ICAR-DGR Annual Report 2015-16

वार्षिक प्रतिवेदन
ANNUAL REPORT

मूँगफली अनुसंधान निदेशालय
Directorate of Groundnut Research

2015-2016

Storage structure used by tribal groundnut farmers

भाकृअनुप-मूँगफली अनुसंधान निदेशालय
ICAR-DIRECTORATE OF GROUNDNUT RESEARCH
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ICAR-Directorate of Groundnut Research

(Indian Council of Agricultural Research)

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Preface

I am extremely happy to present this annual report of ICAR-DGR for the year 2015-16 highlighting the significant activities of the Directorate. Realizing the pivotal role of quality seed in realizing increased productivity, during 2015-16 we have produced about 6926 quintals of breeder seed of 38 groundnut varieties cultivated in different states. A brain storming session involving the experts and stake holders in seed production also was organised to chalk out future strategies in improving and augmenting the quality seed production. To demonstrate the new and improved technologies on groundnut production to the farming community we have organised 760 field level demonstrations (FLDs) and 40 training programmes spread over the groundnut growing areas of the country. Considering the poor livelihood conditions of the tribal and hill region farmers, the DGR has implemented the Tribal Sub Plan programme in 7 states benefiting 1632 farmers. A groundnut-mela-cum exhibition for the groundnut farmers of Gujarat was organised to familiarize farmers for the latest production technologies and to provide a platform for interacting with the other stake holders of groundnut production, trade and industry. Taking into account of the relevance of the an effective between the processing and exporting industry and the production system, an Industries Interface meeting was held at this Directorate on 15 December, 2015 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. Being the national repository of groundnut germplasm we have been conserving 9129 accessions of groundnut from 84 countries. Looking forward for the future of the groundnut as a food crop, the DGR has developed high oleic groundnut which are under evaluation at the Directorate. Through the AICRP on groundnut, two varieties have been identified for release. During 2015-16, the DGR scientists published 43 research articles, 14 book chapters, and presented 25 papers in conferences and symposia. During 2015-16, one scientist of this Directorate went abroad on deputation under Borlaug International Fellowship Program. Utilization of the grants was to the tune of Rs 389.5 lakhs under head 'Plan' and Rs. 978.52 under the head 'Non-plan' for DGR and Rs. 788.93 lakhs for AICRP-Groundnut. The funds received through the externally funded projects were also utilized effectively.

I thank all the scientists of DGR as well as those of AICRP-G for their hard work towards generating the data reported in this volume. I sincerely appreciate the efforts of my colleagues in bringing out this report.

Radhakrishnan T.
Director

Contents

Executive **Summary**

Crop Improvement

- Genotype PBS 15020, 15025, 15027 and 15054 had high haulm yield under water stress.
- Genotypes PBS 15022, 15041 and 30055 had high yield compared to check variety at both Junagadh and Anantapur.
- Genotype PBS 15044 had high pod yield when compared to best check variety SG 99.
- Under water stress condition genotype PBS 11092 had low SLA and high HKW when compared to check varieties.
- Thirteen crosses were effected to develop improved varieties resistant/tolerant of foliar diseases, stem rot, *Alternaria* leaf spot, *Spodoptera* and sucking pest during *kharif* 2015.
- A total of 32 hybrids were isolated from 13 crosses during summer 2015.
- Nineteen new advanced high yielding breeding lines (eight of Spanish and eleven of Virginia habit group) were developed during *kharif* 2015.
- Progenies of 68 crosses were advanced to different filial generations (F_2-F_6), of which eight crosses were rejected due to large proportion of poor recombinants.
- Based on two year yield evaluation, two advanced breeding lines (PBS 12200 and PBS 12201) were identified as high yielding elite genotypes and proposed for multi-location testing under AICRP-G trials.
- Supplied segregating materials of three different crosses to three AICRP-G centres.
- Based on three year results, only two genotypes PBS 12029 and PBS 18037 were recorded less stem rot incidence as compared to the tolerant genotype CS-19 in summer 2013 to 2015.
- Four genotypes PBS 12191, PBS 12192, PBS 22092 and PBS 22097 recorded average of less than 10% collar rot incidence in all the replications as compared to the tolerant genotype OG 52 1 (9.0%) and J 11(8.7%) at ARC, Bikaner.
- Based on the three year screening results (Summer 2013-15), two advance breeding lines PBS 12169 and PBS 12190 showed near resistance reaction and seventeen genotypes has been identified tolerant to *Alternaria* leaf spot.

- It was observed that *Alternaria* leaf spot incidence increased under drought conditions.
- Nine thousand one hundred and twenty nine (9129) groundnut accessions have been maintained in the medium term cold storage (4±1 °C; 30% RH) module.
- A total of 109 accessions in six sections *viz. Arachis* (44), *Caulorhizae* (1), *Erectoides* (7), *Heteranthae* (5), *Procumbentes* (8) and *Rhizomatosae* (38) were maintained in the field gene bank.
- Seeds of eight amphidiploid derivatives (Synthetic Groundnut) obtained from ICRISAT have been field established for further use in crop improvement programme.
- A total of 132 germplasm accessions in summer 2015 and two thousand one hundred and fifty four accessions (2154) have been rejuvenated and multiplied during *kharif* 2015.
- One high yielding (2671 kg/ha) accession, NRCG 1108 with high shelling outturn (72.7%) has been identified in the Valencia group.
- Two candidate farmers' varieties "Budhram Badam 1" and "Gulabi" have been characterised for 13 qualitative 5 quantitative descriptor traits as per DUS test guidelines.
- Screening of 36 released varieties and 25 mini-core accessions which were identified as low temperature tolerant under two different sowing dates viz. early (January 27, 2015) and late (March 16, 2015) revealed that two mini-core accessions NRCG 14383, NRCG 14424 and one released variety ICGV 00350 were found promising for tolerance of low temperature.
- Under late sown conditions of summer 2015, one germplasm (NRCG 14383) and six released varieties (ALR 3, Kisan, TG 17, TAG 24, Dh 86, and TG 26) were found promising for tolerance of high temperature. One germplasm NRCG 14383 was found promising for both low and high temperature tolerance.
- In *kharif* 2015, a total of 589 genotypes were screened for resistance to stem rot under sick plot conditions. The disease incidence ranged from nil (ICGV 00387) to 86% (ICGV 03397). The genotypes which exhibited < 10% incidence at harvest were ICGVs' 07268, 02206, 00387, 97058, 03056, 07223 among advanced breeding lines; ISK I 2015-12, IVK I 2015-4, GPBD 4 among AICRP-G entries; and ICGV 11447, VGs 0411, 0502, 0507 and 1012.
- Out of the 317 working collection accessions evaluated for oil and protein contents, oil content ranged from 43.3% - 54.7% and the protein content ranged from 23.7% - 37.1%. The accession, NRCG 11875 had low oil and high protein contents (oil- 43.3%; protein- 37.1%) while the Valencia accession NRCG 11923 had high oil and low protein contents (oil- 54.7%; protein- 23.7%).
- Among Spanish types, NRCG 12128 recorded low oil (43.3%) and high protein (36.1%) content. Another accession NRCG 11927 registered high oil (50.3%) and low protein (29.7%) contents.
- In case of Virginia bunch types analyzed, two accessions NRCG 414 (oil- 44.5%; protein- 35.4%) and NRCG 11981 (oil- 44.7%; protein- 35.4%) recorded low oil but high protein contents. On the contrary, one accession, NRCG 12124 recorded high oil (53.8%) but with low (24.5%) protein contents.
- Fatty acid composition in 113 accessions of all the four habit groups has been estimated using GCMS. The O/L ratio was between 0.99 - 4.4 with an average value of 1.88. In each of the four habit groups accessions with high O/L accessions were identified. The accessions with high O/L ratios were: among Spanish bunch types- TKG 19A (3.3); in Virginia bunch types- GG 20 (4.4); and in Virginia Runner types- UF 70 (4.1).

- In preliminary yield trials, two advanced breeding lines PBS 29148 and PBS 29143 were found to be superior with respect to hundred pod and kernel weight compared to checks at Bikaner.
- At Junagadh PBS 19029 showed higher pod yield per plant and hundred kernel weight than check varieties, Mallika, GG 20, BAU 13 and TKG 19A.
- During drought stress, the *AtDREB1a* transgenic lines in T_4 generation showed significant higher level of relative water content, superoxide dismutase, catalase, glutathione peroxidise, ascorbate peroxidase, glutathione reductase activity, while significant lower level of hydrogen peroxide and malondialdehyde content was recorded when compared to untransformed wild type plants. Among studied antioxidant enzymes activity, at pegging and pod formation stage, the transgenic lines exhibited significantly higher levels of POD and APX activity.
- Twenty new polymorphic SSR markers were identified for genotyping of F_2 mapping population of cross GJG 17 x GPBD 4.
- Three new SSR markers namely - DGR 308, DGR 508 and DGR 800 were identified to be associated to Late Leaf Spot (LLS) disease resistance.
- Nine fresh crosses were made to introgress resistance to stem rot and PBND diseases in to cultivated groundnut.
- Two interspecific pre-breeding lines were identified for tolerance to drought.
- Two wild *Arachis* accessions, NRCG 12035 and NRCG 12047 were found resistant to stem rot disease with mortality less than 20 per cent disease incidence.
- Four RILs (Nos. 5, 16, 42 and 53) were found with significantly higher pod yield/plant under irrigated conditions and minimum yield reduction under imposed drought conditions which also had significantly lower SLA, higher SCMR values and high HI.
- Based on pooled analysis over summer 2015 and *kharif* 2015, genotype no. 107 with short duration and high oil content was found significantly superior over checks in terms of pod yield.
- Based on pooled analysis over *kharif* 2014, summer 2015 and *kharif* 2015, one genotype 25-5-32 (sel) with resistance to stem rot disease was found significantly superior over checks in terms of pod yield.
- Based on pooled analysis over *kharif* 2014 and *kharif* 2015, two genotypes 281-21-1 and 281-40-4 with higher kernel weight were found significantly superior over checks in terms of pod yield.
- Three RILs progenies (5-8, 15-1 and 15-3) from cross GG 20 x CS 19 were found highly resistant to stem rot disease with less than 10% mortality.
- Groundnut Varieties, CSMG 84-1, GG 12 and TG 17 recorded less than 10% stem rot during summer 2015 and Kadiri 3 and S 230 recorded 12% stem rot during *kharif* 2015.

Crop Protection

- *T. harzianum T-170* and *T. koningiopsis* supported maximum inhibition of stem rot over control.
- DGROF2 supported maximum inhibition of pest and diseases as well as enhanced yield as compared to control.
- Raised bed (with three rows) recorded minimum stem rot disease.
- Module-M15 supported maximum inhibition of stem rot.

- *A. flavus*, infection on pods and kernels, and subsequent aflatoxin contamination in kernels were low in groundnut grown after onion and garlic.
- Soil application of sodium chloride, sodium bicarbonate, rock salt and carbendazim at 60DAS, and Trichoderma at basal, 30 and 60 DAS lowered the aflatoxin contamination compared to botanicals.
- Freshly stripped pods were less contaminated with aflatoxin than the gleaned pods collected from farmers' field.
- Pods stored upto 8 months at room temperature in high density polythene bag (160µ thickness) has lesser *A. flavus* infection and aflatoxin contamination compared to pods stored in jute gunny bag.
- Yellow coloured sticky traps were more efficient in trapping leafhopper while blue sticky traps were suitable for trapping thrips at all three heights. Leafhopper catches in either yellow or blue traps was not influenced by the direction of wind however, thrips catches was influenced by wind from South-West direction.
- Treatment, NPK@ 37.5:70.0:0.0 was observed with significantly lower thrips population.
- Thrips population was lowest in groundnut intercropped with castor, maize, bajra and sesamum.
- Genotype, PBS 12181 registered lowest number of eggs laid, adults emerged, damage and weight loss against bruchids.
- Tamarind and groundnut were found with lowest amount of trypsin inhibitor activity and were best suited for bruchid rearing.
- Treatment, blue plastic drum + neem oil proved best for reducing the bruchid incidence in stored groundnut and saved produce for six months period.
- Myo-inositol content was increased in susceptible genotypes after infection of alterneria leaf spot pathogen.
- Constitutive level of cinnamic and salicylic acid was higher in alterneria resistant genotypes.
- Higher constitutive and induced activities of phenyl alanine ammonia lyase and tyrosine ammonia lyase enzyme were observed in alterneria resistant genotypes.
- Glucose, ribofuranose, linoleic acid and linolenic acids were higher in late leaf spot resistant genotypes.

Crop Production

- Under check basin irrigation, 150 per cent plant population and 100 per cent NPK gave significantly higher pod and haulm yield, and net returns. While under drip irrigation, 100 per cent plant stand and 75 per cent NPK gave yield and net returns at par to their higher levels.
- Use of mulch film significantly enhanced pod yield of groundnut by 14.6% over no mulch film.
- Fertigation of normal as well as water soluble fertilizers significantly enhanced pod yield over application of normal fertilizers with surface irrigation.
- Raised bed and furrow method, and biodegradable mulch significantly improved pod and haulm yields of groundnut.
- Application of 75% RDF + 5 t FYM/ha in groundnut and 75% RDF in wheat gave significantly highest pod yield of groundnut and grain yield of wheat over farmers' practice.

- Groundnut + pigeonpea-greengram (green manuring), closely followed by groundnut + pigeonpea–*Sesbania* (green manuring) and groundnut + pigeonpea system, gave significantly higher system productivity in terms of groundnut pod equivalent yield over groundnut-wheat system.
- Application of FYM @ 5 t/ha + enriched compost 1429 kg/ha + plant growth stimulant + plant growth promoter + nutrient mobilizers gave significantly higher pod and haulm yield over application of recommended dose of fertilizers.
- Sowing of groundnut with crop geometry of 30x10 cm spacing, being at par with 45/10x10 cm spacing, gave significantly higher pod and haulm yield over 45x10 cm spacing. Application of PGPR significantly improved pod and haulm yield of groundnut over control.
- Minimum tillage is as effective as normal tillage in getting higher yield of groundnut. In wheat, minimum tillage and zero tillage gave higher productivity as compared to normal tillage. Wheat stubble retention and wheat stubble retention + C*assia tora* mulch improved yield of groundnut and wheat.
- Significantly higher pod and haulm yield were recorded in TKG19A under Spanish group during both seasons.
- Significantly higher pod yield was recorded with the application of 2 dSm^{-1} saline irrigation water but it was at par with control (0.5 dSm^{-1}).
- Significantly higher pod and haulm yield with 34.2% and 30.4% were recorded under polythene mulch as compared to no mulch, respectively.
- Application of potassium @ 60 kg ha^{-1} ameliorated the effect of water salinity by countering the effect of salinity.
- Application of phosphorus up to @30 kg P_2O_5 ha^{-1} had significant affect and found most optimum for both summer as well as *kharif* season groundnut.
- Application of FYM was found most congenial for solubilization and mobilization of soil phosphorus followed by compost and citric acid in groundnut wheat cropping system.
- Despite of high P buffering capacity of Saurashtra soils have the great potential for P nutrition of plants using appropriate management practices for their solubilization and mobilization.
- Significant genotypic variation were observed among groundnut germplasm for pod yield under soil phosphorus levels.
- Spatial distribution maps using GIS tools was generated for area, production and productivity of different groundnut growing districts of six major and other minor groundnut growing states based on the season of cultivation. Per cent distribution of the same was calculated into low, medium and high categories. Soil samples from the selected sites was collected and analyzed for different yield-influencing soil attributes.

Basic Sciences

- Ca, K, B and Zn were identified as important nutrients for pod-filling in groundnut.
- The response of Zn and Fe on yield and their contents varied in 190 groundnut cultivars.
- Ten high Fe and 15 high Zn density groundnut cultivars were identified.
- Though all Zn sources increased Zn content of groundnut seed, zinc sulphate was best.
- 190 groundnut cultivars screened for iron chlorosis and tolerant ones identified.

- High Zn and Fe dense accessions in the minicore were identified.
- Different temperature regime resulted in differences in total degree days required to the crop to obtain maturity. The initiation of germination was hastened by ~ 4 days due increase in mean day-night temperature.
- Among the mini-core subset of groundnut germplasm accessions, a few (NRCG 14380, 14368, 14377, 14334, 14404) showed least change in photosynthetic efficiency with changing temperature regime, and thus may be used for heat stress tolerance.
- Although high temperature stress resulted in loss of both pod and fodder yield, but it didn't alter the seed quality parameters significantly, except the seed protein content showing little drop with increasing temperature level.
- Photosynthetic efficiencies varied among Indian groundnut cultivars.
- Pod zone moisture contents is the deciding factor for pod yields losses.
- Biochemical study reveals up-regulation of SOD, CAT and POD under salt stress.
- 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 TG 37A by 17-21%.
- Leaf epiphytic bacterial isolates antagonistic to Alternaria and late leaf spot pathogen were identified.
- Plant growth promoting rhizobacteria of groundnut showing zinc and potassium solubilizing abilities were identified.
- Among ten groundnut endophytes screened, *in vitro*, for antifungal activities against *Alternaria* leaf spot pathogen, 3 isolates *Pseudomonas aeruginosa* R24, *Pseudomonas otidis* J11 and *Bacillus tequilensis* SEN15 showed strong inhibition against the pathogen.
- Significant improvement in the yield of groundnut was achieved with the application of endophytes *Pseudomonas pseudoalcaligens* SEN29 and *Bacillus firmus* J22 with the application of single irrigation water at the time of sowing.
- Among the Bt isolates tested against white grubs, HBN2 was found most effective with larval mortality of 87% as compared to control (7%).

Social Sciences

- On studying the Resource Use Management (RUM) behaviour of groundnut growers, the medium land holders of Porbandar district had medium RUM behaviour in cropping systems management and had high level of RUM behaviour in soil-moisture management.
- Farmers in Amreli district of Gujarat showed low level management behaviours in all other RUM indicators, except seeds management.
- Farmers in Dharwad district of Karnataka were having low to medium RUM behaviour in cropping systems management and soil-moisture management. There were low levels of RUM behaviour among them for weeds and pests and disease management.

कार्यकारी **सारांश**

फसल सुधार

- जीनोटाइप पीबीएस 15020, 15025, 15027 एवं 15054 में पानी की कमी/सूखा की स्थिति में अधिक पुआल की उपज प्राप्त हुई।
- जीनोटाइप पीबीएस 15022, 15041 एवं 30055 से जूनागढ़ और अनंतपुर दोनों स्थानों पर चेक किस्म की अपेक्षा अधिक उपज प्राप्त हुई।
- जीनोटाइप पीबीएस 15044 की फली की उपज सबसे अच्छी चेक किस्म एसजी 99 की तुलना में अधिक थी।
- पानी की कमी/सूखा की स्थिति में जीनोटाइप पीबीएस 11092 में चेक किस्मों की तुलना में कम एसएलए (SLA) और उच्च एचकेडब्लू (HKW) था।
- खरीफ-2015 में तेरह क्रास को पत्ती रोगों, तना विगलन, ऑल्टरनेरिया पर्ण चित्ती रोग, स्पोडोप्टेरा, एवं चूसने वाले कीड़ों के लिए प्रतिरोधी/सहनशील उन्नत किस्में विकसित करने के लिए प्रभावी पाया गया।
- दो साल की उपज के मूल्यांकन के आधार पर दो उन्नत प्रजनन लाइनों (पीबीएस 12200 और पीबीएस 12201) को अधिक उपज देने वाली अभिजात जीनोटाइपों के रूप में पहचाना गया तथा इन्हें एआईसीआरपीजी के अंतर्गत बहु-स्थान परीक्षण के लिए प्रस्तावित किया गया।
- तीन वर्ष के परिणामों के आधार पर (ग्रीष्म 2013-2015) केवल दो जीनोटाइपों, पीबीएस 12029 और पीबीएस 18037 में सहिष्णु जीनोटाइप सीएस19 की तुलना में को कम तना विगलन रोग देखा गया।
- बीकानेर के क्षेत्रीय केंद्र पर कॉलर विगलन रोग की सहिष्णु जीनोटाइपों ओजी 52-1 (9.0%) तथा जे 11 (8.7%) की तुलना में चार जीनोटाइपों पीबीएस 12191, पीबीएस 12192, पीबीएस 22092 और पीबीएस 22097 में 10% से कम कॉलर विगलन रोग दर्ज किया गया।
- ऑल्टरनेरिया पर्ण चित्ती रोग सूखे की स्थिति में अधिक पाया गया।
- नौ हजार एक सौ उनतीस (9129) मूंगफली वंशक्रमों को मध्यम अवधि कोल्ड स्टोरेज(4±1 सेल्सीयस; 30% सापेक्ष आर्द्रता) में अनुरक्षित किया गया।
- कुल 109 वंशक्रमों के छ: वर्गों *Arachis* (44), *Coleorhiza* (1), *Ericoides* (7), *Heterantha* (5), *Procumbentes* (8) और *Rhizomatosa* (38) को प्रक्षेत्र जीन बैंक में अनुरक्षित किया गया।
- ICRISAT से प्राप्त आठ एम्फीडिप्लोइड व्युत्पन्न (सिंथेटिक मूँगफली) के बीजों को फसल सुधार कार्यक्रम में आगे उपयोग के लिए उगाया गया।
- ग्रीष्म 2015 में मूँगफली के 132 वंशक्रमों तथा खरीफ 2015 में 2154 वंशक्रमों को उगाया गया।
- वेलेंसिया समूह की एनआरसीजी1108 जीनोटाइप को एक अधिक उपज (2,671 किलोग्राम/हेक्टेयर) तथा अधिक शेलिंग प्रतिशत (72.7%) के लिए पहचाना गया।

- मूँगफली की 36 जारी किस्मों तथा मिनी-कोर की 25 वंशक्रमों को कम तापमान सहिष्णुता की पहचान के लिए दो अलग-अलग तारीखों पर, जल्दी (27 जनवरी, 2015) और देर से (16 मार्च, 2015) बुवाई की गई। इससे पता चला है कि दो मिनी-कोर वंशक्रमों एनआरसीजी-14383 तथा एनआरसीजी 14424 और एक जारी किस्म आईसीजीवी 00350 कम तापमान के लिए सहिष्णु पाई गई।
- ग्रीष्म 2015 में वंशक्रम (एनआरसीजी 14383) और छ: जारी किस्मों (एएलआर 3, किसान, टीजी 17, टीएजी 24, डीएच 86 और टीजी 26) को देरी से बुवाई/उच्च तापमान की सहिष्णुता के लिए उपयुक्त पाया गया।
- मूँगफली के 317 वंशक्रमों का तेल और प्रोटीन की मात्रा के लिए मूल्यांकन किया गया। जिसमे तेल की मात्रा 43.3% से लेकर 54.7% और प्रोटीन की मात्रा 23.7% से लेकर 37.1% पाई गयी। वंशक्रम एनआरसीजी 11875 में कम तेल और अधिक प्रोटीन (43.3% एवं 37.1%) था जबकि वेलेंसिया वंशक्रम एनआरसीजी-11923 में अधिक तेल और कम प्रोटीन (54.7% एवं 23.7%) पाया गया।
- मूँगफली के सभी चार समूहों में से 113 वंशक्रमों में GCMS द्वारा वसीय अम्लों विश्लेषण किया गया है। ओलिक/लिनोलिक अनुपात 0.99 से लेकर 4.4 तक था तथा 1.88 औसत ओलिक/लिनोलिक था। वालेंसिया वंशक्रम में ओलिक/लिनोलिक अनुपात 0.99 था । जबकि स्पेनिश जीनोटाइप टीकेजी 19ए में ओलिक/लिनोलिक अनुपात ३.३ तथा वर्जीनिया जीनोटाइप जीजी20 में 4.4 था। स्पेनिश वंशक्रमों में एनआरसीजी 12128 में कम तेल (43.3%) और अधिक प्रोटीन (36.1%) पायी गई। जबकि एनआरसीजी11927 अधिक तेल (50.3%) और कम प्रोटीन (29.7%) पायी गयी।
- बीकानेर में प्रारंभिक उपज परीक्षण में दो उन्नत प्रजनन लाइनों पीबीएस 29148 और पीबीएस 29143 में चेक की तुलना में सौ फलीयों एवं दानों का वजन बेहतर पाया गया।
- जूनागढ़ में पीबीएस 19029 की सौ फलीयों एवं दानों का वजन मल्लिका, जीजी 20, बीएयू 13 और टीकेजी 19ए से अधिक पाया गया।
- सूखे की स्थिति में *DREB1A* ट्रांसजेनिक लाइन की टी$_4$ पीढ़ी में बिना ट्रांसफोर्म किये गए मूँगफली के पौधों की तुलना में सापेक्ष पानी की मात्रा, सुपरऑक्साइड डिसम्यूटेस, केटालेज, ग्लूटाथायोन परओक्सीडेज, एस्कॉर्बेट परओक्सीडेज, ग्लूटाथायोन रिडक्टेस की क्रियाशीलता अधिक पायी गयी | जबकि हाइड्रोजन पेरोक्साइड और मेलोनडाईएलडीहाईड की मात्रा कम दर्ज की गयी। *DREB1A* ट्रांसजेनिक लाइन एवं बिना ट्रांसफोर्म किये गए मूँगफली के पौधों में यह अध्ययन पेगिंग और फली बनते समय किया गया।
- बीस नए बहुरूपी एसएसआर मार्करों को जीजेजी17 x जीपीबीडी 4 की F_2 जनसंख्या की जीनोटाइपिंग के लिए पहचाना गया।
- तीन नए एसएसआर मार्करों, डीजीआर 308, डीजीआर 508 एवं डीजीआर 800 को पछेती पर्ण चित्ती रोग प्रतिरोध से संबंधित पाया गया।
- दो अंतर जातीय, प्रजनन-पूर्व वंशक्रमों को सूखे के प्रति सहिष्णुता के लिए पहचान की गई।
- मूँगफली के दो जंगली वंशक्रमों (एनआरसीजी 12035 और 12047) को तना विगलन रोग के लिए प्रतिरोधी पाया गया, जिसमे पौधों की मृत्यु दर 20 प्रतिशत से कम थी।
- चार संयोजक इनब्रेड लाइनों (नं. 5, 16, 42 और 53) में सिंचित स्थिति में प्रति पौधा फली की उपज अधिक पायी गयी तथा सूखे की स्थिति में भी उपज में न्यूनतम कमी देखी गयी। इन लाइनों में कम एसएलए, अधिक SCMR तथा अधिक हार्वेस्ट इंडेक्स पाया गया।
- खरीफ 2014 एवं 2015 के विश्लेषण के आधार पर दो जीनोटाइप 281-21-1 और 281-40-4 में चेक की तुलना में दानों का वजन तथा फली की उपज बेहतर थी।
- ग्रीष्म 2015 में मूंगफली की किस्मों, सीएसएमजी 84-1, जीजी 12 और टीजी 17 में तना विगलन रोग 10% से कम तथा खरीफ 2015 में कादिरी 3 और एस 230 में 12% से कम तना विगलन रोग दर्ज किया गया।

फसल सुरक्षा

- ट्राईकोडरमा हरजीयानम टी-170 तथा ट्राईकोडरमा कोनिनजियोप्सिस के प्रयोग से तना विगलन रोग का सबसे अधिक नियंत्रण हुआ।
- डीजीआरओएफ-2 के प्रयोग से कीट और रोगों का अधिकतम नियंत्रण हुआ साथ ही उपज भी बढ़ी।
- ऊँची उठी क्यारी विधि (तीन पंक्तियों के साथ) से बुवाई करने पर न्यूनतम तना विगलन रोग दर्ज किया गया।
- मॉड्यूल-एम१५ से तना विगलन रोग का सबसे अधिक नियंत्रण हुआ।
- मूँगफली को प्याज एवं लहसुन के बाद बुवाई करने पर एस्परजिलस फ्लेवस का संक्रमण तथा बाद में फली एवं दानों में अफ्लाटॉक्सिन का संक्रमण कम पाया गया।
- बुवाई के ६० दिन बाद सोडियम क्लोराइड, सोडियम बाइकार्बोनेट, सेंधा नमक और कार्बेन्डाजिम को मिट्टी में मिलाने तथा ट्राइकोडर्मा को बुवाई के ३० और ६० दिन बाद मिट्टी में मिलाने पर वनस्पति नियंत्रण की तुलना में अफ्लाटॉक्सिन का संक्रमण कम पाया गया।
- मिट्टी से मूँगफली निकलते समय पौधे से लगी हुई मूँगफली में अफ्लाटॉक्सिन का संक्रमण कम होता जबकि बाद में मिट्टी से एकत्रित की हुई मूँगफलीयों में अफ्लाटॉक्सिन का संक्रमण अधिक होता है।
- कमरे के तापमान पर 8 महीने तक उच्च घनत्व वाली पॉलिथीन बैग (160 माइक्रोन मोटाई) में संग्रहित मूँगफली में जूट की बोरी में रखी मूँगफली की तुलना में एस्परजिलस फ्लेवस का कम संक्रमण हुआ तथा अफ्लाटॉक्सिन की मात्रा कम पायी गयी ।

- पीले रंग के चिपचिपे जाल पत्तीहोपर्स को फँसाने में अधिक उपयोगी थे। जबकि नीले चिपचिपे जाल थ्रिप्स को सभी तीन ऊंचाइयों पर फँसाने में अधिक उपयोगी थे। पीले एवं नीले रंग के चिपचिपे जाल में पत्तीहोपर्स को फँसाने में हवा की दिशा का कोई प्रभाव नही था जबकि थ्रिप्स को फँसाने के लिए दक्षिण-पश्चिम दिशा की हवा प्रभावी थी।
- नाइट्रोजन फोस्फोरस एवं पोटेशियम उर्वरकों का 37.5:70.0:0.0 के अनुपात में उपयोग करने पर थ्रिप्स की जनसंख्या में प्रभावी रूप से कमी देखी गयी।
- मूँगफली के साथ अरंडी, बाजरा, मक्का एवं तिल का अंतरासस्य करने पर थ्रिप्स की जनसंख्या में कमी देखी गयी।
- जीनोटाइप पीबीएस 12181 में सबसे कम ब्रुचीड एवं उसके अंडे पाए गए।
- इमली एवं मूँगफली में सबसे कम ट्रिप्सिन इन्हीबिटर पाया गया जिसके कारण ये ब्रुचिड के पालन के लिए उपयुक्त हैं।
- नीले प्लास्टिक के ड्रम में मूँगफली को नीम का तेल लगाकर रखने से ब्रुचीडस का आक्रमण कम होता है तथा मूँगफली को छः महीने तक संग्रहित किया जा सकता है।अल्टर्नेरिया पर्णचित्ति रोग के संक्रमण से रोगसहनशील जीनोटाइपों में मायो-इनोसिटोल की मात्रा बढ़ जाती है।
- अल्टर्नेरिया पर्णचित्ति प्रतिरोधी जीनोटाइपों में संक्रमण से पूर्व सिन्नेमिक अम्ल तथा सेलिसिलिक अम्ल की मात्रा अधिक थी।
- अल्टर्नेरिया पर्णचित्ति प्रतिरोधी जीनोटाइपों में फिनाइलएलानिन अमोनिया लयेज एवं टायरोसीन अमोनिया लयेज एंजाइम की क्रियाशीलता विधान एवं प्रेरित स्तर पर अधिक पाई गई।

फसल उत्पादन

- चेक बेसिन सिंचाई पद्धति के तहत 150 प्रतिशत मूँगफली के पौधों के साथ 100 प्रतिशत नाइट्रोजन, फोस्फोरस एवं पोटेशियम उर्वरकों को देने से अधिक फली, पुआल उपज और शुद्ध लाभ मिला। जबकि टपक सिंचाई के अंतर्गत 100 प्रतिशत मूँगफली के पौधों के साथ 75 प्रतिशत नाइट्रोजन फोस्फोरस एवं पोटेशियम उर्वरकों को देने से उनकी उच्च स्तर के बराबर उपज और शुद्ध लाभ मिला।
- पलवार के उपयोग से मूँगफली की उपज में बिना पलवार की मूँगफली की तुलना में 14.6% अधिक उपज प्राप्त हुई।
- पानी में घुलनशील उर्वरकों का फर्टिगेशन करने पर परंपरागत रूप से उर्वरक एवं सिंचाईं देने की अपेक्षा उर्वरकों की २५ प्रतिशत मात्रा बचाई जा सकती है।
- मूँगफली में 75% अनुशंसित उर्वरक दर एवं ५ टन गोबर की खाद देने तथा बाद में गेंहूँ में 75% अनुशंसित उर्वरक दर पर किसानों की प्रथा के अनुसार उर्वरक देने की अपेक्षा मूँगफली एवं गेंहूँ की उपज सार्थक रूप सेअधिक हुई।
- मूँगफली+ अरहर-मूंग (हरी खाद), मूँगफली+ अरहर-सेस्बेनिया (हरी खाद) और मूंगफली + अरहर प्रणाली, मूँगफली- गेहूं प्रणाली की तुलना में सार्थक रूप से अधिक उत्पादकता प्राप्त हुई।
- मूँगफली की बुवाई 30x10 सेमी दुरी की फसल ज्यामिति से करने पर फलीयों और पुआल की उपज सार्थक रूप से अधिक थी जो कि 45x10 सेमी दुरी के बराबर थी। पीजीपीआर के उपयोग से फलीयों और पुआल की उपज में सार्थक वृद्धी हुई।
- मूँगफली में अधिक उपज प्राप्त करने में न्यूनतम जुताई भी सामान्य जुताई जितना ही प्रभावी है। गेहूं में न्यूनतम जुताई और शून्य जुताई से सामान्य जुताई की तुलना में अधिक उत्पादकता प्राप्त हुई।
- लवणीय सिचाई जल (2 डीएसएम$^{-1}$) के उपयोग से फलियों की उपज में उल्लेखनीय वृद्धी हुई।
- प्लास्टिक की पलवार के प्रयोग से फलियों की उपज में 34.2% एवं पुआल की उपज में 30.4% की वृद्धी हुई।
- 60 कि. ग्रा./हे. की दर से पोटेशियम उर्वरक देने से लवणीय पानी के प्रभाव को कम करता है।
- ग्रीष्म एवं खरीफ मूँगफली में 30 कि. ग्रा./हे. की दर से फोस्फोरस उर्वरक की मात्रा इष्टतम है।
- मूँगफली-गेहूं सस्य पद्धति के अंतर्गत मृदा में पाए जाने वाले फास्फोरस को विलेय एवं गतिशील बनाने हेतू गोबर कि खाद सबसे अनुकूल है।
- सौराष्ट्र कि मृदा में अत्यधिक फोस्फोरस प्रतिरोधक क्षमता के बावजूद उचित प्रबंधन तरीकों का उपयोग करके पौधों में फोस्फोरस की घुलनशीलता एवं गतिशीलता को बढाया जा सकता है।
- मूँगफली के जर्मप्लाज्म में मृदा के विभिन्न फास्फोरस स्तरों में फली कि उपज के लिए उल्लेखनीय विभिन्नता पायी गयी।
- जीआईएस के उपयोग से छ: प्रमुख और अन्य मूँगफली की खेती करने राज्यों के जिलों का स्थानिक वितरण नक्शा क्षेत्र, उत्पादन एवं उत्पादकता के लिए तैयार किये गए। तथा उनका प्रतिशत वितरण कम मध्यम एवं अधिक वर्गों में किया गया। चुनिन्दा स्थानों से मृदा के नमूने एकत्रित करके उपज को प्रभावित करने वाले मिट्टी गुणों का विश्लेषण किया गया।

मूलभूत विज्ञान

- मूँगफली में फलियाँ भरने कि लिए केल्शियम, पोटेशियम, बोरोन एवं जिंक की महत्वपूर्ण पोषक तत्वों के रूप में पहचान की गई।
- मूँगफली की दस अधिक आयरन तथा 15 अधिक जिंक वाली किस्मों की पहचान की गई।

- यद्यपि जिंक के सभी स्रोत मूँगफली के दानों में जिंक की मात्रा बढ़ाते है पर जिंक सल्फेट सबसे अच्छा है।
- मूँगफली की 190 किस्मों की आयरन क्लोरोसिस के लिए जाँच की गई एवं सहिष्णु किस्में पहचानी गई।
- विभिन्न तापमानों में फसल की परिपक्वता प्राप्त करने की अवधि भिन्न- भिन्न प्राप्त हुई। दिन-रात के औसत तापमान में वृद्धि के कारण अंकुरण की शुरुआत लगभग 4 दिन से हो गई।
- दिन-रात के औसत तापमान में वृद्धि के कारण, प्रकाश-संश्लेषण दर कम हो गई , जबकि रंध्र चालकता, वाष्पोत्सर्जन और केनोपी तापमान में वृद्धि हुई।
- विभिन्न तापमान में मूँगफली की मिनी-कोर वंशक्रमों (एनआरसीजी 14380, 14368, 14377, 14334, 14404) में सबसे कम प्रकाश-संश्लेषण क्षमता में परिवर्तन देखा गया अतः इन वंशक्रमों को अधिक तापमान सहिष्णु कहा जा सकता है।
- फली जोन का नमी स्तर फलियों की उपज में कमी का निर्णायक कारक है। मूँगफली के बीज का आकार एवं फली की उपज, वृद्धी नियामकों के प्रयोग से प्रभावित होती है।
- जैवरसायनिक अध्यन से पता चला है कि, लवणता कि स्तिथि में सुपर ओक्साइड डिसम्यूटेज, केटालेज एवं परओक्सीडेज एंजाइमों की क्रियाशीलता अधिक होती है।
- डीएपीजी पैदा करने वाले प्रतिदीप्ति स्यूडोमोनास (प्रमुख मृदा जनित कवक रोगजनकों के विरुद्ध कवकरोधी गतिविधियों के लिए पहचानी गयी) के प्रयोग से टीजी 37ए किस्म में फली की उपज में 17-21% तक वृद्धी पायी गयी।
- पत्तों के उपर पाए जाने वाले जीवाणुओं को अल्टर्नेरिया और पछेती पर्ण चित्ती रोगज़नकों के प्रतिरोधी के रूप में पहचाना गया।
- मूँगफली के पादप वृद्धी को बढ़ाने वाले राइजोबैक्टेरिया में जिंक एवं पोटेशियम घुलनशीलता की क्षमता पायी गयी।
- दस एन्डोफाईट को प्रयोगशाला में अल्टर्नेरिया पर्ण चित्ती कवकरोधिता के लिए जाँच की गयी जिनमे से तीन एन्डोफाईट-स्यूडोमोनास ऐरूजीनोसा आर 24, स्यूडोमोनास ओटीडिस जे-11 एवं बैसिलस टेक्वीलेंसिस एसइएन-15 रोगजनक के नियंत्रण में मुख्य भूमिका निभाते है।
- एन्डोफाईट-स्यूडोमोनास स्यूडोएल्कलीजन एसइएन-29 एवं बैसिलस फर्मस का प्रयोग करने से एक सिचाई में भी (बुवाई के समय) मूँगफली की उपज में उल्लेखनीय वृद्धी हुई।

सामाजिक विज्ञान

- मूँगफली उत्पादकों के संसाधन उपयोग प्रबंधन व्यवहार का अध्ययन करने पर पाया गया कि, पोरबंदर जिले के मध्यम भूमिधारक का संसाधन उपयोग प्रबंधन व्यवहार फसल प्रणाली के लिए मध्यम था जबकि मृदा नमी प्रबंधन के लिए अधिक था।
- बीज प्रबंधन के अलावा अमरेली जिले के किसानों का संसाधन उपयोग प्रबंधन व्यवहार सभी प्रबंधन सूचकों के लिए कम था।
- कर्नाटक के धारवाड़ जिले के किसानों का संसाधन उपयोग प्रबंधन व्यवहार फसल प्रणाली एवं मृदा नमी प्रबंधन के लिए कम से लेकर मध्यम तक था। जबकि खरपतवार, कीट एवं रोग नियंत्रण के लिए संसाधन उपयोग प्रबंधन व्यवहार कम था।

Genetic improvement of groundnut

Breeding for tolerance to abiotic stress in groundnut

Hybridization, selection and advancement of generation in segregating breeding lines

Ten fresh crosses were attempted in *kharif* 2015 to enhance thermo-stability, earliness and tolerance to drought stress and yield attributes. In summer 2015 the probable hybrid pods from ten crosses attempted in *kharif* 2014 were raised and total of 65 F_1 hybrids were harvested as single plants. One cross was rejected in F_4 generation, and 104 single plant progenies (spp) were selected from the remaining crosses. In F_5 generation 113 spp were selected. In F_6 generation,16 new non-segregating advanced breeding lines were selected.

New advanced breeding lines developed

In stabilized (non-segregating) F_7 generation 10 new advanced breeding lines were selected from 9 crosses which comprised of 4 Spanish and 6 Virginia types.

Maintenance breeding and seed enhancement

Ten new advanced breeding lines (4 Spanish and 6 Virginia) were developed and will be sown for seed enhancement in summer 2016 for evaluation in different yield trials. Twenty nine new advanced breeding lines (2 Spanish and 27 Virginia) developed in *kharif* 2014 were raised for seed enhancement and bulk harvested for their evaluation in succeeding seasons.

Advanced breeding lines in AICRP-G trials

The advanced breeding line PBS 25053 was evaluated in the initial varietal trial stage-I of Virginia groundnut (IVT-I) in *kharif* 2015, and PBS 16038 line under initial varietal trial stage-I of Spanish groundnut (PIT-I) in the AICRP-G trials in summer 2016.

Yield evaluation of advanced breeding lines

Yield evaluation of advanced breeding lines

Summer 2015: A total of 16 Spanish advanced breeding lines were evaluated under two irrigation treatments with four checks (TAG 24, Dh 86, TG 26 and TG 37A). Genotypic differences were significant for days to flower initiation, SLA, SCMR, pod yield, kernel yield, hundred kernel weight (HKW), seed length, seed width, oil, protein and sugar contents. Interaction effect of genotype and irrigation treatment was significant for pod yield, kernel yield, oil, protein and sugar contents. Genotype PBS 11092 had low SLA and high HKW when compared to check varieties.

