

वार्षिक प्रतिवेदन

ANNUAL REPORT

2012-13



मूँगफली अनुसंधान निदेशालय

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Directorate of Groundnut Research

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

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

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Cover illustration :

- (i) Breeder seed production under polythene mulch**
- (ii) Groundnut flower**
- (iii) Lady bird beetle adult feeding on aphids as natural enemy**
- (iv) A view of Kisan Mela at Kodinar on January 07, 2013**

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P r e f a c e

During the year 2012-13, though the monsoon rains was low and erratic in many parts of the country, the total food grain production is likely to touch a figure of 255 million tons the second highest ever achieved. It is a happy augury. According to the advanced estimates for groundnut crop, in the year 2012-13, the area under groundnut was about 5.0 million ha with an estimated production of 5.43 million tons and an average productivity of 1086 kg ha⁻¹. Obviously, this is not heartening news because in 2011-12, the productivity in India had touched a level of 1341 kg ha⁻¹. The average area, production and productivity of groundnut during XI five year plan period (2002-07) has been reported to be 5.8 million ha, 7.4 million tons, and 1274 kg ha⁻¹, respectively. During this period, although a negative average growth was recorded for groundnut area (0.69%), the average growth in production and yield was quite high i.e. 15.75% for production and 13.65% for yield. The positive growth in productivity can easily be ascribed to a wider adoption of new varieties as well as improved production technologies. The export of groundnuts from India during 2012 touched a new height of 853 thousand tons compared to 434 thousand tons during 2011. Thus in 2012, the export nearly doubled which fetched a foreign exchange equivalent to ₹ 5249.59 crores.

During 2012-13, a total of 17241 q breeder seed comprising 61 varieties was produced at various AICRP-G centers and for demonstrating the new technologies, as many as 705 FLDs were organized in different parts of the country.

Utilization of the grants to the tune of ₹ 424.99 lakhs under 'Plan' and ₹ 780.15 lakhs under 'Non-Plan' for DGR and ₹ 956.2 lakhs for AICRP-G indicate nearly a cent per cent utilization. The funds received through the externally funded projects were also utilized very efficiently as well as effectively.

All the scientists and certain other officials of DGR have contributed the material for this report. But for the painstaking efforts of Dr. R. Dey, Principal Scientist and Dr. G. P. Mishra, Senior Scientist, this report would not have come into the shape it required. I sincerely appreciate their efforts.

Five scientists joined the directorate during 2012-13 taking the total strength of scientists to 33, the maximum so far in the history of DGR. I take this opportunity to thank all the scientists of DGR as well as those of AICRP-G for their untiring efforts in developing new technologies to overcome the existing yield barriers of groundnut and also touching the new frontiers of science. The scientists of DGR published several research articles in refereed national and international journals besides bringing out technical bulletins and contributing book chapters. A variety of training programs designed for scientists, extension officers and farmers were also organized during the year.

I feel extremely happy in presenting this Annual Report of DGR for year 2012-13. I shall appreciate receiving comments from the readers on the content and style of presentation.

J.B. Misra
Director

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Executive Summary

CROP IMPROVEMENT

Kharif- 2012

- To broaden the genetic base of the cultivated groundnut, four interspecific derivatives viz. CS 1, CS 385, CS 409 and CS 410, were used as donor parents.
- Ten fresh crosses were attempted to incorporate traits related to WUE, drought tolerance, thermo-stability, uniform maturity and high shelling outturn. Seven crosses were attempted for incorporating phosphorus-use efficiency into superior genotypes.
- For incorporating the trait of large seed size along with high yield, and other traits of confectionary quality, 19 crosses were attempted. A total of 3328 buds were pollinated and 838 probable hybrid pods were harvested.
- In F_7 , a total of 20 superior and non-segregating new advanced breeding lines were identified for improved water-use efficiency.
- Forty-four advanced breeding lines for various breeding objectives were maintained for future use and were evaluated in different yield evaluation trials. Under strict rain fed conditions i.e. without providing any supplementary irrigation, 210 advanced breeding lines were evaluated.
- From F_6 generation, 18 new advanced breeding lines were developed, among these 17 belonged to Virginia group and one to Spanish group. So far, 85 advanced breeding lines that have been developed for large-seed and other confectionary traits which are being maintained.
- Two lines (PBS 16038 and PBS 16040) were evaluated under IVT II and IVT I trials of AICRP-G.
- Among Virginia group, three entries namely, PBS 25076, PBS 25075 and PBS 25080 were found superior for yield in preliminary evaluation. The Spanish entry, PBS 15041 was found superior in yield across the two seasons (2011 and 2012).
- In advanced trials of Virginia groundnuts, PBS 25033 was found promising for yield traits in 2012 and PBS 25053 in both 2011 and 2012.



