at Krishi Bhavan, N. Delhi on 21st Nov. 2014.
- Group meeting of All India Network Project on Soil Biodiversity – Biofertilizers at DGR from 6-8 December 2014

N.K. Jain

- Annual Meeting of Groundnut Researchers, held at Tamil Nadu Agricultural University, Coimbatore during 27-29, May, 2014.
- MDP Workshop on PME of Agricultural Research Projects, organised by NAARM, Hyderabad during 4-8 August, 2014.
- National Symposium on Agricultural Diversification for Sustainable Livelihood and Environmental Security, held during 18-20 November 2014 at PAU, Ludhiana, Punjab; Organized by Indian Society of Agronomy, New Delhi.
- ICAR-DGR-Industries Interface Meeting held on 15 December 2014 at ICAR-Directorate of Groundnut Research, Junagadh.
- National Seminar on Strategic Interventions to Enhance Oilseeds Production in India, held during 19-21 February 2015 at ICAR-DRMR, Bharatpur, Rajasthan; Organized by Indian Society of Oilseeds Research, Hyderabad (Oral presentation).

R.S. Yadav

- International conference on natural resource management for food security and rural livelihoods. NASC, New Delhi during 10-13 February, 2015.
- Annual workshop of AICRP-G during 27th – 29th May, 2014 held at TNAU, Coimbtore, Tamilnadu.

M.K. Mahatma

- National Conference on 'Recent trends in processing, quality and safety of ethnic and organic foods' at TANUVA, Chennai (June 26-27, 2014)
- National symposium on "Challenges and Management Approaches for crop Diseases of National Importance –Status and Prospectus" during 12-14.02.2015 at TNAU, Madurai
- Workshop on "Effective implementation of PME cells in ICAR institutes" on 23rd Feb 2015 at NASC complex , New Delhi

Anita Mann

- International Conference of Plant Physiology (ICPP), held at Bali, Indonesia organizedby Malaysian Society of Plant Physiology and Indonesian Coffee and Cocoa Research Institute (ICCRI) from 26-28 August 2014.

Poonam Jasrotia

- International Conference on *"Changing Scenario of Pest Problems in Agri-horti Ecosystem and their Management"* at Maharana Pratap University of Agriculture and Technology, Udaipur from 27-29th November, Udaipur Rajasthan.

- International Conference on *"Innovative Insect Management Approaches for Sustainable Agro Eco System (IIMASAE)"* at Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu from January 27-30th, 2015.
- *"National Entomologist's Meet -2015"* at ICAR-Indian Institute of Natural Resins and Gums (IINRG), Namkum, Ranchi from 5th to 7th February, 2015.
- International Conference on *"Natural Resource Management for Food Security and Rural Livelihoods"* at NASC complex, New Delhi from 10th to 13th February, 2015.

P.P. Thirumalaisamy

- Member, inspection team of APEDA with IOPEPC for inspection of Saaz food industry, Talaza (19 May 2014); Charbhuja, Rajkot (20 May, 2014); Saurashtra containers pvt ltd, Mundra (10 June 2014); Soniya foods pvt ltd at Kadi, Ahmedabad (25 June, 2014); LCL logistix (I) pvt ltd at Pipava port, Gujarat (20 July, 2014); Mother Nutri food, Mahuva (1 Dec, 2014); Shree Shant mohanam Peanuts, Kuvadva, Rajkot (2 Dec 2014).
- AICRPG workshop at TNAU, Coimbatore from 27-29 May 2014.
- Brainstorming session on 'minimizing aflatoxin contamination in groundnut' held at PC Mehalanobis hall, Krishi Bhavan on 13.11.2014.
- 4th annual review meeting of the national agricultural science fund (NASF) at NASC complex on 10th February, 2015.

Narendra Kumar

- Annual review meeting of the NFBSFARA funded project "Relationship between *Sclerotium rolfsii, Rhizoctonia solani*, the soil and climatic variables in three major cropping system in the country and identification of markers for resistance to *Sclerotium rolfsii*" at DGR Junagadh from 4-5 April, 2014.
- AICRP-G annual groundnut workshop from 27-29/05/2014 at TNAU, Coimbatore.
- CGIAR-CG Project Launch Meet on 'Multi-locational Evaluation of Disease Resistant MABC Lines in Groundnut' on 12th January 2015 at DGR, Junagadh.