Kharif 2015: A total of 12 Spanish advanced breeding lines were evaluated under two irrigation treatments with four checks (TAG 24, Dh 86, TG 26 and TG 37A). Genotypic differences interaction effect of genotype and irrigation treatment were significant for days to flower initiation, SLA, SCMR, pod yield, kernel yield, hundred kernel weight (HKW), seed length and seed width. Genotype PBS 15020, 15025, 15027 and 15054 had high haulm yield under water stress. A total of 15 Spanish advanced breeding lines were evaluated at Junagadh and Anantapur locations for tolerance to drought conditions. Significant genotypic differences were observed for days to flower initiation, SLA, SCMR, pod yield, kernel yield, hundred kernel weight (HKW), seed length and seed width under both the locations. Genotypes PBS 15022, 15041 and 30055 had high yield compared to check variety at both the locations. A total of 15 Spanish advanced breeding lines were evaluated along with 5 check varieties (SG 99, GG 7, GJG 9, JL 501 and TG 37A). Significant genotypic differences were observed for days to flower initiation, SLA, SCMR, pod yield, kernel yield, hundred kernel weight (HKW), seed length and seed width.

Genotype PBS 15044 had high pod yield when compared to best check variety SG 99. A total of 51 Virginia advanced breeding lines were evaluated along with 5 check varieties (Somnath, GG 20, Kaushal, KDG 12 and KDG 128). Significant genotypic differences were observed for days to flower initiation, SLA, SCMR, pod yield, kernel yield, hundred kernel weight (HKW), seed length and seed width. None of the lines were superior to best check (Kaushal) for pod yield per plant.

Drought screening nurseries

Three hundred and seventy five advanced breeding lines were raised in augmented design in four drought screening nurseries. 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. Genotypes PBS 24111, 25034, 26057, 24115, 25058, 15021, 26038, 25059, 25077, 25084, 24129, 14068, 25048, 25057, 15020, 25093, 25031, 21118, 11085, 25047, 25075, 24104, 25028, 15028, 21099, 25076, 25038, 26015, 26025, 30044, 26033, 11087, 15007 had high pod yield when compared to check varieties.

Similarly, genotypes PBS 25025, 21095, 21106, 25107, 21110, 25023, 25024, 25092, 16044, 21093, 24128, 25026 had high SCMR and genotypes PBS 15034, 25023, 25024, 24073, 15018, 25107, 21107, 25116 had low SLA compared to check varieties.

Breeding for resistance to major diseases and insect pests in groundnut

Crosses effected

Thirteen crosses were effected in *kharif* 2015 to develop improved varieties resistant/ tolerant of foliar diseases, stem rot, Alternaria leaf spot, Spodoptera and sucking pest. The number of harvested crossed pods varied from 4 to 101. The mean success rate (%) of the entire hybridization programme was 25.1, which ranged from 5.6% to 34.4%.

Identification of true hybrids

Thirteen different crosses were raised in summer 2015 to identify true F_1's effected for developing resistant/tolerant genotypes to foliar diseases, stem rot and insect-pests of groundnut. A total 32 hybrids were isolated from the thirteen crosses.

Generation advancement

The breeding materials generated earlier were advanced to next higher filial generation in *kharif* 2015. Progenies of 68 crosses were advanced to different filial generations (F_2-F_6), of which eight crosses were rejected due to large proportion of poor recombinants and absence of desirable trait of interest in the recombinants. In F_6 generation, individual plant progenies of nine crosses were raised to identify high yielding stable genotypes, among these crosses eight new advanced high yielding breeding lines were identified and given number according to objective of their botanical group.

Development and generation advancement of mapping populations

The mapping populations developed earlier were advanced to next filial generation in *kharif* 2015. A total five mapping populations were advanced from F_6 to F_7 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. From these crosses, a total 11 new advanced high yielding breeding lines were developed, of which two lines (PBS 12221, PBS 12222A) belonged to Spanish and nine lines (PBS 22125, PBS 22126, PBS 22127, PBS 22128, PBS 22129, PBS 22130, PBS 22131, PBS 22132, PBS 22133) belongs to Virginia botanical group.

Two mapping populations were advanced from F7 to F8, in which one (JL 24 × VG 9816) meant for foliar diseases resistance and one (GG 20 × CS 19) for tolerance to stem rot. One set of about 50 seeds of these eight RILs have been deposited in cold storage as genetic stock for future use.

Generation advancement of mapping populations

Yield evaluation of advanced breeding lines

Summer 2015: A total 45 Spanish advanced breeding lines with three checks (TAG 24, Dh 86 and TG 37A) were evaluated in RBD with three replications for yield and its other traits during summer 2015. The results revealed that none of the genotype significantly surpass the best check for pod and kernel yield (kg/ha). Four genotypes viz., PBS 12163, PBS 12175, PBS 18006 and PBS 12198 significantly recorded high shelling outturn over the best check TAG 24 and Dh 86.

***Kharif* 2015:**

First year evaluation: A total thirteen genotypes of Spanish (4) and Virginia bunch (9) along with checks viz. GG 7, TG 37A, JL 501 for Spanish bunch and GG 20, KDG 123 and KDG 128 for Virginia bunch were evaluated in five rows of 5m length for yield and its component traits in RBD with three replications. The results revealed that none of the

Spanish genotype significantly surpass the best check for no. of pods/plant, pod and kernel yield (kg/ha), shelling outturn (%) and harvest index (%) but genotypes PBS 12203 for pod and kernel yield (kg/ha) was found at par with best check variety TG 37A for pod yield and kernel yield (2056 and 1375 kg/ha).

Second year evaluation: Nine 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* 2014 and *kharif* 2015. The genotype PBS 12200 was slight missed significantly superior over best check but it was fond at par with best check TG 37A for pod and kernel yield. One genotype PBS-12201 (2300 kg of pod and 1555 kg kernel/ha) was found significant superior over the best check variety TG 37A for kernel yield (1287 kg kernel/ha). Hence, based on two year evaluation, these two elite genotypes were identified as high yielding and further these need to be testing for yield and other component traits under AICRP-G trials.

Another experiment comprising eight Virginia bunch genotypes along with high yielding checks viz. GG 20 were evaluated in five rows of 5m row length for yield and its component traits in a RBD with three replications during *kharif* 2014 and *kharif* 2015. The results revealed that none of the genotype were significantly superior over best check for all the traits except genotype PBS 22093 (12 pods/plant and 1972 kg/ha) which was found significantly superior over the best check variety GG 20 for these traits (8 pods/plant and 1532 kg/ha) and at par for kernel yield. The genotype PBS 22105 (37.7%) was found significant superior over the best check for harvest index. Hence, this genotype can be used in breeding programme for improving harvest index.

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

Development of new advanced breeding lines

A total 19 new advanced high yielding breeding lines were developed from advanced materials during *kharif* 2015, of which eight lines (PBS 12215, PBS 12216, PBS 12217, PBS 12218, PBS12219, PBS 12220, PBS 12221, PBS 12222) belonged to Spanish and 11 lines (PBS 22123, PBS 22124, PBS 22125, PBS 22126, PBS 22127, PBS 22128, PBS-22129, PBS 22130, PBS 22131, PBS 22132, PBS 22133) belongs to Virginia habit group.

Multiplication and maintenance of breeding materials

Summer 2015: A total of nine new advanced breeding lines and nine advanced breeding lines of Spanish and Virginia bunch, 34 groundnut genotypes found resistance/tolerance to different biotic stresses were also mass multiplied to get sufficient seed for conducting yield trials and screening for resistance to different biotic stresses.

Kharif 2015: A total of nine new advanced breeding lines (Spanish bunch- 3, Virginia bunch- 6) developed during *kharif* 2014 and 36 groundnut genotypes found having resistance/tolerance to different biotic stresses were also mass multiplied to get sufficient seed for conducting yield trials and screening for resistance to different biotic stresses.

Multiplication and status of AICRP-G lines

During *kharif* 2015, In IVT-II (Virginia): Two entries (PBS 22066, PBS 22067) are tested for yield and its component traits but none of the genotype significantly surpassed the yield level to the best check hence were not promoted in AVT. The genotype PBS 22066 was the best for pod (2821 kg/ha) and kernel yield in zone-II especially in Udaipur and Pratapgarh. In AVT (Virginia): One entry (PBS 22062) was tested in zone-II but it is not significantly superior over the best check. Now one entry, PBS 22080 being tested in IVT-I (Virginia). The final result will be present in next year.

Distribution of breeding materials to different AICRP-G centres

The breeding material of three different crosses from two segregating generations (F_3 and F_5) was selected in *kharif* 2015 and supplied to three AICRP-G centres to effect location specific selections for different biotic stresses for *kharif* 2016.

Screening of genotypes for resistance/tolerance of soil borne diseases

Summer 2015: A total of 46 advanced breeding lines along with tolerant genotype CS 19 were screened in replicated trial for resistant to stem rot under sick plot during summer 2013, 2014 and 2015. Data were recorded on per cent stem rot, which included per cent dead plant during growing period and pod infection at the time of harvesting.
The disease incidence was highest in genotype GG 2 (54.8%), PBS 12018 (71%) and PBS 12175 (24.1%) during summer 2013, 2014 and 2015 respectively. Based on three year results, only two genotypes PBS 12029 and PBS 18037 recorded less disease incidence as compared to the tolerant genotype CS 19 (32.5, 33.8, 11.5% in summer 2013, 2014 and 2015 respectively). These genotypes have been identified as tolerant to stem rot and can be used in breeding programme.

***Kharif* 2015:** A total of 46 advanced breeding lines along with tolerant genotype CS 19 were screened in replicated trial for resistant to stem rot under sick plot during *kharif* 2013 to *kharif* 2015. Data were recorded on per cent plant mortality and disease infected plants basis at the time of harvesting then total disease incidence was calculated. The average disease incidence varied between 9.7 to 41.8% among the genotypes. Results revealed that seven genotypes (PBS 12067, 12116, 12172, 12175, 18006, 18037, 18038) recorded less disease incidence as compared to the tolerant genotype CS 19). These genotypes have been identified as tolerant to stem rot and these genotypes can be used in breeding programme.

A total of 47 advanced breeding lines along with two tolerant genotypes OG 52-1 and J 11 were screened in replicated trial for resistance/tolerance to collar rot at CSWRI-ARC, Bikaner during *kharif* 2015. Data were recorded on plant mortality up to 40 DAS. The average collar rot incidence varied between 6.4 to 36.8%. Results revealed that four genotypes PBS 12191, PBS 12192, PBS 22092 and PBS 22097 recorded less than 10% disease incidence in all the replications as compared to the tolerant genotype OG 52-1 (9.0%) and J-11 (8.7%). Therefore, these genotypes need to be tested for two to three year for confirm their durability and stability of tolerance to collar rot.

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

A total of 53 groundnut genotypes screened for *in vitro* colonization by *Aspergillus flavus* at pod as well as kernel levels during summer 2015 using modified progressive 1-4 scale suggested by Thakur *et al.*, 2003. The seed infection score ranged from 1.3 to 3.8 while pod infection ranged from 1.0 to 4.0 on 1-4 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 ranged from 0.1 to 33.8 ppb. Some genotypes have less than 2 score on 1-4 scale and less than 4 ppb AFB1. These genotypes need to be tested for more years for *in-vitro* seed and pod colonization and aflatoxin content.

Screening of advanced breeding lines for foliar disease resistance

Summer 2015: A total of 45 advanced breeding lines were screened for resistant to *Alternaria* leaf spot with resistant check *viz*., CS 349 (4.3, 3.7 and 4.0 disease score on 1-9 scale in summer-2013, 2014 and 2015 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 pressure was observed in genotype PBS 12092 and PBS-18037 (7.7 and 7.1 score on 1-9 scale) in three years summer 2013, 2014 and 2015. Screening results of the three years indicated that two genotypes namely PBS 12169 and PBS-12190 showed resistance or tolerant reaction (<4.7 on 1-9 scale) to *Alternaria* leaf spot. These genotypes were identified as new sources of resistance/tolerance.
Among the 46 genotypes, seventeen genotypes *viz*., PBS 12032, PBS 12066, PBS 12116, PBS 12168, PBS 12171, PBS 13020, PBS 18006, PBS 18035, PBS 18057, PBS 12189, PBS 12191, PBS 12192, PBS 12196, PBS 12196, PBS 12198, NRCGCS 85 and GPBD 4 found tolerant reaction (<6.0 on 1-9 scale) to *Alternaria* leaf spot. Hence above mentioned genotypes can be used in breeding programme for improving tolerance to *Alternaria* leaf spot along with yield.

Another experiment under abiotic stress project, 16 genotypes were screened for *Alternaria* leaf spot under irrigated and drought conditions during summer 2015. The maximum disease pressure was scored 6.7 on 1-9 scale in both the conditions but under drought condition, disease incidence was increased in all the genotypes except PBS 11088, PBS 15047 and Dh 86. The maximum per cent disease was increased in genotype PBS 15020, PBS 15025 (28.6%) followed by PBS 15054 (27.3%). From this study it was observed that *Alternaria* leaf spot incidence was increased under drought conditions.

Kharif 2015: A total of 82 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 (early, late leaf spot and rust) during *kharif*, 2015. The maximum disease pressure for early leaf spot (ELS), late leaf spot (LLS) and rust was 6.0, 6.7 and 6.3 respectively on modified 1-9 point scale. The disease score in resistant check was 3.3, 2.0 and 2.0 for ELS, LLS and rust respectively.

For early leaf spot, two genotypes PBS 22069 and PBS 22104 recorded score around 3 on 1-9 scale. Eight genotypes *viz*., PBS 220093, PBS 22094, PBS 22106, PBS 22115, PBS 22116, PBS 12192, PBS 22028 and JL 776 for late leaf spot and one genotype PBS 12203 for rust recorded low disease score ⩽ 3 on 1-9 scale. The genotypes *viz*., PBS 22105, PBS 22040, PBS 28008, PBS 22098, KDG 123 and KDG 128 recorded resistant reaction for both LLS and rust. Some genotypes recorded resistance reaction but due to medium disease pressure their resistance cannot be ascertain thus stability of resistance/tolerance of genotypes will be confirmed for one or more year of under high disease pressure.

Another experiment under abiotic stress project, 16 genotypes screened for ELS, LLS and rust under rainfed and supplementary irrigated conditions during *kharif* 2015. The maximum ELS and rust pressure was scored 7.0 and 6.0 on 1-9 scale respectively in the both conditions while LLS pressure was scored 6.3 and 6.0 under rainfed and supplementary irrigated conditions respectively. The results revealed that per cent ELS and rust incidence was higher under irrigated conditions while LLS was higher under rainfed conditions.

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

Summer 2015: Fifty two groundnut genotypes were screened for resistance to sucking-pests such as, leafhoppers and thrips during summer 2015. None of the genotypes were found significantly differing with respect to both the mean leafhopper and thrips populations at 15, 30 and 45 days after sowing (DAS).

Kharif 2015: A total of 82 groundnut genotypes, 16 in BYET-SB, 20 in BYET-VB, 20 in BIST-SB and 26 in BIST-VB were screened for resistance to sucking-pests (leafhoppers and thrips) and *Spodoptera*. Leafhoppers, thrips and *Spodoptera* recorded maximum visual score of 2, 5 and 3 on 1-9 scale respectively. None of the genotypes were significantly differing with respect to mean leafhopper, thrips and *Spodoptera* populations. Due to low insect pressure during crop season definite conclusions could not be drawn.

Screening of advanced breeding lines for resistance/ tolerance of iron chlorosis

Under abiotic stress project, a total of 50 genotypes including advanced breeding lines, interspecific derivatives and cultivars were screened for tolerance of iron chlorosis in summer 2013, 2014 and 2015. The experiment was conducted under natural field condition in RBD with three replications. The genotypes showing interveinal chlorosis in their top five leaves are rated for visual chlorotic rating (VCR) score on 1-5 scale at various growth stages. The average highest iron chlorosis score was observed in genotype PBS-12172 (4.8 on 1-5 scale) and PBS 18029 (4.6 on 1-5 scale) in three years of study and well known iron tolerant source ICGV 86031 recorded score 3.5. Among the 50 genotypes, seven genotypes viz., PBS 12074, PBS 12169, PBS 12193, PBS 12194, PBS 12198, GPBD 4 and NRCG CS 349 recorded an average three year score ≤ 3.0 on 1-5 scale. Besides that one advanced breeding line PBS 22040 recorded an average score ≤ 2.0 on 1-5 scale. Hence, these genotypes have been identified as tolerant to iron chlorosis and could be used as a new source of iron tolerant genotype.

Enhancement and management of groundnut genetic resources

Conservation of working collection

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

Field maintenance of wild Arachis germplasm

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

Distribution of germplasm accessions

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

Multiplication of elite germplasm accessions

Multiplication of elite germplasm accessions

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

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

Morphological characterization

Characterization of elite Valencia accessions

Twenty-eight large seeded accessions belonging to the ssp. *fastigiata* along with two check varieties were evaluated for 18 yield components in summer 2015. The design adopted was randomized block design with three replications. Days to initiation of flowering ranged from 23 (NRCG 13016) to 29 days (NRCG 794, 13066); days to 50% flowering ranged from 26 (NRCG 13016) to 32 days (NRCG 794, 9746); days to 75% flowering ranged from 30 (NRCG 13016, 4290) to 36 days (NRCG 13066); days to maturity of these accessions ranged from 102 (NRCG 14428) to 112 days (NRCG 4220, 9746). The maturity duration of the genotype which flowered early was 107 days. Pod yield ranged from 774 kg/ha (NRCG 794) to 2937 kg/ha (TPG 41). The other high yielding accessions were NRCG 1108 (2671 kg/ha) and NRCG 5177 (2598 kg/ha). Shelling out-turn ranged between 55.0% (NRCG 9746) to 72.9% (TPG 41) and closely (72.7%) followed by NRCG 1108. Hundred Seed Mass was in the range of 28.5 g (NRCG 794) to 56.9 g (TPG 41) followed by (47.3 g) NRCG 5177. The accession, NRCG 1108 has been identified as promising for pod yield and high shelling.

Characterisation of interspecific derivatives

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

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

The seeds of two candidate varieties "Budhram Badam 1" and "Gulabi" received under DUS Project have been sown in the *kharif* season along with eight reference varieties in three replications as per DUS test guidelines. Reference varieties utilized were: ALR 2, JL 24 and TKG 19A in Spanish Bunch; MH 4 and Gangapuri in Valencia; BAU 13 in Virginia Bunch and: Punjab 1 and Somnath in Virginia Runner. Data on the 13 qualitative and 5 quantitative descriptor traits were recorded at appropriate growth stages as per test guidelines and submitted to PPV&FRA.

Screening for low temperature and high tolerance under field conditions

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

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

The temperature was in the range of 19.7 °C to 39.2 °C during the week followed by sowing of accessions meant for screening for high temperature tolerance. The temperature after sowing was in the range of 21.6 °C - 39.4 °C (April) and 25.5 °C - 40.2 °C (May). Few promising accessions were identified both under early and late sown conditions (NRCG 14383, ALR 3, Kisan and TG 17; TAG 24, Dh 86, TG 26) based on field emergence, flowering duration and pod yield.

Screening for resistance to stem rot under sick plot conditions

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

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

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

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

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

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

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

Fatty acid composition in 113 accessions of all the four habit groups has been estimated using GCMS. The oleic acid content was in the range 38.1% - 65.6% with an average of 49.2%. Linoleic acid content was in the range 15.1% - 38.5% with an average of 28.8%. The O/L ratio was between 0.99 - 4.4 with an average value of 1.88. In each of the four habit groups accessions with high O/L accessions were identified. In the lone Valencia accession, the O/L ratio was 0.99. The accessions with high O/L ratios were: among Spanish bunch types- TKG 19A (3.3); in Virginia bunch types- GG 20 (4.4); and in Virginia Runner types- UF 70 (4.1).

Genetic improvement of groundnut for large seed and confectionery traits

Hybridization

During *kharif* 2015, ten crossed were effected for large seed and confectionery characters. A total of 511 pods were harvested from ten crosses as well as for further generation advancement. The average success rate of hybridization was 26.8%. The individual success rate of crosses was highest in NRCG 14332 × PBS 19021 (35.8%) and lowest in PBS 29148 × ICGV 86564 (15.88).

Crosses attempted during kharif 2015

Name of Cross	Purpose of cross	Bud Pollinated	No. of F_1 pods harvested	Success (%)
ICGV 86564 × PBS 29148	LS, HPY, Low oil and high protein	145	37	25.52
PBS 29148 × ICGV 86564	LS, HPY, Low oil and high protein	277	44	15.88
NRCG 14499 × GG 20	HPY, Low oil and high protein	131	24	18.32
GG 20 × NRCG 14499	HPY, Low oil and high protein	161	50	31.06
ICGV 86564 × SunOleic	LS, HPY and high O/L ratio	212	66	31.13
TKG 19A × SunOleic	LS, HPY and high O/L ratio	236	79	33.47
PBS 29146 × TG 37A	HI, low oil and high protein	242	46	19.00
TG 37PBS 19021 x NRCG	HI, low oil and high protein	260	75	28.84
14332A × PBS 29146	LS, HPY and low oil	212	61	28.77
NRCG 14332 × PBS 19021	LS, HPY and low oil	81	29	35.80

Identification of hybrid plants

F_1s from ten crosses generated during *kharif* 2014, were raised with their parents during summer 2015 and total of 69 hybrid plants were identified and harvested individually for further generation advancement

Identified individual hybrid plants in F_1 generation during summer 2015

Cross	Characters	Bud pollinated	F_1 pods	Success (%)	Probable hybrids
BAU 13 × NRCG 14492	Large seed and high protein	92	14	15	3
NRCG 14492 × BAU 13	High protein and large seed	107	24	22	4
Gangapuri × NRCG 14492	High sugar and high protein	132	36	27	7
NRCG 14492 × Gangapuri	High protein and high sugar	94	19	20	8
Mallika × NRCG 14424	High pod yield and large	191	49	26	7
PBS 29079 A × NRCG	Large seed and high yield	128	39	30	6
TG 51 × PBS 19022	High sugar and large seeded	281	77	27	21
NRCG 9036 × Mallika	Large seed and high yield	151	31	21	5
PBS 29148 × CS 281	Large seed and high protein, oil	123	38	31	4
GG 7 × PBS 29079 B	Large seed	256	72	28	4

Generation advancement

Thirteen crosses of advanced generations were raised during summer 2015 and 162 individual plants were selected; 52 (F_5), 91(F_6) and 19 (F_7) respectively. During *kharif* 2015, individual plant progenies of 44 crosses were advanced to different filial generations (F_2-F_6), of which five crosses were rejected due to large proportion of poor recombinants and absence of desirable trait of interest in the recombinants. Among them 16 crosses in early generations (up to F_4) and 28 in advanced generation.

New Advanced Breeding Lines

In F_6 generation, nineteen crosses were sown to identify stable advanced breeding lines for according to their objectives. Five crosses were rejected due to poor yield and from remaining crosses 18 advanced breeding lines have been developed (sixteen belong to Virginia bunch PBS-29220, PBS 29221, PBS 29222, PBS 29223, PBS 29224, PBS 29225, PBS 29226, PBS 29227, PBS 29228, PBS 29229, PBS 29230, PBS 29231, PBS 29232, PBS 29233, PBS 29234, PBS 29235 and two belong to Spanish bunch habit group PBS 19033 and PBS 19034). These individual plants will be multiplied in the next season for making sufficient seeds to conduct their evaluation trial.

TPG 41-mutated with EMS

The TPG 41 which is a Spanish large seeded variety mutated with different doses of EMS and sown in summer 2015, for exploring the desirable biochemical parameters in kernels.

Advancement and evaluation of GG 20-mutant population (*Kharif* 2015)

For enhancing oleic acid content and Oleic/Linoleic ratio in groundnut, chemical mutagen EMS was used to mutate seeds of variety GG 20. M_2 generation was grown in the summer 2015 and individual plants were harvested. Thus in M_3 generation there is about 1764 lines grown with GG20 check in *kharif* 2015.

Large-seeded yield evaluation trial

During *kharif* 2015, twenty advanced breeding lines with four check varieties were sown in randomized block design with three replications for large-seeded and other yield component traits. For pod yield and 100 pod weight, advanced breeding line PBS 19029 (3050.66 kg /ha; 80.76g) showed higher pod yield and 100 pod weight than check varieties Mallika (2555.66 kg /ha; 134.9g), GG 20 (2503.6 kg /ha; 126.09g) and BAU 13 (2046.3 kg/ha, 140.21g) respectively. This trial will be conducted for one more season in *kharif* 2016 for consolidated results.

Large-seeded yield evaluation trial

Preliminary large-seeded yield evaluation trial

Forty advanced breeding lines with four check varieties were evaluated in randomized block design with three replications during *kharif* 2015 at Experimental Seed Production Unit at ARC, Bikaner. With respect to 100 pod weight, advanced breeding lines PBS 29148 (190.22g) was found superior than check varieties, TKG 19A (157.05g) and ICGV 86564 (153.66). For 100 kernel weight, PBS 29143 (91.0g) was showed higher values than checks TKG 19A and ICGV 86564.

Superior advanced breeding lines identified for yield attributes at Junagadh (Gujarat) and Bikaner (Rajasthan)

Location	Bikaner			Junagadh	
Advanced breeding line/checks	Hundred pod weight (g)	Hundred kernel weight (g)	Advanced breeding line/checks	Pod yield (kg/ha)	Hundred pod weight (g)
PBS 29148	190.2	-	PBS 19029	3050.6	-
PBS 29143	-	91.01	PBS 19029	-	180.7
Checks					
ICGV 86564	153.7	76.07	Mallika	2555.6	140.2
Mallika	149.2	72.49	GG 20	2503.6	134.9
BAU 13	146.2	71.00	BAU 13	2046.3	126.09
TKG 19 A	157.05	67.68	TKG 19A	1892.3	114.4

Evaluation of Virginia mini-core germplasm lines for yield and confectionery traits

Fifty six Virginia germplasm lines with 4 checks (GG 20, BAU 13, M 13 and Mallika) were evaluated in randomized block design in *kharif* 2015 season. The genetic variability was present for each studied traits.

Multiplication and maintenance of advanced breeding lines

During *kharif* 2015, two high yielding advanced breeding lines PBS 19018 and PBS 19022 were multiplied and seed were submitted for multi-location trials in summer/*rabi* season in AICRP-G. About 100 germplasm lines were multiplied for maintenance and use. About 130 advanced breeding lines were multiplied for further maintenance and yield evaluation trails. Two Spanish bunch (PBS 19031and PBS 19032) advanced breeding lines and eight Virginia (PBS 29212, PBS 29213, PBS 29214, PBS 29215, PBS 29216, PBS 29217, PBS 29218 and PBS 29219) bunch breeding lines were multiplied for testing in advanced yield evaluation trials.

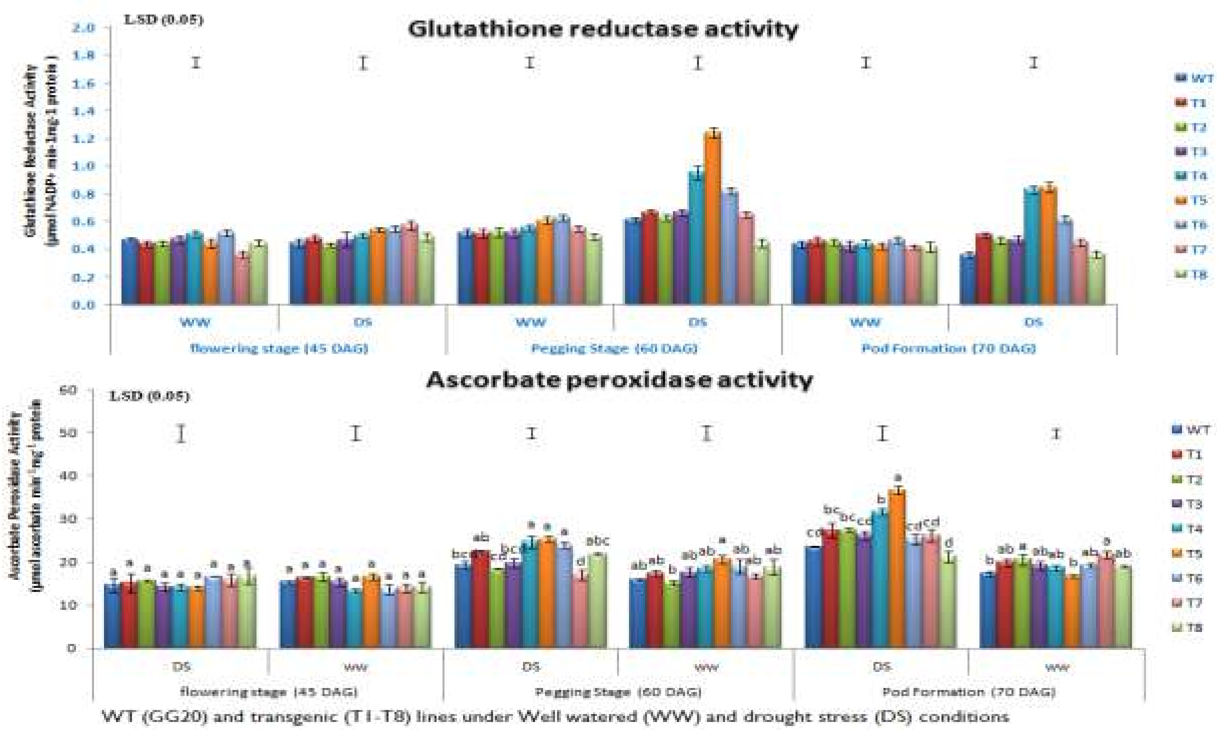
Biotechnological approaches to the characterization and genetic enhancement of groundnut

Evaluation of transgenic groundnut expressing a *AtDREB1a* gene under drought stress

Eight transgenic lines of transgenic groundnut namely T1, T2, T3, T4, T5, T6, T7 and T8 in T_4 generation, having single copy insertion and confirmed through Southern blotting hybridization experiments were used for analysis under drought stress using a lysimeter system under glasshouse conditions. Wild type (WT) (cv. GG 20) and T lines were sown in lysimeter system (in triplicate) under drought stress (WS) and controlled conditions (WW).

The *AtDREB1a* transgenic lines were assessed for effects of drought stress in near field conditions at 3 stages namely – flowering stage (45 DAG), pegging stage (60 DAG) and pod formation stage (70 DAG). Various growth and physio-biochemical factors like total protein content, anti-oxidant enzymes and other stress metabolites, ROS accumulation and antioxidant response in transgenic lines compared to WT under drought stress were analyzed.

During drought stress, all the transgenic lines showed significant higher level of superoxide dismutase, catalase, glutathione peroxidise, ascorbate peroxidase, glutathione reductase activity, while significant lower level of hydrogen peroxide and malondialdehyde content was recorded when compared to wild type plants. Among studied antioxidant enzymes activity, at pegging and pod formation stage, the transgenic lines exhibited significantly higher levels of POD and APX activity.



Antioxidant enzymes activity in WT and T lines at flowering, pegging and pod formation stage under different salt treatments. Comparison of antioxidant enzyme glutathione reductase (A) and ascorbate peroxidase (b) activity from leaf sample of WT (GG-20) and eight independent T4 transgenic lines (T1-8) grown under drought stress under lysimeter system condition. Graph represents the mean ± SE (of three replicates; n=3) followed by similar lower case letter are not significantly different according to Tukey's multiple range at $P \leq 0.05$.

Similarly, significantly higher ascorbic acid and relative water content was recorded in transgenic lines. The study revealed that the transgenic lines has exhibited enhanced antioxidant response, RWC, sugar accumulation and growth parameters and reduced H_2O_2 and MDA content as compared to WT plants. The presence and expression of *dreb1a* gene was also confirmed through RT-PCR. These findings show that the expression of *dreb1a* gene has contributed towards scavenging of ROS and hence transgenic lines exhibited improved salt stress tolerance.

Analysis of transgenic groundnut expressing the *mtlD* gene under drought stress

Quantitative real-time PCR (qPCR) was carried out to determine the relative gene expression of *mtlD* transcript in the transgenic lines (T_3 generation). The $2^{-\Delta\Delta C_T}$ method was used to calculate relative gene expression. Amplicon abundance was monitored in real-time by measuring SYBR® Green fluorescence. The level of *mtlD* gene transcript in transgenic lines was normalized with reference to *Ah-actin* taken as an internal control. MTD 3.5.2.1 line was found to be lowest expressing (as they retain higher Δ^{C_T}) transgenic line, hence was used as a calibrator to determine fold expression of other *mtlD* transgenic lines. The amplification profile of *mtlD* T lines showed the expression of MTD 3.5.2.2 was almost similar with reference to calibrator. MTD 4.18.2.1, MTD 4.18.2.2 and MTD 1.38.29.1 showed significant higher levels of expression up to 15.36, 11.10 and 11.14 fold compare to calibrator (MTD 3.5.2.1), respectively. Whereas, other *mtlD* T lines showed expression level in a range of 7.64-9.6 fold.

Variation of root growth between WT (GG 20) and T lines (MTD1-4) under well watered (WW) and drought stressed (DS) condition after harvesting (120 days)

Growth parameters were measured from WT (GG 20) and T lines (MTD1-4) after harvesting (120 DAS) under well watered (WW) and drought stressed (WS) condition. Under well watered condition there was no significant difference found in growth parameters of WT and T lines while it differs in drought stressed condition (except shoot length).

Transgenic lines under drought stress treatment were comparatively healthier than WT plants and showed enhanced growth parameters under stress conditions. Root length, root fresh and dry weight, shoot fresh and dry weight, pod weight, and harvest index of T lines were significantly higher compared to WT under drought stress. Pod weight and harvest index was significantly increased in T lines compared to WT under drought stressed condition. Compared to WT, pod weight and harvest index of MTD1, MTD2 and MTD4 was increased in range of 1.52-2.19 and 1.23-1.38, fold respectively.

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

The foreground selection of BC_3F_1 plants was done and 4^{th} backcross with recurrent parents is under progress. The true hybrids were selected by using linked polymorphic markers in *kharif* 2015 season. All the plants were screened with 4 primers including viz.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 homozygous introgression lines developed will be identified and screened for disease resistance under artificial disease pressure.

The common QTL for LLS as well as rust on Linkage Group AhXV flanked by GM2009 and GM1954 markers (20.6 cM) which contribute up to 67.98 and 82.96% phenotypic variation, respectively. Another genomic region (29.3 cM) is on LG AhXII and is flanked by GM1573/GM1009 and seq8D09 which contributes up to 62.3% phenotypic variation. These two genomic regions, therefore, seem to possess candidate genes that are either directly involved in or control the expression of the genes conferring resistance to these important fungal diseases. Recently, after integrating the data from different maps, Gajjar *et al.* (2014) reported that most of these QTLs were present on the LG_03.

A total of 150 BC_1F_2 seeds were planted in this season. 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. Among these, lines having foliar diseases were selected and further advancement for in next generation.

Mapping Quantitative trait loci for foliar disease resistance (Cross: GJG 17 x GPBD 4)

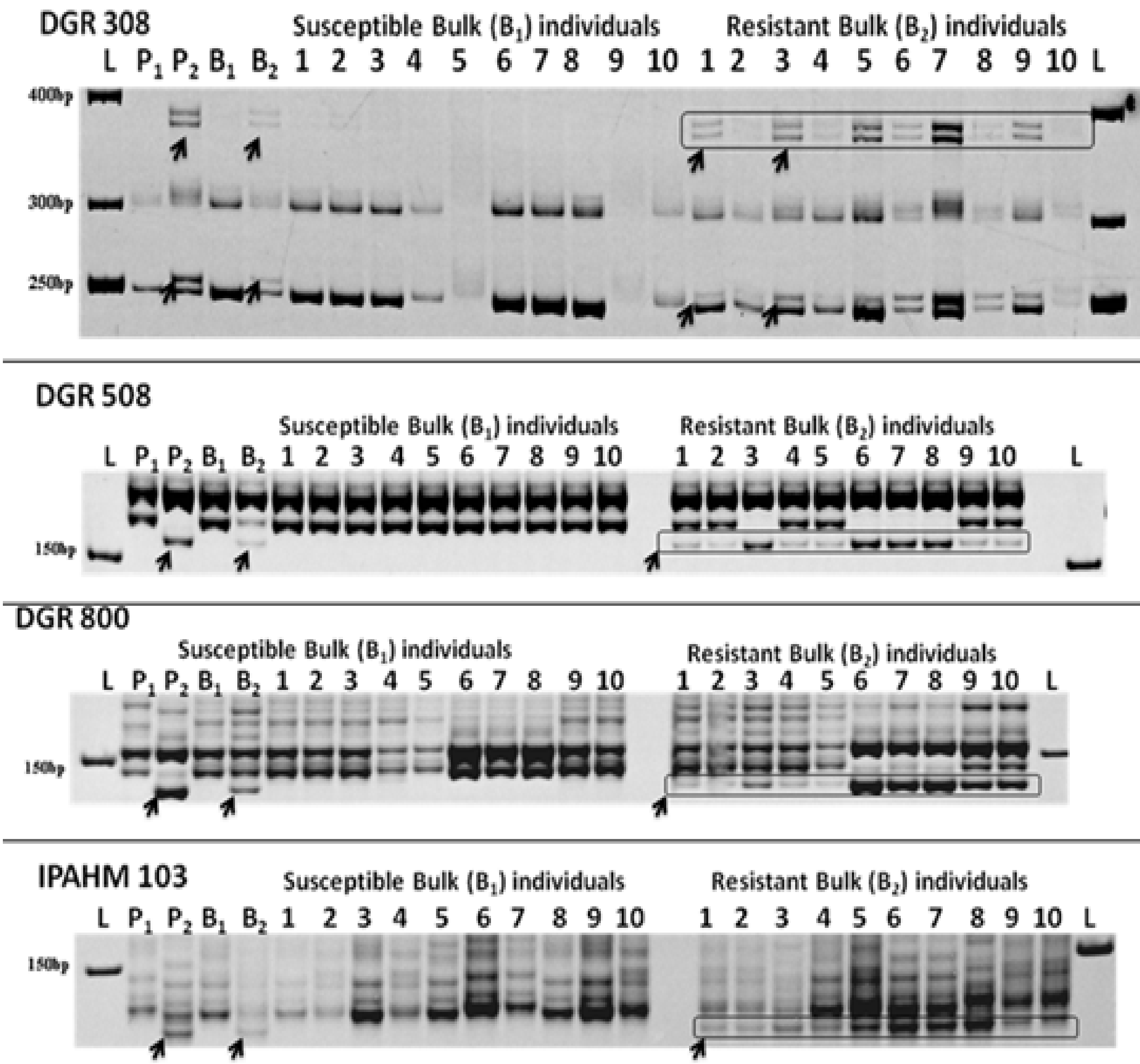
Genotyping of F_2 population with SSR markers

Initially, 30 linked SSR markers were used for screening of parents (GJG 17 and GPBD 4) to identify polymorphic markers and 10 markers were found to be polymorphic. These 10 markers were used for the genotyping 328 individuals in F_2 population. A set of 850 newly designed EST-SSR markers have been screened in parents for polymorphism survey. Out of 850 markers, thirty eight (38) markers were found polymorphic. These polymorphic markers are further being used for genotyping of F_2 mapping population (GJG 17 x GPBD 4). Genotyping of 328 individuals in F_2 was done using 10 new SSR markers. In total, 48 SSR markers are found polymorphic and genotyping of 328 F_2 has been done so far with 20 SSR markers (10 linked and 10 newly designed).

Bulk Segregant Analysis (BSA) to identify putatively linked markers to LLS and rust resistance

BSA is a rapid and easy method to identify the markers associated to any trait of interest in segregating population. In our study, BSA is used to identify putatively linked (associated) SSR markers to LLS and rust in F_2 population, segregating for both the foliar diseases.

Two bulks were made using 10 extreme genotypes i.e. susceptible and resistant based on phenotyping and genomic DNA of selected 10 F_2 plants was pooled to constitute Bulk 1 (B_1) and Bulk 2 (B_2), respectively. Similarly genomic DNA from parents (Susceptible-P_1 and Resistant-P_2) was also extracted and used for BSA. BSA was performed using all 48 polymorphic markers and four markers were found to be associated with LLS and rust resistance, as these makers showed specific bands (amplicons) only in resistant parent (P_2) and resistant bulk (B_2) but not in susceptible parent (P_1) and susceptible bulk (B_1). Out of four markers, three markers are newly designed (DGR 308, DGR 508 and DGR 800) by ICAR-DGR and one (IPAHM 103) was already reported linked marker to LLS.



BSA results showing four markers associated to LLS and rust resistance

Genetic Utilization of wild *Arachis* gene pools for improvement of groundnut

Hybridization

A total of nine crosses comprising six interspecific and three intraspecific were attempted during *kharif* season. Probable cross pods, ranging from 60 to 160 pods in these crosses, will be used further during ensuing *kharif* season.

Characterization interspecific derivatives for tolerance to drought

Pre-breeding lines developed by using wild species, *A. pusilla* were sown in irrigated and water deficit stress conditions. Fifty one lines were sown in augmented design with three blocks. Observations were recorded for pod yield, SLA and SCMR and yield reduction under irrigated and stress conditions. NRCGCS Nos. 459, 521, 461, 436, 446 recorded low SLA and NRCGCS Nos. 448, 461, 438, 446, 458 recorded high SCMR. NRCGCS No. 461 and 446 having high SCMR and low SLA could be promising under drought stress conditions.

Phenotyping of wild species for stem rot resistance

Selected 25 accessions based on availability of seeds of 12 *Arachis* species representing four sections were screened for stem rot under pot conditions in net-house. Mortality per cent at 15 days after inoculation and pod infection per cent at harvest were recorded. None of these accessions recorded less than 10% disease scoring while, two accessions, NRCG 12035 and NRCG 12047 were found resistant with mortality less than 20%. Accessions NRCG12035 and NRCG12047 belong to two different species viz., *A. appresipila* and *A. pusilla*. In addition, two more accessions, NRCG 11789 and NRCG 11805 were found moderately resistant with mortality less than 30% and belong to *A.monticola* and *A.duranensis*. Rest of the accessions were found susceptible with mortality ranging from 30% to 100%. Pod infection in these four resistant/ moderately resistant accessions was less than 20% indicating presence of resistance in pods also.