- Four test entries namely, PBS 14060, PBS 14064, PBS 11058 and JUN 27 were found significantly superior for yield in both Rainfed and normal irrigated conditions.
- Under low-input conditions, without any application of phosphorus, four genotypes viz., NRCG 7085, NRCG 10126, FeESG 8 and FeESG 10 gave high yield whereas, at under high input conditions i.e. with high dose of phosphorous, TPG 41 and TG 37A were identified as the most responsive.
- Among Spanish mini-core germplasm lines, NRCG14500 was identified for high protein content (33%), NRCG 14470 for low oil content (48%), and NRCG 14430 for high shelling outturn (73%).
- Among Valencia mini-core germplasm lines, NRCG 14379 was identified for high shelling (72%), NRCG 14470 for low oil content (47%), and NRCG 14448 for high protein content (31%).
- For identification of QTLs, recombinant inbred lines ($F_{1,2}$) were developed for the traits of higher harvest index (NRCG-4747 x TMV2 NLM), resistance to PBNB (JL-24 x NRCGCS-86) and enhanced tolerance of salinity (NRCG-4659 x NRCGCS-237).
- Fourteen inter-specific derivatives and five accessions/cultivars were acquired. A few seeds of seven amphidiploids namely: *A. cardenasii* x *A. villosa*; *A. batizocoi* x *A. kuhlmannis*; *A. correntina* x *A. helodes*; *A. helodes* x *A. pusilla*; *A. duranensis* x *A. stenosperma*; *A. duranensis* x *A. cardenasii* and *A. stenosperma* x *A. cardenasii* were also acquired.
- An interspecific derivative, NRCGCS-414, found promising for pod yield, shelling out turn and sound mature kernel weight over two seasons, was identified for AICRP testing.
- Interspecific lines derived from 'J11 x *A. pusilla*' and identified to be resistant to major foliar diseases also showed higher SCMR and low SLA.
- The accession number NRCG 14396, recorded a low (10%) incidence of stem rot.
- Across the ploidy levels, 2C value differed significantly in *Arachis* and an approximately 1.15-fold increase in 2C value was observed in pentaploid genome



over its diploid one. C-value, however, did not increase proportionately with the increase of ploidy level though it was found positively co-related with ploidy level.

- The transgenic events carrying the *mtlD* gene were characterized for their tolerance to water-deficit stress and improved tolerance in the transgenics was established.
- The quantitative transgene expression in the transgenic events, carrying *defensin* gene was worked out and the events expressing higher levels of transgene were identified.
- Validation of the SSR markers, associated with late leaf spot and rust was carried out using 100 selected genotypes.
- SSR markers linked with higher kernel mass in groundnut was identified and validated.
- Molecular diversity was detected in 115 interspecific derivatives resistant to PBNB and diverse parents were identified for mapping of resistance genes/QTLs.
- A total of 600 accessions were supplied to various indenters including scientists of DGR (573), SAUs (25) and others (2) for crop improvement programme aimed at identifying promising lines for WUE, large-seed, diseases and nematode tolerance.
- As many as 1424 accessions comprising voucher samples (284), DGR mini-core collection (167), exotic accessions (59), new germplasm accessions (47), accessions repatriated from ICRISAT (223), released varieties (173), large-seed accessions (30), 28 accessions having low carbon isotope discrimination ($\Delta^{13}\text{C}$) and others traits (413) were multiplied.
- Multiplication of 2000 accessions received from NBPGR, was arranged at five AICRP-G centers (TNAU, Vridhachalam, ANGRAU Kadiri, UAS Dharwad, MPKV Rahuri and JAU Junagadh).
- Quality seed (34.78 q) was produced at DGR farm and another programme to produce 50 q seed has been taken up. A sum of ₹ 373199/- was earned by selling 51.69 q seed of different classes.



Summer 2012

- Seed of 15 new advanced breeding lines were multiplied, and 13 advanced breeding lines and 188 RILs were evaluated under irrigated and drought stress conditions.
- One advanced breeding line (PBS 15031), was found to be highly tolerant to drought stress.
- The yield of two genotypes viz., NRCG 10078 and SP250 was found quite high even under low-input conditions (without application of any phosphorus).
- Twenty-eight genotypes, which included 12 released varieties, 7 ICRISAT mini-core collections, and 9 accessions of subset of DGR working collection which exhibited low ^{13}C values (around 18.0) were studied for 16 yield component traits, physiological traits (SLA and SCMR), and biomass production under moisture-deficit and irrigated conditions.
- The pod yield plant⁻¹ was the lowest in the variety TMV 10 under both irrigated (3.0 g) and moisture-deficit stress (1.2 g) conditions, while it was highest (18.8 g plant⁻¹) in variety BG 2 under irrigated conditions. Under moisture-deficit stress conditions, the yield of the check-variety ICGV 86764 was the highest (8.1 g plant⁻¹), followed by GG 2 (7.3 g plant⁻¹).
- Among the genotypes evaluated, the incidence of stem rot was in the range of 25-100% and the lowest incidence was observed in accession NRCG 14499.
- From the eleven cross combinations (generated during *kharif*-2011), 170 single plant progenies (SPP) were selected for further generation advancement.
- Two large-seeded advanced breeding lines, PBS 19018 and PBS 19022, identified for high yield were entered into AICRP-G trials for *Rabi* summer season.

CROPPRODUCTION**Khariif-2012**

- Application of polythene mulch significantly improved pod yield by 14.4%. Application of 75% NPK through drip significantly improved pod yield by 11.4% over 50% NPK. Thus, there was an effective saving of 25% NPK when applied



through drip irrigation compared to soil application of RDF (with check basin method of irrigation).