K.S. Jadon

- 36th annual conference & national symposium on "Challenges and Management Approaches for crop Diseases of National Importance –Status and Prospectus during 12-14.02.2015 held at TNAU, Madurai jointly organized by AC&RI, Madurai (Tamil Nadu Agricultural University) and Indian Society of Mycology and Plant pathology, Udaipur for oral presentation at the conference.

K. Chakraborty

- National Seminar on Water Management & Climate Smart Agriculture. February 13-14, Junagadh Agricultural University, Junagadh, Gujarat.
- 4th BharatiyaVigyanSammelan& Expo-2015 organized by VignanaBharati and Goa University. February 5-8, Panaji, Goa.

Debarati Bhaduri

- 4th BharatiyaVigyan Sammelan & Expo-2015. February 5-8, Panaji, Goa.

M.D. Meena

- Attended AICRP workshop on groundnut at TNAU, Coimbtore during 27 to 29 May 2014.

Nataraja M.V.

- Mid-term RFD review meeting of Crop Science Division at Krishi Bhavan, New Delhi (21 Nov, 2014)
- *All India Network Project on Soil Biodiversity Biofertilizers* from 06th to 08th December, 2014 at ICAR-DGR, Junagadh.
- National Seminar on *"Technologies for Enhancing Oilseeds Production Through NMOOP"* from 18th to 19th January, 2015 at ICAR-IIOR, Hyderabad.

Scientists on Deputation

Dr. R.A. Jat, Senior Scientist (Agronomy) has participated in 6th World Congress on Conservation Agriculture held during June 22-25, 2014 at Winnipeg, Manitoba, Canada and delivered oral presentation on "Climate change mitigation and adaptation potential of conservation agriculture: effects on rainwater use efficiency, runoff, soil moisture, soil organic carbon and energy use".

AWARDS / HONOURS / RECOGNITION

- Two technologies, developed by **Dr. K.K. Pal, Dr. R. Dey** and **Dr. J.B. Misra**, were transferred to M/s Paccar Biotech Ltd., Ahmedabad. The technologies are process/knowhow for production of enzyme cellulase from groundnut shell and process/knowhow for production of protease from de-oiled groundnut cake.
- **Dr Koushik Chakraborty,** Scientist (plant physiology), selected for the prestigious 'Endeavour Research Fellowship-2014' of Australian Government and went to University of Tasmania, Hobart, TAS on six months deputation (23rd April to 22nd October).

- **Mr Sahil Patel**, SRF, Biotechnology bagged ***'Best Poster Award'*** for the poster entitled '*Marker assisted selection for high oleate trait in groundnut' In*: National Conference Biodiversity and Bioresource Utilization (17-18 March, 2015) at Department of Biosciences, Saurashtra University, Rajkot
- **Mr Tanmoy Sarkar,** SRF, Biotechnology bagged ***'Best Poster Award'*** for the poster entitled '*Development and physio-biochemical characterization of AtDREB1A transgenic groundnut for drought tolerance' In*: UGC Sponsored One Day National Seminar on Recent Advances in Biochemical Research, held at Department of Biochemistry, Saurashtra University, Rajkot, Gujarat on 14th Feb, 2015.

MEETINGS

XVI RAC meeting

The XVI meeting of Research Advisory Committee was held at DGR, Junagadh from 15-17 April, 2014. Dr. S.K. Patil, (VC, Indira Gandhi Krishi Vishwavidyalaya, Raipur) chaired the meeting and other members who had participated in the meeting were Dr. Masood Ali, (Ex-Director, IIPR, Kanpur), 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) and Shri. J.K.B. Gunde (Progressive Farmer, Kolhapur, MH). Dr. S.K. Bera (PS, DGR, Junagadh) was the Member Secretary of 16th RAC meeting.