Evaluation of RILs for tolerance to drought

Recombinant Inbred Lines (RIL) developed using ICG 4747 and TMV 2 NLM were evaluated under both irrigated and imposed drought conditions at DGR during summer 2014 and 2015. Sixty seven RILs along with two parents and five checks 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 treatment, regular irrigation was provided to the crop. While for drought treatment, 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), SCMR, SLA and harvest index (%) in both irrigated and drought conditions. One cultivar (Girnar 2) and four RILs (Nos. 5, 16, 42 and 53) out of 67 RILs were found with significantly higher pod yield/plant under irrigated conditions and minimum yield reduction under imposed drought conditions. These four RILs were at par with elite cultivar Girnar 2 in terms of yield under irrigated conditions and yield reduction ratio. However, these four RILs with lower YR values could be potential under water deficit stress conditions which also had significantly lower SLA, higher SCMR values and high HI. Besides, RIL-60 which had YR value zero along with other RILs with YR value less than 0.10 might be potential source for water deficit stress tolerance in groundnut.

Screening for tolerance to drought under field conditions

Evaluation of advanced breeding lines

A total of six different yield evaluation trials were conducted during both summer and *kharif* seasons 2015.

i) Virginia bunch genotypes, resistant to stem rot disease were evaluated for yield in RBD with three replications during *kharif* season. Thirty-three genotypes along with three checks were sown in four lines of four meter bed. A spacing of 45 and 10 cm were given between lines and plant, respectively. The check variety GG 20 was found superior among checks with a plot yield of 1575 g per plot. None of the test genotypes had significantly higher pod yield per than GG 20, although nine genotypes out yield than GG 20. Based on pooled analysis over *kharif* 2014 and *kharif* 2015 none of these genotypes were found significantly superior over checks in terms of pod yield.

ii) High yielding and short duration Spanish bunch genotypes, received from ICRISAT were evaluated for yield in RBD with three replications during *kharif* season. Twelve genotypes along with four checks were sown in four lines of four meter bed. A spacing of 45 and 10 cm were given between lines and plant, respectively. The check variety JL 501 was found superior among checks with a plot yield of 1373 g per plot. None of the test genotypes had significantly higher pod yield per plot than JL 501, although two genotypes out yield than JL 501. Based on pooled analysis over summer 2015 and *kharif* 2015 none of these genotypes were found significantly superior over checks in terms of pod yield.

iii) High oleate Spanish bunch genotypes were evaluated for yield in RBD with three replications during *kharif* season. Four genotypes along with 12 checks were sown in four lines of four meter width. A spacing of 45 and 10 cm were given between lines and plant, respectively. The check variety TG 37A was found superior among checks with a plot yield of 1558 g per plot. None of the test genotypes had significantly higher pod yield per plot than TG 37A. Based on pooled analysis over summer 2015 and *kharif* 2015 none of these genotypes were found significantly superior over checks in terms of pod yield. Further, these lines would be included in multi location trial under high oil project.

iv) High oil content Spanish bunch genotypes, received from ICRISAT were evaluated in RBD with three replications during *kharif* season. Twenty-one genotypes along with four checks were sown in four lines of four meter width. A spacing of 45 and 10 cm were given between lines and plant, respectively. The check variety JL 501 was found superior among checks with a plot yield of 1546 g per plot. None of the test genotypes had significantly higher pod yield per plot than JL 501, although one genotype out yielded than JL 501. Based on pooled analysis over summer 2015 and *kharif* 2015 genotype no. 107 was found significantly superior over checks in terms of pod yield. Further, this line would be multiplied for testing under AICRP.

v) Promising Virginia bunch genotypes, resistant to LLS, Rust and stem rot were evaluated in RBD with three replications during *kharif* season. Nine genotypes along with five checks were sown in four lines of four meter width. A spacing of 45 and 10 cm were given between lines and plant, respectively. The check variety GG 20 was found superior among checks with a plot yield of 1716 g per plot. None of the test genotypes had significantly higher pod yield per plot than GG 20, although four genotypes out yield than GG 20. Based on pooled analysis over *kharif* 2014, summer 2015 and *kharif* 2015, one genotype 25-5-32 (sel) was found significantly superior over checks in terms of pod yield. Further, this line would be multiplied for testing under AICRP.

vi) Promising Virginia bunch genotypes with higher kernel weight, developed by mutagenesis from pre-breeding lines were sown in RBD with three replications during *kharif* season. Six genotypes along with seven checks were sown in four lines of four meter width. A spacing of 45 and 10 cm were given between lines and plant, respectively. The check variety KDG 123 was found superior among checks with a plot yield of 1584 g per plot. None of the test genotypes had significantly higher pod yield per plot than KDG 123, although two genotypes out yielded than KDG 123. Based on pooled analysis over *kharif* 2014 and *kharif* 2015, two genotypes 281-21-1 and 281-40-4 were found significantly superior over checks in terms of pod yield. Further, these lines would be multiplied for testing under AICRP.

Phenotyping of segregating progenies for stem rot resistance

Hundred and seventy-eight F_3 progenies of cross between GG 20 and CS 19 along with parents were screened under artificially inoculated field conditions and observation on mortality were recorded on 15 days after inoculation and expressed in percentage. Progenies were grouped based on their disease scoring using standard disease scale. Three progenies (5-8, 15-1 and 15-3) were found highly resistant with less than 10% mortality followed by six, 21, and 148 progenies were resistant, moderately resistant and susceptible, respectively.

Screening for resistance to stem rot

Groundnut Pests and Diseases-Emerging Problems and their Management

Development of management module for soil borne diseases of groundnut

Screening of cultivated varieties for resistance to stem rot

The experiment was conducted during summer 2015 and *kharif* 2015. Altogether, 53 cultivated varieties were screened for resistance to stem rot disease during summer 2015, where minimum (4.55%) stem rot was recorded with variety CSMG 84-1 followed by GG 12 (8.05%) being at par with RS 1 (8.05%) and TG 17 (8.89%). However, the maximum (2181 kg/ha) pod yield was recorded with ICGS 76 at par with TG 26 (2178 kg/ha) followed by JL 24 (2078 kg/ha). However, the minimum pod yield of 552 kg/ha was recorded with Tirupati-3.

During *kharif* 2015, 60 cultivated varieties were screened for resistance to stem rot disease, where minimum (11.8%) stem rot was recorded with variety Kadiri 3 followed by S 230 (12.1%). However, the maximum (41.5%) disease was recorded with DH 8. Whereas, the maximum (4496 kg/ha) pod yield was recorded with ICGV 000348 followed by M 548 (4478 kg/ha). The collar rot was recorded in very negligible amount.

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 harzianum* isolate S1, *T. koningiopsis, T. bravicompactum*, *T. longibrachiiatum*, *T. virens*, *T. harzianum* T-170 isolate and

and *T. harzianum* dharwad isolate was tested for management of *Sclerotium rolfsii* during summer 2015, and all seven Trichoderma and one PGPR during *kharif* 2015.

The maximum (55.4%) inhibition of stem rot was achieved by *T. harzianum* T-170 followed by *T. koningiopsis* (49.0%) against control. However, *T. brevicompactum* could inhibit only 29.4% over control. Whereas, the maximum (3351 kg/ha) pod yield was supported by *T. harzianum* S1 followed by *T. viride* dharwad (3282 kg/ha), which was 20% and 18% increase over control, respectively. The maximum (5053 kg/ha) fodder yield was supported by *T. harzianum* S1 followed by *T. viride* dharwad (4969 kg/ha), which was 9% and 7% increase over control, respectively during summer 2015. Additionally, two organic/eco-friendly formulations were also tried during summer 2015 for management of stem rot as well as their effect on yield; minimum stem rot was received on DGROF2 supporting highest yield as compared to control.

During *kharif* 2015, the maximum (37%) inhibition of stem rot was achieved by *Trichoderma harzianum* 170 *followed* by *T. longibrachiatum* (35.7%) against control. However, *T. virens* could inhibit only 10.5% over control. However, maximum (1158 kg/ha) pod yield was supported by *T. longibrachiatum*, which was followed by T. *virens* (1153 kg/ha). Further, the maximum (4354 kg/ha) fodder yield was supported by *Trichoderma* dharwad isolate followed by T. *bravicompactum* (4210 kg/ha). Additionally, three organic/eco-friendly formulations were tried during *kharif* 2015 for management of stem rot as well as their effect on yield; minimum stem rot was received on DGROF3, whereas DGROF2 supported highest yield as compared to control.

Varietal screening plot for stem rot

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 (9.20%) stem rot was recorded in treatment with raised bed (with three rows) as compared to farmers' practice, the control. It was noted that maximum (14.5%) 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 during summer 2015.

Experiment on land configuration for effect on stem rot

During *kharif* 2015, the minimum (5%) stem rot was recorded in treatment with raised bed (with three rows) as compared to farmers' practice, the control. It was noted that maximum (15%) 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 and collar rot disease

Altogether, 9 modules were identified and tested for soil borne diseases with farmers' practice and absolute control during summer 2015 and *kharif* 2015. During summer 2015, there was only one set of experiment for stem rot, whereas during *kharif* 2015, there were two sets of experiment, one for stem rot and another for collar rot.

Effect of modules on stem rot and yield during summer 2015:

Stem rot: The maximum (52.4%) inhibition of stem rot was achieved by Module-M11 i.e. Deep summer ploughing with mould board plough+ seed of variety TG 37A+ 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), followed by Module M-17 (40.4%) i.e. Deep summer ploughing with mould board plough + seed of variety TG 37A + 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 farmers' practice. However, Module-M4 i.e. Deep summer ploughing with mould board plough + seed of variety TG 37A + seed treatment with *Trichoderma* @ 10g/kg of seed + soil application of *Trichoderma* @ 4 kg/ha enriched in FYM first at the time of sowing, received maximum stem rot (15.7% inhibition) over farmers' practice.

Pod yield: The maximum pod (2688 kg/ha) was supported by Module M17 i.e. Deep summer ploughing with mould board plough+ seed of variety TG 37A + 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 farmers' practice, followed by M15 (2636 kg/ha) i.e. deep summer ploughing with mold board plough + seed of variety TG 37A + 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.

Fodder yield: The maximum fodder (5175 kg/ha) yield was supported by Module-M11 i.e. Deep summer ploughing with mould board plough+ seed of variety TG 37A + 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-M17 i.e. Deep summer ploughing with mould board plough + seed of variety TG 37A + 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 farmers' practice, which supported fodder yield of 4797 kg/ha.

Effect of modules on stem rot and yield during *kharif* 2015:

Stem rot: The maximum (50%) inhibition of stem rot was achieved by Module-M15 i.e. Deep summer ploughing with mold 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-M4 and Module-9 received maximum stem rot (26% inhibition) over farmers' practice.

Pod and fodder yield: The maximum pod (1007 kg/ha) yield was supported by Module-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 followed by Module-M5 (979 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 at the time of sowing, which was 27% and 24% more over the farmers practice. The maximum fodder (3897 kg/ha) yield was supported 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, followed by Module-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, which was 13% and 11% more over the farmers practice.

Effect of modules on collar rot and yield during *kharif* 2015:

Collar rot: The maximum inhibition (36%) of collar rot was achieved 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, followed by Module-M17 (34%) 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 the farmers practice.

Pod yield and fodder yield: The maximum pod (869 kg/ha) yield was supported by Module-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 followed by Module-M11 (807 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, which was 33% and 24% more over the farmers' practice. The maximum fodder (3707 kg/ha) yield was supported 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, followed by Module-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, which was 24% and 15% more over the farmers' practice.

Management of aflatoxin contamination in groundnut

Effects of crop rotation on soil population of A. *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 rotation system of *kharif* groundnut with onion, garlic, pearl millet, sesame, groundnut and fallow in summer. In summer, the population of A. *flavus* was low in soil at harvest compared to that of before sowing and *vice-versa* in *kharif*. Nevertheless, the lowest population of A. *flavus* was recorded in soil collected after rotation with onion and garlic. In these soils, the population of beneficial fungi, bacteria and actinomycetes were more in comparison to soils in that other rotational crops were followed. Less than 5% of the groundnut samples were positive to aflatoxin contamination collected from onion and garlic rotations and the level of contamination ranged from 0 to14ppb. However, the highest level of aflatoxin contamination was detected in groundnut-groundnut rotational system.

Effects of crop rotation on soil population of A. flavus, pod and kernel infection and aflatoxin contamination

Rotational crop	*A. flavus* population ($x10^3$ cfu/g soil)		*A. flavus* infection (%)		Positive sample for aflatoxin contamination (%)	Range of aflatoxin contamination (ppb)
	At sowing	At harvest	Pod	Kernel		
Onion	6.2	0.3	8	5	4	0 - 4.1
Garlic	5.8	0.8	17	9	4	0 - 4.4
Pearl millet	6.1	1.2	23	11	12	0 - 8.2
Wheat	5.2	0.3	12	7	4	0 - 4.8
Sesame	5.9	2.1	25	14	16	0 - 12.9
Groundnut	6.3	5.1	27	19	44	0 - 14.2
Fallow	6.9	2.7	18	11	28	0 - 12.3

Growth of Aspergills flavus on kernels

Effects of bioagents, botanicals, salts and fungicides on soil population of *A. flavus*, pod and kernel infection and aflatoxin contamination

Soil application of sodium chloride, sodium bicarbonate, rock salt and carbendazim at 60 DAS, and Trichoderma at basal, 30 and 60 DAS lowered the aflatoxin contamination compared to botanicals (soil application of neem and *Calotropis* leaves at 30 and 60 DAS) and control.

Effects of bioagents, botanicals, salts and fungicides on soil population of A. flavus, pod and kernel infection and aflatoxin contamination

Rotational crop	*A. flavus* population (x10^3 cfu/g soil)		*A. flavus* infection (%)		Positive sample for aflatoxin contamination (%)	Range of aflatoxin contamination (ppb)
	At sowing	At harvest	Pod	Kernel		
Calotropis	8.3	4.0	23	16	36	0 - 18.1
Neem leaf	7.9	1.8	17	11	28	0 - 12.4
Rock salt	8.2	1.2	13	6	16	0 - 28.2
NaCl	6.2	0.9	12	7	12	0 - 13.9
Baking soda	5.9	0.8	7	5	8	0 - 11.6
Carbendazim	5.6	0.9	7	6	8	0 - 21.2
Mancozeb	7.1	3.2	21	19	28	0 - 32.0
Trichoderma	6.9	2.7	18	11	16	0 - 22.3
Pseudomonas	5.8	4.1	27	19	44	0 - 19.0
Control	6.4	5.9	29	23	36	0 - 17.9

Aflatoxin contamination in stripped and gleaned pods

Freshly stripped and gleaned pods were collected from 22 farmers field and analyzed of pod and kernel infection and aflatoxin contamination in groundnut kernels. The level of aflatoxin contamination was ranged from 0.0 to 6.1 ppb in pods collected from stripping compared to gleaned pods (0.0 to 11.6 ppb). Less than 10% of the stripped pod samples alone got aflatoxin contaminated above 4 ppb whereas, 18.2% samples received from gleaned pods were contaminated with aflatoxin above 4 ppb.

Growth of Aspergillus flavus on pods

Aflatoxin contamination in 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
Jetpur-1	0.8	6.6	9.0	0.8	5.6	2.0	2.8
Jetpur-2	0.2	4.2	4.5	1.2	18.0	0.0	0.5
Vadiya-1	1.0	5.4	19.0	0.5	6.4	1.2	1.5
Vadiya -2	0.4	1.4	2.2	2.0	0.8	3.0	0.0
Rajkot -1	1.7	0.0	13.3	0.2	12.8	6.1	0.7
Rajkot -2	0.7	2.0	3.2	0.0	1.8	0.8	1.7
Mendrada-1	1.0	0.0	11.0	1.0	8.9	0.5	2.1
Mendrada-2	1.0	4.0	14.0	1.8	14.0	0.2	1.3
Sasan Gir-1	0.8	4.0	11.1	0.0	4.8	0.0	3.5
Sasan Gir-2	0.5	4.5	13.3	3.2	9.3	0.0	11.6
Talala-1	0.2	0.0	3.0	0.0	1.8	2.0	4.3
Talala-2	0.3	5.2	10.0	2.0	8.0	1.0	2.0
Amreli-1	0.5	3.4	12.6	0.6	4.8	0.2	0.5
Amreli-2	0.7	0.0	3.8	0.4	2.6	1.5	2.5
Doraji-1	0.8	1.4	2.2	2.0	0.8	0.2	0.0
Doraji-2	0.7	0.8	3.3	2.2	6.8	5.0	0.5
Jamkandora-	1.1	0.2	0.9	0.6	1.2	0.5	1.2
Jamkandora-	0.9	0.1	11.2	1.0	8.9	0.0	2.1
Vanthli-1	1.9	4.0	14.0	1.8	14.0	1.0	1.2
Vanthli-2	1.2	4.0	8.1	1.0	4.8	0.2	3.5
Bilkha-1	0.2	2.5	13.3	2.2	7.3	0.4	4.6
Bilkha-2	1.3	1.8	2.2	0.0	1.2	1.0	5.5

Aflatoxin contamination in stripped and gleaned pods

Details	Stripped pods	Gleaned pods
Samples detected with aflatoxin contamination	14%	45%
Samples detected with aflatoxin contamination above 4ppb	9.1%	18.2%
Range of aflatoxin contamination	0.0 – 6.1 ppb	0.0 – 11.6 ppb

Determination of safe storage conditions for pods to prevent aflatoxin contamination

Pods stored upto 8 months at room temperature (28±2 °C) in high density polythene bags has lesser A. *flavus* infection and aflatoxin contamination compared to pods stored in gunny bags (jute bags). In addition to this, storage pests (bruchid, corcyra and flour beetle) infestation were not detected and germination was recorded in the range of 68-83% in groundnut stored in high density polythene bags.

Evaluation of storage bags for groundnut pods

Treatments	Pod damage by storage pests (%)	Aflatoxin contamination	Germination (%)
Woven polythene	43 - 67	*	Below 10
High density polyethylene bags	Less than 2	0 - 1.7	68-83
Jute gunny bag	72 - 91	*	*

Storage of groundnut pods in High Density Polyethylene Bag

Management of insect-pests of groundnut

Effect of trap colour and height on sucking pest incidence (Summer 2015)

An experiment was carried in summer, 2015 to determine the effect trap colour and height on trapping efficiency for sucking pests of groundnut. Observations were recorded in two types of trap colours (yellow and blue), four directions (East, West, South and North), three heights (15, 45 and 75 cm from ground level) and in four cultivars (TG 37A, GG 2, TAG 24 and GJG 31). Genotypes differed non-significantly with respect to trap catches in both yellow and blue coloured traps however; they differed significantly with pod yield. The highest pod yield of 3208 kg/ha was noted in TG 37A which was at par with TAG 24 and GJG 31. Yellow coloured sticky traps were more efficient in trapping leafhopper while blue sticky traps were suitable for trapping thrips at all three heights. Leafhopper catches in either yellow or blue traps was not influenced by the direction of wind however, thrips catches was influenced by wind from South-West direction.

Effect of nitrogen and potassium fertilization on the incidence of sucking pests (Summer 2015)

An experiment was carried in summer, 2015 to determine the effect of nitrogen and potassium fertilization on the incidence of sucking pests of groundnut. The populations of sucking pest viz., thrips, aphids and hoppers were recorded at fortnightly intervals by using yellow and blue colored sticky traps. Differences were observed in the thrips population caught on blue sticky traps at 45 days after germination. Treatment-4 (NPK @ 37.5:70.0:0.0) was observed with significantly lower population (3.1 thrips per square). Yellow colored traps were found to have higher pest population as compared to blue colored traps. Pod yield also varied non-significantly amongst treatments however, highest (2911.4 kg/ha) was observed in Treatment-8 (NPK @ 50.0:70.0:30.0).

Influence of inter-crops on population dynamics of groundnut insect-pests (*Kharif* 2015)

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 blue sticky traps revealed that the population of leafhoppers was non-significant at 30, 45, 60 and 75 days after germination. While, population of thrips was non-significant on all observed says, except on 75 DAG. Thrips population was lowest (0.3 thrips/square) in groundnut + castor which was at par with groundnut + maize (0.4), groundnut + bajara (0.6) and groundnut + sesamum (0.9). Groundnut pod yields did not differ significantly however, highest pod yield was observed in control (1279.5 kg/ha).

Cost: Benefit ratio was highest (3.7) in groundnut + castor.

Groundnut intercropped with castor and maize

Screening of groundnut germplasm for resistance against bruchid

Twenty groundnut genotypes were screened for resistance to bruchid during rabi-2015. Genotypes significantly differed with respect to number of eggs laid, number of adults emerged, damage (pods and kernels) and weigh losses in pods. Genotype, PBS 12181 was registered with lowest number of eggs laid (34.7), adults emerged (32.3), damage (51.4% in pods and 85.1% in kernels) and weight loss (47.5% in pods).

Bio-assay of bruchid on different hosts

Bruchids were reared on seeds of five plants (tamarind, latakaranj, groundnut, cowpea and golden shower) in laboratory. The highest numbers of eggs (23.3) were laid in cowpea followed by latakaranj (23.0) and golden shower. However, no larvae were able to feed on latakaranj seeds. Highest numbers of larvae were observed in cowpea (26.3) followed by groundnut (17.7). Bruchid completed its life cycle in shortest span (49.3 days) in tamarind while longest in cowpea (86.3 days). Adult emergence was highest in groundnut (147.3) followed by tamarind (79.3). Tamarind and groundnut were found with lowest amount of trypsin inhibitor activity (11.4 and 12.7%, respectively). Total sugars were found to be highest in latakaranj and golden shower.

Evaluation of storage bins and botanical oils on infestation of bruchids

Two botanical oils (neem and castor oils @ 50 ml/kg pods) and two storage containers (blue plastic drum and galvanized bins) were evaluated for their efficacy against bruchids. All the treatments showed at par results up to 90-days and later on they differed significantly with damage and weight loss in pods. After 4-months of storage, neem oil treated pods stored in blue plastic drums were found with lowest damage (2.8%) and weight loss (2.6%) in pods followed by castor oil treated pods stored in blue plastic drum (14.3 and 13.5%, respectively).

After 5 and 6 months of storage, again the same treatment (neem oil + blue plastic drum) was observed with 8.5 and 27.5% damage, respectively and 8.9 and 27.4% weight loss, respectively. Either oil treatment or storage container has no detrimental effect on seed germination after six months of storage where germination was around 90%.

Evaluation of storage bins and botanical oils on infestation of bruchids

Three types of storage containers (yellow plastic can, blue plastic drum and galvanized bin) were evaluated for their efficacy against bruchid in stored prods. Treatments differed significantly with respect to damage and weight loss in pods and temperature of produce. Damage and weight loss in pods was least i.e., less than 2.6 and 1.6%, respectively up to four months of storage in case of yellow plastic can and blue plastic drum. The same trend was continued up to six months of storage period where the damage was 9.9 and 24.7%, respectively at 5th and 6th month in yellow plastic cans while 16.5 and 24.3%, respectively observed in blue plastic drums. Weight loss was 10.4 and 23.3% in yellow plastic cans and 15.4 and 22.1% in blue plastic drums at correspondingly 5th and 6th month. Temperature of produce varied, where highest (34.5, 34.5, 35.0 and 34.5 °C) was observed in galvanized bins respectively at 3, 4, 5 and 6 months of storage.

Influence of fungal pathogens on metabolomes of groundnut

Changes in metabolites in groundnut genotypes during Alternaria leaf blight

Alternaria leaf blight resistant (GPBD 4, CS 74, CS 186 and CS 349) and susceptible genotypes (GG-2, JAL 42 and TPG 41) of groundnut were grown in pots during *rabi*-summer 2015. Two sets of pots were kept, one set for control and one for infection. Groundnut plants were infected with *Alternaria tenuissima* (Kunze. Fr) Wiltshire at 60 DAS. Leaves were collected from both control and infected plants 5 and 20 days after infection (d.a.i.). Sugars and phenolics were extracted in 80% alcohol and 80% methanol respectively and analyzed by Ion chromatography. Mainly four sugars i.e. *myo*-inositol, glucose, fructose and sucrose were detected in leaves of groundnut genotypes. After infection with pathogen (5 and 20 d.a.i.), *myo*-inositol content was increased in susceptible genotypes while decreased in resistant genotypes. Similarly, glucose and fructose content was also found higher in susceptible genotypes at 5 d.a.i. At 20 d.a.i. a distinct trend of glucose and fructose was not observed with susceptibility and resistance. Sucrose content was drastically decreased in all genotypes at 20 d.a.i.

Total ten phenolic acids (caffiec, catechol, chlorogenic, cinnamic, coumaric, ferulic, galic, salicylic and syringic acid along with resveratrol) were used as a standard to identify and quantitate phenolic acids present in groundnut genotypes using ion chromatography.

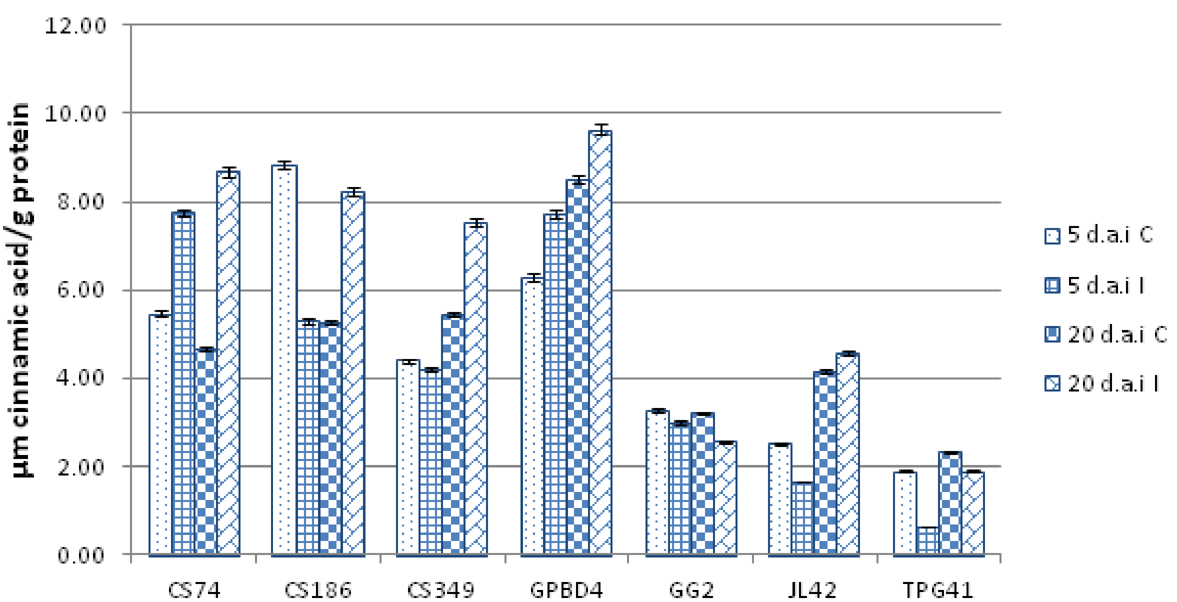
Constitutive level of cinnamic and salicylic acid was higher in resistant genotypes than that of susceptible genotypes.

Interestingly, salicylic acid was not observed in control and infected leaves (5 d.a.i.) of TPG 41(susceptible genotypes). At 20 d.a.i. , salicylic acid content was also less in susceptible genotypes than that of resistant genotypes.

TCA cycle products (standards) i.e. succinic, citric, malic and oxalic acid and oxaloacetate were separated by ion chromatograph. Higher citric, malic and oxalic acid were detected in leaves of groundnut genotypes after infection.

Changes in defense related enzymes in groundnut genotypes during Alternaria leaf blight

Higher activity of phenyl alanine ammonia lyase enzyme was observed in resistant genotypes at 5 d.a.i. than that of susceptible genotypes. Both constitutive and induced higher activities of tyrosine ammonia lyase enzyme were observed in resistant genotypes. Activities of polyphenol oxidase and peroxidase enzymes were higher in non- infected leaves of resistant genotypes.

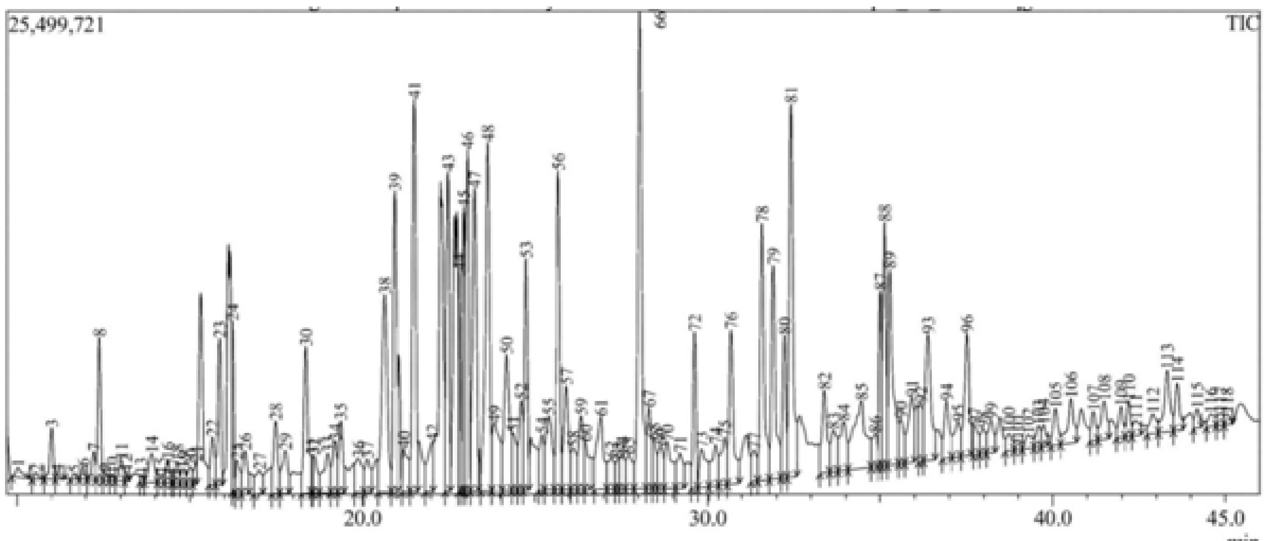


Changes in phenylalanine ammonia lyase activity in groundnut genotypes. Where, C: control and I: infected

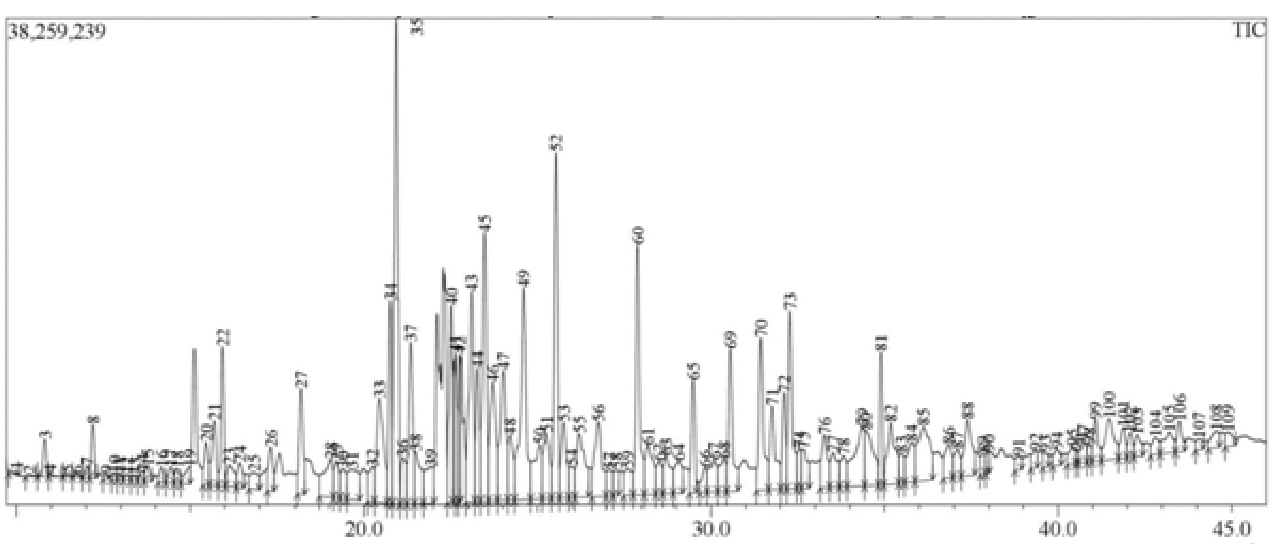
Identification of various metabolites during Groundnut-*Cercosporidium personatum* interaction

Various metabolites were extracted, derivatized and identified using GC-MS from resistant and susceptible genotypes during Groundnut-*Cercosporidium personatum* interaction. About 70 to 122 metabolites were identified based on retention time and m/z ratio of available compounds in NITS library from different genotypes that include sugars, amino acids, fatty acids, phenolics, organic acids and sterols.

Glucose, ribofuranose, linoleic acid and linolenic acids were higher in resistant genotypes than that of the susceptible genotypes. Linoleic acid may provide more substrate for lipoxygenase enzyme which plays important role in HR induction. While in susceptible genotypes, sterols (stigmasterol and beta-sitosterol) were observed higher. Increased content of stigmasterol after pathogen attack attenuate pathogen-induced expression of the defense regulator thus promotes plant susceptibility.



Metabolites identified in GPBD-4 (resistant genotype) after 5 days infection. Peak no. 41: D-ribofuranose, 46,47: D-glucose, 66: Hexadecanoic acid, 79: linoleic acid, 81:linolenic acid



Metabolites identified in JAL-42 (Susceptible genotype) after 5 days infection. Peak no. 37: D-ribofuranose, 46: D-glucose, 60: Hexadecanoic acid, 71: linoleic acid, 73:linolenic acid

Changes in phenyl propanoid pathway enzymes during Groundnut-*Cercosporidium personatum* interaction

Higher activities of phenyl alanine ammonia lyase, tyrosine ammonia lyase and peroxidase were observed in resistant genotypes than that of susceptible genotypes. Higher activities of these enzymes may be correlated with higher content of various phenolics in resistant genotypes.

Estimation of TCA cycle products (organic acids) during Groundnut-*Cercosporidium personatum* interaction

TCA cycle compounds i.e. malic and citric acid was observed higher in susceptible genotypes. These compounds increased after infection in all genotypes. Thus higher content of these TCA cycle products implies higher respiration rate and higher catabolism during pathogen infection.

Services

Oil, protein and moisture content of 2500 groundnut samples from different section of DGR and 300 samples from different AICRP-G centers were measured by NIR spectroscopy.

Enhancing the Productivity, Sustainability and Resilience of Groundnut Based Production System

Development of technologies for enhancing resource use efficiency in groundnut-based cropping systems

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, 2015 to know the response of summer groundnut to plant population and fertilizer doses under check basin and drip irrigation at ICAR-DGR research farm. The experiment was conducted in split plot design with three replications. The treatments consisted of three plant population densities viz., 100% (3,33,333), 125% (4,16,666) and 150% (4,99,999); and three fertilizer doses viz., 75%, 100% and 125% of recommended NPK. Under check basin irrigation 150% plant population significantly improved pod and haulm yield, and net returns over 100% plant population. Application of 100% NPK (25:50:30 kg/ha of NPK) significantly increased pod and haulm yield, net returns, and B:C ratio as compared to application of 75% NPK.

Under drip irrigation increasing plant population did not significantly improved pod and haulm yield, net returns and B:C ratio. Similarly, different doses of NPK also did not affect above parameters significantly.

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

A field experiment was initiated during summer 2015 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 mulch film significantly enhanced pod yield of groundnut by 14.6% over no mulch film while there was no significant effect on haulm yield. The mulch film was observed to get degraded by 60-70% during the crop season; hence it should be detached from the haulm prior to feeding to animals. On the other hand, time of sowing and seed priming did not bring out any significant variation in pod and haulm yield.
The activities of soil enzymes like dehydrogenase and phosphatases (acid and alkaline) were significantly altered by mulching and sowing time. However, a non-significant difference was observed with seed priming during summer season. The highest activities for these enzymes were observed under mulching followed by sowing time (i.e., first fortnight of February). The higher enzymatic activities were observed up to 90DAS especially under mulching for both acid and alkaline phosphatases. The activities for dehydrogenases increased up to 60 DAS and then decreased till crop harvest.

Effect of water soluble fertilizers on productivity of summer groundnut

A field experiment was initiated during summer 2015 to study the effect of water soluble fertilizers on productivity of summer groundnut grown under raised bed with mulch film. The experiment, consisting of 10 treatments namely, control (100% normal fertilizers with surface irrigation), 100% RDF at sowing (normal fertilizers 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 fertigation with normal fertilizers (at sowing), was laid out in randomized block design with three replications.

All the treatments had significant effect on pod yield of groundnut over control i.e. normal fertilizers with surface irrigation. However, there was no significant difference in pod yield obtained under drip irrigation with soil application of fertilizers, drip fertigation with normal fertilizers and various levels of water soluble fertilizers applied at different time intervals through drip but maximum pod yield was obtained under drip fertigation with normal fertilizers. Methods of fertilizer application also could not bring significant difference in pod yield. On the other hand, significantly higher haulm yield was obtained with application of 100% WSF fertigation [sowing (1/2), 20 DAS (1/4) and 40 DAS (1/4)] over all the treatments including control and was at par with 100% WSF fertigation [sowing (1/4), 20 DAS (1/4), 40 DAS (1/4) and 60 DAS (1/4)].

Irrespective of the water soluble fertilizers the highest soil enzymatic activities for dehydrogenase, acid and alkaline phosphatase was observed up to 60 days after sowing which were reduced at later crop growth stages till harvest. Although, the activities for these soil enzymes was found at par to activities observed at 30 DAS showing that the activities for these soil enzymes was governed by active plant growing phases. The effect of different water soluble fertilizers on these soil enzymes was found non-significant.

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

A field experiment was initiated during *kharif* 2015 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.

Significantly higher pod and haulm yields were recorded in raised bed and furrow method over conventional method of planting and were at par with ridge and furrow method. Among the mulching treatments, significantly higher pod and haulm yield were recorded with the use of biodegradable mulch film over control and was at par with organic mulch treatment. The dehydrogenase activity of the soil was significantly affected under different land configuration and mulching treatments. However the phosphatases (acid and alkaline) activity was found non-significant both under land configuration as well as application of mulch. The activities of these enzymes were higher (3 to 45%) under application of mulch using organic as well as polythene mulch as compared to without mulch.

Integrated nutrient management studies in groundnut-wheat cropping system

A field experiment was initiated during *kharif* 2015 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) in groundnut and 100% RDF in wheat; T_3, 75% RDF in groundnut and 75% RDF in wheat; T_4, 100% RDF in groundnut and100% RDF in wheat; T_5, 75% RDF + 5 t FYM/ha in groundnut and 75% RDF in wheat; T_6, 75% RDF + 2.5 t FYM/ha in groundnut and 100% RDF in wheat; T_7, 75% RDF + 2.5 t GM/ha (*dhaincha*) in groundnut and 75% RDF in wheat; T_8, 50% RDF + 5 t GM/ha (*dhaincha*) in groundnut and100% RDF in wheat; T_9, 100% RDF + biofertilizers(BF) in groundnut and 100% RDF + BF in wheat; T_{10}, 100% RDF + 5 t FYM/ha+BF in groundnut and 75% RDF in wheat; T_{11}, 75% RDF + 5 t FYM/ha + BF in groundnut and 100% RDF in wheat; and $T_{12,}$ farmers' practice for groundnut and wheat, respectively.

Treatment involving application of 75% RDF + 5 t FYM/ha in groundnut and 75% RDF in wheat, being at par with treatment 100% RDF in groundnut and100% RDF in wheat, gave significantly highest pod yield of groundnut in *kharif* . The significantly highest haulm yield of groundnut was also recorded with application of 75% RDF + 5 t FYM/ha in groundnut and 75% RDF in wheat. During *rabi* season application of 75% RDF + 5 t FYM/ha in groundnut and 75% RDF in wheat, being at par with 75% RDF + 2.5 t FYM/ha in groundnut and 100% RDF in wheat, produced significantly highest grain yield of wheat. Highest straw yield of wheat was also produced with application of 75% RDF + 5 t FYM/ha in groundnut and 75% RDF in wheat but differences were found non-significant among the treatments.

The enzymatic activities in soil were measured during active growth phase of groundnut in *kharif* season. The activities of soil dehydrogenase were significantly altered under different nutrient management practices with higher under use of FYM, GM and bio-fertilizers along with inorganic fertilizers. However, the activities for acid and alkaline phosphatases were found non-significant. The highest enzymatic activity was found for alkaline phosphatase followed by acid phosphatase and least for dehydrogenase enzymes.

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

A field experiment was initiated during *kharif* 2015 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. The recommended dose of sulphur was 40 kg S/ha.

There was no significant difference in pod and haulm yield of groundnut due to cropping systems, periodicity of fertilization, and doses of sulphur application. Similarly, grain/seed and fodder yield of wheat and chickpea were also not significantly affected due to periodicity and doses of sulphur application. But application of 50% sulphur to both the crops once in two years gave highest grain and fodder yield of wheat. In case of chickpea, application of sulpur every year gave highest seed and fodder yield. Highest seed and fodder yield of chickpea was recorded with application of 100% sulpur to chickpea and 50% sulpur each to groundnut and chickpea, respectively.

The enzymatic activities in soil were measured during active growth phase of groundnut in *kharif* season. The soil enzymes like dehydrogenase and phosphatases (acid and alkaline) were non-significantly altered under different levels and periodicity of sulphur application both in groundnut-wheat and groundnut-chickpea cropping sequences. The activity of dehydrogenase was higher under groundnut-chickpea whereas the activity of soil phosphatases was observed higher under groundnut-wheat sequences. The activity for alkaline phosphatase was higher than the acid phosphatase under all the treatments for sulphur as well as under cropping sequences.

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 2015-16. The experiment, consisted of 14 various treatment combinations viz., groundnut-monoculture, groundnut-*Sesbania* (green manuring), groundnut-greengram (green manuring), groundnut-wheat, groundnut-wheat-*Sesbania* (green manuring), groundnut-wheat-greengram (green manuring), groundnut-wheat-wheat (stubble incorporation), groundnut-wheat (zero tillage), groundnut-wheat (zero tillage)-*Sesbania* (green manuring), groundnut-wheat (zero tillage)-greengram (green manuring), groundnut-wheat (zero tillage)-wheat (stubble incorporation), groundnut + pigeonpea, groundnut + pigeonpea-*Sesbania* (green manuring) and groundnut + pigeonpea-greengram (green manuring), was laid out in randomized block design with three replications.