- Application of 20-40-30 kg NPK (urea-DAP-MOP)+250 kg gypsum+10:2:1 kg Fe Zn B ha^{-1} produced maximum pod yield (1616 kg ha^{-1}) while haulm yield was maximum (3595 kg ha^{-1}) with application of 12.5:25:0 kg recommended NPK + 5 t FYM + 500 kg gypsum ha^{-1} .
- Changes in schedules of irrigation did not significantly affect the yield attributes as well as pod and haulm yields. Application of hydrogel @ 1.5 kg ha^{-1} significantly improved pod and haulm yields by 9.6 and 16.4%, respectively.
- Application of 25 kg N, 26.4 kg P and 24.9 kg K ha^{-1} significantly improved the productivity over the current RDF (12.5 kg N and $17.6 \text{ kg P ha}^{-1}$).
- Water with four levels of salinity (0.5 to 6 dS m^{-1}) was used in groundnut – cluster bean rotation for one year (2012-13). It was concluded that $2\text{-}3 \text{ dS m}^{-1}$ salinity of water was the threshold salinity but the yield of dry fodder of cluster bean was significantly reduced with use of saline water for irrigation. Significant differences in pod and haulm yields were observed among the varieties. The pod and haulm yields of TG 37A was significantly higher than those of GG 2 in summer season but the opposite was true for *kharif* season. Moreover, the performance of seeds obtained from crop irrigated with normal water better than the seeds obtained from the crop irrigated with saline water. Application of potassium @ 30 kg ha^{-1} ameliorated the effect of water salinity.

Summer- 2012

- Application of 2 t FYM + 2 kg citric acid ha^{-1} improved both pod and haulm yields as well as economic returns. Soil phosphorus status also improved due to this treatment.
- Application of sulphur through SSP (40 kg ha^{-1}) to groundnut and 75% of recommended dose of sulphur to maize, significantly improved the productivity of summer groundnut-maize cropping system.
- Application of 37.5 kg N, 30.8 kg P and 24.9 kg K ha^{-1} improved the yield over RDF ($25:22:0 \text{ kg NPK ha}^{-1}$) besides improving soil fertility.



- Pendimethalin and imazethapyr have only a transient adverse effect on available ammonium, nitrate-N and available phosphorus as the activities recover within a few days or weeks.
- Application of irrigation, either at 6-day intervals through drip, or 15-day intervals with check basin method to summer groundnut, resulted in saving of 2.3% and 21.7% water over 4-day intervals through drip or 10-day intervals under check basin, respectively.
- Overall, there was a saving of about 48% water in drip irrigation. Pod and haulm yields improved significantly with application of 75% NPK through drip by 17.9 and 9.9%, respectively over 50% NPK through drip and were at par with other treatments. Thus, there was a saving of 25% NPK over RDF.
- Maximum net returns (₹ 85,099 ha⁻¹) were obtained with a combination of use of polythene mulch, application of 2.5 kg ha⁻¹ hydrogel and integrated management schedule.
- There was a significant increase in pod yield with the application of 40-60-60 kg NPK (Ammonium sulfate-single super phosphate-muriate of potash) + 10:2:1 kg Fe:Zn:B ha⁻¹.

CROPPROTECTION

Entomology

- Among four combination-insecticides evaluated in summer and *kharif* 2012, the combination of acephate 25% + fenvalerate 3% @ 0.028% applied at 30 DAG was found the best in controlling leafhopper and thrips and was at par with the standard check, monocrotophos @ 0.04% applied at 30 and 45 DAG. Another combination, profenophos 40% + cypermethrin 4% @ 0.044% applied at 30 and 45 DAG was found effective during only *Rabi*-summer.
- Among seven new molecules evaluated during *Rabi*-summer as well as *Kharif*-2012, acetamiprid @ 0.01%, thiamethoxam @ 0.01%, imidacloprid @ 0.008% and monocrotophos @ 0.04% were found effective for controlling thrips, while thiamethoxam @ 0.01%, imidacloprid @ 0.008% and monocrotophos @ 0.04% were effective for controlling leafhopper.



- The population of leafhopper (4.7 to 8.3 hoppers per 5 sweeps) was quite low in five advanced breeding lines, viz., PBS12038, 12074, 12171, 12172 and 18062. Whereas, the genotypes, PBS12032, 12038, 12163, 12169, 12171, 12172, 12186, 13022 and 18064 while being at par with each other, harbored the very small population of thrips (8.6 to 11.1 thrips per 5 sweeps).
- Among ten genotypes of groundnut screened for resistance to bruchid, there were not significant differences in for beetle's egg-laying capacity and emergence rate, and damage caused to kernels. However, the lowest damage to pods (57.9%) and kernels (64.5%) was observed in groundnut variety Girnar 2.
- Amongst four different types of storage bags evaluated for their ability to prevent bruchid beetle infestation, super-grain bag was found to be most effective with lowest pod damage during a storage period of four months. However, there was no damage in pods and kernels treated with castor oil, eucalyptus oil, neem oil, or pongamia oil at 10% (ml oil/g seed) and neem oil at 5% (ml oil/g seed).

Plant Pathology

- Different genotypes were screened for resistance to stem rot and collar rot pathogens in sick soil. The lowest disease incidence was recorded in CS 405, CS 407 and CS 319.
- A combination of application of *Trichoderma harzianum* isolate T-170, ploughing with mould-board, and soil solarization with transparent polythene sheets, was found quite effective for managing stem rot.
- For controlling the severity of leaf spots and rust diseases, spray of difenoconazole and tebuconazole were found quite effective
- Cabrio and nativo were found effective for alternaria blight, which often appears in groundnut grown during summer.
- Plots treated with arbuscular mycorrhizal fungus (100 g/m²) showed a low incidence of stem rot.
- Rotation of *kharif* groundnut with maize, sorghum, or fallow in summer effectively lowered the population of *Aspergillus flavus* in soil.