The meeting started with the brief introduction of the scientists followed by welcome of the RAC members by Dr. J.B. Misra, Director. Further, Dr. S.K. Bera, Member Secretary, RAC presented the action taken report of XV RAC meeting and presentations on ongoing research projects were made by the PIs or co-PIs which were discussed thoroughly and the plan of work 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 RAC meeting, field- and lab- visit

ICAR-DGR — Industries Interface meeting

(15 December 2014, Junagadh)

In the current scenario of groundnut gaining more and more relevance as a food crop besides an oilseed, the stake of food industries and export houses is on the rise. Realizing this fact, all the stakeholders in groundnut cultivation and industry were brought on a common platform to facilitate their interactions for identifying issues of mutual interest and formulating strategy for research, extension and trade and also addressing the policy issues, through an Industries Interface meeting at this Directorate.

The meeting was formally inaugurated by Dr. C.J. Dangaria, Director of Research (JAU). In the meeting, a panel discussion was held on 'Issues and strategies for export promotion in groundnut and groundnut products from India' to draw suitable technological, commerce and policy related interventions'. The panel included Dr. I.U. Dhruj (DR-JAU); Dr. Tarun Bajaj, (GM, APEDA); Mr. Tushar Thumar, (Director, Khedut Food and Feeds); Dr. M.S. Basu, (Ex-Director, DGR); Dr. J.B. Misra (Technical Advisor, IOPEPC); Mr. J.L. Kukhreja (Dy Sec. IOPEPC); Dr. P. Janila (ICRISAT) and Mr. S.J. Solnanki (Jt. Dir, Agril. Extn., Gujarat). Representatives from local export houses, seed industries, major food industries, progressive farmers and manufacturers of farm implements participated in the meeting.

During this meet, there were detailed deliberations on the topics like comprehensive aflatoxin management techniques, possibility of storing the kernels under cold storage especially for the seed purpose, production of large scale quality seeds in short time, high O/L ratio in kernels for oil stability, discouraging the practice of 'Pick and Pack' by the exporters, possible policy interventions for increasing the groundnut exports, possibilities of organic groundnut production, quality characterization of ruling varieties of India and its database management, etc. This Meet also brought out a few action points for carrying the process forward, underlining objectivity and flexibility in building these partnerships.

Director-DGR, Dr. Radhakrishnan T. in his remark thanked all the speakers from both private and public sectors, who had contributed to the success of the Meet and hoped that this would surely mark a milestone in furthering the cause of increasing the groundnut productivity and benefits to both farmers and industries through joint partnerships.

ICAR-Directorate of Groundnut Research - Industries Interface meeting

STAFF LIST AS ON 31.03.2015

1.	Dr. J.B. Misra	Director (Retired on 31.07.2014)
2.	Dr. T. Radhakrishnan	Director (w.e.f. 25.09.2014)
3.	Dr. A.L. Singh	Pr. Scientist (Physiology)
4.	Dr. A.L. Rathnakumar	Pr. Scientist (Plant Breeding)
5.	Dr. Chuni Lal	Pr. Scientist (Plant Breeding)
6.	Dr. S.K. Bera	Pr. Scientist (Genetics & Cytogenetics)
7.	Dr. N.K. Jain	Pr. Scientist (Agronomy)
8.	Dr. K.K. Pal	Pr. Scientist (Microbiology)
9.	Dr. Rinku Dey	Pr. Scientist (Microbiology)
10.	Dr. Ram Dutta	Pr. Scientist (Pathology)
11.	Dr. R.S. Yadav	Sr. Scientist (Soil Science)
12.	Dr. R.A. Jat	Sr. Scientist (Agronomy)
13.	Dr. Gyan P. Mishra	Sr. Scientist (Pl Breeding)
14.	Dr. Anita Maan	Sr. Scientist (Pl 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. Manesh C. Dagla	Scientist (Pl Breeding)
19.	Sh. Abhay Kumar	Scientist (Pl Biotechnology)
20.	Sh. Sujit K. 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. K.A. 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. Exten.)
33.	Sh. Murlidhar Meena	Scientist (Agril Economics)
34.	Dr. D.L. Parmar	CTO
35.	Sh. D.M. Bhatt	CTO
36.	Sh. N.R. Ghetia	CTO
37.	Sh. P.R. Naik	ACTO