Significantly highest pod and haulm yield of groundnut was recorded in groundnut-wheat (zero tillage)-*Sesbania* (green manuring) cropping system while, groundnut + pigeonpea-*Sesbania* (green manuring) system gave lowest pod and haulm yield of groundnut. Highest pigeonpea yield was recorded with groundnut + pigeonpea-*Sesbania* (green manuring) system.

During *rabi* season under both the tillage systems groundnut-wheat-greengram (green manuring), being at par with groundnut-wheat-*Sesbania* (green manuring), gave significantly highest grain and straw yield of wheat over groundnut-wheat system. Groundnut + pigeonpea-greengram (green manuring), closely followed by groundnut + pigeonpea–*Sesbania* (green manuring) and groundnut + pigeonpea system, gave significantly highest system productivity in terms of groundnut pod equivalent yield over groundnut monoculture which was reportedly found to have lowest system productivity. Among the groundnut-wheat based cropping systems, groundnut-wheat (zero tillage)-*Sesbania* (green manuring) system gave significantly highest system productivity over groundnut monoculture.

Effect of organic manures, growth promoters and nutrient solubilisers on summer groundnut

A field experiment was initiated during summer, 2015 to evaluate the effect of different organic plant nutrient sources, growth promoters, and nutrient solubilizers for organic cultivation of groundnut at ICAR-DGR research farm, Junagadh. The treatments tested were: recommended dose of fertilizers (T_1), FYM @ 10 t/ha (T_2), *neem* cake @1634 kg/ha (T_3), enriched compost @ 2858 kg/ha (T_4), FYM @ 5 t/ha + enriched compost 1429 kg/ha (T_5), T_5 + plant growth stimulant (T_6), T_6 + plant growth promoters (T_7), T_7 + nutrient solubilizer (T_8), recommended dose of fertilizers + *Amrit pani* (T_9). The experiment was laid out in randomized block design with four replications.

The results indicated that application of FYM @ 5 t/ha + enriched compost 1429 kg/ha + plant growth stimulant + plant growth promoter + nutrient mobilizers, being at par with enriched compost @2858 kg/ha; FYM @ 5 t/ha + enriched compost @1429 kg/ha, FYM @ 5 t/ha + enriched compost @1429 kg/ha + plant growth stimulant; FYM @ 5 t/ha +

enriched compost 1429 kg/ha + plant growth stimulant + plant growth promoter, gave significantly higher pod and haulm yield over application of recommended dose of fertilizers. Application of *Amrit pani* also improved pod and haulm yield considerably over recommended dose of fertilizers but, differences were not significant at 5% level of probability.

Response of groundnut to crop geometries and growth promoting substances

A field experiment was conducted during *kharif* 2015 to identify suitable crop geometry in groundnut (variety TG 37 A) to facilitate mechanical interculturing to reduce cost on weed control and enhance productivity, and know response of groundnut to growth promoting substances. For mechanical interculturing with mini-tractor or bullock-drawn implements wider spacing (at least 45 cm between rows) is required but it reduces yield of Spanish group varieties due to reduced plant stand. Therefore, suitable crop geometry is needed to be identified. The experiment was laid out in split plot design with three replications. In main plot five treatments of crop geometries viz., 30x10 cm, 45x10 cm, 45/10x10 cm, 45/15x10 cm, and 45/20x20 cm spacing, while in sub plot four treatments of growth promoting substances viz., control, plant growth promoting rhizobia (PGPR), *Amrit pani*, and PGPR + *Amrit pani* were tested.

Groundnut crop grown with different crop geometries: 30x10 cm (left), 45x10 cm (centre) and 45/20x10 cm (right)

The response of groundnut to crop geometries and growth promoting substances was found significant. Sowing of groundnut with crop geometry of 30x10 cm spacing, being at par with 45/10x10 cm spacing, gave significantly higher pod and haulm yield. While lowest pod and haulm yield was recorded with crop geometry of 45x10 cm spacing. Seed treatment with PGPR significantly improved pod and haulm yield of groundnut over control. Foliar spray of *Amrit pani* slightly improved pod and haulm yield of groundnut.

Development of conservation agriculture technologies for groundnut–based cropping system(s)

Developing Conservation Agriculture technology for groundnut-wheat cropping system

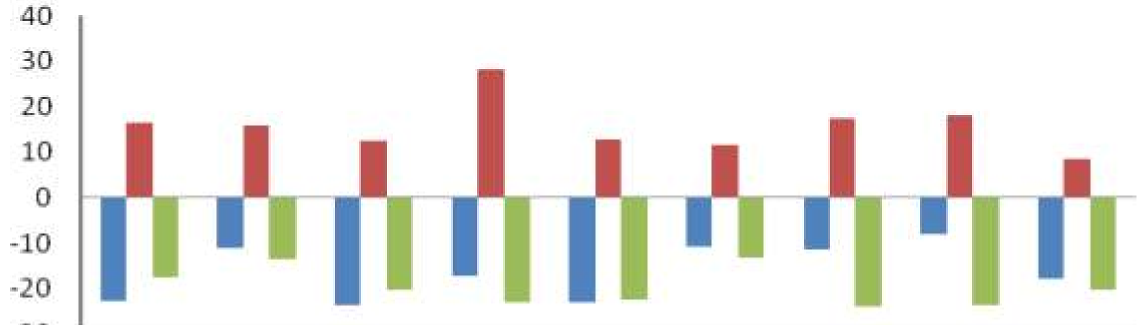
A field experiment was conducted during 2015-16 to know the effects of three tillage practices viz. conventional tillage, minimum tillage and zero tillage, and three residue management practices viz. no residue application, wheat stubble retention, and wheat stubble retention + *Cassia tora* mulch in groundnut-wheat cropping system. The experiment was laid out in split plot design with three replications.

Groundnut grown on permanent raised beds with normal tillage (left) and minimum tillage (right)

Effect on productivity: Normal tillage, being at par with minimum tillage, gave significantly higher pod and haulm yield of groundnut over zero tillage. Wheat stubble retention, and wheat stubble retention + *Cassia tora* mulch significantly improved pod and haulm yield of groundnut over no stubble retention.

In wheat, grown in sequence after groundnut, minimum and zero tillage, being at par, gave significantly higher total and effective tillers per meter row length, length of ear, spikelets per spike, SPAD value, chlorophyll content, and grain yield over normal tillage. Similarly, wheat stubble retention, and wheat stubble retention + *Cassia tora* mulch significantly improved total and effective tillers per meter row length, length of ear, spikelets per spike, SPAD value, chlorophyll content, and grain yield over no stubble retention.

Effect on soil phosphorus pools: Generally, the changes in different soil phosphorus pools viz., inorganic, organic and residual remained non-significant among different tillage and crop residues recycling levels at third year of groundnut-wheat cropping sequence.



	MTNR	MTWR	MTWCR	NTNR	NTWR	NTWCR	ZTNR	ZTWR	ZTWCR
Pi	-22.6	-11.0	-23.7	-17.2	-23.0	-10.6	-11.3	-8.0	-17.8
Po	16.5	15.9	12.6	28.3	12.8	11.7	17.6	18.0	8.7
Resid P	-17.4	-13.6	-20.3	-23.1	-22.3	-13.2	-23.8	-23.5	-20.3

Per cent change in soil phosphorus pools over three years

Management of soil and irrigation water salinity in groundnut

Evaluation of released varieties of groundnut in summer & *kharif* season in saline black clay soil

Groundnut was taken in summer 2015 to test the eight released varieties namely Dh 86, Dh 101, GPBD 5, GG 7, JL 501, K 9, TKG 19A and TPG 41 under Spanish group in the saline environment having salinity levels of 0.5, 2, 4 and 6 dSm^{-1}. The five meter rows length of each variety and seven supplementary irrigations were given. The performances of the said varieties were normal under salinity condition. It was observed that the pod and haulm yields of all the varieties were at par up to the irrigation of saline water of 4 dSm^{-1} but significant difference was recorded at a water salinity of 6 dSm^{-1} in comparison to water salinity of 0.5 dSm^{-1} (control). Further, the significant difference in pod and haulm yield were also recorded within the varieties and significantly higher pod yield was recorded in TPG 41, TKG 19A and K 9 and haulm yield in K 9, TPG 41 and TKG 19A, respectively under Spanish group. Almost similar trend was observed for other yield contributing characters under saline environment.

The same experiment was taken in *kharif* 2015 at similar site of field to evaluate the similar set of varieties under similar level of salinity but four supplementary saline irrigations were given in this season in place of seven irrigations during summer season. In this season also, it was observed that pod and haulm yields of all the varieties were at par up to the irrigation of saline water of 4 dSm^{-1} but significant difference was recorded at a water salinity of 6 dSm^{-1} in comparison to water salinity of 0.5 dSm^{-1} (control). Further, the significant difference in pod and haulm yield were also recorded within the varieties and significantly higher pod and haulm yield was recorded in TKG19A and GG 7, respectively under Spanish group during *kharif* season.

Screening of groundnut genotypes at different salinity levels

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

The experiment was conducted during summer 2015 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 dSm^{-1}), two levels of mulching (polythene mulch and without mulch) and three levels of potassium (0, 30 and 60 kg/ha). The results revealed that significantly higher pod yield was recorded with the application of 2 dSm^{-1} saline irrigation water but it was at par with control and significant reduction was recorded at 4 dSm^{-1} as compared to 2 dSm^{-1} & control. The 43.0% higher pod yield was recorded at 2 dSm^{-1} compared to 4 dSm^{-1} saline irrigation water. The haulm yield of groundnut was also showed non-significant results up to 2 dSm^{-1} as compared to fresh irrigation water (i.e., control) but 2 dSm^{-1} and 4 dSm^{-1} saline irrigation water was also at par to each other and significant reduction was recorded at 4 dSm^{-1} as compare to control. Further, significantly higher pod and haulm yield with 34.2% and 30.4% were recorded under polythene mulch as compare to no mulch, respectively. The application of potassium @60 kg/ha improved the pod and haulm yield of groundnut indicating ameliorative effect of potassium on salinity stress. Although, interaction effect of salinity x mulching revealed that as the level of saline irrigation water increases pod and haulm yield of groundnut significantly increase under polythene mulch as compared to without mulch.

Studies on dynamics of soil phosphorus under various management practices in groundnut cultivation

Optimum phosphorus requirement for groundnut in calcareous soil

Summer 2015: Groundnut crop (cv. TG 37A) was grown with 0 to 100 kg P_2O_5 ha^{-1} with 10 kg incremental levels for each treatment during summer 2015. A non-significant and inconsistent effect of different phosphorus levels were observed on plant growth, yield attributes and yield of groundnut. However, in pooled results plant height, number of nodules per plant, fresh shoot weight, pod and haulm yield were significantly altered by application of different phosphorus levels. Also the application of phosphorus @30 kg P_2O_5 ha^{-1} and above were resulted in an at par yield of groundnut. Soil enzyme activities (viz., dehydrogenase and phosphatases), availability of soil phosphorus and phosphorus uptake by the plants were also found non-significant under different phosphorus levels. Although, a considerable difference in these parameters were observed at different crop growth periods.

***Kharif* 2015:** Groundnut crop (cv. TG 37A) 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* 2015. There was no application of phosphorus in control plot. The plant growth and yield attributes like plant height, fresh root and shoot weight, number of mature pods, pod weight per plant and yield of groundnut was significantly ($p=0.05$) differed among phosphorus levels. The pod as well as haulm yield of groundnut was highest under application of 50 kg ha^{-1} phosphorus supplied either through SSP or DAP among different phosphorus levels. However the significant increase in groundnut yield by application of different phosphorus levels was observed up to 30 kg/ha and on subsequent application an at par difference in both pod as well as haulm yield was observed.

Among P-fertilizers sources, both the sources were found at par effect on growth and yield of groundnut. The phosphorus fertilizer use efficiency was also found at par with slightly higher for use of SSP in terms of pod and haulm yield of groundnut.

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

***Rabi*-Summer:** Wheat crop (cv. GW 496) 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 @ 2.5 kg ha^{-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 *rabi* 2014-15. The yield and yield attributes of wheat (viz., ear head/m^2, test weight, grains/ear-head, grain and straw yield etc.) were significantly altered among different soil phosphorus gradients whereas the effect of different phosphorus solubilizers were found non-significant except on the straw yield of wheat. The interaction effect of P-gradients and P-solubilizers were also found significant on straw and total biomass yield of the wheat.

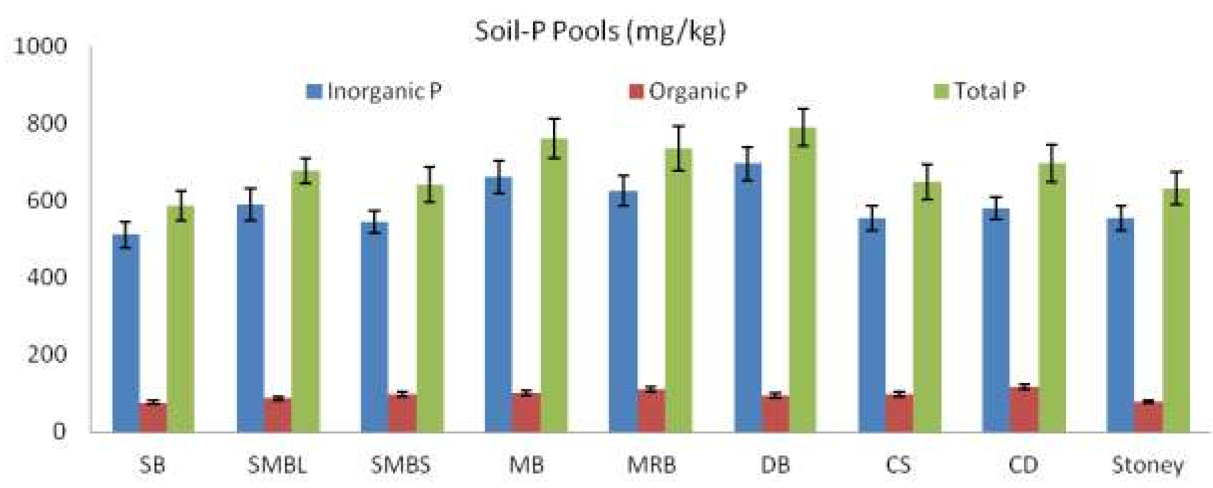
***Kharif*:** Groundnut crop (cv. TG 37A) was grown in sequence to wheat with same treatments during *kharif* 2015. The growth and yield attributes of groundnut like root weight, branches, hundred pod weight, pod and haul yield of groundnut yield were significantly differed among different soil phosphorus gradients. However, significant difference in pod yield was observed among different phosphorus solubilizers. The highest groundnut yield was observed with higher dose of phosphorus application compared to the lower levels. Similarly, application of FYM was proved most effective soil phosphorus solubilizer followed by compost and citric acid in terms of growth and yield of groundnut.

Soil phosphorus management in groundnut-wheat cropping sequence

Characterization and availability of soil phosphorus under groundnut cultivation in Saurashtra

Soil samples collected from Junagadh, Rajkot, Amreli and Bhavnagar districts of Saurashtra region in Gujarat were analyzed for different soil phosphorus (P) fractions. Phosphorus in these soils predominately occurs in the inorganic form (> 80%) depending upon the soil parent material and land use. Total P content varies from 600 - 900 mg kg^{-1} whereas < 2.5% of the total soil P was observed as available P for plant nutrition in different soils of Saurashtra region. Generally soils of these districts were ranged from low (50 to 95%) to medium (5 to 50%) in availability of soil phosphorus.

The high index for available soil P was also observed in some pockets of Junagadh and Bhavnagar (about 5-10%). About two third of the total inorganic P was recovered as Ca-P (>65%) and rest were found in the order of Al-P > Fe-P > Reductant-P > Saloid-P and Occluded-P. Further characterization of soil phosphorus in to different conceptual pools revealed that highest labile and mineralizable P were recovered from soils collected from Junagadh district followed by Bhavnagar, Amreli and Rajkot. A wide variability was observed for stable soil phosphorus pool which is highly recalcitrant and resistant to solubilize and mobilize for nutrition of plants. These results indicates that despite of high P buffering capacity these soils have the great potential for P nutrition of plants using appropriate management practices.



Soil P pools in different soil types in Saurashtra region of Gujarat (SB; Shallow black, SMBL; Shallow to medium black limestone, SMBS; Shallow to medium black sandstone, MB; Medium black, MRB; Mixed red and black, DB; Deep black, CS; Coastal shallow, CD; Coastal deep)

Raising of F_1 generation and advancement of segregating generations

Ten crosses affected during *kharif* 2014 were raised during summer 2015 and true F_1's were identified. Two crosses namely Girnar 3 x FDRS 10 and TG 37A x FDRS 10 in F_7 generation and eight crosses in F_6 generation were advanced to their next filial generations by single seed descent (SSD) method. Meanwhile three crosses in F_4 generation and five crosses in F_3 generation were advanced to next filial generation.

Screening of promising breeding lines and germplasm for yield under phosphorus levels

Ninety one (91) promising breeding lines were evaluated with five checks (Somnath, GG 20, GG 2, GG 7 and TG 37A) under two phosphorous levels (i.e., Native soil-P and RDP @ 50 kg P_2O_5 ha^{-1}) using augmented design during summer 2015. Four and twenty six promising breeding lines had significantly higher pod yield per plant compared to superior check (Somnath) under native soil-P and RDP, respectively.

Similarly 158 germplasm accessions with four check genotypes (ICGV 86590, SP 250A, VRI 3 and NRCG 162) were evaluated for phosphorus use efficiency in terms of pod yield under low (native soil P) and high (RDP) phosphorus levels during summer 2014. Significant genotypic differences were observed among different germplasm for pod yield per plant. None of the germplasm accessions could surpass best check (VRI 3) under low-P except the genotype NRCG 12296 was on par with the best check whereas under high-P, genotype NRCG 12296 was superior and four genotypes namely NRCG 11679, 12049, 12069 and 12423 were on par with the best check (VRI 3).

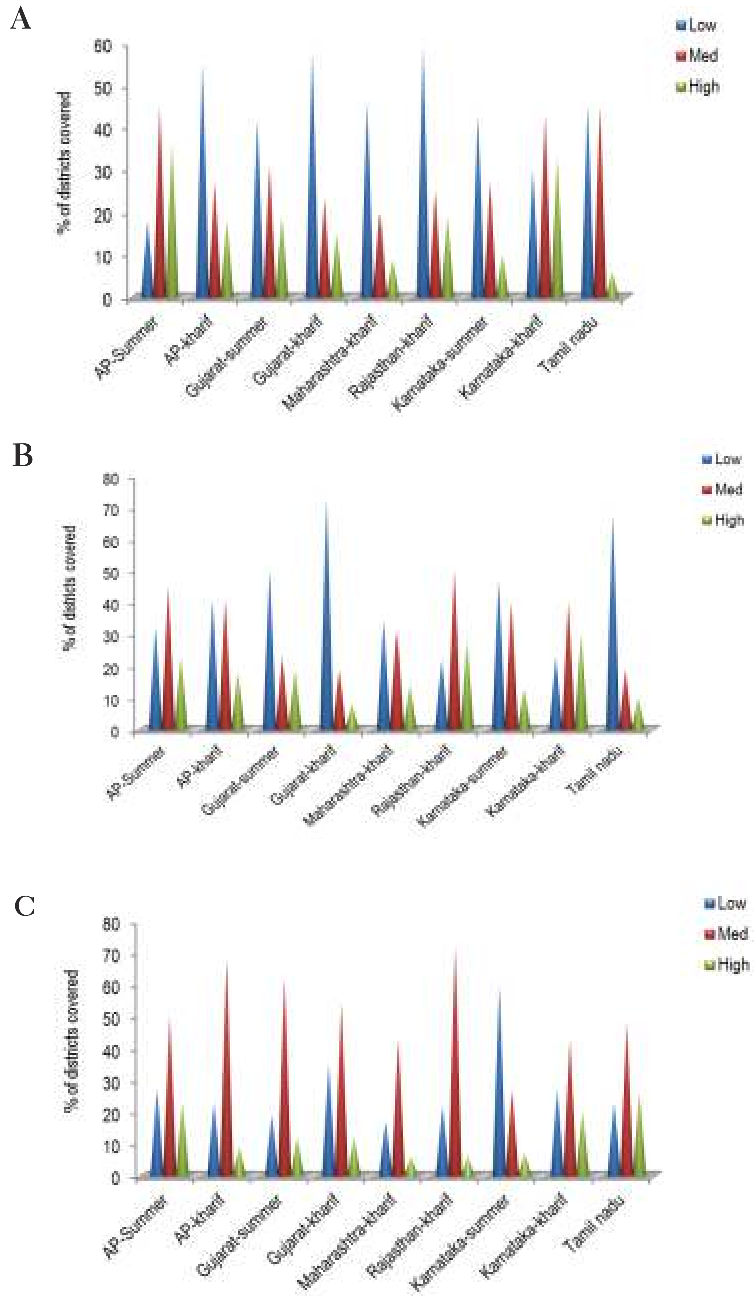
Characterization of soil fertility status using GIS tools for location-specific nutrient management in groundnut

Soil attributes of various groundnut growing districts

Representative soil samples from several high productive and low productive districts of Gujarat, Andhra Pradesh and Tamil Nadu was collected. Soils of different districts and states were analyzed to generate primary database of soil attributes. Different soil physicochemical (pH, electrical conductivity, total dissolved solids) and fertility parameters viz. major nutrients (available N, P, K), secondary nutrients (Ca, S, Na) and micronutrients (Fe, Zn, Cu, Mn) was estimated which revealed a wide variability of soil attributes among the districts. Ranges of different soil attributes was found as: pH (5.16-7.63), EC (0.10-0.92 dS m^{-1}), TDS (0.05-0.46 ppm), av. N (63.3-248.7 kg ha^{-1}), av. P (10.4-63.6 kg ha^{-1}), av. K (57-242 kg ha^{-1}), Ca (0.35-9.48 µg kg^{-1}), S (0.61-5.43 mg kg^{-1}), Na (0.07-1.04 µg kg^{-1}), Zn (0.31-4.42 ppm), Fe (0.69-25.12 ppm), Cu (0.26-3.40 ppm), and Mn (3.44-11.72 ppm). Apart from that secondary database of soil attributes was generated from the different AICRP-G centers.

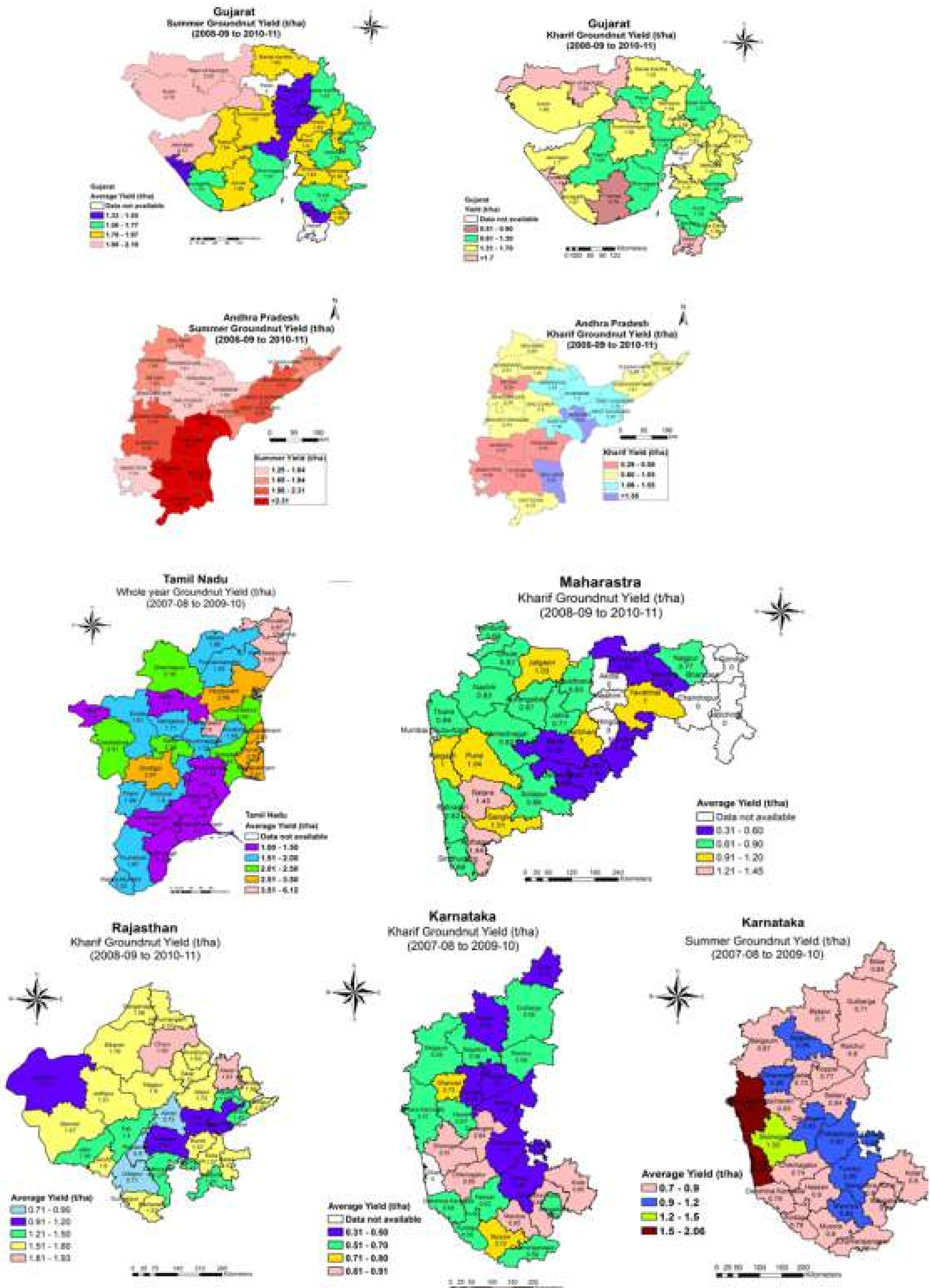
Spatial distribution of area, production & amp; yield of groundnut cultivated areas

Spatial distribution of area, production and productivity of groundnut growing districts of major states like Gujarat, Maharashtra, Tamil Nadu, Rajasthan, Andhra Pradesh and Karnataka was developed by GIS mapping. Separate maps were generated based on season of cultivation. Spatial analysis of different districts under these states was enumerated and was classified as low, medium and high area, production and yield. A contrasting picture showed the season-wise (*kharif*, *rabi*-summer) differentiation of districts contributing productivity. This zonation will further help to understand the soil-related factors associated with productivity.



Percentage distribution of districts into low, medium and high categories of (A) area, (B) production, and (C) yield for major groundnut producing states at rabi-summer and kharif seasons as revealed from GIS generated maps

Spatial distribution of yield of groundnut growing districts of minor states like Orissa, Uttar Pradesh, West Bengal, Bihar and Chhattisgarh was developed by GIS mapping. Separate maps were generated based on the season of cultivation. Spatial analysis of different districts under these states was enumerated and was classified as low, medium and high yield categories.



Seasonal yield differentiation of major groundnut producing states using GIS

Biochemistry and Physiology of Groundnut in Relation to Photosynthetic Efficiency, Nutritional Quality, Biotic and Abiotic Stress Tolerance

Iron and zinc bio-fortification in groundnut

Fe and Zn responses and their densities in groundnut cultivars

The Zn and Fe densities in seed of 190 groundnut cultivars grown under unfertilized (control) and fertilized with Zn (2 kg/ha, 50% soil and 50% foliar) or foliar application of iron sulphate (0.5%) was studied with an objective to study the response of these micronutrients on pod yield and their enrichment in kernels. There was a large variation in the photosynthetic rates, SCMR and VCR readings among cultivars with the growth stages which reflected on pod yield/ha. Though the pod yield increased substantially with application of Fe and Zn, all the cultivars did not respond to these Fe and Zn fertilizers.

The seed analysis of these groundnut cultivars for Fe and Zn contents revealed that the Zn concentration in seed ranged from 24-80 mg kg^{-1} Zn with a mean value of 49 mg kg^{-1} Zn and there were certain high Zn (more than 55 ppm) groundnut cultivars (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) and high Fe (> 125 ppm) groundnut cultivars (MH 4, Somnath, ICGV 86031, ICGV 86325, Tirupati 3,

GG 2, M 145, M 13, DSG 1, AK12-24, TAG 24, ALR 3, JSP 19). Foliar application of these Fe and Zn enriched these in seed. The phytic acid, in seeds of a few selected cultivars, when estimated wide variation in the range of 0.587 (TMV 2) to 0.992 (KRG 123) were observed with an average of 0.784 g $100g^{-1}$.

The study clearly demonstrated high Zn and Fe density groundnut cultivars which need extensive cultivation and consumption as food to combat the Fe and Zn malnutrition in India.

Fe bio-fortification in groundnut through foliar spray of iron sulphate

In field, spray of aqueous solution of 0.5 % iron sulphate thrice at 40, 55 and 70 days after emergence (DAE) in 60 groundnut cultivars, influenced yield and yield attributes, and increased the seed Fe and Zn contents in most of the cultivars, though variations were observed. The mean Fe and Zn concentrations in seeds of 60 groundnut cultivars were 51 and 43 mg kg^{-1} which with spray of iron sulphate increased to 81 and 46 mg kg^{-1}, respectively.

Fe bio-fortification through seed dressing of various iron sources

Five iron sources ($FeSO_4$, $FeCl_3$, Ferric Citrate, FeEDDHA, Fe-EDTA) were applied as a seed dressing to see the effect of these on pod yield and Fe content in seed produce taking 12 groundnut cultivars, where only iron sulphate and FeEDDHA increased yield. The seed of these produce when analysed, though varietal differences were observed, the Fe contents in seed increase due to iron sulphate, $FeCl_3$ and FeEDDHA. However the Zn content in seed was decreased due to various Fe- sources.

Screening groundnut for high micronutrient density

Zinc bio-fortification in groundnut

The soil and foliar application of various sources of zinc at 2 kg Zn ha^{-1} were studied in 20 groundnut cultivars through field experiments, during *kharif* and summer seasons, where zinc sulphate was better than Zn-EDTA in influencing the yield, however both of these increased the Zn content in seed. Three foliar spray of aqueous solution of 0.2 % zinc sulphate at 40, 55 and 70 days after emergence, influenced yield attributes, and increased the seed Zn content and hence recommended. However foliar application of Zinc chloride showed scorching on groundnut leaves, and hence should not be used. The mean Zn concentrations in seeds ranged from 19-63 ppm which with spray of Zn increased to 32-65 ppm.

Thus application of Zn fertilizer is recommended to increase Zn content of groundnut seed.

Zn and B nutrition of various seed-sizes groundnuts

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 (T_1-control, T_2-Ca_{100} + K_{100}+ 1 kg ha^{-1} B, T_3-T_2 + 2 kg Zn) where a large variation in the response depending upon the seed size was observed. The seeds of these produce are being analyzed to see the effect of B and Zn and their contents in seed.

Screening of mini-core germplasm for high Fe and Zn densities

The Fe and Zn densities in the seeds of 179 mini-core ICRISAT germplasm, grown in field with and without Fe and Zn fertilizers, when analyzed majority of these responded to Fe and Zn fertilizers, however there were a number of nonresponsive genotypes mainly due to their poor yielding or utilization capacities and hence low requirement. There were 13 minicore genotypes which showed high seed Zn (with >53 ppm Zn) and 12 with high Fe in seed.

Screening groundnut varieties under screening block

B and Z interactions in relation to their content in seed

In field trials on effect of B and Zn using three treatments (i.e. control, 1 kg ha^{-1} B, 1 kg ha^{-1} B + 2 kg ha^{-1} Zn) when studied in 20 cultivars it showed synergistic effects and both of these micronutrients were important for pod development and high yields.

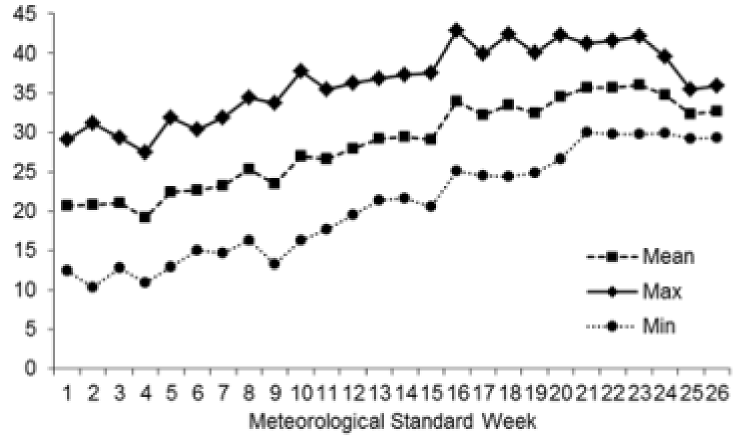
Screening groundnut for iron chlorosis

The 190 cultivars when screened for their reaction to lime-induced iron chlorosis (LICC), 23 were tolerant (Mallika, RSB 87, RG 510, RG 425, R8808, S230, Kadiri 7, 8, and 9, Tirupati 3, TG 42, Kadiri Gold, HNG 69, M 145, M 197, M 522, GJG 22, Champawat, LGN 2, BG1, DH4-3, ICGV87846) and several others moderately tolerant, besides 18 were very sensitive to iron chlorosis. Besides these 114 groundnut genotypes of various sections were screened for and thirteen were identified as Fe-efficient which could show tolerance of iron chlorosis.

Impact of climate change on physiology and productivity of groundnut

Screening of Spanish bunch sub-set of mini-core groundnut germplasm collection for high temperature stress tolerance using staggered sowing method

The experiment was conducted to identify groundnut genotypes which are having superior high temperature stress behaviour. For this, an experiment was conducted in summer 2015 to evaluate the Spanish bunch subset (49 genotypes) of mini-core groundnut germplasm collection using staggered sowing method at three different dates (D_1: 20 Jan, D_2: 10 Feb and D_3: 2 Mar) with ~20 days interval. As we found significant variation in daily temperature in this period, hence the experimental situation simulated the treatment effect of different temperature regime in the present study. Although there wasn't much temperature variation observed at the time harvest in three treatment condition, but the weekly mean of day/night temperature at the time of sampling (50% flowering stage) varied significantly.



Changes in mean, min & max temperature during entire crop growth period

Weekly mean temperature at the time of sampling and harvest

	Sampling Time				Harvesting Time			
	Met. Std. Week	Max T	Min T	Mean T	Met. Std. Week	Max T	Min T	Mean T
D1	9	33.6	13.3	23.5	20	42.2	26.6	34.4
D2	11	35.4	17.7	26.5	22	41.5	29.7	35.6
D3	14	37.3	21.6	29.4	24	39.5	29.9	34.7

The difference is sowing time resulted in differences in total degree days required to the crop to obtain maturity and thus affected every phenological observations. On an average the initiation of germination was delayed by ~ 4 days in D_1 treatment as compared to D_3. Similarly, the genotypes took 38 days to attain 50% flowering at early sown condition, while it took only 31 days in late sown condition. The physiological maturity was also hastened by almost 18 days in D_3 treatment than D_1.The rate of photosynthesis (P_N) was significantly affected by heat stress. The P_N of all genotypes was 25.7 µmol m^{-2} s^{-1} under D_1 condition, which was reduced to 23.1 and 19.6 µmol m^{-2} s^{-1} under D_2 and D_3 conditions, respectively. Unlike, PN the stomatal conductance, transpiration rate and mean canopy temperature was found to be higher with increase in day-night temperature. Among the genotypes, a few (NRCG 14380, 14368, 14377, 14334, 14404) showed least change in photosynthetic efficiency with changing temperature regime.

As a whole increased temperature showed detrimental effect on final crop yield (both pod and fodder yield). On an average the pod and fodder yield reduced from 151 and 455 g m^{-2}, respectively in D_1 condition to 114 and 404 g m^{-2} in D_3 condition. High temperature stress didn't alter the different seed quality parameters significantly, except the seed protein content showed little drop with increasing temperature condition.

Physiological and biochemical characterization of high temperature stress tolerance in groundnut using contrasting cultivars

To identify the basis of high temperature tolerance, this experiment was conducted with two relatively tolerant (ICGS 44 & GG 7) and two susceptible (DRG 1 & AK 159) genotypes (as identified from our previous experiments) by growing them in three different temperature regimes. Hence, the mean day-night temperature was 33.5/23.5, 35.4/26.5 and 37.3/29.4 ºC at the time of sampling for D_1, D_2 and D_3 condition. From the present study it was found that the tolerant cultivars were able to maintain membrane stability index (MSI) above 45% even under D_3 condition, while it was down to 26.5 and 20.6%, respectively for AK 159 and DGR 1. Similarly, with increase in mean day/night temperature of 4/6 ºC drastic reduction in pollen viability was observed (from 79% in D_1 condition to 58% in D_3 condition), again the reduction was much higher in DRG 1 and AK 159 as compared to ICGS 44 and GG 7. Hence, it can be said that MSI and pollen viability could be a key physiological factor responsible for high temperature stress tolerance in groundnut.

Effect of temperature stress on leaf sugar metabolism

Leaf sugar profiling of these cultivars under different temperature regime showed higher accumulation of innositol in all the cultivars under D_3 condition as compared to D_1, with highest level of accumulation observed in ICGS 44 and GG 7. Similarly, the concentration of glucose and fructose was found to be increased under D_3 condition as compared to D_1, but relatively higher reduction of sucrose was observed with increase in mean day-night temperature. This changing pattern of sugar accumulation indicates faster degradation of storage carbohydrates (sucrose) in high temperature condition, while the increased content of breakdown product may have direct role in thermostability of groundnut genotypes or may be supporting higher respiration rate in elevated temperature.

Physiological studies in groundnut under water-deficit and salinity stresses

Photosynthetic efficiencies of Indian groundnut cultivars

To know how physiologically efficient our groundnut cultivars are?, the photosynthesis (P_N), transpiration (E), stomatal conductance (g_s), chlorophyll fluorescence, SCMR and yields were studied in field grown 186 cultivars during *kharif* season, where large variability was observed. Accordingly these cultivars were categorized as high and low in their physiological traits. The study revealed 27 cultivars as high P_N (> 23.9 µ mol $m^{-2}s^{-1}$) and 30 as lowP_N (< 15.7 µ mol $m^{-2}s^{-1}$), 35 cultivars as high and 24 as low E, 35 cultivars as high g_s and 28 as low g_s. These accounted for the yield potential and 33 cultivars with > 225 g m^{-2} pod were high yielder, 26 as low yielder < 133 g m^{-2} pod and 127 cultivars medium with 133-225 g m^{-2} pod.

Positive correlation between, P_N and g_s, P_N and E,P_N and number of pods, SCMR and pod yield, SCMR and WUE, haulm yield and plant height, haulm yield and pods, plant height and pods, and a negative correlations between SCMR and plant height, SCMR and E, and E with WUE were found, however there was no any correlation of P_N with yield.

Physiological elasticity among 60 groundnut cultivars for their drought tolerance

The groundnut cultivars of four botanical groups, were evaluated during *kharif* season under control with protective irrigation (P) and rain-fed (RF) having natural drought conditions taking 60 cultivars during first year and 36 during another year and compared for physiological attributes. During first year only 229 mm rainfall was received from sowing-harvest and the RF crop faced three drought spells (11-20 DAS with only 1.2 % rainfall, 21-40 DAS with 13 % and from 72 DAS to harvest 40-60 days drought only 2.0 mm rainfall. The 50 % flowering took 28 and 30 days with a cumulative thermal time θ_f of 546 and 602 ºC d, respectively, in P and RF crops and 14 cultivars showed early flowering under both the situations. At 70 DAS, the mean SCMR value was more under

RF condition than P, however the mean RWC was 95.6 under P which decreased to 84.9 under RF. The mean SLA was 185 and 147 cm^2g^{-1} under P and RF conditions, respectively.

During next *kharif*, 36 cultivars were grown both under P, RF as well as mid season drought (MSD), and late sesson drought (LSD) using ROS where varietal differences were noticed. There was severe drought spell of about a month (25 June -22 July) during germination and early crop growth and hence crop was sown on 3rd July under proper moisture condition and once the crop germinated the treatment imposed were: Protected (the crop was provided 5 irrigation), RF (only irrigation for germination and seedling establishment, crop faced drought from 10-20, 30-40, 50-68 and 80-100 DAS), MSD (crop exposed to drought during 50-70 DAS), LSD (crop was exposed to drought 70-90 DAS).

The drought affected the overall maturity of the crop as a result the RF crop took 112-132 days with a CTT of 2114-2420 ºC d to mature as against 113-119 days with 2130-2224 ºC d in protected crop. Interestingly 30 cultivars matured within 112 days at 2114 ºC d under both the conditions indicating their adaptability and elasticity to drought. Though the mean pod yield of groundnut cultivars were 1260 kg ha^{-1} under P and 1130 kg ha^{-1} under RF conditions, cultivars ICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, Girnar 1, AK 159, SB XI showed > 1300 kg ha^{-1} pod yield under both the conditions. The HI ranged from 0.11-0.41 under P and 0.17-0.42 under RF conditions. The LSD was most detrimental to crop.

The cultivars with early flowering, high SCMR, low SLA, high yield and HI and early maturity showed escape mechanism and were considered as highly suitable for rainfed cultivation under drought situation. Spanish bunch (VUL) group was more suitable compared to Virginia bunch (HYP), Virginia runner (HIR) and Valencia (FST) for desirable traits in rain-fed condition and cultivars JGN 23, SB XI, and Girnar 1 showed desirable characters.

Screening groundnut varieties for drought tolerance under rain out shelter (ROS)

Pod zone moisture contents influences yield and yield attributes

In a micro-plot study, 24 groundnut cultivars were exposed to various moisture content in their pod zone (>16.3, 14.7-16.2, 13.2-14.6, 11.6-13.1 and < 11.6% moisture content) through drip irrigation and their influence was studied on yield and yield attributes. The study reveals that, though various cultivars behaved differently, there were no pod yield losses till the soil moisture content in pod zone was > 13.2 %, below which drastic reduction in yield and other parameters were observed. There were variations in the other physiological parameters also.