Nematology

- The virulence of entomopathogenic nematode, *Steinernema carpocapsae* against *Spodoptera litura*, showed that the LC_{50} (no. of infective juveniles per cm^2 for 50% larval mortality after 48, 72 and 96 h of inoculation) was 49, 5 and 4 cm^{-2} for on 3rd instar larvae while it was 253, 7 and 2 cm^{-2} for 4th instar larvae.
- *In-vitro* application of *Eucalyptus* oil (4000 ppm), caused 100% and 81.5% mortality in juveniles of root-knot nematodes, *M. arenaria* and *M. incognita*, respectively after an exposure of 72 h.
- Soil infestation of the root-knot nematode, *M. arenaria* at high level (1000 J₂/100 cm^3 of soil) resulted in significantly higher number of galls and egg-masses and consequent increase in reactive oxygen species in the leaves of groundnut.

BASIC SCIENCES

Plant physiology

- Imposition of water-deficit stress during pod development stage adversely affected pod yield. The yield of DRG 1 was the lowest (143 $g\ m^{-2}$) while that of ICGS 44 was the highest (206 $g\ m^{-2}$).
- With the least increase in H_2O_2 content, variety TG 37A (0.99 $\mu mol\ g^{-1}\ FW$) and JL 24 (1.21 $\mu mol\ g^{-1}\ FW$) was considered the best under high temperature stress.
- Under late season drought conditions the application of salicylic acid @ 2.0 ppm resulted in only 19% loss of yield compared to 40% loss observed otherwise.
- Under water deficit stress (irrigation 25% of normal) the maximum trehalose (81.71 $mg\ g^{-1}$) content was seen in AK 159 and minimum in JL 501 (14.21 $mg\ g^{-1}$).
- The seed dressing with Mo (source and dose) exerted synergistic effect along with biofertilizers and biocontrol agents in groundnut.
- Ten high Fe and 15 high Zn density groundnuts were identified.
- Foliar application of Zn fertilizer fortified Zn content in groundnut seeds.
- Out of 114 groundnut genotypes screened for iron chlorosis, several genotypes were identified to be tolerant.



Microbiology

- Application of AM fungi, *Glomus mosseae*, *Glomus etunicatum* and *Glomus fasciculatum* enhanced the pod (7-16%) and haulm yields. Among the five newly isolated strains of groundnut rhizobia viz., RH17, SRR7, RH11, RH29 and PAS1 7-2 the strain RH17 was adjudged to be the best for enhancing pod yield of cultivar TG 37A.
- In cultivar GG 20, the application of DAPG-producing fluorescent pseudomonads (known for its antifungal activities) brought down the plant mortality due to stem rot from 70% to nearly 40%..

Biochemistry

- Among 44 popular groundnut cultivars, M 13, M 548 and ICGS 76 were identified for low oil and high sucrose contents with a desirable fatty acid composition.
- The cultivars GG 14, GG 16 and GG 21 were identified as high O/L ratio cultivars.
- Under water deficit stress, sucrose content of groundnut kernels increased by 15-28% while O/L ratio value decreased.

SOCIAL SCIENCES

- The superiority of improved technologies was demonstrated in farmers' fields so far as pod yield and in quality of both pod and haulm are concerned. Compared to the farmers' practice, the pods produced by adopting improved practices fetched a sale price higher by ₹ 3-4 per kg.
- In summer OFTs, among the four taluks, maximum pod yield (3261kg/ha) was recorded in Una while the minimum (700 kg/ha) in Sutrapada. The highest "average taluk pod yield (2963 kg/ha) was recorded in Una while the highest BCR (3.13) was recorded for Kodinar.
- In Kharif OFTs, among the 8 taluks, the maximum pod yield (4000 kg/ha) was in Kodinar and the minimum (750 kg/ha) was in Keshod.
- The highest average taluk pod yield (2980 kg/ha) was recorded for Kodinar but the highest BCR (4.36) was seen in Una.



- The analysis of data on monthly peanut oil wholesale prices revealed that the price variation was highest in the Chennai markets. The highest average wholesale price of ₹ 5,652 Qt⁻¹ was observed in Delhi markets.
- During January 1992 to December 2011, all the major markets viz. Chennai, Hyderabad, Kolkata, Mumbai, Rajkot and Delhi markets were found to be integrated with one or more markets in long run.
- Analysis of time series data from 1980-81 to 2010-11 on groundnut area, production, and productivity in India, indicated a positive growth during pre-liberalization phase, negative growths in post-liberalization and post-WTO periods.

PUBLICATIONS, TRAININGS, SEMINARS ETC.

- A total of 20 research papers were published during 2012-13 in various national and international journals.
- Most of the scientists participated and presented their research findings in various national and international conferences, symposia, seminars and other fora.
- In DGR during 2012-13, total six trainings/ symposia/ seminars were organized for the farmers, scientists and students, covering different aspects of groundnut improvement technologies.