38.	Sh. V.G. Koradia	ACTO
39.	Sh. P.K. Bhalodia	ACTO
40.	Sh. P.V. Zala	ACTO
41.	Sh. H.B. Lalwani	ACTO
42.	Dr. H.K. Gor	ACTO
43.	Sh. H.M. Hingrajia	ACTO
44.	Dr. J.R. Dobaria	ACTO
45.	Dr. M.V. Gedia	ACTO
46.	Sh. Ranvir Singh	ACTO
47.	Sh. V.K. Sojitra	ACTO
48.	Dr. S.D. Savaliya	ACTO
49.	Sh. B.M. Chikani	ACTO
50.	Mrs. V.S. Chaudhari	ACTO
51.	Sh.Virendra Singh	ACTO
52.	Sh. D.R. Bhatt	Sr. Technical Officer
53.	Sh. R.D. Padvi	Technical Officer
54.	Sh. H.V. Patel	Technical Officer
55.	Sh. J.G. Kalariya	Technical Officer (Tractor Driver)
56.	Sh. K.H. Koradia	Technical Officer (Driver)
57.	Sh. A.M. Vakhariya	Technical Officer (Photographer)
58.	Sh. C.B. Patel	Technical Officer
59.	Sh. G.J. Solanki	Sr. Technical Assistant
60.	Sh. P.B. Garchar	Sr. Technical Assistant (Electrician)
61.	Sh. N.M. Safi	Sr. Technical Assistant (Driver)
62.	Sh. A.D. Makawana	Technical Assistant
63.	Sh. G.G. Bhalani	Technical Assistant (Driver)
64.	Sh. B.M. Solanki	Technical Assistant (Driver)
65.	Sh. Anil K. Maurya	Technical Assistant
66.	Sh. Lokesh Kumar	Technical Assistant
67.	Sh. Pitabas Das	Technical Assistant
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. C.G. Makawan	UDC
77.	Sh. H.S. Mistry	UDC
78.	Sh. P.N. Solanki	LDC
79.	Sh. N.M. Pandya	SSS
80.	Sh. R.B. Chawada	SSS
81.	Sh. D.M. Sachaniya	SSS
82.	Sh. M.B. Shaikh	SSS
83.	Sh. J.G. Agrawat	SSS
84.	Sh. K.T. Kapadia	SSS
85.	Sh. V.N. Kodiatar	SSS
86.	Sh. R.P. Sondarwa	SSS
87.	Sh. V.M. Chawada	SSS
88.	Sh. G.S. Mori	SSS
89.	Mrs. D.S. Sarvaiya	SSS
90.	Sh. P.M. Solanki	SSS
91.	Sh. N.G. Vadher	SSS
92.	Sh. B.J. Dabhi	SSS
93.	Sh. C.G. Moradia	SSS
94.	Sh. D.A. Makwana	SSS
95.	Sh. Jay R. Purohit	SSS

FOR THE YEAR 2014-2015

2. Staff Strength

Category of staff	Sanctioned	Filled	General	SC	ST	OBC
Scientific	39+01RMP	32+1RMP	21	04	03	05
Technical	40	34	20	03	05	06
Admin.	17	11	06	02	0	03
SSS	19	17	06	02	02	07
Total	115+1	94+1RMP	53	11	10	21

DPC/Promotion/ Probation/ MACP

- DPC held on 29th January 2014 for Tech. Staffs; benefit to 05 Employees.
- DPC for MACP Held on 17th and 18th March 2015 for Shri H.S. Mistry (for Rs. 2800/- GP to Rs.4200/-GP).
- DPC for Probation of SSS (2 employees) on 17th and 18th March 2015; Tech. Staff (02 employees) on 26 December, 2014.
- Assessment committee for Scientist 6000/- to 7000/- GP on 3rd and 4th February 2015.