Influence of growth regulators on groundnut

In a field experiment under normal irrigation, foliar spray of (40, 60 and 75DAS) five commercial growth regulators (Lihocine, Planofix, Chamatkar, Progibb and Herbozymes) in four groundnut genotypes influenced the yield, seed size and germination. All these growth regulators increased seed size in, however the pod and haulm yields and shelling per cent increased due to Lihocine, Planofix, and Herbozymes only. The Chamatkar, Progibb and Herbozymes helped in increasing HI and Progibb controlled the over growth.

In another study the influence of growth regulators spray (T_1: control, T_2: 200 ppm succinic acid, T_3: 500 ppm salicylic acid, T_4: 200 ppm ascorbic acid and T_5: $T_2 + T_3 + T_4$) was studied for amelioration of water deficit stress in 8 groundnut cultivars which varied results. The study of sugar profiles revealed decrease in glucose, fructose and sucrose contents under water stress (50%), but the spray of the growth regulators arrested these decrease which was least in T_4, however, highestmyo-inositol was observed in T_5. Thus spray of ascorbic acid @ 200 ppm may protect water deficit stress induced sugar reduction in groundnut.

Screening for salinity tolerance

An *in situ* screening of 20 recently released cultivars attended at 2 salinity levels (2 dS m^{-1} and 4 dS m^{-1}) during summer 2015, by recording the germination, plant survival, and yield attributes reveals that imposition of soil salinity delayed the germination by 7-10 days followed by seedling mortality (0-68%) and reduction in germination (8-41%), plant height, number of pods per plant and yield. The groundnut showed 15% lesser germination and 34% lesser pod yield at 4 dS m^{-1} than that of at 2 dS m^{-1} with more than 70 % pod yield reduction in VRI 16, LGN 1 and VRI 4. However, the cultivars TLG 45, CO 3 and JGN 23 with lesser reduction in yield and other attributes showed their comparatively high tolerance with 130 g m^{-2} pod yield and hence can be grown in area with up to 4 dSm^{-1} salinity.

Understanding salinity stress tolerance mechanism and biochemical parameters

In a pot study, 6 differentially salt-sensitive genotypes ('CS 240', 'NRCG 357', 'TMV 2', 'Girnar 1', 'TPG 41', 'Somnath') were grown at four levels of salinity (0, 25, 50 and 100 mM NaCl) and major oxidative stress tolerance pathway and sugar profiling were studied under stress. There was stress build-up with ECe values 3.7 and 5.4 dSm^{-1} at 50 and 100 mM, respectively which decreased membrane stability index from 83% in control to 64% in 50 mM. Severe plant mortality was observed at 100 mM which led to complete loss of susceptible genotypes TMV 2 and NRCG 357.

Sugar profiling of these genotypes, through ion chromatograph, identified total four sugars i.e. myo-inositol, glucose, fructose and sucrose. The myo-inositol and sucrose decreased under salinity with more pronounced effect in sensitive genotypes. The glucose and fructose contents, on the other hand, though decreased in sensitive genotypes, increased in tolerant genotypes indicating that glucose and fructose play important role under salinity stress and may impart osmotic adjustment to the tolerant genotypes.

Activity assay of major ROS-detoxifying enzymes (SOD, CAT, POD, APX & GR) and their relative transcript abundance through real-time qPCR technique revealed up-regulation of SOD, CAT and POD under salt stress, while no significant induction was found in GR and APX.

Studies on microorganisms in relation to soil health and plant nutrition in groundnut

Evaluation of DAPG-producing fluorescent pseudomonads (summer and *kharif* 2015)

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 *Pseudomonas* sp. FP20, *Pseudomonas* sp. FP46, *P. putida* FP86 *and P. putida* FP93 enhanced the pod and haulm yield, and shelling out-turn significantly over uninoculated control at harvest. The yield enhancement ranged from 17 to 21%, the maximum was obtained with *P. putida* FP93.

Soil enzymes and microbial biomass carbon (MBC) were estimated to assess soil biological health under application of DAPG-producing fluorescent pseudomonads. Five soil enzymes (dehydrogenase, acid and alkaline phosphatases, urease and fluorescein di-acetate hydrolyzing activity) were assessed at 60 DAS of groundnut crop. For dehydrogenase enzyme, the strain FP46 performed best followed by FP93 and FP133, whereas DAPG7 showed lowest enzyme activity at par with the control. The acid and alkaline phosphatase activities seemed to be invariant among all the strains. For urease enzyme the strains DAPG7 and FP133 were observed to have more activities than rest of the strains. Fluorescein di-acetate hydrolyzing activity also differed among the treatments and FP86 and FP20 proved to be efficient strains. Microbial biomass carbon (MBC), another important soil biological health indicator, was assessed and the strains FP86 and FP20 treated soil had significantly more MBC over other strains and control.

During *kharif* 2015, inoculation with *Pseudomonas* sp. FP20, *Pseudomonas putida*

FP86, *P. monteilii* FP133 and *Pseudomonas putida* DAPG 7 resulted in significant increase in pod yield (18 – 21%) of groundnut, cultivar TG37A. The maximum pod yield was obtained in treatment with FP20. Inoculation with FP20, FP46 and DAPG7 resulted in significant enhancement of haulm yield. There was significant increase in shelling out-turn as a result of inoculation with these pseudomonads.

Studying the diversity of groundnut rhizobia in the Saurashtra region of Gujarat

A total of 127 rhizobial isolates have been obtained from samples collected from different groundnut growing fields in the Saurashtra region. The nod+ and nif+ groundnut rhizobium isolates were processed for 16S sequencing. 16S rRNA sequence based approach was undertaken. Initial results of 16S rRNA sequence of groundnut nodulating bacteria indicated that besides traditional rhizobial genera, *Enterobacter clocae*, *Pantoea dispersa*, *Ochrobactrum*, etc. are also found to be nodulating groundnut.

Application of DAPG-producing fluorescent pseudomonads for suppression of stem rot of groundnut (*kharif* 2015)

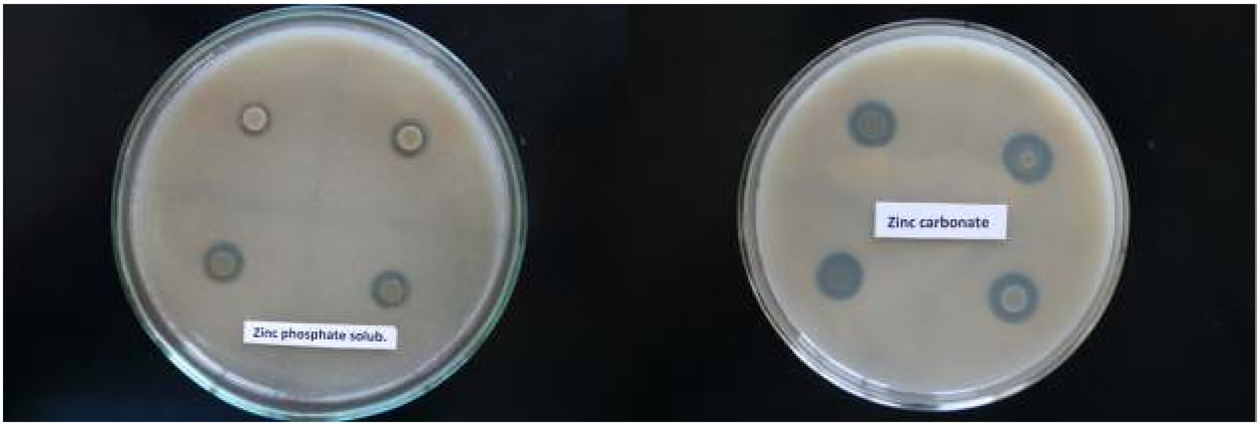
Some fluorescent pseudomonads are known to produce 2, 4-diacetylphloroglucinol (2, 4-DAPG) which is antifungal and inhibits the soil-borne fungal pathogens. To develop suppressive soils for fungal pathogens, twelve DAPG-producing fluorescent pseudomonads, highly antagonistic to *Sclerotium rolfsii* were evaluated in field condition for their potential in development of suppressive soils for management of *S. rolfsii*. Application of the DAPG-producing fluorescent pseudomonads suppressed the seedling mortality of groundnut, cultivar GG20 from 73% in pathogen control to 21-38% in treatments inoculated with different DAPG-producing fluorescent pseudomonads during *kharif* 2015. Moreover, application of *P. putida* DAPG4, *P. putida* DAPG7, *P. putida* FP121 *P. putida* FP86, *P. fluorescens* FP93, and *P. fluorescens* FP98 significantly improved the pod yield of groundnut, cultivar GG20 during *kharif* 2015. The enhancement in yield ranged from 12.7 to 21.8%, the maximum was with the inoculation of DAPG7 (2921 kg/ha as compared to uninoculated control, 2397 kg/ha). Whereas maximum haulm yield was obtained with the inoculation of *P. fluorescens* FP98, maximum shelling out-turn was achieved with the inoculation of *P. putida* DAPG7.

Isolation, characterization and *in vitro* evaluation of leaf epiphytes of groundnut for biological control and other traits

One of the major uses of phyllosphere bacteria would be in the biological control of air-borne fungal pathogens. Different groundnut genotypes, 40 in number, including 19 released cultivars and 21 groundnut accessions across different habit groups of groundnut (Valencia, Virginia and Spanish) were selected for studying the population dynamics of bacteria in the phyllosphere of groundnut, and for isolating leaf epiphytic bacteria of groundnut. Forty-eight morphologically different isolates of epiphytic bacteria were selected for studying their antifungal activities against two major foliar pathogens of groundnut, i.e. *Alternaria* and LLS pathogen. Out of the 48 bacterial endophytes tested, 19 cultures showed antifungal activity against *Alternaria*, the inhibition zone ranged from 3 to 18 mm. Six isolates were promising in showing high degree of antifungal activity against *Alternaria*. The 48 bacterial epiphytes were also tested for their antifungal activities against LLS pathogen. Nine epiphytes showed antifungal activities against LLS pathogen, the inhibition zones ranging from 6 to 12 mm. Eight of the epiphytes showed antifungal activities against both the pathogens.

Characterization of rhizobacteria for Zn and K solubilization

The PGPR cultures available in the microbiology section were screened for zinc solubilization using ZnO as the insoluble source. Three PGPR cultures showed Zn solubilization, zones ranging from 9 to 14 mm. Twenty-nine PGPR isolates were screened for solubilization of Zn using zinc phosphate and zinc carbonate as sources of Zn. Five PGPR isolates showed solubilization of zinc phosphate and zinc carbonate – the solubilization zone for zinc phosphate ranged from 7 to 10 mm and for zinc carbonate from 8 to 13 mm. The PGPR cultures BHU-1, FP82, BM6, FP93 and *Bacillus megaterium* were efficient zinc solubilizers. Sixteen PGPR cultures showed clear zones of K solubilization in petridishes, using potassium aluminosilicate as insoluble source of K. The zone of solubilization ranged from 11 to 22 mm, the maximum was with BHU-1.



Solubilization of Zn phosphate and Zn carbonate by DAPG-producing fluorescent pseudomonads

Application of microorganisms for management of biotic and abiotic stresses in groundnut

Isolation, characterization and identification of rhizobia tolerant to salinity and moisture deficit stress

From the nodule samples collected from the severely drought-stressed groundnut cultivated at Junagadh, 73 isolates were purified and characterized. The isolates were obtained from the nodules when soil moisture at 0-15 cm zone was below 10% at 50 DAS. Out of the 73 isolates only 39 were found to be *nod*$^+$. 16S rRNAs of all the 39 *nod*$^+$ isolates were sequenced. Blast search of the 16S rRNA revealed that majority of the *nod*$^+$ isolates belonged to the genus *Enterobacter* (*Enterobacter cloacae and Enterobacter sacchari*). Only two isolates (DTR34 and DTR47) showed similarity with the genus *Rhizobium*. All these *nod*$^+$ isolates will be tested for the presence of *nif* genes and then will be evaluated for nodulation and nitrogen fixation in groundnut in severe drought-stress condition. The salt tolerant isolates (57 isolates) obtained from Bhuj will be further characterized for *nod* and *nif* functions.

Evaluation of groundnut endophytes for antifungal activities against fungal pathogens of groundnut

Ten endophytic isolates were evaluated for antifungal activities against *Alternaria*. Only three endophytic isolates showed antifungal activities. Whereas *Pseudomonas aeruginosa* R24 produced 24 mm of inhibition zone, *Pseudomonas otidis* J11 and *Bacillus tequilensis* SEN15 produced inhibition zone of 11 mm and 15 mm, respectively in petridish bioassay. Besides antifungal activities, *Acetinobacter junii* J20, *Bacillus firmus* J22 and *Pseudomonas aeruginosa* R24 gave 15 mm, 19 mm, and 18 mm of solubilisation zone of insoluble potassium, potassium aluminosilicate, respectively. These endophytes are being evaluated for their efficiency in controlling the fungal pathogens of groundnut.

Evaluation of endophytes for alleviation of moisture deficit stress

Six 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 drought-stress in groundnut, cultivar TG 37A. The crop was sown on 27th January, 2015 with flood irrigation at field capacity and no further irrigation was applied till the harvest. However, there was 30.2 mm of rainfall during crop growth. Besides monitoring the population of the endophytes in different tissues of groundnut at different intervals, moisture content at 0-15, 15-30 and 30-45 cm layers, soil temperature at 15 cm and 30 cm layers; physiological parameters like SCMR, SLA, RWC, stomatal aperture, chlorophyll content; and biochemical changes that might occur during alleviation or scavenging of the stress factors were also monitored. As we have reported the C3-CAM transition in drought-stressed peanut, modulation of the transition has been studied.

Alleviation of moisture-deficit stress in groundnut (cultivar TG 37A) by application of endophytic bacteria (red arrow: uninoculated control; white arrow: inoculated with endophyte; kharif 2015)

It was found that all the endophytes except REN51 enhanced the production of PEPC, and NAD(P)-MDH of the carboxylation module of C3-CAM transition. Similarly, except *Acinetobacter junii* J20, *B. subtilis* REN51N, remaining three endophytes enhanced the activities of PPDK.

Effect of alleviation of moisture-deficit stress on pod yield of groundnut (cultivar TG37A) by application of endophytic bacteria (E0: control; E2: Pseudomonas maxicana REN47; E3: Pseudomonas pseudoalcaligenes SEN29; E6: Acetinobacter junii J20; E7: Bacillus subtilis REN51 and E8: Bacillus firmus J22)

In case of decarboxylation module, application of endophyte enhanced the production of PEPCK, and NAD(P)-ME of decarboxylation of C3-CAM transition. Modulation has also occurred at transcriptional level by endophytes. Inoculation of *P. pseudoalcaligens* SEN29 enhanced the expression of mRNA of PEPC, NAD-MDH, VATPase, and PEPCK thus enhanced carboxylation and decarboxylation in a better way on the induction of C3-CAM transition in drought stressed groundnut.

Evaluation of endophytes for enhancing growth and yield in summer groundnut (summer 2015) raised without application of supplementary irrigation after sowing

Treatments	Pod yield (kg/ha)	Haulm yield (kg/ha)
Control	695	2470
Pseudomonas maxicana REN47	809	2737
Pseudomonas pseudoalcaligenes	850	2737
Acinetobacter sp. J20	650	2593
Bacillus subtilis REN51	749	2736
Bacillus firmus J22	921	2843
CD (0.05)	116	194

Maximum accumulation of malic acid has been found with the inoculation of *P. pseudoalcaligenes* SEN29 and *Bacillus firmus* J22. Significant improvement in the yield of groundnut has been achieved with the application of *P. pseudoalcaligens* SEN29 and *Bacillus firmus* J22 with the application of single irrigation water at the time of sowing.

Evaluation of Bt isolates against white grubs

White grubs, *Phyllognathus dionysius* (Fab.) collected from infested groundnut fields of Junagadh district were utilized for this study during *kharif* 2015. Grubs were reared on organic manure in earthen containers. Three Bt isolates, BRN1, DHL1 and HBN2 were evaluated against white grub larvae. Organic matter (1 kg) was treated with suspension of isolates (10 mL mixed with 100 mL distilled water) and five larvae of 3^{rd} instar stage were released. Each treatment was replicated thrice and incubated in room temperature. An untreated control (distilled water) was also kept for comparison. Among the Bt isolates tested, HBN2 was found most effective with larval mortality of 87% as compared to control (7%). It was observed that, larvae become inactive and stopped feeding prior to their death which occurred in 10-12 days' time. These Bt isolates will be further evaluated for determining their efficiency.

5

Socio-economic Research and Extension for Groundnut in Developments

Innovative approaches to bridging yield gaps in groundnut through technology dissemination and capacity building

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

A survey was conducted in the *kharif* 2015 among the three different taluks viz., Kutiyana, Porbandar, Ranavav of Porbandar district and Babra, Bagasara and Dhari of Amreli district of Gujarat, both known to be high and low productivity areas respectively. In Amreli district, 70 farmers adopting rainfed farming were selected randomly. In Porbandar district also 70 farmers following rainfed farming were surveyed. The general social profile of the surveyed village was as follows: In Amreli district it was found that about one-third of the farmers were in young age group and most of them were illiterate while a few of them studied up to primary level. Of them 69% farmers were having small land holding (1.1-2 ha) and reports cost of cultivation of Rs. 63135/ha, whereas the farmers with the medium land holding (2-4 ha.) spends Rs. 46430/ha. In Porbandar district the majority (57%) of the farmers belongs to middle aged category and 65% had primary education while 43% of farmers had secondary level of education. They had medium (2-4 ha.) land holdings and reported cost of cultivation as Rs. 75898/ha.

RUM indicators contributing to groundnut productivity in Gujarat

Indicators	Unstandardized coefficients			
	Groundnut productivity- Amreli district		Groundnut productivity- Porbandar district	
	Beta value	SE	Beta value	SE
Constant	-76.80	53.9	-0.65	1041.65
Land management	5.69**	2.05	18.32 NS	35.91
Cropping systems management	4.72**	0.85	3.74 NS	5.63
Seeds management	19.50**	3.20	10.53*	34.35
Nutrients management	10.87**	2.75	52.70**	3.43
Weeds management	1.14 NS	7.32	7.81 *	51.45
Insect pests management	8.72**	3.07	135.23**	15.97
Diseases management	2.76 NS	1.45	12.09 NS	23.45
Irrigation management	4.50**	7.14	109.40**	31.33

Through efficient Resource Use Management (RUM) behaviour, the factors for wider yield gap in groundnut and groundnut production constraints can be addressed. Thus there is a need to assess the existing level resource use management behaviour of Amreli and Porbandar district farmers. There were medium levels of RUM behaviour among them for weeds and pests' management is concerned and low level for disease management systems. As far as Amreli farmers were 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. According to the survey undertaken, as far as training is concerned most of them rated training on agronomic techniques as most important training need followed by scientific storage methods.

Study on cost of cultivation, resource use management behaviour and training needs of groundnut growers of Karnataka

The survey was conducted during *rabi* 2015 among the two taluks viz., Dharwad, Kundgol of Dharwad district in Karnataka, this district known for high productivity and rainfed farming. In these taluks 70 farmers were randomly selected. The general social profile as follows: about two-third of the farmers belonged to middle age group and mostly of them had only primary education, while a few had secondary level of education. Fifty-three per cent farmers had marginal land holdings (< 1ha) and reported a cost of cultivation of Rs. 35500/ha whereas the small land holders (2-4ha) spent Rs. 46430/ha. Along with the cost of cultivation a need was felt to assess the existing level of resource use management behaviour of groundnut growers of Dharwad district. As far as medium land holders of Dharwad district are concerned, most of the groundnut growers had low to medium RUM behaviour in cropping systems management and had medium level of RUM behaviour in soil-moisture management. There were low levels of RUM behaviour among them for weeds and pests management and not much concerned about the disease management systems. According to the survey undertaken, training on integrated crop management practices is most important training need followed by mechanized harvesting for these farmers.

Visit of farmers

This year (2015-16), a total of 954 farmers from 3 different States which includes 256 students and 23 staff belonging to different agriculture universities visited DGR. Thus during the year, altogether 1233 visitors from various states viz. Gujarat, Madhya Pradesh, Arunachal Pradesh and Rajasthan visited the Directorate. The visits were sponsored by State Department of Agriculture or State Agricultural universities concerned. These visitor-groups were taken to the 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.

Development activities for tribal and hill regions: Reaching the unreached

Generally the tribal farmers cultivate low investment crops like minor millets and coarse grains for their livelihood security. Groundnut, the wonderful legume crop may be good choice for them to uplift them from poverty and nutritional insecurity. The major hurdles faced by them in cultivating the groundnut are lack of awrereness, seed availability and sustainability. The ICAR-DGR had planned to make some intervention in these areas with rationale of introducing groundnut as new crop in valley for higher income and asset creation, making seed self-sufficiency to the groundnut growers by exchanging seeds from place to place and *kharif* to *rabi* /Summer. Promoting organic groundnut in tribal areas and alleviating malnutrition among them and turning subsistence agriculture into surplus.

During 2015-16 ICAR-DGR has taken up extensive technology transfer programme among the tribal farmers through Tribal Sub Plan (TSP). About 1600 tribal farmers got benefited out of this scheme. The states being covered are Arunachal Pradesh, Meghalaya, Jharkhand, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Gujarat, Madhya Pradesh and West Bengal. The main objectives of the scheme were achieving livelihood security through adoption of improved groundnut production and post-harvest technologies and capacity building of tribal farmers thereby helping them in asset creation.

To achieve these objectives through Tribal Sub Plan (TSP) the following activities are conceived at ICAR-DGR and implemented in collaboration with various AICRP-G centers, SAUs, and KVKs. Most important activities planned were promotion of groundnut cultivation through demonstration with good agronomic practices in resource poor tribal farmers, on-farm demonstration of improved groundnut production technologies, supply of minor farm implements/tools like storage bins, sickles, tarpaulins and capacity building programmes, supply of critical inputs viz., groundnut seed, fertilizers, *Pseudomonas flouresecens*, bioformulations, and vemicompost etc.

Because of these collaborative efforts, constant coordination and monitoring by ICAR-DGR, remarkable changes among the tribal farming community has witnessed. Specifically this joint venture resulted in adding groundnut in tribal cropping system predominated by the low yielding cereal crops and introduced groundnut as new crop with improved variety and other agronomic management technologies among them, promoted organic groundnut cultivation and made awareness of its market demand, popularized groundnut as remunerative crop and done capacity building of tribal farmers there by alleviating malnutrition among them. The visible outcome is that the intervention of livelihood enhancement of tribal farmers through intensive groundnut cultivation made sustainable groundnut seed production by tribal farmers as source of livelihood. This intervention helped to achieve seed self-sufficiency among the groundnut growers. It helped to reduce the drudgery of women tribal farmers and made available seed on time. Storage bins were distributed to store harvested produce for next season a critical intervention to keep sustainability in groundnut cultivation. By supplying the hand decorticators, the ICAR-DGR has addressed the issue of non-availability of labour for decortications of seeds.

TSP monitoring on programme implementation: Interaction with tribal farmers, Purulia, West Bengal

Capacity building programme under TSP in Jamunamarathur block of Tiruvannamalai district, TN

Groundnut cultivation by women tribal farmer under TSP in Jamunamarathur block of Tiruvannamalai district, TN

Interaction with Tribal women on programme implementation under TSP at Vizianagaram, AP

Mera Gaon Mera Gaurav programme

Under the *Mera Gaon Mera Gaurav* programme, 30 villages were adopted by the Directorate. Our scientists have conducted a base line survey and identified the needs of the farmers. Need based intervention have been planned and on a continues basis our teams are providing technical support to the farmers to adopt improved technologies. We have issued soil health cards to those who were not having one. The Directorate has organised training programmes especially for the empowerment of the women farmers of the adopted villages. The general social up-liftment programmes like *Swachh Bharat Abhiyan* were also taken up in those adopted villages.

ICAR- Directorate of Groundnut Research, Junagadh celebrated 'World Soil Day' and distributed Soil Health Cards to farmers in the 'International Year of Soils-2015'. The programme was held at the Simasi village (Taluka-Mendarda, Gujarat) in the afternoon of 5th December. In this occasion 75 soil health cards was distributed to the farmers of eight villages (Simasi, Ivnagar, Majewadi, Galiyavada, Maliyavada, Sargavada, Khamdhrol and Khalipur) of Junagadh district. This soil health card has reported the available status of major nutrients (nitrogen, phosphorus, potassium) and micronutrients (zinc, copper, manganese, iron) in soil along with general fertilizer recommendations for groundnut, cotton, wheat and coriander.

About 300 participants including soil health card recipients, local farmers and staff of ICAR-DGR, Junagadh attended the programme.

Distribution of soil health card

Awareness campaign on Swachh Bharat Abhiyan

Regional Research Station (RRS), ICAR-Directorate of Groundnut Research, Anantapur

In view of the approval of RRS ICAR-DGR at Anantapur under 12th Plan, experiments were laid out at this new location for the first time during *kharif* 2015 to screen germplasm accessions, advanced breeding materials and endophytes for drought/water stress conditions of Anantapur. Following experiments were laid out at the new station during *kharif* 2015 in a total area of 1800m^2.

Screening of genotypes for drought/water stress

Twenty-eight genotypes were screened under rainfed conditions at Anantapur without any supplemental irrigation. Genotypes used in the experiment consisted of twelve mutant lines derived from TG 37A (S 1, S 3, S 5, S 13, S 17, S 19, S 20, S 24, S 29, S 31, S 32 and S 41), fourteen advanced breeding materials (PBS series) and two check varieties (VRI GN 6 and K 6). Analysis of variance indicated significant genotypic differences for haulm yield per plant, pod yield per plant, shelling per cent and 100 kernel weight. All the genotypes were ranked for pod yield per plant and haulm yield per plant using DMRT. Genotype PBS 15041 had high pod yield per plant whereas VRI (Gn) 6 had high haulm yield per plant. Genotypes PBS 15041, PBS 15047, PBS 30055, PBS 15020, PBS 15022, S 1, S 17, S 19, S 29 and S32 had higher pod yield per plant when compared to superior check K 6. For haulm yield none of the genotypes were superior to VRI (Gn) 6.



PBS 15041 *PBS 15022* *S 32*

Screening of endophytes under drought/water stress condition

Three endophytes namely S 15, J 22, REN 51 and control were screened for drought/ water stress under rainfed conditions at Anantapur without any supplemental irrigation. Experiment was laid out in an area of 4.5 x 10 m^2 per plot. Yield related data were recorded at the time of harvest. Analysis of variance indicated significant genotypic differences for haulm yield per plant and shelling per cent and genotypic differences were non-significant for pod yield per plant and 100 kernel weight. J 22 had higher haulm yield compared to other treatments whereas for pod yield control treatment was superior than other treatments.



J 22 *S 15* *REN 51*

Screening of advanced breeding lines for drought/water stress

This experiment involved 40 advanced breeding lines developed at DGR, Junagadh for various other abiotic and biotic stresses. These advanced breeding lines are being screened under treatments having with and without supplemental irrigation. Data on yield related parameters were recorded at the time of harvest. Analysis of variance indicated significant genotypic differences for all yield related characters. Significant differences were also observed between two irrigation treatments for pod yield per plant, haulm yield per plant and shelling per cent. Under treatment with supplemental irrigation none of the advanced breeding lines (ABL) were superior to best check i.e. ICGV 86590 whereas for haulm yield genotypes PBS 29143, PBS 29152 and PBS 29153 had higher haulm yield than superior check BAU 13. Under treatment without supplemental irrigation, three genotypes namely PBS 29157, PBS 29159 and PBS 29160 had higher pod and haulm yield than superior check Somnath.

Screening of germplasm accessions identified based on SLA and SCMR for drought/water stress

Thirty germplasm accessions identified based on SLA and SCMR from working set of germplasm were screened for drought/water stress under treatments having with (T_1) and without (T_2) supplemental irrigation at Anantapur. Data on yield related parameters were recorded at the time of harvest. Under the treatment with irrigation genotypes NRCG 12244, 10078, 11865, 10090 had higher pod yield whereas genotypes NRCG 10057, 14390, 14442 and 11865 had high haulm yield than other genotypes. Under treatment without supplemental irrigation genotypes NRCG 12244, 14342, 14352 and 14432 had high pod yield per plant and genotypes NRCG 10078 and NRCG 14352 had high haulm yield than other genotypes.

Research Highlights: All India Coordinated Research Project on groudnut (AICRP-G)

Crop Improvement

Germplasm enhancement

Multiplication of groundnut germplasm

A Consortium Research Platform (CRP) on Agro-biodiversity has been approved by ICAR, for implementation in the XII Plan. CRP on Agro-biodiversity is a national project on germplasm characterization and evaluation. The major objective of this project is that the germplasm conserved at NBPGR could be effectively linked with enhanced use of germplasm in the crop improvement programme in NARS. There are two components envisaged in this project viz., Component I (characterization, regeneration, distribution and documentation) and Component II (detailed evaluation). Of which ICAR-DGR is one of the important partners identified for Component I. The project will be implemented through two AICRP-G centres: 1. ANGRAU, Kadiri and 2. TNAU, Vridhachalam.

Out of 995 groundnut germplasm accessions received by ICAR-DGR, 344 accessions have been multiplied and deposited with NBPGR for conservation by ICAR-DGR. The rest (618) of the accessions were multiplied in *rabi*-summer 2014-15 at the two AICRP-G centres

ANGRAU, Kadiri and TNAU, Vridhachalam. The same set of accessions have been re-sown in *kharif* for further multiplication and characterization for 30 descriptor traits.

In *kharif* 2015, 5627 germplasm accessions have been multiplied and maintained at 11 centres. This included 64 wild accessions; 299 interspecific derivatives; 119 Exotic collection; 2217 Spanish bunch accessions; 287 Valencia accessions; 775 Virginia Bunch accessions; 447 Virginia Runner accessions and 1157 other germplasm accessions.

Field maintenance of interspecific wild derivatives

At TNAU-Vridhachalam centre (TN), a field gene bank comprising 60 accessions of 24 wild *Arachis* species; 28 triploid interspecific hybrids; 11 amphidiploids; four auto tetraploids and 15 allo-hexaploids have been maintained. Seeds of each of these wild derivatives were conserved for further multiplication and use in crop improvement programme.

Evaluation of germplasm accessions

At PDKV-Akola (MS), 32 Valencia accessions have been evaluated for yield and its component traits. One (ICG 10890) high yielding (17.8 g/plant), low oil type (41.1%), red kernel genotype has been identified. Two more accessions (ICG 14106-16.8g; ICG 9315-13.4g) exhibited high yield and four (ICG 1142 and ICG 4670 -51.3%; ICG 115 and ICG 397-50.5%) high oil types have been identified in the Valencia background. Six accessions which matured in less than 100 d viz. ICGs 10131(96 d), 10286 (97 d), 10620 (99 d), 10983 (97 d), 11580 (98 d) and 10662 (99 d) have been identified at BSKVV-Shirgaon (MS).

Hybridization programme

For developing high-yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses which limit yield and *rabi*-summer seasons, hybridization programme was undertaken at 15 AICRP-G centers. Altogether, 147 crosses in *kharif* and 175 crosses during *rabi*-summer and using different cultivars/advanced breeding lines, germplasm accessions were made.

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

During *kharif* season, progenies of 1733 crosses were advanced to their respective next filial generation from which a very large number (15911) of selections were made at 18 AICRP-G centres. The selections comprised of large number (11258) of single plants and 4653 progeny bulks. Of the total crosses, which were advanced to different filial generations, 1132 crosses were in early generations (F1- F3) and 601 crosses in advanced generations (F_4 onwards). A vast majority number of single plant selections made during the last season were in early generations (6920) and the rest (4338) in advanced generations.

During *rabi*-summer season, progenies of 610 crosses were advanced to their respective next filial generation at 11 AICRP-G centres from which most (20323) of selections were made. The selections comprised mostly (18801) of single plants and 1522 progeny bulks. Of the total crosses, which were advanced to different filial generations 427 crosses were in early generations (F_1- F_3) and 183 crosses in advanced generations (F_4 onwards). A vast majority (14455) of single plant selections made during the last season were in early generations and the rest (4346) in advanced generations.

Varietal Evaluation

A three tier system of evaluation of groundnut entries under the nomenclature of Initial Varietal Trial-Stage I (IVT-I); Initial Varietal Trial-Stage II (IVT-II) and Advanced Varietal Trial (AVT) are being adopted and the trials were allotted to the 29 locations distributed over five eco-geographical zones of *kharif* and 24 centers located in five eco-geographical zones of *rabi*-summer.

Initial Varietal Trial Stage-I (IVT-I)

In *kharif*, 13 entries were tested in all the 5 zones along with respective zonal checks. The trial was allotted to 25 centres and all of them have conducted and reported the trial data except for Bhubaneswar centre. The trial will be repeated as such in all the centres in *kharif* 2016, by using the harvest of IVT I at each centre as the source of seed for IVT II.

In *rabi*-summer 11 entries were tested in all the five zones against TAG 24 as the national check (NC), and the respective zonal check (ZCs') varieties. The trial was allotted to 24 centres and 20 centres have conducted the trial except for the Modipuram centre in zone I and all the three centres, Mohanpur, Bhubaneswar, and Badachana in Zone IV. This trial is to be repeated as such at all the centres in rabi-summer, 2015-16 by using the produce of IVT I harvested at each centre as seed for IVT II.

Initial Varietal Trial Stage-I and II Pooled (IVT-I & II Pooled)

During *rabi*-summer, there were 13 entries in this trial which were tested at 24 locations along with respective check varieties. In Zone IIIb (Tamil Nadu and Andhra Pradesh) across the five locations and over two years, the zonal check variety, R 8808 (ZC) was the best for both pod (2115 kg/ha) and kernel (1461 kg/ha) yield.

Over two years, for pod yield, four test genotypes, ICGV 07222 (3098 kg/ha), K 1609 (2916 kg/ha), ICGV 03042 (2914 kg/ha), and ICGV 06424 (2870 kg/ha) were found significantly superior over the best check for pod yield. For kernel yield, six genotypes, ICGV 07222 (2100 kg/ha), K 1609 (2068 kg/ha), ICGV 03042 (1998 kg/ha), K 1621 (1951 kg/ha), ICGV 06424 (1925 kg/ha) and K 1604 (1904 kg/ha) were found significantly superior over the best check and are promoted to AVT.

In *kharif*, there were 17 entries which were tested in 26 locations/centres. In zone III at two test locations namely Akola, and Jalgaon of Maharashtra, GG 8 (ZC) was found as the best check for pod (1762 kg/ha) as well as kernel yield (1205 kg/ha). Two test genotypes, TCGS 1157 (2638 kg/ha of pod and 1802 kg/ha kernel) and AK 335 (2280 kg/ha of pod and 1446 kg/ha kernel) could significantly surpass the yield levels of this best check and are promoted to AVT.

Advanced Varietal Trial (AVT)

Two entries K 1719 and KDG 160 promoted to AVT were tested in *rabi*-summer 2014-

15 in zone IIIb along with three check varieties TAG 24 (NC), R 8808 (ZC), and ICGV 00350 were used in zone IIIb. Across the four locations in this zone, among the three check varieties, ICGV 00350 (ZC) was the best for both pod (2802 kg/ha) and kernel (1826 kg/ha) yield and over the four locations, both the test entries, KDG 160 (3778 kg/ha and 2588 kg/ha) and K 1719 (3165 kg/ha and 2248 kg/ha) in order of merit recorded significantly superior pod and kernel yields over those of the best check ICGV 00350 (ZC).

Over different check varieties and different stages in the three years testing, the increase in pod yield of **KDG 160** was 54% over TAG 24; 30.1% over R 8808 and 28.1% over ICGV 00350. Whereas increase in kernel yield of this genotype over these check varieties was 55.9% over TAG 24; 26.2% over R 8808 and 33.0% over ICGV 00350. KDG 160 matured in 116d with 67% of shelling; 43 g as Hundred Seed Mass and with a very high oil content (52%).

The increase in pod yield of **K 1719** was 40.6% over TAG 24; 30.2% over R 8808 and 12.5% over ICGV 00350. Whereas increase in kernel yield of this genotype over those of check varieties was: 52.3% over TAG 24; 38.7% over R 8808 and 25.3% over ICGV 00350 (Table 10f). The entry K 1719 matured in 113d with 70% of shelling; 54 g as Hundred Seed Mass and with a moderate oil content (49%).   Hence, these two entries are proposed for identification.

In *kharif* four entries, ICGV 03043, ICGV 03042, ICGV 05155 and ICGV 06420 were promoted to AVT in zone V comprising the states of Tamil Nadu, Andhra Pradesh, and Karnataka in *kharif* 2015. The trial was allotted to eight centres–two centres-Vridhachalam and Tindivanam in Tamil Nadu; three centres, Kadiri, Jagtial and Tirupati- in Andhra Pradesh and three-Dharwad, Raichur and Chinthamani in Karnataka. Four varieties, R 2001-2, R 2001-3, GPBD 4 and VG 9816 were used as zonal checks in this trial.

Across the seven locations, the zonal check variety, R 2001-2 was the best and recorded a very high pod (2861 kg/ha) and kernel (1873 kg/ha) yield. Over this check variety, although the test genotype, ICGV 03043 recorded a high pod (3028 kg/ha) and kernel (2014 kg/ha) yields, but it remained at par with those of R 2001-2 (ZC).

Over different check varieties, the increase in pod yield of **ICGV 03043** was 13.8% over R 2001-2; 44.8% over GPBD 4; 27.0% over VG 9816 and 18.1% over R 2001-3. Whereas increase in kernel yield of this genotype over these check varieties was 12.2% over R 2001-2; 40.4% over GPBD-4; 23.4% over VG 9816 and 16.8% over R 2001-3. (Table 19d). The genotype **ICGV 03043** matured in 109d with 66% of shelling; 35 g as Hundred Seed Mass, which was little higher over the check varieties and with a moderately high oil content (48%) which was 1-3% higher over the check varieties and deserves identification.

Breeder seed production

During *kharif* 2015, DAC indents to the tune of 7128.80 q of breeder seeds were received for 40 groundnut varieties. Based on the availability of nucleus/breeder seed stage I, a production target of 6925.80 q was assigned for 38 groundnut varieties to 19 centres. During *kharif* 2015, a total quantity of 2808.13 q breeder seed could be produced. To mitigate the short fall, a compensatory programme was undertaken during *rabi*-summer 2015-16 and the anticipated production is 7015.0 q. Thus, the total production of breeder groundnut seeds during 2015-16 would be 9823.13 q.

Crop Production

Kharif 2015

Survey of agronomic management practices in the farmer's field

The survey was conducted by fourteen centers covering more than 700 farmers growing groundnut in different AICRP-G zones of India during *rabi*-summer 2014-15 and *kharif* 2015. The surveys indicated that generally the adoption of improved production technologies is low to fair but some of the activities like field preparation, manual weeding, intercultural operations, inorganic nutrient management etc. having high degree of adoption throughout the India. Some of the centers like Junagadh, Durgapura, Kadiri, Vridhachalam etc. reported a high degree of adoption for use of improve varieties, mechanical seeding, plant protection measures using chemicals and use of inorganic complex fertilizers etc. Bikaner center reported an exhaustive use of groundwater using 100% sprinkler irrigation. Other than these centers the adoption of improved varieties has reported fair to good degree of adoption by farmers. Similarly, seed rate, plant spacing and population were also reported in fair to good degree of adoption by majority of the centres. There was also fairly good adoption of improved package of practices viz., fertilizer application, integrated weed management, manure use, irrigation management etc. The agronomic management practices having poor adoption and required to be taken care are like use of bio-fertilizer, seed treatment using bio-agents, insecticides and pesticides, use of micronutrients and plant protection measures, use of soil amendments, use of organics, availability and use of quality seed etc.

Some of the common constraints highlighted are as:

- Timely non-availability of good quality improved groundnut varieties seed at local market.
- Miser use of seed treatment for soil borne disease and plant protection measures.
- Poor use of organics and soil amendments due to less availability in the market.
- Non-optimal plant population in the field due to improper seed rate, seed quality or spacing.
- Preference for use groundnut kernels instead of pod for seed purpose.
- White grub and rots (collar as well as root) are the most common stresses in light soils
- Unawareness and lack of viable bio-agents both for nutrition as well as for bio-control of pests and diseases.
- Yellowing of groundnut foliage is the common problem.
- Poor, timely non-availability and ignorance for use of soil amendments as liming material.

- The high cost of cultivation, low price, labour intensive and poor availability of labourers.
- Competition from crops like pulses, hybrid Bt-cotton, hybrid maize and soybean etc.
- Awareness on mechanization due to non-availability of the machineries.
- Erratic, insufficient, uneven rainfall pattern during crop period.

Nutrient management in prevalent groundnut-based cropping system

The experiment was conducted by eight centres using four levels of nutrient management in *kharif* crop and three levels in rabi-summer crops of prevalent groundnut based cropping systems. All centres completed three years of experimentation except Bikaner. At Bikaner, application of 100% N with 150% PK in groundnut crop left its best effect on all growth and yield attributing factors with yields and economics. Significantly higher groundnut equivalent yield (GEY) recorded in application of 100% N + 150% PK to groundnut and application of 100% NPK to *rabi* wheat crop at Dharwad, *rabi* maize crop at Jagtial. However, application of 100% N + 150% P to groundnut crop in kharif season followed by 75% RDF to wheat crop found most effective nutrient management practice in the cropping sequence and produced significantly higher yield and economics at Jalgaon, Shirgaon and Vridhachalam. Application of 100% N + 125% P to *kharif* groundnut and 100% RDF to *rabi* wheat crop found best for groundnut yield, wheat yield, GEY and economics in the groundnut-wheat cropping sequence at Junagadh. Similarly application of 100% N + 125% PK to *kharif* groundnut and 75% RDF to *rabi* maize crop resulted in significantly higher groundnut yield, maize yield and GEY of the groundnut –maize cropping system at Kadiri centre.