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

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

Sub-project 1 : Breeding for tolerance of abiotic stresses in groundnut

(CHUNI LAL, AJAY B.C. AND A.L. SINGH)

Hybridization, selection and generation advancement in F₂ and onward generations

In *kharif* 2012, ten fresh crosses were attempted to incorporate drought tolerance its related traits; high thermo stability and yield attributes; (Table 1a). Empirical selection was exercised at the time of harvest on the basis of perceived pod yield, plant characters, pod numbers, pod shape and pod filling, was exercised. Two crosses were rejected in F₂ and the remaining crosses were advanced to F₃ as selected bulks. In case of P-use efficiency also two crosses were rejected in F₂ and the remaining crosses were advanced to F₃ by single seed descent method. Similarly bulk selections were operated in F₃ to F₄ generations and the selected bulks were advanced to the respective next filial generations. Seven and three bulks in F₄ and F₅ generations respectively were also selected for AICRPG centres for further selection at the selected locations.

Table 1a. Cross wise pollinations attempted, hybrid pods harvested and crossing success during *kharif* 2012 season

Parents	Trait of interest	Buds pollinated (no.)	F ₁ pods harvested (no.)	Crossing success (%)
Girnar 2 x CS 385	High SCMR and Low SLA	349	110	35.9
Girnar 3 x CS 409	Drought tolerance	355	151	38.1
Girnar 2 x PBS 14081	High yield/pods	354	107	31.1
PBS 14081 x CS 410	High SCMR and low SLA	331	115	24.8
PBS 15031 x ICGS 44	High thermo-stability	357	111	29.3
Girnar 3 x NRCG 14425	Uniform maturity	342	105	31.9
PBS 14081 x NRCG 14405	High shelling	371	76	34.1
PBS 21087 x CS 1	Drought tolerance (Low SLA)	331	100	22.4
PBS 16038 x CS 1	Drought tolerance (Low SLA)	312	58	22.1
JAL 42 x CS 385	Drought tolerance	271	64	29.8
Girnar 3 x FDRS 10	P-use efficiency	193	80	41.5



TG 37 A x FDRS 10	P-use efficiency	233	124	53.2
BAU 13 x NRCG 1308	P-use efficiency	262	23	8.8
CS 281 x NRCG 1308	P-use efficiency	252	58	23.0
GG 20 x NRCG 1308	P-use efficiency	243	42	17.3
GPBD 4 x NRCG 1308	P-use efficiency	320	99	30.9
CS 196 x NRCG 1308	P-use efficiency	216	65	30.1
Total		4743	1378	29.0

Raising of F_1 generation and identification of true hybrids

Ten crosses attempted in *kharij* 2011 were raised in summer 2012 and cross wise true hybrid plants were selected. In total 981 fully mature kernels were obtained from 1162 pods (others have rudimentary pods) harvested as probable hybrid pods in *kharij* 2011, and these kernels were sown cross-wise. At the time of harvest, true hybrid plants were identified. Over all 40 plants in all the crosses were harvested which were true hybrids (Table 1b).

Table 1b. Identification of true hybrid plants in summer 2012

Parents	Objective of cross	True hybrid plants selected (no.)
Girnar 2 x Girnar 3	Fresh seed dormancy	5
Girnar 2 x Girnar 1	Drought tolerance	8
Girnar 2 x PBS 14081	High yield/pods	4
PBS 14081 x TMV 2 NLM	Drought tolerance (High SCMR)	Rejected
PBS 14081 x PBS 15031	High HI	Rejected
Girnar 3 x NRCG 14425	Uniform maturity	4
PBS 14081 x NRCG 14405	High shelling	7
PBS 21087 x CS 1	Drought tolerance (Low SLA)	1
PBS 16038 x CS 1	Drought tolerance (Low SLA)	2
JAL 24 x ICR 3	Drought tolerance	9

Similarly, ten crosses generated in *kharij* 2011 for P-use efficiency were raised along with their parents in summer 2012. On the basis of plant-vigour, pod characters, and other dominant male characters, the true hybrids were identified. Pods of the identified plants were harvested separately for further advancement. Two doubtful crosses were rejected and from the remaining eight crosses, 130 confirmed hybrid plants were identified.



New advanced breeding lines developed

In F₇ filial generation, 20 non-segregating and superior advanced breeding lines (6 Spanish and 14 Virginia) were isolated. These lines were derived from single or three way crosses attempted to introgress surrogate traits of water-use efficiency (Table 2).

Table 2. Superior advanced breeding lines isolated during *kharif* 2012 season

Parents	Advanced breeding line isolated
Spanish	
GG 2 x TAG 24	PBS 15049
JL 24 x TAG 24	PBS 15050
NRCG 11535 x TAG 24	PBS 15051
GG 2 x (TAG 24 x TMV 2 NLM) F ₁	PBS 15052
PBS 11049 x (TAG 24 x TMV 2 NLM) F ₁	PBS 15053
ICGV 98383 x (TAG 24 x TMV 2 NLM) F ₁	PBS 15054
Virginia	
PBS 24030 x TAG 24	PBS 25101
PBS 24030 x TAG 24	PBS 25102
PBS 12160 x TAG 24	PBS 25103
PBS 12160 x TAG 24	PBS 25104
NRCG 1022 (NCAc 1705) x TAG 24	PBS 25105
NRCG 1022 (NCAc 1705) x TAG 24	PBS 25106
Chico x TMV 2 NLM	PBS 25107
PBS 24030 x TMV 2 NLM	PBS 25108
PBS 24030 x TMV 2 NLM	PBS 25109
PBS 24030 x (TAG 24 x TMV 2 NLM) F ₁	PBS 25110
PBS 24030 x (TAG 24 x TMV 2 NLM) F ₁	PBS 25111
JL 24 x (TAG 24 x TMV 2 NLM) F ₁	PBS 25112
PBS 12160 x (TAG 24 x TMV 2 NLM) F ₁	PBS 25113
PBS 12160 x (TAG 24 x TMV 2 NLM) F ₁	PBS 25114