Discipline and grade wide sanction scientific positions

Discipline	Scientist	Sr. Scientist	Pr. Scientist	Total
Agricultural Biotechnology	02	01	0	03
Agricultural Economics	01	0	0	01
Agricultural Entomology	02	01	0	03
Agricultural Extension	01	0	0	01
Agricultural Microbiology	01	01	0	02
Agricultural Statistics	0	01	0	01
Agronomy	01	01	01	03
Genetics & Plant Breeding	07	03	01	11
Nematology	01	0	0	01
Plant Biochemistry	01	01	0	02
Plant Pathology	02	02	01	05
Plant Physiology	02	01	0	03
Seed Science & Technology	0	01	0	01
Soil Science	01	01	0	02
Total	22	14	03	39

Retirement

1. Dr. J.B. Misra, Director, retired on 31.07.2014
2. Sh. V.K. Sojitra, ACTO, retired on 30.11.2014
3. Sh. Pravin Kandas, TSL, retired on 30.09.2014

Transfer

- Dr. Ajoy Saha, Scientist (Agril. Chemistry), ICAR-DGR, Junagadh to ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand and he was relieved from DGR on May 02, 2014.
- Dr. Prasnna Holajjer, Scientist (Nematology), ICAR-DGR, Junagadh to ICAR- Directorate of Floricultural Research, Pune and he was relieved from ICAR-DGR on 15th November 2014.

Institute Joint Staff Council

Chairman: Director, ICAR-DGR

Members (Staff Side)

1. Shri Y.S. Karia, Secretary-IJSC and Membe-CJSC
2. Smt. M.N. Vaghasia, Member
3. Shri G.G. Bhalani, member
4. Shri A.K. Maurya, Member
5. Shri B.J. Dabhi, Member
6. Shri C.G. Moradia, Member

Members (Office Side)

1. Dr. Chuni Lal, Pr. Scientist, ICAR-DGR
2. Dr. R. Day, Pr. Scientist, ICAR-DGR
3. FAO, ICAR-DGR
4. AO, ICAR-DGR

FINANCE & ACCOUNTS

DGR Main Unit (Rs. in lakhs)						
Budget Head	Non Plan			Plan		
	BE	RE	Expenditure	BE	RE	Expenditure
Establishment charges	725.00	709.99	709.99	0.00	0.00	0.00
Wages	55.00	51.13	50.99	0.00	0.00	0.00
Loans & Advances	5.00	4.00	4.06	0.00	0.00	0.00
Pension	75.00	73.50	73.49	0.00	0.00	0.00
T.A.	8.00	6.87	6.87	0.00	10.41	10.41
Recurring Contingencies	106.00	198.92	198.84	0.00	242.26	242.20
Works	0.00	0.00	0.00	0.00	0.00	0.00
Equipment	5.00	4.00	3.97	0.00	109.03	109.03
Furniture	3.00	2.00	1.99	0.00	6.08	6.08
IT	0.00	0.00	0.00	0.00	1.10	1.10
Books	0.00	0.00	0.00	0.00	8.79	8.78
HRD	1.00	0.54	0.53	0.00	4.33	4.33
Vehicles	0.00	6.00	6.00	0.00	0.00	0.00
TOTAL	983.00	1056.95	1056.73	475.00	382.00	381.93

AICRP-G (Rs. in lakhs)		
Budget Head	**RE 2014-15**	**Expenditure**
Pay & Allowances	618.00	618.00
TA	6.68	6.68
Recurring Contigency	46.65	46.65
Need Based Research	11.67	11.67
TSP	15.00	14.97
TOTAL	698.00	697.97

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

Results-Framework Document (RFD)

for

Directorate of Groundnut Research (2013-2014)

Address: Ivnagar Road, P.B. No.5, Junagadh -362 001, Gujarat

Website: www.nrcg.res.in

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

Section 1:
Vision, Mission, Objectives and Functions

Vision

Enhancing efficiency of groundnut based production system on a sustainable basis through appropriate cropping system, value-addition and diversification of products so that the groundnut system as a whole becomes sustainable, remunerative and globally competitive.