Standardization of periodicity and rates of sulphur and/or zinc/iron/boron fertilization in prevalent groundnut based cropping systems

The experiment was conducted by nine centers for sulphur and other deficient micro-nutrients in prevalent groundnut based cropping systems of the region during *kharif* 2015. The promising treatments for standardization of periodicity and rates of application of deficient nutrients in most prevailed cropping system are summarized as under:

At Bikaner, application of 100% Zn (i.e., 25 kg/ha $ZnSO_4$) gave good response than zero and 50% application with respect to pod and biological yield. The net return and B:C ratio also followed the same trend as for pod yield. Application of sulphur @ 20kg/ha and boron @10 kg/ha every year to groundnut crop produced significantly higher pod yield and net return under groundnut-horse gram cropping system. Further, application of 100% dose of fertilizer to both the crops recorded significantly higher pod yield, net return and BCR at Bhubaneswar. Application of 100% fertilizer dose of sulphur every year in both the crops gave significantly higher GEY, gross return, net return and BCR at Jalgaon. Application of sulphur, zinc and iron fertilizer once in two year produced higher pod and haulm yield whereas significantly higher wheat grain and straw yield by every year application of these fertilizers. Further, significantly higher pod and haulm yield, GEY and economics were observed under application of 100% recommended doses of sulphur, zinc and iron (20 kg, 5 kg and 10 kg/ha, respectively) in both crops but a non-significant effect was observed in wheat crop at Junagadh. Application of 100% recommended dose of fertilizer to both crops every year gave significantly higher *rabi* groundnut and *kharif* rice yield, net returns and B:C ratio in groundnut-rice cropping system under *Konkan* condition at Shirgaon. Application micronutrients (Fe and B) as soil application every year along with farm yard manure @ 7.5 t/ha and recommended dose of NPK fertilizer gave the maximum groundnut pod yield & yield attributes, net return and BCR at Tindivanam. Application of micronutrients ($ZnSO_4$@ 25 kg/ha, $FeSO_4$ @10 kg/ha and Borax @ 10 kg/ha) every year to both the crops along with FYM @12.5 t/ha and recommended dose of NPK fertilizer (25:50:75 NPK kg/ha) produced highest pod yield, net return and BCR at Vridhachalam. Non-significant results were obtained by periodic application of deficient fertilizers at Jagtial and Tirupati centres. However, application of 100% fertilizers for sulphur, zinc, iron and boron to both the crops was recorded maximum yield at Jagtial and better yield was obtained with application of zinc sulphate once in three years at Tirupati.

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

This experiment was conducted by eight centres using four land configuration namely conventional, BBF, RF and RBF and three levels of mulches namely no mulch, organic mulch and polythene mulch during *kharif* 2015. Significantly higher pod yield and net return were observed by use of broad bed and furrow (BBF) with polythene mulch or organic mulch at Bhubhneshwar, Mohanpur and Shirgaon centres. Conventional method i.e., flat bed sowing with polythene mulch produced significantly higher pod, haulm, kernel yield and BCR as compared to other methods of sowing but remained statistically at par with broad bed and furrow method at Durgapura. The land configuration raised bed and furrow (60cm) or ridges and furrow methods with poly mulch (7µ) found superior in yield as well as monetary returns at Jalgaon, Tindivanamand and Vridhhachalam. Significantly higher groundnut growth, yield and monetary returns were achieved with broad bed and furrow method of land configuration. However, non-significant differences in pod and haulm yield were recorded with mulching material at Tirupati.

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

Results not reported by Kadiri centre.

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

This experiment was conducted by six centres using five concentrations of paclobutrazol and one water spray used at three crop growth stages as spray namely 20 DAS, 40 DAS and 20 DAS & 40 DAS. Non-significant difference in groundnut yield, yield attributes and economics with highest under either control or application of paclobutrazol @ 25-50ppm were observed both under doses of paclobutrazol and its time of spray at Durgapura, Kadiri, Tirupati and Vridhachalam. Whereas, application of paclobutrazol @ 200ppm with double spraying at 30 and 50 DAE produced highest pod, haulm and kernel yield, harvest index and net return at Mohapur and Puducherry. About 27-29%

pod yield enhancement of groundnut was observed by these two sprays of paclobutrazol @ 200ppm.

Evaluation of DAPG-producing fluorescent pseudomonads for enhancing nutrient use efficiency, bio-control of soil-borne diseases and yield of groundnut

The study was undertaken by twelve centres using six treatments of bio-agents and one as control (i.e., no application of bio-agent) during *kharif* 2015. Significantly higher pod yield was observed with FP 86 strain of DAPG producing fluorescent pseudomonads over other strains at Bhubhneshwar, Durgapura, Jagtial, Kadiri and Mohanpur centers. This was closely followed by FP 98, DAPG 1, DAPG 2 & DAPG 4 in respect to yield and yield attributes and economics at these centres. Application of DAPG-4 bio-inoculant for seed treatment of groundnut produced significantly higher pod yield and economic at Jalgaon, Junagadh and Tindivanam centres. Considerable enhancement in nutrient uptake as well as decrease in soil-borne diseases was observed by application of these strains. At Shirgaon, application of DAPG producing fluorescent pseudomonads strain FP 98 found most promising for enhancing yield of groundnut followed by FP 86 and DAPG 4 for economic returns. Also the least incidence of soil borne disease was observed with application of these strains as compared to control. Non-significant effect of DAPG-producing fluorescent pseudomonads was observed for groundnut yield and yield attributes, nutrient uptake and use efficiency but found to be effective on bio-control of collar rot and stem rot incidence at Dharwad, Tirupati and Vridhachalam centres. Comparatively DAPG 4, DAPG 1 and *Trichoderma spp* were found promising among the DAPG producing strains at Vridhachalam.

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

The study was undertaken by five centres using twelve treatments combinations of tank mixed application of early post-emergence herbicides including weedy check, farmer's practice and weed free control for efficient weed control in groundnut during *kharif* 2015. At Kadiri, application of pendimethalin @1.5 kg ai/ha (PE) + imazethpyr @ 75 g a.i./ha at 20-30 DAS (T_4) resulted in lowest weed density, weed dry matter, highest weed control efficiency, lower weed index, pod yield, haulm yield and pods per plant. Same treatment was also found effective after weed free check At Tirupati.

At Puducherry, application of pendimethalin @ 1.5 kg a.i./ha (PE) + tank mix of imazethpyr (40%) + quizalofop ethyl (60%) at 20-30 DAS (T_8) was found most effective combination for weed control in terms of yield, net return and BCR. Application of either pendimethalin @ 1.5 kg a.i./ha (PE) + one hand weeding at 25 DAS (T_3) or pendimethalin @ 1.5 kg a.i./ha (PE) + tank mix imazethpyr (50%) + quizalopfop ethyl 50 (50%) at 20-30 DAS (T_6) were found most effective and significant in terms of growth and yield, weed density, WCE and economics for weed control in groundnut at Vridhachalam. At Tindivanam, application of pendimethalin @ 1.5 kg a.i./ha (PE) + one hand weeding at 25 DAS (T_3) found best for groundnut yield and economics. Application of pendimethalin @ 1.5 kg a.i./ha (PE) + tank mix imazethpyr (50%) + quizalopfop ethyl 50 (50%) at 20-30 DAS (T_6) was also found best for lowest weed density and higher weed control efficiency and at par in pod yield.

Economizing phosphorus use in groundnut production by exploiting phosphorus build-up in soil

The study was undertaken by thirteen centres using ten treatment combination having no external P application, FYM @ 5t/ha, 50% RDP, 100% RDP and their combinations with and without phosphorus solubilizers (i.e., DGRC 1 and DGRC 2) during *kharif* 2015. Application of 5.0t FYM/ha + 100% P with either DGRC 1 or DGRC 2 as phosphate solubilizers produced highest groundnut pod yield with yiels attributes and getting maximum economic return from *kharif* groundnut at Akola, Bikaner, Bhubhaneshwar, Dharwad, Jalgaon, Junagadh, Kadiri, Shirgaon, Tindivanam, Tirupati, Vridhachalam centres. Although, at most of the centres application of 5.0t FYM/ha + 50% P with either DGRC 1 or DGRC 2 as phosphate solubilizers was found at par effect on yield and yield attributes of *kharif* groundnut. Application of FYM @ 2.5t/ha + 50% P (30 kg/ha) with DGRC-1 was significantly superior in terms of pods, haulm & kernel yields and ancillary characters of groundnut over rest of the treatments at Durgapura. At Jagtial, significantly superior yield and economic returns were recorded with application of FYM @ 5 t/ha + 100% P and BCR with application of FYM @ 5 t/ha + 50% RDP with and without P solubilizers.

Agronomic management of AVT Entries

The study was undertaken by four centres using AVT entries with local checks and tested for their production potential at different agronomic management practices during *kharif* 2015. At Dharwad, the AVT entry ICGV 05155 performed better in terms of pod yield, oil content, net return and B:C ratio as compared to checks. However shelling percentage was higher in checks. At Junagadh, the AVT entry JSSP 46 performed better than GJG 22 (check) in terms of pod yield, and reverse results was obtained for kernel yield. Early sowing gave significantly higher yield of groundnut. Fertilizer levels exhibited a non-significant effect on groundnut yield. At Kadiri, the pod yield of AVT entry ICGV 03042 was significantly higher than check variety K-6. Sowing of groundnut with normal onset of monsoon resulted in significantly higher pod yield. Effect of fertility levels was found non-significant. Similarly the pod yield of test AVT entry K 1725 (VG) was significantly higher over check variety ICGV 86325. Non-significant difference in pod yield was observed among dates of sowing and fertilizer levels. At Vridhachalam, test AVT entries performed better than check VRI 2 in terms of pod yield of groundnut.

Rabi-Summer 2014-15

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 to know the effect of irrigation methods, plant density, and fertilizer levels on productivity of summer groundnut. However, only three centres compared drip irrigation with check basin irrigation. Drip irrigation gave significantly higher pod yield over check basin method at Jalgaon and Junagadh centres while no significant difference was reported by Vriddhachalam centre. Three centres namely Akola, Jalgaon, and Junagadh reported significantly higher pod yield with 5.0 lakh plant population (20x10 cm spacing) while Bhubhneshwar and Jagtial reported significantly higher yield with 4.0 lakh plant population (25x10 cm spacing).

However, at Dharwad and Vriddhachalam significantly higher pod yield was found with 3.33 lakh plant population (30x10 cm spacing). Application of 125% RDF gave significantly higher yield at Akola, Bhubhneshwar, Dharwad and Jalgaon while 100% RDF gave significantly higher yield at Jagtial and Vriddhachalam centres. At Junagadh no significant effect of doses of fertilizers was observed.

Standardization of periodicity and rates of sulphur/zinc/iron/boron fertilization in prevalent groundnut-based cropping systems

This experiment was started in *rabi*/summer 2013-14 to identify the periodicity and doses of application of sulphur and micronutrients in groundnut-based cropping systems. Four centres have reported the results for *rabi*/summer 2014-15. At Jagtial application of 100 RDF every year to both the crops gave significantly higher yield of sesame. Similarly, Junagadh, Shirgaon and Vriddhachalam also reported significantly higher pod yield of groundnut with application of 100 RDF to both the crops every year. However, no significant effect of periodicity and doses of fertilizer was found on wheat crop at Rahuri.

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

This experiment was initiated in *rabi*/summer 2013-14 with the objective of ascertaining the effect of biodegradable mulch, hydrogel, and nutrient management practices on groundnut productivity. Use of biodegradable mulch significantly improved pod yield over no mulch at all the centres. Application of hydrogel @ 5.0kg/ha significantly improved pod yield of groundnut at Jagtial, Jalgaon, and Vriddhachalam centres while application of hydrogel @ 2.5 kg/ha significantly improved pod yield of groundnut at Bhubhneshar and Rahuri over no application of hydrogel. However, no significant effect of hydrogel application was reported on groundnut yield at Mohanpur and Shirgaon. Integrated nutrient management significantly improved groundnut pod yield at all the centres except Mohanpur.

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

This experiment was initiated from *rabi*-summer 2014-15 to evaluate the effect of DAPG-producing fluorescent pseudomonads on nutrient use efficiency, biocontrol of soil-borne diseases, and yield of groundnut. Treatment with DAPG-2 gave significantly higher groundnut pod yield at Dharwad, Kadiri, and Shirgaon centres and significantly lowest incidence of diseases like collar rot and stem rot at Dharwad, and that of collar rot, dry root rot, and stem rot at Kadiri. DAPG-2 was also reported to have significantly highest N and P uptake over control at Junagadh. Treatment with FP-98 gave significantly highest yield at Bhubaneswar, Jalgaon and Mohanpur while FP- 86 was found superior over control at Pondicherry. Application of DAPG-4 gave significantly highest pod yield, and N and P uptake at Junagadh, and significantly lowest incidence of collar rot and stem rot at Jalgaon and Junagadh. DAPG-4 and *Trichoderma* had significantly lowest incidence of collar rot and root rot at Vriddhachalam over control. At Vriddhachalam groundnut pod yield was not significantly affected by different DAPG-producing fluorescent pseudomonads treatments or *Trichoderma*.

Studies on tank mix application of early post emergence herbicide for efficient weed control in groundnut

This experiment was conducted at Pondichery centre only during *rabi*/summer 2014-15 to identify most suitable herbicide combinations for chemical weed control in groundnut. Application of pendimethalin @ 1.5 kg ai/ha (PE)+tank mix of Imazethpyr (40%)+ quizalofop ethyl (60%) at 20-30 DAS followed by pendimethalin @ 1.5 kg ai/ha (PE)+ tank mix of imazethpyr (60%)+quizalofop ethyl (40%) at 20- 30 DAS gave significantly highest pod yield (3865 kg/ha) over control.

Agronomic management practices for advanced varietal trials (AVT) entries during *rabi*-summer 2014-15

At Vriddhachalam, no significant difference between entry KDG-160 and the local check VRI 2 was reported with respect to pod yield. At Dharwad entry KDG 171 did not differ significantly with respect to dry pod yield over local check Dh 86 however, cultivar KDG 171 produced higher dry pod yield over Dh 86. At Kadiri, KDG-160 (2418 kg/ha) has recorded significantly higher pod yield compared to K-6 (1763 kg/ha). Irrigation scheduling based on 1.0 IW/CPE ratio has given significantly higher mean pod yield (2387 kg/ha) over 0.8 ratio (1794 kg/ha). 125% RDF and 150% RDF being at par significantly increased the mean pod yield over recommended fertilizer level.

Crop Protection

Altogether 27 trials, 14 during *rabi*-summer 2014-15, 13 during *kharif* 2015 from pathology and entomology were conducted. Some of the experiments have been concluded, for which the recommendations have been suggested. The highlights of the achievements from experimental results are presented:

Pathology (Rabi-summer 2014-15)

Disease situation in farmers' fields

Soil borne and foliar diseases were reported from different locations. Early leaf spot was moderate in Raichur (2-5). Late leaf spot was severe at Aliyarnagar (2-8), Vriddhachalam (5-9) and moderate at Bhubaneswar (5-7), Kadiri (3-5) and Raichur (2-7). Rust was severe at Aliyarnagar (2-9), Dharwad (4-8) and moderate at Raichur (0-4) and Vriddhachalam (1-5). *Alternaria* was moderate at Junagadh (0-5). Collar rot was reported from Vriddhachalam (10%) and 6% from Bhubaneswar, Junagadh and Kadiri; while root rot incidence was 10% and 8% at Kadiri and Aliyarnagar, respectively. Moderate incidence of stem rot was reported at Dharwad and Raichur (12%), whereas rest of the centres recorded <10%.

Screening of IVT-I & II, AVT and other coordinated trial materials for resistance/ tolerance to major diseases

Entries were screened at different locations; among them entries INS-II-2013-8, INS-I-2014-27 and INS-I-2014-28 were resistant for multiple diseases *viz*. collar rot, stem rot; and entries INS-I-2014-27 and INS-I-2014-28 for late leaf spot at various locations.

Screening of groundnut germplasm for resistance/tolerance to major diseases

One genotype RHRG-1185 exhibited multiple disease resistance against stem rot and collar rot with <5% incidence. Whereas, JL 578, JL 777, RHRG 1192, JL 776 and RHRG 1305 recorded <10% stem rot incidence; and RHRG 1108, JL 578, JL 777, JL 776 and RHRG 1305 recorded <5%collar rot incidence at Jalgaon.

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

The experiment was conducted at Aliyarnagar, Junagadh, Kadiri and Raichur. The results received from most of the centres, indicated that both sorghum and maize are effective in reducing *Aspergillus* population in soil and there after the aflatoxin contamination. Groundnut in *kharif* followed by sorghum/maize in *rabi* crop rotation were effective.

Management of *Alternaria* leaf blight of groundnut

The experiment was conducted by Junagadh centre and based five years results; minimum (23%) incidence of alternaria blight was recorded from mancozeb followed by difenconazole (24%). The mancozeb treatment also recorded highest pod (1873 kg/ha) and haulm (4648 kg/ha) yield followed by difenconazole i.e. 1846 kg/ha and 4619 kg/ha, respectively, with highest ICBR of 1:7.0 and 1:2.49, respectively.

Monitoring of *Sclerotium rolfsii* population in sick plot

This experiment was conducted at Aliyarnagar, Kadiri and Raichur for development of sick plot and monitoring of *Sclerotium rolfsii* population. Groundnut haulm and paddy straw were found suitable for mass maintenance of inoculum in sick plot after inoculation. Serial dilution and potato bait technique were used for the estimation of *S. rolfsii* population, which was increased towards harvest in the month of May reaching to 5.0 x 10^3 to 10 x 10^3 CFU/g of soil. Though, the population was least during December (3.33 x 10^3 CFU/g of soil).

Integrated management of peanut bud necrosis disease (PBND) in groundnut

This experiment was conducted at Jalgaon, Kadiri and Raichur. Based on three years results, the lowest thrips damage, lowest PBND, and highest pod and haulm yield was recorded by Module-III. The results were proposed for recommendations as under: Growing border crop of jowar (4 rows) with higher seed rate (@ 200 kg/ha) of groundnut treated with imidacloprid 600 FS @ 1 ml/kg of seed followed by foliar application with thiocloprid 480 SC@ 150 ml/ha at 20 DAS, and acetamiprid 20 SP @ 100 g/ha at 35-40 DAS reduces PBND incidence and thrips damage up to 58%, as well as increasing pod and haulm yield up to 18% and 29%, respectively with ICBR up to 1:2.5.

Pathology (Kharif 2015)

Disease situation in farmers' fields

Soil borne and foliar diseases were reported from different locations. Early leaf spot was moderate in Pavagad (3-5) and Latur (4-5). Late leaf spot has been severe to moderate at Dharwad (2-9), Aliyarnagar (5-7), Pavagad (5-7), Kadiri (4-7), Latur (3-7), Raichur (2-7) and Junagadh (1-2). Rust was severe at Aliyarnagar (7-9), moderate in Bhubaneswar (1-

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

The experiment was conducted at Aliyarnagar, Junagadh, Kadiri and Raichur. Based on the results, it was concluded that high pod yield was obtained by sowing groundnut in *kharif* followed by fallow in *rabi* and crop rotation having groundnut in *kharif* and onion in rabi. 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 maize/jowar.

Screening of genotypes in developed *Sclerotium rolfsii* sick plot

The experiment was conducted at Aliyarnagar, Kadiri, Vrindhachalam and Raichur for three years and is concluded. Based on results, ICG 13838 and ICG 14267 recorded least infection at Kadiri.

Entomology (Rabi-Summer 2014-15)

Monitoring of insect pests and natural enemies at various centers

Monitoring of insect-pests and their natural enemies was done at different centers. Incidence of *Spodoptera* has been moderate to high (31-60%) at Dharwad, Jagtial, Raichur and Vriddhacahalam. Leafminer incidence was moderate (31-50%) at Jagtial, Kadiri and Raichur. Thrips was high (41-70%) at Dharwad, Jagtial, Jalgaon, Raichur and Vriddhachalam while, leafhopper incidence was moderate to high (31-50%) at Jagtial and Junagadh. The minor pests such as, whiteflies (1-10%) at Junagadh and red spider mite (11-20%) at Vriddhachalam were also reported. Natural enemies such as, coccinellids, spiders, syrphids, green lace wings, *Apanteles* sp. and *Campoletis chloridae* and *Bracon hebetor* were observed with <10% natural incidence at all the locations.

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

Insect-pests were monitored using the pheromone or sticky traps at various centers. The peak incidence of *Spodoptera* (428/trap) was observed in Jalgaon at 11th standard week while, at remaining centers it ranged from 8th to 14th standard weeks. Moth catches of leafminer was maximum at 16th standard week at Kadiri (3/trap). The peak incidence of thrips (6/trap) was observed during 5th standard week at Raichur.

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

Groundnut entries, INS I-2014–19, INS I-2014–21, INS I-2014–24, INS I-2014–31, AVS 2014-1, INS I-2013-34 and INS I-2013-35 showed multiple resistance to sucking pests, thrips and leafhoppers with <10% foliar damage. Similarly, entries ISK 2014-3 and ISK 2014-10 showed resistance to *Spodoptera* and AIS 2014-1, AIS 2014-4, INS I-2014-3, INS I-2014-10 and INS I-2014-11 showed resistance to leafminer with foliar damage <10%.

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

Seed treatment formulations were evaluated in all the major and voluntary centers against sucking pests. Seed treatment with imidacloprid 600 FS @ 2 mL/kg seed was

5), Dharwad (3-6) and Vriddhachalam (3-6) while rest of the centres reported low (<3) incidence. *Alternaria* was moderate in Vriddhachalam (1-6). Collar rot was reported from Bikaner (20%), Bhubaneswar (16%) and Vriddhachalam (12%), whereas root rot from Bhubaneswar (15%) and and Kadiri (18%). Low to moderate incidence of stem rot was reported at Pavagad (10-12%), Aliyarnagar (12%) and Bhubaneswar (18%).

Screening of IVT-I & II, AVT and other coordinated trial materials for resistance/ tolerance to major diseases

Entries were screened at different locations, among them entry ASK 2015-7 and ASK 2015-8 were resistant at Aliyarnagar and Vridhachalam for leaf spot and rust. Entries ISK I-2015-4 was resistant for rust and late leaf sport at Aliyarnagar, and for rust at Vridhachalam. Entry ISK I-2015-6 was resistant for rust and lea spot at Aliyarnagar, for rust at Kadiri and Vridhachalam, and for late leaf spot at dharwad and Vridhachalam. Entries, ISK II-2014-5, ISK II-2014-10 and ISK II-2014-11 were resistant for rust and late leaf spot at Vridhachalam.

Refinement of integrated disease management in groundnut

The experiment was concluded as it has completed 3 years at most of the locations. The results were proposed for recommendations as under:

- Ø Seed treatment with Tebuconazole 2DS @ 1.5 g/kg of seeds with furrow application of *T. viride* @ 4kg enriched in 50 kg FYM/ha has reduced the incidence of collar rot to 74% with highest ICBR (1:33.7) {for Rajasthan (Hanumangarh)}; and dry root rot and stem rot 44% and 53%, respectively with highest ICBR (1:7.1) {for Andhra Pradesh (Kadiri)}.

- Ø Seed treatment with Tebuconazole 2DS @ 1.5 g/kg followed by furrow application of *T. viride* @ 4kg enriched in 50 kg FYM/ha as basal application, then broadcasting of *T. viride* @ 4kg enriched in 50 kg FYM/ha at 40 DAS and two spray of Tebuconazole @1mL/L, starting from initiation of foliar diseases and 2^{nd} spray at 15 days interval has reduced the severity of leaf spots up to 30% and rust up to 38% with ICBR (1:6.9){for Gujarat (Junagadh)}; leaf spots up to 66% and rust up to 62% with highest ICBR (1:3.98) {for Tamilnadu (Aliyarnagar)}; and late leaf spots up to 43% and stem up rot to 30% with highest ICBR (1:5.27) {for Karnataka (Dharwad)}.

Development of technologies for management of soil borne diseases

This experiment was initiated from *kharif* 2015 at Aliyarnagar, Bhubaneswar, Bikaner, Kadiri, Raichur, Pavagada and Vriddhachalam. Among them treatment (T_4) i.e. deep summer ploughing with mould board plough + Soil application of *Trichoderma* @ 4 kg/ha enriched in 50 kg FYM/ha + Seed treatment with Tebuconazole @ 1.5 g/kg of seed followed by Seed treatment with PGPR @625g/ for per ha of seed + Soil application of *Trichoderma* @ 4 kg/ha enriched in 250 kg FYM/ha at 35 and 80 DAS found to be the best both in reducing the diseases and fetching higher yield.

effective followed by thiamethoxam 30 FS @ 2 mL/kg seed. Imidacloprid 600 FS @ 2 mL/kg seed treatment recorded highest pod yield (4250 kg/ha) with BCR (2.9) at Jagtial.

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

This experiment was conducted at Dharwad and Kadiri and results revealed that the spray of deltamethrin 2.5 SC @ 0.5 mL/L on the storage bags was effective with <12% of damaged pods after six months of storage.

Monitoring of groundnut Bruchid beetle, *Caryedon serratus* in storage using TNAU two-in-one model insect-trap

Bruchid population was monitored in storage condition at Dharwad, Junagadh and Pavagada using TNAU Two in one model insect trap. The highest numbers of bruchid adults were trapped (32/trap) at Junagadh.

Studies on virus vector relationship of thrips fauna and peanut stem necrosis disease (PSND)/ peanut bud necrosis disease (PBND) incidence in groundnut

Thrips incidence was very high (3/10 plants) with PBND incidence (13.5%) at Raichur.

Entomology (Kharif 2015)

Monitoring of insect pests and natural enemies at various centers

Monitoring of insect-pests and their natural enemies was reported from different centers. Incidence of *Spodoptera* was high (41-60%) at Dharwad, Jagtial and Vriddhacahalam. Leafminer incidence was moderate (31-50%) at Jagtial, Kadiri, Latur, Pavagada and Vriddhacahalam. Thrips was moderate to high (31-60%) at Dharwad, Jagtial, Jalgaon, Junagadh, Kadiri and Pavagada while, leafhopper incidence was moderate to high (31-60%) at Jagtial and Junagadh. The incidence of minor pests such as, *Maruca vitrata* at Dharwad (41-50%); aphids (11-20%) at Jalgaon, Latur and Pavagada; and whiteflies (1-10%) at Junagadh were also recorded. Natural enemies such as, coccinellids, spiders, syrphids, green lace wings, *Apantles* sp. and *Campoletis chloridae* were observed along with entomopathogens like, *Nomuraea rileyi* and NPV with <10% natural incidence in all the locations.

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

Insect-pests were monitored using the pheromone or sticky traps at various centers. The peak incidence of *Spodoptera* (16/trap) was observed in Vriddhacahalam at 28th standard week while, at remaining centers it ranged from 33rd to 40th standard weeks. Moth catches of leafminer was maximum at 38th, 40th and 44th standard weeks, respectively at Pavagada (10/trap), Latur (333/trap) and Kadiri (4/trap). The peak incidence of thrips (11/trap) and leafhoppers (5/trap) was observed, respectively during 31st and 33rd standard weeks at Kadiri.

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

Groundnut entries, ISK I-2015-1, ISK I-2015-4, ISK I-2015-7, ISK I-2015-9, ISK I-2015-

10, ISK I-2015-12, ISK I-2015-13, ISK I-2015-23, ISK I-2015-24, ISK I-2015-27, ISK I-2015-31, ISK I-2015-34, ASK 2015-3, ASK 2015-5, IVK I-2015-14, AVK 2015-2, AVK 2015-3, AVK 2015-12, ISK 2014-3, ISK 2014-9, ISK 2014-10, ISK 2014-11, ISK 2014-16, ISK 2014-29, ALSVT 04, ALSVT 06, IVK 2014-3, IVK 2014-4, IVK 2014-8, IVK 2014-28, AVK 1-2014-4 and AVK 1-2014-7 showed multiple resistance to sucking pests, thrips and leafhoppers with <10% foliar damage. Similarly, entries ISK-I-2015-31 and AVK-2015-2 showed multiple resistance to *Spodoptera* and leafminer with foliar damage <10%.

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

Seed treatment formulations were evaluated in all the major and voluntary centers against sucking pests. Seed treatment with imidacloprid 600 FS @ 2 mL/kg seed was effective followed by thiamethoxam 30 FS @ 2 mL/kg seed. Imidacloprid 600 FS @ 2 mL/kg seed treatment also recorded pod yield of 1316 kg/ha with the cost benefit ratio of 2.1 at Jagtial.

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

This experiment was conducted at Kadiri and found that spray of spinosad 45 SC @ 0.3 mL/L on the storage bags was effective with <10% of damaged pods after four months of storage.

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

This experiment was conducted at Dharwad, where the TNAU two in one model insect trap caught very few bruchid adults and grubs. However, the size of holes in trap is smaller than the size of groundnut bruchid beetle.

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

Thrips incidence was very high ranging from 4 to 36 per ten plants with PSND incidence of 10 to 63% at Kadiri. Though, the population of thrips was maximum (44/10 plants) at Pavagada and the incidence of PBND was 0.3%.

Management of lepidopteran pests using botanicals

This experiment was carried out at Dharwad, Jalgaon, Kadiri and Vriddhachalam centers. Foliar applications of ponneem @ 3 to 5 mL/L or azadirachtin 3% @ 3 to 5 mL/L were at par in reducing the damage caused by *Spodoptera*. The highest pod yield (1658 kg/ha) was observed by ponneem @ 5 mL/L at Vriddhachalam.

AICRP-G FLD

- During *kharif* 2015 a total of 375 FLDs were allotted (all Whole Package component) and report received for 334 FLDs (89% implementation)
- Varieties: 29 new varieties against 15 old ruling varieties which are cultivated with farmers using traditional cultivation practices.

- Pod Yield: 2162 kg/ha – Improved Whole Package of practices (WP), 1737 kg/ha with farmers traditional practices increased by 24 %.
- The average cost of cultivation and average net returns with Whole Package (WP) was Rs. 41235/ha and Rs. 58241/ha respectively whereas, in farmers practice it was Rs. 39960/ha and Rs. 40063/ha respectively. The net returns increased by 45 %.
- During *rabi*-summer 2014-15 a total of 297 FLDs were allotted in 8 states having 21 groundnut FLD centres, report received for 250 FLDs from 18 centres (89% implementation). Recorded an average pod yield of 24 qt/ha compared to 20 qt/ha with farmers practice. The pod yield increased by 18 per cent with improved practice over farmers practice.
- The average cost of cultivation and average gross marginal returns with improved variety was Rs. 44k/ha and Rs.104k/ha respectively whereas, in farmers practice it was Rs. 41k/ha and Rs. 86k/ha respectively. The GMR increased by 21%.

Externally Aided Projects

Synthesis, validation and popularization of integrated pest management technology for groundnut crop

(CC PI: Nataraja MV)
Funding Agency: ICAR-NCIPM, New Delhi
Duration: 2013-2018
Total Funds: Rs. 11.00 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.

Achievements

It was observed that synthesized IPDM Modules were significantly reduced the disease and insect-pest incidence on groundnut and enhanced the yield over farmer practices (FP). In *Rabi*-summer and *kharif* of 2015 the module T_5 was significantly superior to FP.

Diseases

During *rabi*-summer 2015, the *Alternaria* diseases severity was recorded highest in T_4 (6.8) followed by T_3 (5.0), T_5 (4.3), T_1 (4.0) and T_2 (3.8). The percent incidence of stem rot was maximum in T_4 (15.0%) and minimum in T_1 (8.0%) and T_5 (6.0%) modules. In *kharif* 2015 the foliar leaf severity index of early leaf spots (ELS), late leaf spot (LLS), and rust being maximum in farmer practice (FP) and minimum in module T_5. The percent incidence of stem rot was recorded significantly higher (24.0%) in FP as compared to module T_5 where the per cent incidence recorded was only 8.0%.

Insect-pests

During *rabi*-summer 2015, the mean population of thrips varied from 1.1 to 2.8 thrips/plant. The population was maximum in T_4 module (2.8 thrips/plant) and minimum in T_5 (1.1 thrips/plant). The mean population of leafhopper was highest (1.7 hoppers/plant) in T_2 and lowest in T_5 (0.8 hoppers/plant). The per cent infestation of thrips varied from 12.0 to 29.3 being maximum in T_4 (29.3%) and minimum in T_5 (12.0%). In *kharif* 2015, the module T_5 harbored significantly lower number of thrips (0.9 thrips/plant) and leafhoppers (0.4 hoppers/plant) as compared to T_4 (1.6 thrips and 1.2 hoppers per plant). The percent plant infestation caused by thrips and leafhoppers was also lower in T_5 than T_4. The plant infestation caused by thrips was 7.3 and 22.0 per cent in T_5 and T_4, respectively. Similarly, plant infestation by leafhopper was 12.0 per cent and 30 per cent in T_5 and T_4, respectively.

Yield

The highest pod yield during *rabi*-summer season was obtained in module T_5 (1757 kg ha^{-1}) and lowest in FP (1179.5 kg ha^{-1}). Also, fodder yield was recorded maximum (2895 kg ha^{-1}) with Benefit Cost (BC) ratio of 2.7 in module T_5 and minimum (2659 kg ha^{-1}) in FP module with BC 1.6. In *kharif* the pod yield was highest in module T_5 (1340 kg ha^{-1}) and lowest in FP (1050 kg ha^{-1}). Also, fodder yield was recorded maximum (3630 kg ha^{-1}) with BC of 1.7 in module T_5 and minimum (2297.5 kg ha^{-1}) in FP module with BC 1.4.

Development of post-harvest technologies for production of aflatoxin free groundnuts by the processing units in India

(PI: Thirumalaisamy PP, CO PI: Jadon KS)
Funding agency: Agricultural & Processed Food Products Export Development Authority (Ministry of Commerce & Industry, Govt. of India)
Duration: 1.1.2013 to 31.12.2015
Fund: Rs. 74.20 Lakhs

Objectives

A. Research

- To study the prevailing practices of handling, storing, and processing in groundnut processing units
- To identify the ambient factors responsible for promoting growth of *Aspergillus flavus* within the premises of processing units
- To develop alternative measures that would arrest the growth of A. *flavus* and production of aflatoxins within the processing units and thus reduce the chances of contamination
- To determine moisture level to be maintained in exportable groundnuts to minimize level of aflatoxin contamination and also split ratio of groundnut kernels at the same moisture level

- To integrate various measures identified for improving the shelling out of the feed stock without enhancing its vulnerability to aflatoxin contamination

B. Training

- To impart capacity building in sampling and analytical methods

Achievements

- Pre-cleaning of farmers stock and storage of groundnut pods and kernels at less than 7% moisture content in high density polyethylene (HDPE) bag with the thickness of 160µ provides a safe storage from the storage insect pests *viz.*, bruchid beetle (*Caryedon serratus*), rice moth (*Corcyra cephalonica*), flour beetle (*Tribolium* sp.) and buildup of aflatoxin contamination in the stored produce due to growth of *Aspergillus flavus*. Using this technology, pods can be stored upto 8 months without compromising seed viability. The HDPE bag is equally suitable for vacuum packing of kernels.
- Pre-cleaning of pods followed by sorting of pods according to the size before decortications/shelling reduces the breakage /splitting of kernels.
- Sorting of kernels either by manual or electronic color sortx or its combination eliminates the aflatoxin contaminated kernels.
- Roasting of kernels at 120-140 degree C for few minutes followed by blanching reduces the aflatoxin load in the groundnut kernels.

Agriculture for nutrition and health (CRP 4)

(CC PI: Thirumalaisamy PP)

Funding agency: ICRISAT, Patancheru, Andhra Pradesh
Duration: 1.10.2012 to 31.12.2015
Fund: Rs. 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

- 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.

- Soil and pod samples were collected from 20 farmers field for analysis of *A. flavus* population in soil, pod and kernel infection and aflatoxin contamination. Below 20% pods were infected at natural conditions and above 80% samples were free from aflatoxin contamination.
- Population dynamics of *A. flavus* in soil ranged from 0.22 x10^3 cfu/g soil to 19.3 x10^3 cfu/g soil in the district of Rajkot, Junagadh, Jamnagar, Amreli and Porbander.

Pest dynamics in relation to climate change (NICRA)

(CC PI: Thirumalaisamy PP, CO PI: Harish G)
Funding agency: Ministry of Agriculture, GOI, New Delhi
Duration: From October 2011 to March, 2017
Fund: Rs. 5 Lakhs

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.
- Farmers of Junagadh and Rajkot districts mostly sown GG 20, TLG 45, TAG 37 and TATA SUMO.
- In *kharif* 2015, 729 mm rainfall was received during the crop season (June 6 to October 31) in 35 rainy days and maximum rain fall occurred in early stage of the crop (June 3rd week, 178.0mm) and at maturity stage (3rd week of September 119.8 mm and 1st week of October).
- Diseases *viz.*, collar rot, stem rot, aflaroot, early and late leaf spots, rust and alternaria were recorded in groundnut during the season.
- The incidence of collar rot (20-25%) was severe in 15-30 days and stem rot (25-30%) was severe in 60-100 days old crop in few fixed fields. The severity of the foliar diseases *viz.*, ELS, LLS, alternaria and rust were low (ELS was 20 to 25%, LLS was 10 to 15%, alternaria 5 to 10% and rust upto 25-30%). The rust severity was more at the stage of harvest.
- Insect pest *viz.*, aphids, thrips, jassids, *Spodoptera*, *Helicoverpa*, ash weevil, leafminer and white grub were recorded in the fields. However, infestation of aphids (10-15%), thrips (35% to 40%), jassids (25% to 35%), *Spodoptera* (35 to 40%) and *Helicoverpa* (25% to 30%) were more. Scattered incidence of white grub damage in Mendarda, Bilkha, Jamkandorna, Keshod and Vanthli was recorded.

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

(PI: Rathnakumar AL, CO-PI: Thirumalaisamy PP and Kumar N)

Funding Agency: National Agricultural Science Fund (NASF)

Duration: 1st April 2012 - 31st March 2017

Total Fund: Rs. 275.95 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

Screening of SSR markers for parental polymorphism

- As low level of polymorphism was observed in the parental combination (TG 37A x NRCG CS85), the novel EST derived SSR markers were synthesized and total 36 new polymorphic SSR markers were identified by screening 716 such markers Thus, as of now, a total of 52 polymorphic primers are available with us for further genotyping of mapping population.

Bulked segregate analysis (BSA)

- BSA was performed by using two DNA pools, made of F_2's (TG 37A x NRCG CS85) exhibiting extreme phenotypes for stem rot disease to identify probable SSR(s) associated with stem rot disease resistance. Of all polymorphic markers, only three SSRs; DGR294, DGR470 and DGR510 distinguished the resistant and susceptible bulks.

Genotyping of F_2 mapping population (TG 37A x NRCG CS85)

- Complete genotyping of total 443 F_2'S (TG 37A x NRCG CS85) is done using 25 polymorphic SSR primer pairs; and it is still continue using remaining polymorphic SSRs.

Genotyping and Phenotyping of F_2 mapping population (TG 37A x NRCG CS319)

- A total of 135 F_2s (TG 37A x CS 319) were planted in earthen pots under controlled conditions and screened for stem rot disease. Significant variability was observed in the population for disease development. The plants were classified in four categories (resistant, moderately resistant, moderately susceptible and susceptible) based on wilting percentages; in each category 5, 6, 10 and 114 plants respectively were recorded. Genotyping of population is under way using polymorphic SSR primers.

Development of RILs (TG 37A x NRCG CS85)

- So as to develop RILs, seeds ($F_{3:4}$ and $F_{4:5}$ respectively) of Cross TG 37A x NRCG CS 85 (attempted during *kharif* 2013) were planted under filled conditions by single seed dissent method in two seasons, *kharif* 2015 and summer 2016 respectively.

Phenotying of groundnut genotypes for resistance to *Sclerotium* stem rot

- Total of thirty four genotypes *viz.*, inter-specific crosses, registered genotypes, and released varieties were subjected for phenotyping to stem rot in the P II glass house. In the released cultivars, none of the varieties has shown resistant to stem rot disease. In the interspecific genotypes few lines has shown resistance. The disease was more prone to 70 days old crop than the 40 days crop.

Histological studies of groundnut stem

- Histological study of groundnut stem was undertaken using scanning electron microscope. In addition to thick stem in resistant genotype (NRCG CS 19), outer layer of the cells (bark layer) were small and compactly arranged whereas, in susceptible genotype (TG 37A), cells were large and loosely arranged.

Rotation of groundnut with cotton/wheat *vis-à-vis* stem rot disease

- Stem rot was recorded in groundnut after rotation with wheat/cotton in the previous season from fourteen fields belongs to different talukas. Soil samples were collected for the analysis of pathogen population in soil, NPK and organic carbon. Stem rot disease was not influenced by the macro nutrients (NPK) and soil organic carbon. However, rotation of groundnut after wheat increased the stem rot incidences than cotton-groundnut rotation.
- Incidence of stem rot ranged from 11 to 32 % in groundnut after wheat has grown in the field. In groundnut rotation after cotton, the disease incidence was in the range of 4 to 7% only. The result indicate that wheat crop favour the survival of the pathogen.

All India network project on soil biodiversity-biofertilizers

(PI: Pal KK, CO-PI: Dey R)
Funding agency: ICAR
Duration: 01.04.2014 - 31.03.2017
Fund: Rs. 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

- 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 shoot length and plant biomass at 45 DAS and pod and haulm yield, SOT, nodule number, and significantly over uninoculated control at harvest. Application DAPG-producing fluorescent pseudomonads like *P. putida* DAPG1, *P. putida* DAPG4, *P. putida* DAPG6, and *P. fluorescens* FP98 enhanced the pod yield (12.9% by DAPG1; 17.2% by DAPG4, 15.7% by DAPG6; and 15.6% by FP98) and haulm yield significantly over uninoculated control (pod yield of 1824 kg/ha) at harvest with cultivar TG37A during summer 2015. Maximum haulm yield was obtained with the inoculation of P. putida DAPG1. There was no significant impact of hundred kernel mass of any of the isolates.
- DAPG-producing fluorescent pseudomonads, identified under AINP-Biofertilizer programme, were evaluation through AICRP-G centres and recorded significant enhancement in the yield of groundnut (20-149%) in eight locations. Significantly higher pod yield of 2460 kg/ha was achieved with the application of *P. fluorescens* FP98 at Shirgaon as compared to control (1896 kg/ha). Similarly, significantly higher pod yield (3192 kg/ha, 3502 kg/ha, 1689 kg/ha, 1488 kg/ha, and 1539 kg/ha, respectively) was achieved with the application of *P. putida* DAPG4 as compared to uninoculated control (2354 kg/ha, 1407 kg/ha, 1065 kg/ha, 774 kg/ha and 1064 kg/ha respectively) at Junagadh (JAU), Jagtial, Jalgaon, Chintamani and Tirupati, respectively.