Maintenance breeding and seed enhancement

Forty-four advanced breeding lines (8 Spanish and 36 Virginia) developed under this project with different breeding objectives were maintained and their seed was multiplied in *kharif* 2012. These lines also included six Spanish and eight Virginia advanced breeding lines developed for early maturity. In addition, seed of eleven advanced breeding lines (PBS 16035, PBS 16038, PBS 16040, PBS 16044, PBS 15031, PBS 14082, PBS 14083, PBS 24133, PBS 24134, PBS 24135, PBS 24136, PBS 24137, PBS 24138 and PBS 24139) was enhanced. These lines have been found promising in the station trials and will be evaluated under the AICRP-G trials.

In addition seeds of 15 new advanced breeding lines (PBS 21109, PBS 21110, PBS 21111, PBS 21112, PBS 21113, PBS 21114, PBS 21115, PBS 21116, PBS 21117, PBS 25094, PBS 25095, PBS 25096, PBS 25097, PBS 14066, PBS 15014), 13 of which were developed in *kharif* 2011, were increased in summer 2012 to meet the seed requirement for testing these entries in station trials.

Advanced breeding lines in AICRP-G trials

Two advanced breeding lines PBS 16038 and PBS 16040 were under evaluation in initial varietal trial stage I (Spanish) and one line PBS 15031 in initial varietal trial stage II (Spanish) of AICRP-G in *kharif* 2012 and summer 2013, respectively.

Station trials for yield evaluation

Eighty-eight advanced breeding lines (test entries) developed earlier were evaluated in station yield evaluation trials. Observations were recorded on WUE-traits (SCMR and SLA, $\text{cm}^2 \text{g}^{-1}$), pod (PY, kg ha^{-1}) and kernel yields (KY, kg ha^{-1}), hundred seed mass (HSM, g), hundred selected seed mass (HSSM, g), sound mature kernels (SMK, %) and shelling out turn (SOT, %) preliminary trials, and also on dry fodder yield (DFY, kg ha^{-1}), harvest index based on pods (HIP, %) and seeds (HIS, %) in advanced yield evaluation trials.

Preliminary yield evaluation trial of breeding lines of Spanish groundnut

Sixteen advanced Spanish breeding lines along with four check varieties (GG 7, JL 501, SG 99 and TG 37A) were evaluated. The differences due to genotypes were highly significant for all the traits studied except for SLA. Among the check varieties, SG 99 was adjudged to be the best for WUE-traits, while for pod yield it was GG 7. Two advanced breeding lines PBS 15024 and PBS 15025 outperformed the best check variety for SCMR. None of the advanced breeding line was found superior for SLA, PY, KY, SMK and SOT. Two lines, PBS 14080 and PBS 11085, were significantly superior for HSM and HSSM. Besides, HSSM was recorded significantly superior in PBS 15024 also. The highest pod yield was recorded in PBS 15022 among the test entries (Table 3).



Table 3. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield traits in preliminary yield evaluation trial (*kharif*2012)

Genotypes	Traits							
	SCMR	SLA	PY	KY	HSM	HSSM	SMK	SOT
PBS 15022	31	151	2546	1614	32	53	46	63
PBS 15047	32	181	2469	1728	41	60	53	70
PBS 15028	31	176	2338	1503	33	52	31	64
PBS 14080	32	189	2259	1433	47*	80*	58	63
PBS 15025	38	153	2209	1360	33	56	44	61
PBS 11085	33	158	1958	1316	49*	75*	51	67
PBS 15024	38	218	1684	1330	45	71*	48	82
GG 7	31	173	2619	1842	43	61	75	70
JL 501	28	185	2248	1621	34	53	46	72
SG 99	35	136	2222	1467	39	59	45	66
TG 37 A	30	171	2171	1486	40	51	58	69
Mean	33	165	2014	1346	38	59	49	67
		135-	1456-					
Range	28-39	218	2619	884-1842	25-49	49-80	31-75	59-82
CD (5%)	3.9	62.6	342.4	272.5	3.5	9.7	13.1	11.6

Advanced yield evaluation trial of breeding lines of Spanish groundnut

Single year evaluation

Fourteen advanced Spanish breeding lines along with three check varieties (GG 7, JL 501, SG 99, TG 37A) were evaluated. Differences due to genotypes were significant for all the traits studied except for SLA. SG 99 was adjudged to be the best check for WUE traits *i.e.* it recorded highest SCMR and lowest SLA. None of the test entries was found superior for these two traits compared with the means of SG 99. GG 7 was the best check variety for PY and KY, and the only significantly superior test entry for both these traits was PBS 15041. JL 501 was the best check for Hip and Hlk, and GG 7 for HSM. The test entry PBS 15048 outperformed the best checks for Hip and HSM. Significantly superior performance PBS 15038 and SE 8 were recorded for the traits SOT and HSSM, respectively (Table 4).