Mission

Conduct research for improving the crop production technologies to eventually enhance groundnut productivity from the current 1050 to 1500 kg/ha for *kharif* (rainfed) and from 1250 to 2000 kg/ha for *rabi*-summer (irrigated), respectively by the year 2017 by developing remunerative, globally competitive and sustainable crop production and protection technologies for groundnut based cropping systems in different agroecological regions of India through a blend of basic and strategic multidisciplinary research.

Objectives

1. Genetic enhancement and development of improved groundnut cultivars
2. Development and identification of appropriate crop production and protection technologies
3. Technology dissemination and capacity building

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

Functions

- Collection, evaluation and characterization of germplasm
- Genetic up-gradation of groundnut for higher kernel and oil yields coupled with resistance to biotic and abiotic stresses by employing both conventional breeding and biotechnological approaches
- Development of production technologies for both low-input rainfed and high-input assured irrigated conditions while integrating technologies to enhance resource-use efficiency
- Development of technologies for management of major pests and diseases of groundnut with special emphasis on peanut bud necrosis and stem rot diseases
- Development of technology for value-addition in groundnut at cottage and small scale industry levels
- Refinement and integration of available and new technologies for Integrated Nutrient Management (INM), Integrated Pest Management (IPM) and water management
- Refinement of technology for prevention of aflatoxin contamination in groundnut
- Identification of the socio-economic constraints in adopting new technologies and other bottlenecks
- Strengthening groundnut seed production system
- Development of modelling and forecasting as a tool for crop management decisions and risk assessment and amelioration
- Development of institutional linkages for conducting research in a collaborative mode or for strengthening the ongoing research programmes through sponsored projects

Section 2:

Inter se Priorities among Key Objectives, Success indicators and Targets

	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target/Criteria Values				
							Excellent	Very good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Genetic enhancement and development of improved groundnut cultivars	45	Evaluation of genetic material	Breeding and germplasm lines evaluated	No.	10	550	500	450	400	380
				Entries tested in AICRP-G trials for multi-location testing	No.	8	50	40	30	25	20
				Lines identified for unique traits	No.	7 0	20 8	15	12	1	
			Development of improved cultivars	Entries contributed for AICRP multi-location trial	No.	6	45	40	35	30	25
				Varieties identified for release	No.	7	5	4	3	2	1
			Seed production programme	Breeder seed produced	To	5	1500	1400	1300	1200	1100
				Truthfully labelled seed produced	Tonnes	2	6	5	4	3	2
2	Development and identification of appropriate crop production & protection technologies	30	Development of new technologies	New technologies tested	No	20	5	4	3	2	1
				New technologies recommended	No	10	5	4	3	2	1
3	Technology dissemination and capacity building	14	Demonstrations conducted	Front line demonstrations conducted	No	7	825	750	725	700	675
			Farmers/ Extension officials training programmes organized	Trainings organized	No	7	7	6	5	4	3

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.00	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1.00	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2.00	100	95	90	85	80
			Prepare an action plan for Innovation	On- time submission	Date	2.00	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013
	Improving internal efficiency /responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2.00	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2.00	100	95	90	85	80

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

Section 3:

Trend Values of the Success Indicators

S. No.	Objectives	Action(s)	Success indicator(s)	Unit	Actual values for 2011-12	Actual values for 2012-13	Target value for 2013-14	Projected values for 2014-15	Projected values for 2015-16
1	Genetic enhancement and development of improved groundnut cultivars	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	863	870	500	525	560
			Entries tested in AICRP-G trials for multi-location testing	Number	55	58	40	45	50
			Lines identified for unique traits	Number	12	13	15	16	17
		Development of improved cultivars	Entries contributed for AICRP multilocation trial	Number	46	48	40	45	50
			Varieties identified for release	Number	1	0	4	5	6
		Seed production programme	Breeder seed produced	Tonnes	2018	0 2000 1700	1400	150	
			Truthfully labelled seed produced	Tonnes	11.7	5.2	5.0	5.5	6.0
2	Development and identification of appropriate crop production & protection technologies	Development of new technologies	New technologies tested	Number	4	3	4	5	6
			New technologies recommended	Number	1	2	4	4	5
3	Technology dissemination and capacity building	Demonstrations conducted	Front line demonstrations conducted	Number	966	850	750	825	900
		Farmers/ Extension officials training programmes organized	Trainings organized	Number	7	7	6	7	8