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: Pal KK, CO-PI: Dey R)
Funding agency: ICAR through AMAAS project
Duration: 01.04.2014-31.03.2017
Fund: Rs. 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 understand the mechanisms of osmotolerance on evolutionary perspectives and isolation of relevant genes, genomes of extreme halophilic bacilli, archaea and fungus were sequenced at draft level and annotated. This includes *Bacillus* sp. MSP5.4 (40 contigs), *Bacillus* sp. MSP13 (13), *Halomonas caseinilyticus* WD26 (63 contigs), *Haloarcula salaria* H5-DGR (195 contigs), *Netrinema altunense* 1A4-DGR (215 contigs) and extreme halophilic fungus, *Aspergillus* sp. WD1 (11 scaffolds).

- To ascertain the probable role of serine, leucine and isoleucine in imparting osmotolerance in extreme haloarchaeon, three genes from *Haloferax volcanii* H1-DGR (glycerol kinase, 2-oxo-methyl valerate dehydrogenase, hypothetical protein) were cloned to expression vector.
- By comparative genome analysis utilizing complete genome sequence data of haloarchaeon 3A1-DGR with the existing genomes of archaea, serine glyoxalate cycle has been identified as likely candidate in imparting osmotolerance, carbon assimilation and anabolism in extreme haloarchaea of the Rann of Kutch. Real time validation of the expression of key enzymes of the serine glyoxalate cycle are underway to validate the finding. This is different from reported involvement of methyl aspartyl pathway in imparting osmotolerance in dead sea archaea which is missing in archaea of salt pan of Rann of Kutch.

Unraveling the biochemical and molecular basis of bacterial and fungal endosymbiosis for alleviation of abiotic stresses in plants

(CC PI: Pal KK, CO PI: Dey R)
Funding agency: ICAR through NFBSFARA
Duration: 01.06.2011-31.05.2016
Total fund: Rs. 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:

- Discovered the C3-CAM transition in drought-stressed groundnut as a mechanism of enhancing water-use efficiency and drought-tolerance. The C3-CAM transited groundnut plants have been identified in the population of TG3A and selected. Cultivation of C3-CAM transited groundnut can save upto 76% of irrigation water with reasonable yield. More, significantly, application of endophytes have been found to modulate the transition further by enhancing the expression of the enzymes of the pathways.
- Application of endophytes like *Bacillus firmus* J22 and *Bacillus subtilis* R51 have been found to alleviate both drought and salinity stress in groundnut, cultivar TG37A. Besides enhancing the yield of groundnut, application of endophytes have also been found to enhance the production of ROS scavenging enzymes while alleviating the salinity stress in trials conducted at RRS, CAZRI, Bhuj.

Developing climate change resilient and sustainable groundnut-based cropping systems through conservation agriculture for Saurashtra region of Gujarat

(PI: Jat RA)
Funding agency: Science and Engineering Board, DST, New Delhi
Duration: 2015-2017
Total funds: Rs. 22.90 Lakhs

Objectives

- Assessing potential of Conservation Agriculture as climate change adaptation strategy by understanding its impact on soil moisture balance, soil surface temperature and crop productivity.
- Assessing carbon sequestration potential of conservation agriculture in Vertisols of Saurashtra region.
- Evaluating impact of conservation agriculture practices on soil quality vis-a-vis conventional agricultural practices.
- To work out the economics of conservation agriculture practices vis-a-vis conventional agricultural practices.

Achievements

A field experiment was initiated during *kharif* 2015 to assess the climate change adaptation potential of Conservation Agriculture in groundnut based cropping systems at ICAR-DGR, Junagadh. The effects of tillage practices, residue management, and cropping systems were studied on productivity of two groundnut based cropping systems, soil moisture and soil temperature. The treatments were: four tillage practices *viz*. normal tillage, minimum tillage, zero tillage, and rota-till in main plots; two residue management practices viz. no residue, and residue application in sub-plot; and two cropping systems *viz*. groundnut+pigeonpea, and groundnut+cotton intercropping systems in sub-sub-plots. The experiment was laid out in split-split plot design with three replications. The salient findings of 2015-16 are reported hereunder:

Groundnut pod and haulm yield: Pod and haulm yield of groundnut was not significantly affected by tillage practices. However, rota-tillage gave slightly higher pod yield compared to other tillage practices. Haulm yield was higher in conventional tillage compared to other tillage practices. Application of crop residues improved pod yield but differences were not significant at 5% probability. Groundnut pod yield was significantly higher, while pod yield was slightly higher, in groundnut+cotton intercropping system as compared to groundnut+pigeonpea intercropping system.

Pigeonpea yield: Pigeonpea seed yield was not significantly affected by tillage practices; however, minimum tillage gave higher yield over other tillage practices. Stover yield of pigeonpea was significantly higher with conventional tillage, and was lowest with zero tillage. Application of crop residues was not found to affect seed and stover yield of pigeonpea positively.

Cotton yield: Seed cotton yield was slightly higher with minimum tillage when compared with conventional tillage, zero tillage and rota-tillage. While cotton stalk yield was slightly higher under rota-tillage, but differences in both seed cotton yield and stalk yield due to tillage practices were statistically non-significant. Application of crop residues marginally increased seed cotton yield.

Groundnut pod equivalent yield: Groundnut pod equivalent yield (GPEY) was not significantly affected by tillage practices; however, minimum tillage gave higher yield compared to other tillage practices. Application of crop residues marginally improved GPEY. Groundnut+pigeonpea intercropping system gave significantly higher GPEY over groundnut+cotton intercropping system.

Soil moisture: Tillage practices failed to significantly affect soil moisture, but minimum tillage and zero tillage were found to have higher soil moisture content in 0-15 and 15-30 cm soil depth, respectively. Application of crop residues significantly improved soil moisture content in 0-15 and 15-30 cm soil depth. Groundnut+cotton intercropping system was found to have significantly higher soil moisture content in 0-15 and 15-30 cm soil depth as compared to groundnut+pigeonpea intercropping system.

Soil temperature: Conventional tillage and minimum tillage was found to have lesser soil temperature in both 0-15 and 15-30 cm soil depth compared to zero tillage and rota-tillage. Application of crop residues also reduced soil temperature in 0-15 and 15-30 cm soil depth over no crop residue application. Soil temperature was found lesser in groundnut+cotton intercropping system compared to groundnut+pigeonpea intercropping system.

Mapping of the stem rot resistant gene(s) in groundnut and its transfer to an elite groundnut cultivar

(PI: Bera SK, CO PI: Ajay BC)
Funding agency: DBT, New Delhi
Duration: 2013-2018
Total fund: Rs. 52.70 Lakhs

Objectives

- Polymorphism survey of TMV 2, *Arachis diogoi*, CS 19 and GG 20 with RAPDs and SSRs
- Development of F_3 mapping populations of cross between genotypes GG 20 X CS 19
- Development of BC_1F_1 of cross between genotypes GG 20 X CS 19
- Screening of F_2 progenies for resistance to stem rot under artificially inoculated conditions
- RAPD and SSR analysis of F_2 progenies with primers which are polymorphic to parents.
- Identification of markers associated with resistance to stem rot caused by *Sclerotium rolfsii*
- MABC to transfer the resistant gene into the genotype GG 20

Achievements

- Out of 1980 SSR markers, 23 were identified polymorphic between parents and differentiated their F1 heterozygotes.
- Linkage map has been constructed and major QTLs associated with resistance to

stem rot in groundnut have been identified

- BC_1F_1 progenies were developed using GG 20 as RP and F_1 hybrids of GG 20 and CS 19 as male parents. Development of BC_1F_2 and BC_2F_1 progenies are in progress.

Genetic characterization of high O/L groundnut genotypes and ORF allele polymorphism of ahfad2 genes of selected groundnut genotypes

(PI: Mishra GP)
Funding Agency: Science and Engineering Board, DST, New Delhi
Duration: 2013-2016
Total Funds: Rs. 21.72 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

- In groundnut (*Arachis hypogaea* L.), the customization of fatty acid profile is an evolving area to fulfil the nutritional needs in the modern market. A total of 173 peanut genotypes, including 167 Indian cultivars and 6 advanced breeding lines were investigated using AS-PCRs, CAPS and SNP assays for the *ahFAD2* allele polymorphism and its fatty acid compositions. Of these, 80 genotypes were found to have substitution (448G>A) mutation in *ahFAD2A* gene, while no genotype recorded 1-bp insertion (441_442insA) mutation in *ahFAD2B* gene. Moreover, 22 wild peanut accessions were also studied, which were found lacking both the mutations.

- Among botanical types, the *ahFAD2A* mutation was more frequent in ssp. *hypogaea* (89%) than in ssp. *fastigiata* (17%). This single gene mutation, not only affected the oleic to linoleic acid fluxes, but also the composition of other fatty acids.

- Repeated use of certain genotypes in the Indian varietal development programs were also reflected in its *ahFAD2* allele polymorphism. Absence of mutations in the wild relatives indicated that these mutations might have happened after the allotetraploidization of cultivated peanut.

- The SNP analysis for *ahFAD2A* and *ahFAD2B* genes revealed haplotype diversity of 1.05% and 0.95%, while K_a/K_s ratio of 0.36 and 0.39, indicating strong purifying selection pressure on these genes respectively. Cluster analysis using *ahFAD2* gene SNPs showed presence of both mutant and non-mutant genotypes in the same cluster, which might be due the presence of *ahFAD2* gene families.

- Since, significant variation for oleic acid content was found in the genotypes that were identified having mutant *ahFAD2* gene, therefore phenotypic confirmation is essential to advance the selected lines for further evaluations. It is therefore proposed that the combined selection approach of both, genotypic- as well as phenotypic- based selection should be used for the effective selection of desired lines.
- This investigation provided insights into the large number of Indian peanut genotypes covering various aspects related to O/L flux regulation and *ahFAD2* gene polymorphism. The information generated in the present investigation, will be very useful to develop peanut varieties with right combination of traits in future.

ICAR seed project "Seed production in agricultural crops"

(Nodal Officer: Kumar N; Co-Nodal Officer: Gangadhara K)
Funding Agency: ICAR-Indian Institute of Seed Science, Mau, Uttar Pradesh
Duration: 2006 onwards
Total Fund: Rs. 44 Lakhs

Breeder Seed Production Programme

Summer 2015: An area of 2.77 ha was sown to produce nucleus seed of DGR varieties Girnar 2 and Girnar 3 and TFL seed of TG 37A. Total production was 3.6 q and 3.75 q nucleus seed of Girnar 2 and Girnar 3 variety respectively and 3.95 q of TFL seed.

***Kharif* 2015:** The breeder seed DAC indent for Girnar 2 (13.0 q) and Girnar 3 (279.5 q) has been received for *kharif* 2015. Against the DAC indent, seed production of Girnar 2 variety was taken up in 4.0 ha; and that of Girnar 3 in 4.82 ha of land at DGR, Junagadh (4.22 ha) and ARC, Bikaner (4.6 ha). The total production was 25.10 q (13.0 q breeder seed and 12.10 q nucleus seed) of Girnar 2, and 35.90 q (10.2 q nucleus seed and 25.7 q breeder seed) of Girnar 3.

Compensatory seed production programme of both DGR varieties Girnar 2 and Girnar 3 was not taken up in summer 2016. As the summer produce get ready for sowing after 15th June whereas cutoff date for lifting the breeder seed is by 30th April thus it will not ready for lifting timely. Moreover these varieties have fresh seed dormancy, hence without etherel treatment, seeds of these varieties cannot be used directly in *kharif* season. Besides that seed viability reduced drastically if summer produce will be used for next summer and *kharif* season.

Distribution of seed/planting material

During 2015-16, 7.0 q breeder seed of Girnar 2 was supplied to RSSC, Chittorgarh and 18.0 q breeder seed of Girnar 3 to OSSC, Odisa and 3.6 q TFL seed of TG 37A to the farmers from the produce of *kharif* 2014. From the produce of summer-2015, we have supplied 3.95 q TFL seed of TG 37A to KVK, Kodinar and 40 kg and 10 kg breeder seed of Girnar 2 and Ginar 3 respectively to the indenters.

Resource generation

During 2015-16, revenue of Rs. 3.93 lakhs by sale of 7.0 q (RSSC, Chittorgarh) and 18.0 q (OSSC, Odisa) breeder seed of Girnar 2 and Girnar 3 varieties respectively @ Rs. 15000/q and 3.6 q TFL seed of TG 37A @ Rs. 52/kg to the farmers from the produce of *kharif* 2014 was generated. From the produce of summer 2015, the revenue generated was of Rs. 0.28 lakhs by sale of 3.95 q TFL seed of TG 37A @ Rs. 52/kg and 40kg and 10kg breeder seed of Girnar 2 and Ginar 3 respectively @150/kg to the indenters. Thus, during the year 2015-16 the total revenue generation from the produce of *kharif* 2014 and summer-2015 was Rs. 4.21 lakhs.

An expenditure of Rs. 4.21 lakhs was incurred under this project of annual budget of Rs. 5.5 lakhs received from the ICAR-Indian Institute of Seed Science, Mau during the period under report (01.04.2015-31.3.2016).

Details of training programmes organized during 2015-16

Programme name	Date	Place of farmers
Safer use and handlings of pesticides in groundnut	20th August, 2015	Devgam of Malia (Hatina), Junagadh
Quality seed production for summer groundnut	18-20th Feb, 2016	Ivnagar, Junagadh
Summer Groundnut Seed Production By Scientific Techniques	02-04th March, 2016	Khad Pipali, Meethapur and Aalidra, Junagadh
Improved seed production technologies for groundnut	14-16th March, 2016	Bilkha, Jungadh

Capacity building and technology dissemination

During the 2015-16, under HRD programme of ICAR seed project a total 133 farmers had attended the training programmes organized on groundnut seed production with improved technologies at ICAR- DGR, Junagadh. The aim of training programme was to demonstrate latest technology of groundnut cultivation. Three training programme each of three day and one field day for 25 women farmers from Devgam of Malia (Hatina), Junagadh were organized.

Seed of different classes and varieties produced in summer and kharif 2015

Variety	Area (ha.)	Total production (q)	Seed Production (q) Breeder Seed	Nucleus Seed	TFL Seed
Summer 2015					
Girnar 2	0.75	3.60	--	3.60	--
Girnar 3	0.80	3.75	--	3.75	--
TG 37A	0.66+0.66	3.95	--	--	3.95
Total	**2.77**				**3.95**
***Kharif* 2015**					
Girnar 2	0.60 1.50 1.90	25.10	13.00	12.10	--
Total	**4.00**				
Girnar 3	0.10 1.12 0.90 2.70	35.90	25.70	10.20	--
Total	4.82				

Farmers' training programmes held at ICAR-DGR, Junagadh

Publications

Research Articles

Ajay BC, Bera SK, Devaiah K, James O, Violetka T and Anthony A (2016). Isolation and characterization of inositol tetraphosphate 1-kinase (*Ahitpk1*) and inositol 1,4,5-tris-phosphatekinase (*Ahipk2*) gene in peanut. *Cloning & Transgenesis*, **5**: 150. doi:10.4172/2168-9849.1000150

Bala M, Radhakrishnan T, Kumar A, Mishra GP, Dobaria JR and Kirti PB (2015). Overexpression of a fusion defensin gene from radish and fenugreek improves resistance against leaf spot diseases caused by *Cercospora arachidicola* and *Phaeoisariopsis personata* in peanut. *Turkish Journal of Biology*, **39**: 1-11. doi: 10.3906/biy-1412-46.

Balai TC, Maurya IB, Verma S and Kumar N (2015). Genetic divergence studies in okra [*Abelmoschus esculentus* (L.) Moench.] genotypes. *Electronic Journal of Plant Breeding*, **6**(2): 619-624.

Bhaduri D, Meena HN and Chakraborty K (2016). Variation in phosphorus accumulation in groundnut cultivars under influence of water salinity. *Legume Research*, **39**(2): 215-220. doi: 10.18805/lr.v0iOF.6788

Bhaduri D, Saha A, Desai D and Meena HN (2016). Restoration of carbon and microbial activity of salt-induced soil by application of peanut shell biochar during short-term incubation study. *Chemosphere*, **148**: 86-98. doi: 10.1016/j.chemosphere.2015.12.130

Bishi SK and Vakharia DN (2015). Secondary metabolites and lytic enzymes produced by fluorescent pseudomonads determine *in-vitro* antagonistic potential against *Sclerotium rolfsii* in groundnut (*Arachis hypogaea* L.). *Journal of Pure and Applied Microbiology*, **9**(4): 3283-3293.

Bishi SK, Kumar L, Mahatma MK, Khatediya N, Chauhan SM and Misra JB (2015). Quality traits of Indian peanut cultivars and their utility as nutritional and functional food. *Food Chemistry*, **167**: 107–114.

Bosamia TC, Mishra GP, Thankappan R and Dobaria JR (2015). Novel and stress relevant EST derived SSR markers developed and validated in peanut. *PLoS ONE* 10(6): e0129127.

Chakraborty K, Bhaduri D, Meena HN and Kalariya KA (2016). External potassium (K^+) application improves salinity tolerance by promoting Na^+-exclusion, K^+-accumulation and osmotic adjustment in contrasting peanut cultivars. *Plant Physiology and Biochemistry*, **103**: 143-153. doi:10.1016/j.plaphy.2016.02.039

Chakraborty K, Bishi SK, Goswami N, Singh AL and Zala PV (2016). Differential fine regulation of enzyme driven ROS detoxification network imparts salt tolerance in contrasting peanut genotypes. *Environmental and Experimental Botany*, **128**: 79-90. doi: 10.1016/j.envexpbot.2016.05.001

Chakraborty K, Mahatma MK, Thawait LK, Bishi SK, Kalariya KA and Singh AL (2016). Water deficit stress affects photosynthesis and the sugar profile in source and sink tissues of groundnut (*Arachis hypogaea* L.) and impacts kernel quality. *Journal of Applied Botany and Food Quality*, **89**: 98-104. doi: 10.5073/JABFQ.2016.089.012

Chakraborty K, Uprety DC and Bhaduri D (2015). Growth, physiology and biochemical responses of two different *Brassica* species to elevated CO_2. *PNAS, India Section B: Biological Sciences*, doi: 10.1007/s40011-015-0615-9.

Dagla MC, Gadag RN, Sharma OP and Kumar N (2015). Genetic variability and correlation among yield and quality traits in sweet corn. *Electronic Journal of Plant Breeding*, **6**(2): 500-505.

Deshmukh SB, Bishi SK and Vakharia DN (2015). *Pseudomonas fluorescens* modulate *in-vitro* lytic enzyme production and inhibit the growth of collar rot pathogen (*Aspergillus niger*) in Groundnut (*Arachis hypogaea* L.). *Journal of Pure and Applied Microbiology*, **9**(2): 1531-1538.

Dutta R, Banerjee A, Behere GT, Devi KJ, Chandra S and Ngachan SV (2015). PCR detection of *Ralstonia solanacearum*: A new approach for rapid detection of bacterium from infected plants. *Indian Journal of Agricultural Sciences*, **85**(8): 1007-1011.

Ghorai S, Pal KK and Dey R (2015). Alleviation of salinity stress in groundnut by application of PGPR. *International Research Journal of Engineering and Technology*, **2**(3): 742-750.

Ghorai S, Pal KK and Dey R (2015). Evaluation of the wild type and Tn5::GusA mutants of *Enterobacter* sp. R29 and *Pseudomonas aeruginosa* AMAAS57 on growth and yield of groundnut. *International Research Journal of Engineering and Technology*, **2**(9): 2659-2655.

Jadon KS, Thirumalaisamy PP, Kumar V, Koradia VG and Padavi RD (2015). Management of soil borne diseases of groundnut through seed dressing fungicides. *Crop Protection*, **78**: 198-203. doi: 10.1016/j.cropro.2015.08.021

Jain NK and Meena HN (2015). Improving productivity of groundnut (*Arachis hypogaea*) by using water soluble fertilizer through drip irrigation. *Indian Journal of Agronomy*, **60**(1): 109-115.

Janila P, Pandey MK, Shasidhar Y, Variath MT, Sriswathi M, Khera P, Manohar SS, Nagesh P, Vishwakarma MK, Mishra GP, Radhakrishnan T, Manivannan N, Dobariya KL, Vasanthi RP and Varshney RK (2016). Molecular breeding for introgression of fatty acid desaturase mutant alleles (*ahFAD2A* and *ahFAD2B*) enhances oil quality in high and low oil containing peanut genotypes. *Plant Science*, **242**: 203-213.

doi: 10.1016/j.plantsci.2015.08.013.

Janila P, Variath MT, Pandey MK, Desmae H, Motagi BN, Okori P, Manohar SS, Rathnakumar AL, Radhakrishnan T, Liao B and Varshney RK (2016). Genomic Tools in Groundnut Breeding Program: Status and Perspectives. *Frontiers in Plant Science*, 7:289. doi: 10.3389/fpls.2016.00289

Jasrotia P, Nataraja MV, Harish G, Dutta R and Savaliya SD (2015). Effect of trap design and weather factors on relative efficiency of yellow sticky traps for sampling aphids in groundnut. *Legume Research*, doi: 10.18805/lr.v0iOF.9290.

Jat RA, Wani SP, Pathak P, Singh P, Sahrawat KL, Chander G and Sudi RS (2015). Evaluating climate change mitigation and adaptation potential of conservation agriculture in semi-arid tropics of southern India. *British Journal of Environment and Climate Change*, **5**(4): 324-338. doi: 10.9734/BJECC/2015/18479

Kalariya KA, Singh AL, Chakraborty K, Ajay BC, Zala PV, Patel CB, Nakar RN, Goswami N and Mehta D (2015). SCMR: A more pertinent trait than SLA in peanut genotypes under transient water deficit stress during summer. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, doi: 10.1007/s40011-015-0636-4

Kalariya KA, Singh AL, Goswami N, Mehta D, Mahatma MK, Ajay BC, Chakraborty K, Zala PV, Chaudhary V and Patel CB (2015). Photosynthetic characteristics of peanut genotypes under excess and deficit irrigation during summer. *Physiology and Molecular Biology of Plants*, **21**(3), 317-327. doi: 10.1007/s12298-015-0300-8

Kumar N, Tikka SBS, Ram B and Dagla MC (2015). Heterosis studies for agronomic trait under different environmental conditions in sesame (Sesamum indicum L.). *Electronic Journal of Plant Breeding*, **6**(1): 130-140.

Mahatma MK, Thawait LK, Bishi SK, Khatediya N, Rathnakumar AL, Lalwani HB and Misra JB (2016). Nutritional composition and antioxidant activity of Spanish and Virginia groundnuts (*Arachis hypogaea* L.): a comparative study. *Journal of Food Science and Technology*, doi: 10.1007/s13197-016-2187-y

Mann A, Singh AL, Oza S, Goswami N, Mehta D and Chaudhari V (2016). Effects of iron sources on lime induced iron deficiency chlorosis in groundnut. *Legume Research*, doi: 10.18805/lr.v0iOF.6849

Meena HN, Bhaduri D, Yadav RS, Jain NK and Meena MD (2015). Agronomic performance and nutrient accumulation behaviour in groundnut-cluster bean cropping system as influenced by irrigation water salinity. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, doi: 10.1007/s40011-015-0573-2.

Mishra GP, Radhakrishnan T, Kumar A, Thirumalaisamy PP, N Kumar, Bosamia TC, Nawade B and Dobaria JR (2015). Advancements in molecular marker development and their applications in the management of biotic stresses in peanuts. *Crop Protection*, **77**: 74-86. doi: 10.1016/j.cropro.2015.07019.

Nataraja MV, Chalam MSV, Madhumathi T and Rao VS (2015). Bio-efficacy of new insecticide molecules against major pests of okra. *Indian Journal of Plant Protection*, **43**(2): 233-236.

Pramanik P, Bandyopadhyay KK, Bhaduri D, Bhattacharyya R and Aggarwal P (2015). Effect of mulch on soil thermal regimes - A Review. *International Journal of Agriculture, Environment and Biotechnology*, **8**(3): 645-658. doi: 10.5958/2230-732X.2015.00072.8

Saha A, Bhaduri D, Pipariya A, Jain NK and Basak BB (2015). Behaviour of pendimethalin and oxyfluorfen in peanut field soil: Effects on soil biological and biochemical activities. *Chemistry and Ecology*, **31**(6): 550-566. doi: 10.1080/02757540.2015.1039526

Saha A, Pipariya A and Bhaduri D (2015). Enzymatic activities and microbial biomass in peanut field soil as affected by the foliar application of tebuconazole. *Environmental Earth Sciences*, **75**: 558. doi: 10.1007/s12665-015-5116-x

Saini C, Jain NK, Mandal D and Bhargav T (2015). Influence of sulphur and plant growth regulators on nutrient concentration and available soil nutrient status in summer groundnut (*Arachis hypogaea* L.). *Trends in Biosciences*, **8**(17): 4684-4687.

Sharma S, Jat RA and Sagarka BK (2015). Effect of weed-management practices on weed dynamics, yield, and economics of groundnut (Arachis hypogaea) in black calcareous soil. *Indian Journal of Agronomy*, **60**(2): 312-317.

Sherathia D, Dey R, Thomas M, Dalsania T, Savsani K and Pal KK (2016). Biochemical and molecular characterization of DAPG-producing plant growth-promoting rhizobacteria (PGPR) of groundnut (*Arachis hypogaea* L.). *Legume Research*, doi: 10.18805/lr.v0iOF.9389

Singh AL and Chaudhari V (2015). Zinc biofortification in sixty groundnut cultivars through foliar application of zinc sulphate. *Journal of Plant Nutrition*, **38**(11): 1734-1753. doi: 10.1080/01904167.2015.1042165

Singh AL, Chaudhari V and Ajay BC (2015). Screening of groundnut genotypes for phosphorus efficiency under field conditions. *The Indian Journal of Genetics and Plant Breeding*, **75**(3): 363-371. doi: 10.5958/0975-6906.2015.00057.7

Singh AL, Hariprasanna K and Chaudhari V (2016). Differential nutrients absorption an important tool for screening and identification of soil salinity tolerant peanut genotypes. *Indian Journal of Plant Physiology*, **21**(1): 83-92. doi: 10.1007/s40502-016-0206-7

Singh D, Radhakrishnan T, Kumar V, Bagwan NB, Basu MS, Dobaria JR, Mishra GP and Chanda SV (2015). Molecular characterisation of Aspergillus flavus isolates from peanut fields in India using AFLP. *Brazilian Journal of Microbiology*, **46**: 673-682. doi: 10.1590/S1517-838246320131115

Singh LS, Dutta R and Singh AR (2015). Yield assessment and eco-friendly management approaches against turcicum leaf blight (Exserohilum turcicum) of maize in mid-hill conditions of Meghalaya. *Ecology Environment & Conservation*, **21**(S): S301-S304.

Yadav AN, Sharma D, Gulati S, Singh S, Dey R, Pal KK, Kaushik R and Saxena AK (2015). Haloarchaea endowed with phosphorus solubilization attribute implicated in phosphorus cycle. *Scientific Reports*, **5**:12293. doi: 10.1038/srep12293

Books and Book Chapters

Ajay BC, Singh AL, Kumar N, Dagla MC, Bera SK and Fiyaz RA (2015). Role of phosphorus efficient genotypes in increasing crop production. *In*: Singh AL (Ed.), Recent Advances in Crop Physiology, vol. 2, pp 19-50. Daya Publishing House, New Delhi.

Basak BB, Pal S and Bhaduri D (2015). Soil Biodiversity and microbial-mediated Nutrient Transformation as influenced by introduction of Transgenic Plants. *In*: Hemantaranjan A (Ed.) Advances in Plant Physiology, vol. 16, pp 217-238.

Scientific Publishers, Jodhpur.

Bhaduri D, Pal S, Purakayastha TJ, Chakraborty K, Yadav RS and Akhtar MS (2015). Soil quality and plant-microbe interactions in rhizosphere. *In*: Lichtfouse E (Ed.) Sustainable Agriculture Reviews, vol. 17. pp 307-335. Springer International Publishing, Switzerland. doi: 10.1007/978-3-319-16742-8_9

Chakraborty B, Chakraborty K and Bhaduri D (2015). An insight of iron chlorosis in horticultural crops: physiological and molecular basis, and possible management strategies. *In*: Hemantaranjan A (Ed.) Advances in Plant Physiology, vol. 16, pp 239-270. Scientific Publishers, Jodhpur.

Chauhan JS, Singh AL, Prasad SR and Pal S (2016). Quality seed: A mega factor in enhancing crop productivity. *In*: Singh AL (Ed.), Recent Advances in Crop Physiology, vol. 2, pp 357-426. Daya Publishing House, New Delhi.

Mahatma MK and Mahatma L (2015). Soil suppressive microorganisms and their impact on fungal wilt pathogens. *In*: Meghvansi MK and Varma A. (Ed.) Organic amendments and soil suppressiveness in plant disease management, Soil Biology, vol 46, pp 249-274. Springer International Publishing, Switzerland. doi: 10.1007/978-3-319-23075-7_12

Mann A, Bishi SK, Mahatma MK and Kumar A (2015). Metabolomics and Salt Stress Tolerance in Plants. *In*: Wani SH, Hossain MA (Ed.) Managing Salt Tolerance in Plants, Molecular and Genomic Perspectives, pp 251-266, CRC Press, Taylor & Francis, Florida, USA. doi: 10.1201/b19246-15

Mishra GP, Murkute A, Anandhan S, Kumar A and Radhakrishnan T (2015). Antifreeze proteins: Cold tolerance and other applications. *In*: Parimelazhagan T (Ed.) Modern Methods in Phytomedicine, pp 1-14. Daya Publishing House, New Delhi.

Mishra GP, Singh R, Murkute A, Bhoyar MS, Radhakrishnan T and Srivastava RB (2015). *Capparis spinosa*: Potential medicinal and non-traditional vegetable plant from trans-himalayan region of India. *In*: Parimelazhagan T (Ed.) Modern Methods in Phytomedicine, pp 43-58. Daya Publishing House, New Delhi.

Nakar RN, Jadeja BA and Singh AL (2016). Phenology and productivity of forest flora of Gujarat. *In*: Singh AL (Ed.), Recent Advances in Crop Physiology, vol. 2, pp 261-294. Daya Publishing House, New Delhi.

Ram B, Dayal D, Mangalassery S, Kumar A, Meena SL and Kumar N (2016). Morphological evaluation of sesame (*Sesamum indicum* L.) varieties under high temperature stress conditions. *In*: Dayal D. (Ed.) Improving productivity of drylands by sustainable resource utilization and management, pp 253-261. New India Publishing Agency, New Delhi, India.

Rathnakumar AL, Nigam SN, Muralidharan V and Misra JB (2015). Groundnut at a cross road in India. Indian Oilseeds and Produce Export Promotion Council (India), Mumbai. p.112.

Singh AL (Ed.) (2016). Recent Advances in Crop Physiology, vol. 2, Daya Publishing House, New Delhi. p.437.

Yadav RS, Panwar J, Meena HN, Thirumalaisamy PP and Meena RL (2015). Developing disease-suppressive soil through agronomic management. In: Meghvansi MK and Varma A (Ed.) Organic amendments and soil suppressiveness in plant disease management. Soil Biology, vol. 46, pp 61-94. Springer International Publishing, Switzerland. doi: 10.1007/978-3-319-23075-7_4

Presentations in Conferences/ Symposia/ Seminar/ other forum

Ansari MA, Baishya LK , Sharma SK, Ajeetkumar N, Singh NA, Monsang TL, Singh LS, Kamei G, Bungbungcha C, Dutta R, Devi NR, Prakash N and Ngachan SV (2016). Groundnut bumper harvest in hill and stone pebbles soil and improved the livelihood of tribal farmers- Success story. *In*: National Seminar on Integrating Agri-Horticultural and Allied Research for Food and Nutritional Security in the Era of Global Climate Disruption, March 4-6, 2016. ICAR Research Complex for NEH Region, Imphal, Manipur, pp 44-45.

Balakrishnan N, Maurya AK, Kamdar JH, Kasundra SV, Jasani, MD, Ajay, BC, Dash P and Bera SK (2015). Anther culture and callus induction in Groundnut (*Arachis hypogaea* L.). *In*: National Seminar on Strategic Interventions to Enhance Oilseeds Production in India, Feb 19-21, 2015. Indian Society of Oilseeds Research, Hyderabad, pp 67.

Bera SK, Kamdar JH, Kasundra SV, Darvhankar M, Jasani MD, Ajay BC and Thirumalaisamy PP (2016). An efficient phenotyping technique for wild Arachis species and groundnut breeding lines resistant to stem rot disease under field conditions. *In*: 6th International Conference on "Plant Pathogen and People" Challenges in Plant Pathology to Benefit. ICAR- Indian Agricultural Research Institute, New Delhi, pp 141.

Bishi SK, Mahatma MK and Vakharia DN (2015). Identification and expression analysis of a gene associated with defence response to *Sclerotium rolfsii* in groundnut (*Arachis hypogea* L.). *In*: 3rd International Plant Physiology Congress on Challenges and strategies in Plant Biology Research, Dec 11-14, 2015. Jawaharlal Nehru University, New Delhi, India, pp 255.

Chakraborty K, Bishi SK, Patel K, Goswami N, Bhaduri D, Singh AL and Zala PV (2015). Elucidating dominant enzyme mediated oxidative stress tolerance pathway in groundnut under salinity Stress. *In*: 3rd International Plant Physiology Congress (IPPC-2015): Challenges and Strategies in Plant Biology Research, Dec 11-14, 2015. Jawaharlal Nehru University, New Delhi, India, pp 159.

Darvhankar MS, Kamdar JH, Kasundra SV, Jasani MD, Dash P, Maurya AK, Ajay BC and Bera SK (2015). Genetic Variability and Trait Association in Groundnut (*Arachis hypogaea* L.) *In*: National Seminar on Strategic Interventions to Enhance Oilseeds Production in India, Feb 19-21, 2015. Indian Society of Oilseeds Research, Hyderabad, pp 18.

Dodia SM, Mishra GP, Radhakrishnan T, Joshi B, Rathnakumar AL, Kumar N, Thirumalaisamy PP, Chanda S and Dobaria JR (2015). Parental polymorphism and bulked segregant analysis to identify molecular markers associated with stem rot disease resistance in groundnut. *In*: International Conference on Recent Trend in Applied Sciences: Building the Institutional and Industrial Avenues (ICRTAS-2015), Dec 10-12, 2015. Shri Alpesh N. Patel Postgraduate Institute, Anand, Gujarat, India.

Jadon KS, Thirumalaisamy PP, Dutta R, Koradia VG and Padvi RD (2016). Management of soil-borne diseases of groundnut (*Arachis hypgaea* L.)- Biological control agents. *In*: 6th International Conference on "Plant Pathogen and People" Challenges in Plant Pathology to Benefit. Feb 23-27, 2016. ICAR-IARI, New Delhi, pp 117-118.

Jasani MD, Kamdar JH, Kasundra SV, Ajay BC, Dash P, Maurya AK and Bera SK (2015). Marker-assisted breeding for peanut bud necrosis disease (PBND) resistance in groundnut. *In*: National Seminar on Strategic Interventions to Enhance Oilseeds Production in India, Feb 19-21, 2015. Indian Society of Oilseeds Research, Hyderabad, pp 23.

Jat RA and Solanki R (2015). Tillage and residue retention influences on wheat grain yield and soil moisture content in semi-arid western India. *In*: International conference on Transitioning Cereal Systems to Adapt to Climate Change: Proceedings, Nov. 13-14, 2015. Minneapolis-St. Paul, USA.

Jat RA, Chopda MC and Mathukia RK (2015). Climate change and variability, and farmers' response in Saurashtra region of Gujarat, India. *In*: International conference on Transitioning Cereal Systems to Adapt to Climate Change: Proceedings, Nov. 13-14, 2015. Minneapolis-St. Paul, USA.

Kamdar JH, Kasundra SV, Darvhankar MS, Jasani MD, Ajay BC, Dash P, Maurya AK and Bera SK (2015). Marker-Assisted Breeding for Stem Rot Resistance in Groundnut. *In*: National Seminar on Strategic Interventions to Enhance Oilseeds Production in India, Feb 19-21, 2015. Indian Society of Oilseeds Research, Hyderabad.

Kasundra SV, Kamdar JH, Darvhankar MS, Jasani MD, Ajay BC, Dash P, Maurya AK and Bera SK (2015). Overexpression of PR10 gene in *Arachis hypogaea* confers enhanced tolerance to salinity. *In*: National Seminar on Strategic Interventions to Enhance Oilseeds Production in India, Feb 19-21, 2015. Indian Society of Oilseeds Research, Hyderabad, pp 22.

Kumar N, Radadiya N, Mahatma MK, Jadon, KS, Rathanakumar AL, Dagla MC, Bishi SK, Kumar L and Chikani BM (2015). Biochemical basis of resistance to *Alternaria* leaf spot in groundnut breeding lines. *In*: 3rd International Plant Physiology Congress (IPPC-2015): Challenges and Strategies in Plant Biology Research, Dec 11-14, 2015. Jawaharlal Nehru University, New Delhi, India, pp 302.

Kumar N, Rathnakumar AL, Jadon KS, Dagla MC, Ajay BC, Thirumalaisamy PP, Chikani BM. (2015). Phenotyping for seed coat resistance and aflatoxin production to *A. flavus* in groundnut. *In*: 5th International Conference on Next Generation Genomics and Integrated Breeding for Crop Improvement, Feb 18-20, 2015. ICRISAT, Patencheru, India.

Mahatma MK, Bishi SK, Thawait LK, Jadon KS, Khatediya N, Rathod KJ and Golakiya BA (2015). Changes in metabolites and defense related enzymes in groundnut during leaf spot diseases. *In*: 3rd International Plant Physiology Congress on Challenges and strategies in Plant Biology Research, Dec 11-14, 2015. Jawaharlal Nehru University, New Delhi, India, pp 42.

Mann A and Singh AL (2015). Antioxidant defence system in iron deficient groundnut plants. *In*: of the International Conference on Plant Physiology on Enhancing Strategic Plant Physiological Research and Technologies for Sustainable Resources: Proceedings. Malaysian Society of Plant Physiology, 26-28, 2014. August Bali, Indonesia, pp 59-63.

Mann A, Zala PV, Singh AL, Chaudhari V and Patel CB (2015). Effect of salt on physiological responses of groundnut to iron deficiency. *In*: 3rd International Plant Physiology Congress (IPPC-2015): Challenges and Strategies in Plant Biology Research, Dec 11-14, 2015. Jawaharlal Nehru University, New Delhi, India, pp 26.

Pal KK, Dey R and Mehta DH (2015). Application of DAPG-producing Fluorescent Pseudomonads for Suppression of Stem Rot of Groundnut'. *In*: 56th Annual Conference of Association of Microbiologists of India & International Symposium on Emerging Discoveries in Microbiology, Dec 7-10, 2015 at Jawaharlal Nehru University, New Delhi, India.

Pal KK, Dey R, Patel MB, Thomas M and Sherathia DN (2015). Insight into the genome sequence of *Haloarchaeon sp.* 3A1-DGR for understanding the mechanisms of extreme salinity tolerance. *In*: 56th Annual Conference of Association of Microbiologists of India & International Symposium on Emerging Discoveries in Microbiology", Dec 7-10, 2015 at Jawaharlal Nehru University, New Delhi, India.

Patel SV, Radhakrishnan T, Bera SK, Varshney RK, Janila P, Mandaliya V, Mishra GP and Dobaria JR (2015). Marker assisted selection for high oleate trait in groundnut. *In*: National Conference on Biodiversity and Bioresource Utilization: Proceedings, March 17-18, 2015. Saurashtra University, Rajkot.

Sherathia DN, Dey R and Pal KK (2015). Potential Plant Growth-Promoting Activity of *Rhizobacteria* Isolated from Groundnut in Gujarat. *In*: 56th Annual Conference of Association of Microbiologists of India & International Symposium on Emerging Discoveries in Microbiology, Dec 7-10, 2015. Jawaharlal Nehru University, New Delhi, India.

Singh AL, Nakar R, Chakraborty K, Goswami N and Kalariya KA (2015). Photosynthetic efficiencies among peanut cultivars evaluated. *In*: 3rd International Plant Physiology Congress (IPPC-2015): Challenges and Strategies in Plant Biology Research, Dec 11-14, 2015. Jawaharlal Nehru University, New Delhi, India, pp 72.

Thirumalaisamy PP, Rajyaguru RH, Jadon KS, Lal C, Padvi RD and Dutta R (2016). Epidemiology of Alternaria leaf blight in groundnut and its management. *In*: 6th International Conference on "Plant Pathogen and People" Challenges in Plant Pathology to Benefit. Feb 23-27, 2016. ICAR-IARI, New Delhi, pp 55.

Yadav RS, Meena, HN, Jain, NK, Bhadarka, M, Bhalodia, PK and Parmar H (2016). Distribution of soil phosphorus in different soil types in Saurashtra region of Gujarat. *In*: 25th National Conference on Natural Resource Management in Arid and Semi-arid Ecosystem for Climate Resilient Agriculture and Rural Development, Feb 17-19, 2016. Swami Keshwanand Rajasthan Agricultural University, Bikaner, pp 226.

Technical Bulletins/Popular Articles/Training Manual published

Bera SK and Sunkad G (2016). Prebreeding lines of groundnut resistant to Peanut Bud Necrosis Disease (PBND). ICAR-Directorate of Groundnut Research, Technical Bulletin No. 2/2016. p.20.

Bera SK, Radhakrishnan T, Kasundra SV and Kamdar JH (2016). Phenotyping technique for stem rot disease in groundnut under field conditions. ICAR-Directorate of Groundnut Research, Technical Bulletin No. 1/2016. p.24.