Table 4. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (*kharif* 2012)

Genotypes	Traits										
	SCMR	SLA	PY	KY	DFY	Hlp	Hlk	HSM	HSSM	SMK	SOT
PBS 15041	33	168	2834*	2077*	2960	49	36	39	55	67	73
PBS 14076	33	168	2564	1529	4766	35	21	32	45	44	59
PBS 15048	30	179	2028	1345	1717	54*	36	51*	67	68	66
PBS 15038	28	192	2005	1488	2368	46	34	32	43	57	75*
SE 8	37	158	1957	1346	3567	36	25	45	69*	57	69
GG 7	33	164	2239	1614	3508	39	28	47	63	66	72
JL 501	28	172	2151	1540	2753	44	31	37	53	43	72
SG 99	35	141	2203	1449	4914	31	20	41	57	40	66
TG 37 A	32	157	2156	1478	2960	42	29	41	57	58	69
Mean	22	113	1567	1057	2519	27	19	27	38	36	45
			1957-	1345-	1717-		20-				
Range	28-37	141-192	2834	2077	5461	31-54	36	32-51	43-69	39-68	58-75
CD (5%)	4.1	31.9	405.5	271.4	1130.5	6.7	4.8	3.4	6.2	13.2	2.7

Evaluation over two years

A set of eight advanced breeding lines was evaluated in *kharif* 2011 and 2012 along with two check varieties GG 7 and TG 37A. Highly significant genotypic differences were found for all the traits studied. Barring SLA, highly significant effects of years and interaction between years x genotypes were found for the studied traits. Significant PY and KY were obtained in the test entry PBS 15041 over the best check variety TG 37A – a variety gaining popularity among the farmers of Saurashtra region – for these traits. SE 8 performed significantly superior for HSM and HSSM over the best check GG 7 for these two traits. The best check variety GG 7 for SOT was also outperformed by the test entry PBS 15038 for this trait (Table 5).

Table 5. Performance of selected advanced Spanish breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (*kharif* 2011 and 2012)

Genotypes	Traits							
	SCMR	SLA	PY	KY	HSM	HSMK	SMK	SOT
PBS 14074	28	180	1712	1013	32	43	34	57
PBS 14076	31	180	1639	964	26	36	33	58
PBS 15038	27	205	1257	911	25	34	37	70*
PBS 15041	29	192	1853*	1304*	32	45	46	67
SE 8	33	166	1472	995	40*	58*	48	67
GG 7	29	191	1449	1019	36	47	49	68
TG 37 A	31	179	1589	1053	34	45	42	65
Mean	30	184	1553	1021	32	44	39	64
Range		166-	1257-	911-				
	27-33	205	1853	1304	25-40	34-58	28-49	57-70
CD (5%)	2.9	19.7	253.7	164.9	2.5	3.4	9.0	2.3



Evaluation of selected Spanish advanced breeding lines under irrigated and rain-fed conditions

Sixteen groundnut genotypes were tested in *kharif* 2012 in a split plot design where irrigation was main treatment with two levels (regularly irrigated and rain depended). Observations were recorded on 16 traits. Plots both under the regularly irrigated as well as rain fed treatments received equal rains and no additional irrigation was provided to the irrigated plots. Therefore, the observations on six traits namely, SCMR, SLA, nodule number, active nodule, fresh and dry weights of active nodules recorded in both the treatments was analyzed in a simple RBD. However, at the end of the season, the monsoon had receded and the irrigated plots received two additional irrigations. The data on the traits collected at the time of harvest and post-harvest was subjected to split plot analysis. ANOVAs revealed significant genotypic differences for all the traits studied. The irrigation treatments were found to be significant only for three traits HIp, kernel length and ratio of kernel width to kernel length. Interaction between irrigation treatments and genotypes were significant for HSM. When means of test entries were compared with the check varieties, three test entries JUN 27, PBS 14060 and PBS 14064 were found to be significantly superior for fresh and dry weights of nodules. Pod and kernel yields were also found to be significant in these test entries (JUN 27, PBS 14060 and PBS 14064) in addition to PBS 11058. Two test entries PBS 14060 and PBS 14064 also registered significant HSM, MHSS and kernel length, besides former being significantly superior for kernel width. PBS 14066 also performed significantly superior for IISM, MIISS and kernel length. For kernel length the test entries PBS 11058 and PBS 11084 also performed significantly superior (Table 6).



Table 6. Performance of selected genotypes across the irrigated and rain-fed conditions of *kharif* 2012

Traits	Genotypes										
	PBS 14060	PBS 14064	PBS 11058	JUN 27	PBS 11084	PBS 14066	GG 2	Girnar 3	TG 37A	CD (5%)	CV (%)
Physiological traits											
SCMR	38	35	36	35	34	37	35	35	33	3.7	9.8
SLA	139	140	167	146	150	137	177	154	155	20.9	12
Biological nitrogen fixation traits											
Nodule nos.	44	38	25	52	62	31	34	40	41	18	48.2
Active nodule no.	24	26	8	26	17	15	22	11	29	8.1	47.2
Active nodule's fresh wt. (g)	0.19*	0.16*	0.04	0.17*	0.09	0.08	0.1	0.03	0.11	0.05	52.7
Active nodule's dry wt. (g)	0.07*	0.06*	0.01	0.06*	0.03	0.03	0.03	0.01	0.04	0.02	54.9
Yield traits											
PY (kg ha ⁻¹)	3166*	2958*	2889*	2673*	2550	2066	1755	2127	2205	410	17
KY (kg ha ⁻¹)	2297*	2080*	1905*	1920*	1643	1327	1290	1477	1471	279	17
SOT (%)	73	71	66	72	64	64	74	70	67	2	2
Illp (%)	27	29	37	39	32	41	31	37	45	4	11
Physical traits of kernel quality											
100 kernel wt. (g)	44*	43*	37	38	35	43*	30	29	39	2	6
HSSM	57*	55*	47	49	46	52*	37	39	49	3	5
SMK (%)	50	52	36	42	37	43	42	34	54	10	21
Kernel length (mm)	16*	16*	16*	15	16*	16*	13	15	15	1	4
Kernel width (mm)	10*	9	9	9	9	9	8	8	9	0.44	5
KW/KL	0.62	0.6	0.53	0.59	0.53	0.57	0.64	0.55	0.59	0.03	4.55