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

	Efficient Functioning of the RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	16/05/2013	-	-
		Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	02/05/2013	-	-
	Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
		Prepare an action plan for Innovation	On- time submission	Date	-	-	10/08/2013	-	-
	Improving internal efficiency /responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	-	-	95	-	-
			Independent Audit of implementation of public grievance redressal system	%	-	-	95	-	-

Acronyms
Section 4:

S.No	Acronym	Description
1	INM	Integrated Nutrient Management
2	IPM	Integrated Pest Management
3	AICRP	All India Coordinated Research Project
4	MSP	Minimum Support Price
5	DAC	Department of Agriculture and Cooperation
6	SAUs	State Agricultural Universities

Section 4 : Description and Definition of Success Indicators and Proposed Measurement Methodology

Sl. No.	Success indicator	Description	Definition	Measurement	General Comments
1	Breeding and germplasm lines evaluated	Source material for the improved varieties to be evaluated	Material generated from the basic germplasm	Number of breeding lines evaluated	-
2	Entries tested in AICRP-G trials for multi-location testing	Multi-location testing of breeding lines contributed by different centres	Identification of best performing lines across centres of AICRP	Number of such genotypes identified	-
3	Lines identified for unique traits	Identification of genotypes showing unique traits like span of maturity, resistance to biotic/abiotic stresses, quality, etc.	Identification of breeding lines with unique traits	Number of such genotypes identified	-
4	Entries contributed for AICRP multi-location trial	Breeding lines submitted by participating centres tested along with checks in multi-location trials through AICRPG	Identification of best performing lines at different centres	Number of such genotypes identified	-
5	Varieties identified for release	Breeding lines tested along with checks in multi-location trials through AICRPG and the best performing entries compared to checks are identified as new improved varieties for release	Best performing entries identified as a new variety for release	Number of such varieties identified	Targets for varieties identified given in Section 2 and their respective trend values in Section 3 may vary as the identification of varieties depend upon the availability of superior material with respect to yield, biotic and abiotic resistance/tolerance over the existing varieties

6	Breeder seed produced	Produce from nucleus and breeder seed is the starting point in seed chain of producing quality seeds for farmers	Breeder seed is the starting point in seed chain which is multiplied/ converted in to foundation / certified seed	Quantity produced (Quintals)	Quantity may vary as per indent from DAC
7	Truthfully labelled seed produced	Produce from foundation, certified or labelled seed is the end point in seed chain of producing quality seed for farmers	Truthfully labeled seed is the end point in seed chain	Quantity produced (Quintals)	-
8	New technologies tested	Certain ideas and technologies may be directly developed from the project which can be tested	-	Number	-
9	New technologies recommended	Certain technologies which are developed and tested may be recommended to the end users	-	Number	-
10	Front line demonstrations conducted	Trials and demonstrations conducted for technology testing and proving the technology potential production	Frontline demonstration is the field demonstration conducted on farmers field under the close supervision of scientists	Number	-
11	Trainings organized	Capacity building activities related to knowledge and skill improvement/development programmes conducted for farmers, rural youth and extension personnel	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving productivity in an organization or enterprise	Number	-

Section 5:
Specific Performance Requirements from other Departments

Location Type	State	Organisation Type	Organisation Name	Relevant Success Indicator	What is your requirement from this organisation	Justification for this requirement	Please quantify your requirement from this Organisation	What happens if your requirement is not met.
Central Government		Departments	Department of Agriculture and Cooperation	Breeder seed produced	Rationalized indent for breeder seed (variety wise quantity)	For phasing out old and inferior varieties	The total quantity not to exceed state wise actual requirements	Slowing down of seed replacement rate
State Government	Chiefly Gujarat, AP, Maharastra, Karnataka, Rajasthan, TN and others like Odisha, UP, MP and WB etc.	Seed multiplication agency of the states concerned	Department of Agriculture, State Seed Corporations	Truthfully labelled seed produced	Maintaining high rate of conversion through seed chain	For enhancing availability of quality seed	High seed multiplication ratio	Slow spread of improved varieties