Bishi SK, Mann A, Kumar L, Mahatma MK and Patel KK (2015). Role of miRNAs in plant development. *Agrobios Newsletter*. **XIII**(08): 26-28.

Mann A, Tokas J and Bishi SK (2015). Unlocking genetic diversity through use of molecular markers. *Agrobios Newsletter*. **XIII** (08): 19-21.

Mann A, Tokas J and Bishi SK (2015). Unlocking Genetic diversity through use of molecular markers. *Agrobios Newsletter*. **XIII** (8):19-21.

Nataraja MV and Holajjer P (2015). Insect-pests and nematodes of groundnut and their management. *In*: Narayanan G and Chakraborty K (Ed.) Improved groundnut production technologies for tribal famers of Arunachal Pradesh. ICAR-Directorate of Groundnut Research, Junagadh.

Nataraja MV, Thirumalaisamy PP and Dutta R (2015). IPM-Package for Groundnut. ICAR-Directorate of Groundnut Research, Junagadh, Gujarat, India.

Nataraja MV, Thirumalaisamy PP and Dutta R (2016). IPM-package for groundnut. ICAR-Directorate of Groundnut Research, Junagadh, Gujarat, India. Extension folder 01/2016.

Suresh G, Dobaria KL, Narayanan G, Jain NK, Duraimurugan P, Patel CJ, Rathore B, Padmavathi P, Kumar GDS, and Murthy IYLN (Ed) (2015). Handbook on Technologies for Oilseeds Production in Gujarat. ICAR-Directorate of Oilseeds Research, Rajendranagar, Hyderabad, Telangana. p.124.

Thirumalaisamy PP (2014). Management of aflatoxin contamination in groundnut: Post harvest processing and storage practice. ICAR-Directorate of Groundnut Research, Junagadh. p.1. (English and Hindi)

Thirumalaisamy PP, Dutta R, Jadon KS and Radhakrishnan T (2014). Good agricultural practices for minimizing aflatoxin contamination in groundnut. ICAR-Directorate of Groundnut Research, Junagadh. p.8 (Hindi)

जसरोटिया पी, नटराज एम वी, हरीश जी, होलज्जेर पी एवं सावलिया एस डी (२०१५). मूँगफली में सफ़ेद गिडार का प्रकोप एवं प्रबंधन. गिरनार पत्रिका, २०१४-१५, पृष्ठ १४-१६.

थिरुमलाईसामी पी पी, दत्ता आर, जादौन के एस एवं राधाकृष्णन टी (२०१५). मूँगफली में अफ्लाटोक्सिन संदूषण कम करने की उत्तम कृषि पद्धतियां, भाकृअनुप-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत.

नटराज एम वी एवं जसरोटिया पी (२०१५). मूँगफली कीट प्रबंधन में मेजबान-पौध प्रतिरोध की भूमिका. गिरनार पत्रिका, २०१४-१५, पृष्ठ ३५-३६.

नटराज एम वी एवं सावलिया एस डी (२०१५). मूँगफली में समन्वित कीट प्रबंधन. *In*: मीणा एच न, जादौन के एस व नटराज एम वी (संपा) मूँगफली का उत्पादन, उत्पादकता एवं प्रौद्योगिकी: मध्यप्रदेश में वस्तुस्थिति एवं संभावनाएं. भा कृ अनु प - मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत.

नटराज एम वी, हरीश जी, होलज्जेर पी एवं मीणा एच एन (२०१५). जैविक पद्धति द्वारा मूंगफली में कीट नियंत्रण. गिरनार पत्रिका, २०१४-१५, पृष्ठ १७-१९.

मान ए, टोकास जे और बिशि एस के (२०१५). महिलाओं का कृषि मैं महत्वपुर्न योग्दान. किसान खेती, १(४): १०८-१०९.

मीणा एच एन, जाड़ौन के एस एवं नटराज एम वी (संपा) (२०१५). मूँगफली का उत्पादन, उत्पादकता एवं प्रोधोगिकी: मध्यप्रदेश में वस्तुस्थितिएवं संभावनाएं, प्रशिक्षण पुस्तिका. संयुक्त रूप से आत्मा एवं भाकृअनुप-मूँगफली अनुसंधान निदेशालय, जूनागढ़. पृष्ठ. ९०.

मीणा एच एन, जैन एन के, यादव आर एस एवं राधाकृष्णन टी (२०१५). खरीफ मूँगफली की खेती: समस्याएं एवं समाधान. भाकृअनुप-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत प्रसार फोल्डर ०३/२०१५: पृष्ठ १-८.

मीणा एच एन, भालोडिया पी के, यादव आर एस, जैन एन के एवं राधाकृष्णन टी (२०१५). खरीफ मूँगफली की खेती: समस्याएं एवं समाधान. भाकृअनुप-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत. पृष्ठ १-८. प्रसार फोल्डर ०४/२०१५ (गुजराती)

કુમાર એન, ગંગાધર કે, ગોર એચ કે અને ચીકાણી બી એમ (૨૦૧૫). ગુજરાત માટે સંશોધિત મગફળીની સુધારેલ જાતો. તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના-૨૦૧૬-૧, પૃષ્ઠ ૧૪-૨૫.

કુમાર એન, ગંગાધર કે, ચીકાણી બી એમ, ગોર એચ કે, મકવાણા એ ડી અને પટેલ જે (૨૦૧૫). મગફળી બીજ ઉત્પાદનના સિદ્ધાંત. તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના-૨૦૧૬-૨, ભાકૃઅનુપ-મગફળી સંશોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત. પૃષ્ઠ ૧-૯.

કુમાર એન, ગંગાધર કે, બીશી એસ કે, ગોર એચ કે અને ચીકાણી બી. એમ. (સંકલન) (૨૦૧૬). ઉનાળુ મગફળી માટે ગુણવતા સભર બીજ ઉત્પાદન, તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના-૨૦૧૬-૧, ભાકૃઅનુપ-

મગફળી સંશોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત. પૃષ્ઠ. ૫૮.

કુમાર એન, યાદવ આર એસ, મહાત્મા એમ કે, જાટ આર એ, મકવાણા એ ડી અને ચીકાણી બી એમ (સંકલન)(૨૦૧૬). મગફળી માટે સુધારેલ બીજ ઉત્પાદન ટેકનોલોજી, તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના, ભાકૃઅનુપ-મગફળી સંશોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત. પૃષ્ઠ. ૭૧.

ગેડિયા એમવ., કોરડિયા વીજી અને દત્તા આર (૨૦૧૬). મગફળીના રોગ, લક્ષણ અને સંકલિત રોગ નિયંત્રણ. મગફળી માટે સુધારેલ બીજ ઉત્પાદન ટેકનોલોજી, તાલીમ પુસ્તિકા, ભાકૂઅનુંપ–બીજ પરિયોજના - ૨૦૧૬-૨, ભાકૂઅનુંપ-મગફળી સંસોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત, પૃષ્ઠ ૩૨-૩૮.

જાટ આર એ, કુમાર એન, ગોર એચ કે અને ચીકાણી બી એમ (૨૦૧૬). મગફળી માટે આધુનિક ખેતી પદ્ધતિઓ અને બહાર પાડેલ જાતો. કુમાર નરેન્દ્ર, મહાત્મા એમ.કે., જાટ આર.એ., મકવાણા એ. ડી. અને ચીકાણી બી. એમ. (સંકલન) ૨૦૧૬: મગફળી માટે સુધારેલ બીજ ઉત્પાદન ટેકનોલોજી, તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના - ૨૦૧૬-૨, ભાકૃઅનુપ-મગફળી સંશોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત. પૃષ્ઠ. ૭૧.

જાટ આર એ, કુમાર એન, ગોર એચ કે અને ચીકાણી બી એમ (૨૦૧૫). મગફળી માટે આધુનિક ખેતી પદ્ધતિઓ અને બહાર પાડેલ જાતો. તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના-૨૦૧૬-૨, ભાકૃઅનુપ-મગફળી સંશોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત. પૃષ્ઠ ૧૦-૨૨.

જાટ આર એ, પટેલ એચ વી અને મકવાણા ડી સી (૨૦૧૬). મગફળીના ઉત્પાદન માટેની શ્રેષ્ઠ ખેતી પદ્ધતિઓ. In: કુમાર એન, ગંગાધર કે, બીશી એસ કે, ગોર એચ કે અને ચીકાણી બી એમ (સંકલન) ૨૦૧૬: ઉનાળુ મગફળી માટે ગુણવતા સભર બીજ ઉત્પાદન, તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના - ૨૦૧૬-૧, ભાકૃઅનુપ-મગફળી સંશોધન નિદેશાલય, જુનાગઢ, ગુજરાત, ભારત. પૃષ્ઠ. ૫૮.

જાડોન કે એસ, સાવલીયા એસ ડી, કોરડીયા વી જી, પાડવી આર ડી, થીરુમલાઈસામી પી પી અને દત્તા આર (૨૦૧૫). મગફળીના પાકમાં જમીન જાન્ય રોગોનું વ્યવસ્થાપન. ભાકૃસંપ-મગફળી સંશોધન નિદેશાલય, જૂનાગઢ, ગુજરાત, ભારત.

નટરાજા એમ વી, જાડોન કે એસ, હોલ્લાજર પી, થીરુમલાઈસામી પી પી, જસરોટીયા પી, દત્તા આર અને સાવલીયા એસ ડી (૨૦૧૫). મગફળીના પાકમાં જીવાતો અને રોગોનુ સંકલિત વ્યવસ્થાપન. ભાકૃસંપ-મગફળી સંશોધન નિદેશાલય, જૂનાગઢ, ગુજરાત, ભારત, ટેકનીકલ બુલેટીન નંબર ૦૧/૨૦૧૫, પૃષ્ઠ. ૧૯.

નટરાજા એમ વી, સાવલીયા એસ ડી, જાડોન કે એસ અને દત્તા આર (૨૦૧૫). મગફળીનો ઘેણ અને તેનું વ્યવસ્થાપન. ભાકૃસંપ-મગફળી સંશોધન નિદેશાલય, જૂનાગઢ, ગુજરાત, ભારત. પ્રસાર ફોલ્ડેર ૦૧/૨૦૧૫.

નરેન્દ્ર એન, ગંગાધર કે, ગોર એ કે, ચીકાણી બી એમ અને મકવાણા એ ડી (૨૦૧૬). મગફળી બીજ ઉત્પાદન: સમસ્યા અને સમાધાન. તાલીમ પુસ્તિકા, ભાકૃઅનુપ-બીજ પરિયોજના-૨૦૧૬-૧, પૃષ્ઠ ૧-૮.

સાવલીયા એસ ડી અને નટરાજા એમ વી (૨૦૧૫). મગફળીના પાકમાં જંતુનાશક દવાઓનો સુરક્ષીત ઉપયોગ અને તે અંગેની વિશેષ કાળજીઓ. In: कुमार एन (संपादन) महिला किसानों के लिए मूँगफली में कीटनाशकों का सुरखित उपयोग एवं सावधानियां. भा कृ अनु प-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत.

સાવલીયા એસ ડી અને નટરાજા એમ વી (૨૦૧૬). મગફળીના પાકની જીવતો તેની ઓળખ અને નિયંત્રણ. In: कुमार एन एवं गंगाधारा के (संपादन) ग्रीष्म मूँगफली के लिए गुणवत्ता बीज उत्पादन. भा कृ अनु प-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत.

સાવલીયા એસ ડી અને નટરાજા એમ વી (૨૦૧૬). મગફળીના પાકની જીવતો તેની ઓળખ અને નિયંત્રણ. In: कुमार एन एवं जाट आर ए (संपादन) वैज्ञानिक तकनीक द्वारा ग्रीष्मकालीन मूँगफली का बीज उत्पादन. भा कृ अनु प-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत.

સાવલીયા એસ ડી અને નટરાજા એમ વી (૨૦૧૬). મગફળીના પાકની જીવતો તેની ઓળખ અને નિયંત્રણ. In: कुमार एन एवं बीशी एस के (संपादन) मूँगफली के लिए उन्नत बीज उत्पादन प्रौद्योगिकीयां. भा कृ अनु प-मूँगफली अनुसंधान निदेशालय, जूनागढ़, गुजरात, भारत.

Participation in Conference/ Workshop/ Seminar/ Symposia/ Meetings/ Training Programmes

Bera SK

- 6th International Conference on Plant, Pathogens and People organized by ICAR-IARI, New Delhi on 23-27, February 2016.
- Sustainable Agriculture for Food Security and Better Environment organized by BCKV, Mohanpur, West Bengal on 17-18 December 2015.

- Delivered Lecture on “Utilization of wild *Arachis* species for improvement of groundnut” at National Seminar on 'Sustainable Agriculture for Food Security and Better Environment' organized by BCKV, Mohanpur, West Bengal on 17-18 December, 2015.

Bishi S K

- 3rd International Plant Physiology Congress on “Challenges and strategies in Plant Biology Research” held on 11-14 December, 2015

Chakraborty K

- Attended 3rd International Plant Physiology Congress (IPPC 2015) at Jawaharlal Nehru University, New Delhi, 11-14 December, 2015

Jain NK

- Attended Annual Meeting of Groundnut Researchers, held at Agricultural Research Station, ANGRAU, Kadiri during 12-14 April, 2015.
- Attended Brainstorming Session with Stakeholders of Oilseeds Sector, organized by ICAR-Indian Institute of Oilseeds Research, Hyderabad on 27-28th May, 2015 as DGR Representative.
- Attended Discussion Meeting on Issues Related to Oilseeds by NITI AAYOG, held at ICAR-Indian Institute of Oilseeds Research, Hyderabad on 25th June, 2015.

Jat RA

- Participated in international conference on "Transitioning Cereal Systems to Adapt to Climate Change, Nov. 13-14, 2015, Minneapolis-St. Paul, USA.

Kumar N

- Attended AICRP-G annual groundnut workshop from April 12-14 2015, at ANGRAU, ARS, Kadiri, Andhra Pradesh.
- Monitoring of groundnut AICRP-G trials and breeder seed production in the zone V (Aliyarnagar, Tindivanam, Vriddhachalam and Puducherry) from 21.09.15 to 26.09.15.
- Attended “Brainstorming session on seed quality production” on 19th October, 2015 at DGR, Junagadh.
- Attended and presented poster in 3rd International Plant Physiology Congress (IPPC-2015): Challenges and Strategies in Plant Biology Research” held in December 11-14 at Jawaharlal Nehru University, New Delhi, India.
- Attended project concluding meeting on CGIAR funded project on Multi-location Evaluation of MABC Derived Disease Resistant Groundnut Lines” on 16 December, 2015 at DGR, Junagadh.

Mahatma MK

- 3rd International Plant Physiology Congress on “Challenges and strategies in Plant Biology Research” held on 11-14 December, 2015 and delivered a session lecture on “Changes in Metabolites and Defense Related Enzymes in Groundnut during Leaf Spot Diseases”.

Pal KK

- Attended meeting convened by DDG (CS) for finalizing extramural project proposal 'Alleviation of moisture-deficit stress in groundnut, soybean, chickpea and pigeonpea by application of endophytic bacteria " at ICAR Headquarters on 21-12-2015.
- Attended National Seminar on "Sustainable Agriculture for Food Security and Better Environment" from 17-18th December 2015 at Bidhan Chandra Krishi Visvavidyalaya, Kalyani and made oral presentation of research paper "C3-CAM transition as a tool to develop drought tolerant and WUE crop cultivars".

Rathnakumar AL

- Organized Annual Groundnut Workshop 2015 at ANGRAU-Kadiri from 12-14 April, 2015.

Singh AL

- Attended the workshop on "Enhancement of Production Productivity and area Extension of Groundnut in Bihar" organized by BAMETI and Secretary Agriculture, Bihar on 25th June 2015, and delivered a lecture on the groundnut cultivation in Bihar.
- Attended 3rd International Plant Physiology Congress at JNU, New Delhi from 11-14 Dec, 2015. Also delivered a talk on "Photosynthetic efficiencies in peanut" on 13th Dec, 2016.

Thirumalaisamy PP

- Member, inspection team of APEDA with IOPEPC for inspection at Rajkot and Mahuva.
- Attended annual review meeting of the national agricultural science fund (NASF) at NASC complex on 9th February, 2016.

9

Training and Capacity Building

Ajay BC

- Selected for the prestigious 'Norman E. Borlaug International Agricultural Science and Technology Fellowship Program' and underwent training at Centre for Viticulture and Small Fruit Research, Florida A&M University, Tallahassee, Florida from 7th March to June 4th 2015.

Chandramohan S

- Professional Attachment Training on 'Using genomic tools for groundnut improvement through molecular breeding' at ICRISAT Hyderabad, from 21st May 2015 to 20th August 2015.
- Training programme on 'Computational Tools and Techniques for Molecular Data Analysis in Agriculture' at ICAR-IASRI, New Delhi during Feb 11 - Mar 02, 2016.

Dutta R

- Training for HRD Nodal Officers of ICAR held at NAARM, Hyderabad, 10-12 Feb, 2016.

Ghetia N

- Attended awareness workshop on usage of Unified Messaging Solution held at CIFE, Mumbai, held on 16th Dec, 2015.

Jain NK

- Participated in one day workshop on Development of Roadmap for Agriculture in Gujarat Plains and Hills Region, held on 12th October, 2015 at ICAR-DMAPR, Boriavi, Anand.

Gangadhara K

- Professional Attachment Training on 'Using genomic tools for groundnut improvement through molecular breeding' at ICRISAT Hyderabad, from 21st May 2015 to 20th August 2015.
- Training Programme on Quantitative Techniques for Analysis of Breeding Experiments held at NAARM, Hyderabad, 2-7 Nov, 2015.

Jat RA

- Coordinated workshop on 'Regional Climate Change Adaptation: Envisioning Resilience Building for Coastal Communities of Saurashtra' conducted at ICAR-DGR, Junagadh on 22nd March, 2016.
- Coordinated training programme on 'वैज्ञानिक तकनीक द्वारा ग्रीष्मकालीन मूँगफली का बीज उत्पादन', March 2-4 March, 2016.

Meena HN

- Coordinated training programme on 'मूँगफली का उत्पादन, उत्पादकता एवं प्रोधोगिकी: मध्यप्रदेश में वस्तुस्थितिएवं संभावनाएं', संयुक्त रूप से आत्मा एवं भाकृअनुप-मूँगफली अनुसंधान निदेशालय, जूनागढ़. (5 days)

Kumar N

- Attended Hindi workshop on 'सरकारी कामकाज में राजभाषा कार्यान्वयन' on December 23rd 2015 at ICAR-DGR, Junagadh.

Nataraja MV

- Delivered lecture on 'Integrated Pest Management in Groundnut' at Orientation Course on IPM in Major Crops of Madhya Pradesh, Chhattisgarh and Odisha organized by ICAR-NCIPM, New Delhi at ZPD-7, Jabalpur on 16-17 April, 2015.

Thirumalaisamy PP

- Delivered oral presentation on 'Epidemiology of Alternaria leaf blight in groundnut and its management' at IPS 6th International Conference: Plant, Pathogens and People- Challenges in Plant Pathology to Benefit Humankind from February 23 to 27, 2016 held at NASC Complex, New Delhi, India.
- Delivered lecture on 'Good processing and storage practices for 'minimizing aflatoxin contamination in groundnut' in the ICAR-DGR industrial interface meeting, 2015 at DGR, Junagadh on 15th Dec, 2015.

Singh AL

- Attended workshop on Phenomics and amendments in the Plant/Crop Physiology teaching curriculum in CAUs and SAUs under ICAR organized by Prof. M. Udaykumar at UAS, Banguluru, 27-30 Sept, 2015.

Yadav RS

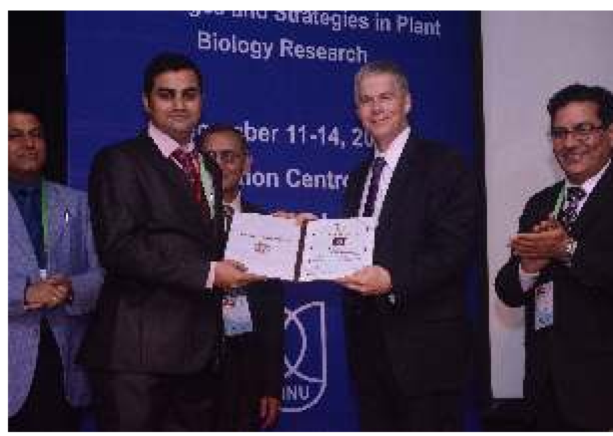
- Coordinated training programme on "મગફળી માટે સુધારેલ બીજ ઉત્પાદન ટેક્નોલૉજી", ભાકૃનુપ-મગફળી સંશોધન નિદેશાલય, જુનાગઢ દ્વારા ત્રણ દિવસીય તાલીમ કાર્યક્રમ (14-16 March, 2016).

Awards / Honours / Recognition

- Ms. Sneha M. Dodia, SRF, Biotechnology bagged 'Second rank in Poster Presentation', for the poster entitled "Parental polymorphism and bulked segregant analysis to identify molecular markers associated with Stem rot disease in groundnut" *In*: International Conference on 'Recent Trends in Applied Sciences: Building Institutional and Industrial Avenues' organized by S.P. University, Anand, Gujarat on 10th - 12th Dec, 2015.

- Dr. Mahesh K. Mahatma, Senior Scientist (Biochemistry) was awarded RD Asana Gold Medal-2015 of Indian Society for Plant Physiology for outstanding contributions in the field of plant physiology and cognate sciences on December 11, 2015 during inaugural session of 3rd International Plant Physiology Congress held at Jawaharlal Nehru University, New Delhi.

- Dr. Koushik Chakraborty, Scientist (Plant Physiology) received 'RD Asana Gold Medal – 2015' from Indian Society for Plant Physiology (ISPP), New Delhi at 3rd International Plant Physiology Congress (IPPC 2015) at Jawaharlal Nehru University, New Delhi, 11-14 December, 2015.



Dr. M.K. Mahatma and Dr. K. Chakraborty receiving the 'RD Asana Gold Medal'

- Dr. R.S. Yadav, Senior Scientist (Soil Science) was awarded Best Paper Award for paper entitled "Distribution of soil phosphorus in different soil types in Saurashtra region of Gujarat"' by Soil Conservation Society of India, SKRAU, Bikaner and Directorate of Watershed Development and Soil Conservation, GOR, Jaipur in 25th National Conference on Natural Resource Management in Arid and Semi-arid Ecosystem for Climate Resilient Agriculture and Rural Development, held during 17-19 February, 2016 at SKRAU, Bikaner.

Meetings

ICAR-DGR Industries Interface Meeting

(15th December 2015, 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 on 15 December, 2015.

Dr Radhakrishnan T, Director, DGR welcomed the participants. Dr K Raja Reddy, Director of Research, ANGRAU, Hyderabad was the chief guest. The other dignitaries attending the meeting were Dr IU Dhruj, Associate Director of Research, JAU, Junagadh; Dr SB Vaghamsi, Deputy Director Agriculture, Junagadh and Dr JB Misra, Technical Adviser, IOPEPC. The meeting was also attended by some groundnut researchers from ICRISAT and AICRP-G centres. Representatives from local export houses, seed industries, major food industries, progressive farmers and manufacturers of farm implements participated in the meeting.

During this meet, the key challenges in the groundnut production across India which needs to be addressed together with industry were discussed thoroughly. Varied aspects like problems faced by the groundnut industries (aflatoxin, etc.), improvement in the seed replacement rate, commercialization of already existing technologies, etc. were covered. The technical session included presentations on successful cultivation of export-worthy groundnut, host resistance for producing disease free export-worthy groundnut, GAP for reducing pre-harvest aflatoxin load, attributes which need improvement for confectionery use, post-harvest aflatoxin contamination and its management in food industries, dovetailing GAP and GMP for export quality groundnut production, biofertilizer formulations developed by DGR (NutBoost and NutMagic), etc.

Dr KK Pal, Principal Scientist, DGR thanked all the speakers from both private and public sectors; entrepreneurs and others who had attended and 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.

XVII Meeting of Research Advisory Committee

The seventeenth meeting of the Research Advisory Committee was held at ICAR-DGR, Junagadh from 5-7th May, 2015. The meeting was chaired by Dr SK Patil, VC, Indira Gandhi Krishi Vishwavidyalaya, Raipur. Other members who have participated in the meeting Dr Masood Ali, Ex-Director, IIPR, Kanpur; Dr A M Parakhia, Director of Extension Education, Junagadh Agricultural University; Dr Radhakrishnan T, Director, ICAR-DGR, Junagadh; Ms Hiraben I Lobi (Progressive Farmer, Jambur, Junagadh) and Shri JKB Gunde (Progressive Farmer, Kolhapur, Maharashtra). Dr. R. Dey (Principal Scientist, ICAR-DGR, Junagadh) was the Member Secretary of 17th RAC meeting.

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

Brainstorming session on Quality Seed Production

(October 19, 2015)

A brainstorming session on quality seed production was held at ICAR-DGR on 19th October, 2015. Dr AR Pathak, VC, Junagadh Agricultural University was the Chief Guest. The meeting was attended by other dignitaries such as Dr JS Chauhan, ADG (Seeds), Shri S Selvaraj, Depty. Commissioner (Seeds), DAC; Dr S Rajendra Prasad, Director, ICAR-DSR Mau; Dr VS Bhatia, Director, ICAR-DSR Indore; and Dr NP Singh, Director, ICAR-IIPR, Kanpur. Dr Radhakrishnan, T., Director, DGR welcomed the delegates. Dr JS Chauhan, ADG (Seeds) presented a brief of the meeting. The issues in seed production were discussed by Shri S Selvaraj, Deputy Commissioner (Seeds). Dr S Rajendra Prasad, Director, ICAR-DSR, Mau gave a presentation on the seed situation in India. The Chief Guest, Dr AR Pathak, in his remarks, mentioned about the importance and significance of quality seed production and its availability to the end users.

This was followed by the presentations on the seed production issues of different crops - Dr VS Bhatia on soybean, Dr Radhakrishnan on groundnut, Dr NP Singh on chickpea, Dr Sanjeev Gupta, Project Coordinator MULLaRP on lentil, Dr AK Sharma, IIWBR on wheat, Dr Jyoti Koul, IIMR on maize. The concluding remarks were presented by Dr JS Chauhan, ADG (Seeds).


Brainstorming session on quality seed production

'Groundnut farmer fair-cum-exhibition' organized by ICAR-DGR

(September 10, 2015)

The Directorate organised a 'Groundnut farmer fair-cum-exhibition' on 10th September, 2015 to acquaint the farmers of Saurashtra region of Gujarat with the improved package of practices for cultivation of groundnut for its sustainable production and improved productivity. In all, there were more than 750 farmers from Devbhoomi-Dwarka, Jamnagar, Amreli, Targhadia, Junagadh, Dhoraji, Bhavnagar, Kodinar,Vishavadar, Keshod, Mangrol, Vanthali, Navsari, Amrapur and Gir-Somnath areas. The sarpanchs of the 30 adopted villages under the "Mera Gaon Mera Gaurav" programme also participated.
Shri Alok Kumar Pandey (District Magistrate, Junagadh) was present as the Chief Guest and Dr BB Singh (ADG-OP, ICAR, New Delhi) as the Guest of honour. The special guests present on the dais included Dr AM Parakhiya (Director of Extension Education, Junagadh Agricultural University, Junagadh); Shri SS Solanki (Joint Director, Agriculture Extension, Government of Gujarat, Junagadh), Deans of Agricultural Engineering, Veterinary College and the Associate Director of Research, JAU were also present. On this occasion, programme coordinators of various Krishi Vigyan Kendras like Targhadia (Rajkot), Porbandar, Jamnagar, Amreli, Bhavnagar, Kodinar and Pipaliya (Dhoraji) and scientists from JAU were also present.

After the inaugural session, lectures on improved groundnut production technologies were delivered by the experts from ICAR-DGR and Junagadh Agricultural University, Junagadh in local languages. Interactive sessions were well organized between scientists and farmers after the formal inaugural session. A competition was also organised for the farmers. As a token of recognition of their efforts in promoting good agricultural practices; some utility items were given away to these farmers as prizes. The farmers were taken around the 'Technology Park' of ICAR-DGR to enable farmers appreciate the impact of various technologies on growth and other yield attributes of groundnut plants. An exhibition comprising 20 stalls was also set up, mainly by the input dealers, the DGR and the JAU. Farmers also visited various stalls exhibiting the agro-chemicals that are now available in market for use in agriculture. Information pamphlets and brochures describing (in Gujarati) various aspects of groundnut were distributed to farmers free of cost.

'Groundnut farmer fair-cum-exhibition' organised by ICAR-DGR

Work Plan 2015-16

Programme 1: Genetic improvement of groundnut

Breeding for tolerance to abiotic stress in groundnut
Ajay BC, Kumar N, Kumar A, Gangadhar K, Chandranohan S

Breeding for resistance to major diseases and insect pests in groundnut
Kumar N, Rathnakumar AL, Lal C, Dagla MC, Jadon KS, Nataraja MV, Dutta R, Gangadhara Kand Chandramohan S

Enhancement and management of groundnut genetic resources
Rathnakumar AL, Bera SK, Mahatma MK, Dagla MC and Ajay BC

Genetic improvement of groundnut for large seed and confectionery traits
Dagla MC, Mahatma MK, Kumar N and Ajay BC

Biotechnological approaches to the characterization and genetic enhancement of groundnut
Kumar A, Mishra GP , Chandramohan S, Rathnakumar AL, Bera SK, Thirumalaisamy PP, Kumar N, Chakraborty K and Nataraja MV

Utilization of wild Arachis gene pools for improvement of groundnut
Bera SK, Thirumalaisamy PP and Ajay BC

Programme 2: Groundnut pests and diseases-emerging problems and their management

Development of management module for soil borne diseases of groundnut
Dutta R and Thirumalaisamy PP

Management of aflatoxin contamination in groundnut
Thirumalaisamy PP and Jadon KS

Management of insect-pests of groundnut
Nataraja MV, Jasrotia P, and Harish G

Influence of fungal pathogens on metabolomes of groundnut
Mahatma MK, Jadon KS & Bishi SK

Programme 3: Enhancing the productivity, sustainability and resilience of groundnut based production system

Development of technologies for enhancing resource use efficiency in groundnut-based cropping systems
Jat RA, Jain NK, Meena HN and Yadav RS

Development of conservation agriculture technologies for groundnut–based cropping system(s)
Jat RA, Jain NK and Yadav RS

Management of soil and irrigation water salinity in groundnut
Meena HN, Yadav RS and Bhaduri D

Studies on dynamics of soil phosphorus under various management practices in groundnut cultivation
Yadav RS, Meena HN, Badhuri D and Ajay BC

Characterization of soil fertility status using GIS tools for location-specific nutrient management in groundnut
Bhaduri D, Yadav RS and Narayanan G

Programme 4: Biochemistry and physiology of groundnut in relation to photosynthetic efficiency, nutritional quality, biotic and abiotic stress tolerance

Iron and zinc bio-fortification in groundnut
Singh AL, Chakraborty K and Bishi SK

Impact of climate change on physiology and productivity of groundnut
Chakraborty K, Singh AL,Bishi SK, Mahatma MK and Jat RA

Physiological studies in groundnut under water-deficit and salinity stresses
Singh AL, Chakraborty K, andMahatma MK

Studies on microorganisms in relation to soil health and plant nutrition in groundnut
Dey R, Pal KK, Thirumalaisamy PP and Bhaduri D

Application of microorganisms for management of biotic and abiotic stresses in groundnut
Pal KK, Dey R, Nataraja MV, Chakraborty K, Ajay BC and Meena HN

Programme 5: Socio economic research and extension for groundnut in developments

Innovative approaches to bridging yield gaps in groundnut through technology dissemination and capacity building
Narayanan G and Jat RA

Staff List

S.No.	Name of employees	Designation
1	Dr. Radhakrishnan T.	Director
2	Dr. A.L. Singh	Principal Scientist (Plant Physiology)
3	Dr. A.L. Rathnakumar	Principal Scientist (Plant Breeding)
4	Dr. Chuni Lal	Principal Scientist (Plant Breeding)
5	Dr. S.K. Bera	Principal Scientist (Genetics & Cytogenetics)
6	Dr. N.K. Jain	Principal Scientist (Agronomy)
7	Dr. K.K. Pal	Principal Scientist (Microbiology)
8	Dr. Rinku Dey	Principal Scientist (Microbiology)
9	Dr. Ram Dutta	Principal Scientist (Plant Pathology)
10	Dr. R.S. Yadav	Senior Scientist (Soil Science)
11	Dr. R.A. Jat	Senior Scientist (Agronomy)
12	Dr. Gyan P. Mishra	Senior Scientist (Plant Breeding)
13	Dr. Anita Mann	Senior Scientist (Plant Physiology)
14	Dr. Mahesh K. Mahatma	Senior Scientist (Biochemistry)
15	Dr. Poonam Jasrotia	Senior Scientist (Entomology)
16	Dr. Har Narayan Meena	Scientist (Agronomy)
17	Dr. Manesh C. Dagla	Scientist (Plant Breeding)
18	Sh. Abhay Kumar	Scientist (Agril. Biotechnology)
19	Dr. Sujit K. Bishi	Scientist (Biochemistry)
20	Dr. Thirumalaisamy P.P.	Scientist (Plant Pathology)
21	Sh. Harish G.	Scientist (Entomology)
22	Dr. Narendra Kumar	Scientist (Plant Breeding)
23	Dr. Koushik Chakraborty	Scientist (Plant Physiology)
24	Dr. Debarati Bhaduri	Scientist (Soil Science)
25	Dr. Kuldeep S. Jadon	Scientist (Plant Pathology)
26	Dr. Kuldeep A. Kalariya	Scientist (Plant Physiology)
27	Dr. Ajay B.C.	Scientist (Plant Breeding)
28	Sh. M.V. Nataraja	Scientist (Entomology)
29	Dr. G. Narayan	Scientist (Agril. Extention)
30	Sh. Murlidhar Meena	Scientist (Agril. Economics)
31	Sh. Sangh Chandramohan	Scientist (Agril. Biotechnology)
32	Dr. K. Gangadhara	Scientist (Plant Breeding)
33	Dr. D.L. Parmar	Chief Technical Officer
34	Sh. D.M. Bhatt	Chief Technical Officer
35	Sh. P.R. Naik	Assistant Chief Technical Officer
36	Sh. N.R. Ghetia	Chief Technical Officer
37	Sh. V.G. Koradia	Chief Technical Officer
38	Sh. P.K. Bhalodia	Chief Technical Officer
39	Sh. P.V. Zala	Assistant Chief Technical Officer
40	Sh. H.B. Lalwani	Assistant Chief Technical Officer

41	Dr. H.K. Gor	Assistant Chief Technical Officer
42	Sh. H.M. Hingrajia	Assistant Chief Technical Officer
43	Dr. J.R. Dobaria	Assistant Chief Technical Officer
44	Dr. M.V. Gedia	Assistant Chief Technical Officer
45	Sh. Ranvir Singh	Assistant Chief Technical Officer
46	Dr. S.D. Savaliya	Assistant Chief Technical Officer
47	Mrs. V.S. Chaudhari	Assistant Chief Technical Officer
48	Sh. B.M. Chikani	Assistant Chief Technical Officer
49	Sh. Virendra Singh	Assistant Chief Technical Officer
50	Sh. D.R. Bhatt	Senior Technical Officer
51	Sh. R.D. Padvi	Technical Officer
52	Sh. H.V. Patel	Technical Officer
53	Sh. J.G. Kalariya	Technical Officer (Tractor Driver)
54	Sh. K.H. Koradia	Technical Officer (Driver)
55	Sh. A.M. Vakhariya	Technical Officer (Photographer)
56	Sh. C.B. Patel	Technical Officer
57	Sh. G.J. Solanki	Senior Technical Assistant
58	Sh. P.B. Garchar	Senior Technical Assistant (Electrician)
59	Sh. N.M. Safi	Senior Technical Assistant (Driver)
60	Sh. A.D. Makwana	Technical Assistant
61	Sh. G.G. Bhalani	Technical Assistant (Driver)
62	Sh. B.M. Solanki	Technical Assistant (Tractor)
63	Sh. Anil K Maurya	Technical Assistant
64	Sh. Lokesh Kumar	Technical Assistant
65	Sh. Pitabas Das	Technical Assistant
66	Sh. Darvesh Kumar	Administrative Officer
67	Sh. R.T. Thakar	Assistant Administrative Officer
68	Mrs. Rosamma Joseph	Personal Secretary
69	Sh. Y.S. Kariya	Personal Assistant
70	Sh. L.V. Tilwani	Personal Assistant
71	Mrs. Santha Venugolan	Assistant
72	Mrs. M.N. Vaghasia	Assistant
73	Sh. M.B. Kher	Security Supervisor
74	Sh. C.G. Makawana	Upper Division Clerk
75	Sh. H.S. Mistry	Upper Division Clerk
76	Sh. P.N. Solanki	Lower Division Clerk
77	Sh. N.M. Pandya	Skilled Support Staff
78	Sh. R.B. Chawada	Skilled Support Staff
79	Sh. D.M. Sachaniya	Skilled Support Staff
80	Sh. M.B. Shaikh	Skilled Support Staff
81	Sh. J.G. Agrawat	Skilled Support Staff
82	Sh. K.T. Kapadia	Skilled Support Staff
83	Sh. V.N. Kodiatar	Skilled Support Staff

84	Sh. R.P. Sondarwa	Skilled Support Staff
85	Sh. V.M. Chawada	Skilled Support Staff
86	Sh. G.S. Mori	Skilled Support Staff
87	Mrs. D.S. Sarvaiya	Skilled Support Staff
88	Sh. P.M. Solanki	Skilled Support Staff
89	Sh. N.G. Vadher	Skilled Support Staff
90	Sh. B.J. Dabhi	Skilled Support Staff
91	Sh. C.G. Moradia	Skilled Support Staff
92	Sh. D.A. Makwana	Skilled Support Staff
93	Sh. Jay Purohit	Skilled Support Staff

Staff Strength

Category of staff	Sanctioned	Filled	General	SC	ST	OBC
Scientific	39+01RMP	32	17	06	03	06
Technical	40	33	19	03	05	06
Administration	17	11	06	02	00	03
SSS	19	17	04	03	03	07
Total	**115+1**	**93**	**46**	**14**	**11**	**22**

DPC/Promotion/ Probation/ MACP

- Sh. VG Koradia promoted to the post of Chief Technical Officer (CTO) from Assistant Chief Technical Officer (ACTO) w.e.f. July 1, 2015.
- Sh. PK Bhalodiya promoted to the post of Chief Technical Officer (CTO) from Assistant Chief Technical Officer (ACTO) w.e.f. July 1, 2015.
- Eight Scientists of our Directorate viz. Drs. MC Dagla, Narendra Kumar, Ajay BC, Prasanna H, D Bhaduri, K Chakaraborty, KA Kalariya and KS Jadon are promoted to RGP 7000 w.e.f. July 1, 2015.

Retirement

- Smt. Mukta Ben Magan Bhai, TSL, retired on 30th September, 2015.

Transfer

- Dr. Poonam Jasrotia, Senior Scientist (Entomolgy) was transferred to ICAR-DWR, Kamal on 10th April, 2015.
- Dr. Anita Mann, Senior Scientist (Plant Physiology) was transferred to ICAR-CSSRI, Kamal on 10th April, 2015.
- Dr. Kuldeep A Kalariya, Scientist (Plant Physiology) was transferred to ICAR-DMAPR, Anand on 25th April, 2015.
- Dr. Ajay BC, Scientist (Plant Breeding) was transferred to ICAR-DGR Regional Research Station, Anantapur as a Station Incharge on 15th June, 2015.
- Dr. Gyan P Mishra, Senior Scientist (Plant Breeding), was relieved from this Directorate on October 23, 2015, upon transfer on promotion as Senior Scientist (GP 9000) at ICAR-Indian Institute of Vegetable Research, Varanasi.

- Dr. Chuni Lal, Principal Scientist (Plant Breeding), was relieved from this Directorate on November 30, 2015, upon transfer to ICAR-Indian Institute of Wheat and Barley Research, Karnal.
- Dr. Manesh C Dagla, Scientist, was relieved from this Directorate on November 30, 2015, upon transfer to ICAR-Central Arid Zone Research Institute, Regional Station, Bikaner.
- Dr. Kuldeep S Jadon, Scientist, was relieved from this Directorate on November 30, 2015, upon transfer to ICAR-Central Arid Zone Research Institute, Jodhpur.
- Dr. Navin K Jain, Principal Scientist, was relieved from this Directorate on December 1, 2015, upon transfer to ICAR Headquarters (HRM Division), New Delhi.

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

Institute Joint Staff Council

Chairman: Director, ICAR-DGR

Members (Staff Side)

1. Shri Y.S. Karia, Secretary-IJSC and Member-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)						
	Non Plan			Plan		
Budget Head	BE	RE	Expenditure	BE	RE	Expenditure
Establishment charges	775.00	750.00	729.68	0.00	0.00	0.00
Wages	50.00	50.00	53.15	0.00	0.00	0.00
Loans & Advances	4.00	4.00	4.58	0.00	0.00	0.00
Pension	20.00	2.06	2.06	0.00	0.00	0.00
T.A.	8.75	8.75	8.73	12.00	10.45	10.45
Recurring Contingencies	135.50	174.44	174.28	233.00	205.40	205.39
HRD	0.75	0.75	0.73	0.00	6.15	6.15
Works	0.00	0.00	0.00	50.00	91.47	91.47
Equipment	5.00	5.00	3.32	15.00	6.25	6.25
Furniture	5.00	2.00	1.99	2.00	0.42	0.42
IT	0.00	0.00	0.00	0.00	0.78	0.78
Books	0.00	0.00	0.00	7.00	0.01	0.01
Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Others	0.00	0.00	0.00	1.00	1.07	1.07
TSP	0.00	0.00	0.00	75.00	71.00	67.51
TOTAL	1004.00	997.00	978.52	395.00	393.00	389.50

AICRP-G (Rs. in Lakhs)		
Budget Head	RE 2015-16	Expenditure
Pay &Allowance	675.00	629.16
TA	9.56	9.56
Recurring Contingency	59.05	59.05
Need Based Research	69.39	29.20
TSP	62.00	61.96
TOTAL	**875.00**	**788.93**