Results- Framework Document for Directorate of Groundnut Research (2013-2014)

Section 6:

Outcome/Impact of organization

S. No.	Outcome / Impact of Organisation	Jointly responsible for influencing this outcome / impact with the following organisation(s) / departments / ministry(ies)	Success Indicator (s)	Unit	2011-12	2012-13	2013-14	2014-15	2015-16
1.	Enhanced productivity and production of groundnut	DAC, SAUs, State Departments of Agriculture	Improvement in productivity*	%	3	6	8	10	12
2.	Improvement in farm income and food quality	DAC, SAUs, State Departments of Agriculture	Improvement in income and nutrition of farm families*	%	4	8	10	12	15

* Improvement over the base year 2011-12

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014 of RSCs i.e. Institutes

Name of the Division: Crop Science
Name of the Institution: Directorate of Groundnut Research, Junagadh- 362001, Gujarat
RFD Nodal Officer of the RSC: Dr Rinku Dey, Principal Scientist

S. No.	Objectives	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target/Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent	Very good	Good	Fair	Poor		Raw score	Weighted score		
							100%	90%	80%	70%	60%					
1	Genetic enhancement and development of improved groundnut cultivars	45	Evaluation of genetic material	Breeding and germplasm lines evaluated	No.	10	550	500	450	400	380	510	92	9.2	102	-
				Entries tested in AICRP-G trials for multi-location testing	No.	8	50	40	30	25	20	42	92	7.36	105	-
				Lines identified for unique traits	No.	7	20	15	12	10	8	12	80	5.6	80	-
			Development of improved cultivars	Entries contributed for AICRP multi-location trial	No.	6	45	40	35	30	25	64	100	6	160	More no. of entries received under AICRP trials
				Varieties identified for release	No.	7	5	4	3	2	1	5	100	7	125	More no. of varieties identified by AICRP for release
			Seed production programme	Breeder seed produced	Tonnes	5	1500	1400	1300	1200	1100	1727	100	5	123.3	Better production than expected

				Truthfully labelled seed produced	Tonnes	2	6	5	4	3	2	4	80	1.6	80	-
2	Development and identification of appropriate crop production & protection technologies	30	Development of new technologies	New technologies tested	No	20	5	4	3	2	1	4	90	18	100	-
				New technologies recommended	No	10	5	4	3	2	1	11	100	10	275	Recommended during AICRP workshop
3	Technology dissemination and capacity building	14	Demonstrations conducted	Front line demonstrations conducted	No	7	825	750	725	700	675	f 850	100	7	113.3	More no. o technologies given to FLDs for demonstration
			Farmers/ Extension officials training programmes organized	Trainings organized	No	7	7	6	5	4	3	7	100	7	116.7	Trainings targeted at the beginning of the year achieved
	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2.0	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013	14/05/2013	100	2.0	-	-
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1.0	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013	01/05/2013	100	1.0	-	-

	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2.0	100	95	90	85	80	100	100	2.0	-	-
			Prepare an action plan for Innovation	On- time submission	Date	2.0	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013	07/08/2013	93	1.86	-	-
	Improving internal efficiency /responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2.0	100	95	90	85	80	100	100	2.0	-	-
				Independent Audit of implementation of public grievance redressal system	%	2.0	100	95	90	85	80	100	100	2.0	-	-

Procedure for computing the Weighted and CompositeScore

1. **Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score/ 100**
2. **Total Composite Score = Sum of Weighted Scores of all the Success Indicators**

Total Composite Score:- 94.62
Rating: Very Good

ICAR-Directorate of Groundnut Research

Post Box No. 05, Ivnagar Road,

Junagadh-362001, Gujarat, India

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	: 0285-2675831 (Residence)
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Administrative Officer	: 0285-2672843
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FAX	: 0285 2672550 (Fax)
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हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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