Preliminary yield evaluation trial of breeding lines of Virginia groundnut

Thirty-three advanced Virginia bunch breeding lines (test entries) along with three check varieties (GG 20, Somnath and Kaushal) were evaluated. Highly significant differences due to genotypes for all the traits studied were observed. The check variety Somnath was adjudged to be the best among the check varieties for SCMR and Kaushal for SLA with the highest and lowest values, respectively for these traits. For PY and KY Somnath was found to be the best check variety. When the means of the test entries were compared with that of the best check variety, it was found that PBS 250294 and PBS 25055 were significantly superior to best check Somnath for SCMR. Significantly superior PY and KY were observed in PBS 25076 and PBS 21040, in addition to PBS 25075 which also had significant PY over the best check for this trait. Significantly superior HSM and HSSM were recorded in seven advanced breeding lines; and three and one lines for SMK and SOT, respectively (Table 7).

Table 7. Performance of selected advanced Virginia breeding lines for SCMR, SLA and yield traits in preliminary yield evaluation trial (*kharif*2012)

Genotypes	Traits							
	SCMR	SLA	PY	KY	HSM	HSSM	SMK	SOT
PBS 25076	34	146	2562*	1521*	40	56	36	60
PBS 25075	34	165	2399*	1422	41	56	46	59
PBS 25080	32	148	2140*	1455*	38	52	44	68
PBS 21093	34	135	2044	1397	46*	73*	43	68
PBS 21104	32	139	1681	1127	52*	86*	36	67
PBS 21105	31	143	1655	1105	44*	72*	56*	67
PBS 25085	31	148	1645	1156	51*	81*	57	70
PBS 25029	38*	125	1625	1127	47*	64	44	69
PBS 26033	31	151	1580	1057	53*	85*	45	67
PBS 21102	33	144	1479	1037	45*	66	37	70
PBS 21107	31	149	1452	1064	37	54	51	73*
PBS 25083	31	174	1378	920	37	53*	45	67
PBS 25055	37*	138	1357	957	40	64	52	70
PBS 25073	32	160	1262	823	42	68*	40	65
PBS 25045	34	153	1084	666	29	46	56*	61
PBS 25064	32	166	883	619	31	48	65*	70
GG 20	29	168	1743	1168	39	63	47	67
Somnath	31	142	1763	1185	39	60	35	67
Kaushal	33	125	1258	846	31	50	41	67
Mean	17	78	861	574	22	33	24	35
Range	29-38	125-174	883-2562	619-1521	29-53	46-86	35-65	59-73
CD (5%)	4.0	30.0	333.5	274.0	5.0	6.7	5.3	3.2



Advanced yield evaluation trial of breeding lines of Virginia groundnut

Single year evaluation

Twenty-eight groundnut genotypes comprising twenty-five advanced breeding Virginia bunch lines and three check varieties (Somnath, GG 20 and Kaushal) were evaluated. Genotypes were found to differ for all the traits studied. In four test entries namely, PBS 21096, PBS 25090, PBS 25091 and PBS 25092 SCMR was recorded to be significantly superior over the best check variety Kaushal. Both PY and HIp were found to be significant in PBS 25033 when compared with the best check GG 20 for PY and Somnath for HIp. Significantly superior HIp was also recorded in PBS 25092 (15042) and PBS 25047 eateries (Table 8).

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

Genotypes	Traits										
	SCMR	SLA	PY	KY	DFY	HIp	Hlk	HSM	HSSM	SMK	SOT
PBS 25033	29	166	2292*	1532	4242	36*	24	33	48	33	67
PBS 25092 (15042)	38*	163	1799	1225	3173	36*	24	39	59	39	67
PBS 21096	38*	149	1600	1142	5622	22	16	45	70	46	71
PBS 25047	32	171	1541	1036	2817	36*	24	35	54	39	67
PBS 25091 (15040)	40*	130	1375	972	3295	29	21	40	55	44	71
PBS 25090 (15039)	39*	127	1089	773	4064	21	15	37	53	50	71
Somnath	32	149	1648	1061	4131	29	19	39	60	32	65
GG 20	32	146	1765	1264	5088	26	18	48	69	57	72
Kaushal	33	134	1473	975	3952	27	18	32	52	35	66
Mean	16	73	802	535	1928	14	9	17	26	19	31
Range	29-40	127-194	1089-2292	773-1532	2817-5622	21-36	15-24	31-48	47-70	32-57	61-72
CD (5%)	4.2	32.0	355.6	292.2	1240.0	7.1	5.6	3.4	6.3	10.8	8.6

Evaluation over two years

A set of 17 advanced breeding lines was evaluated in kharif 2011 and 2012 along with two check varieties GG 20 and Somnath. The variation due to genotypes was highly significant. Differences due to years were also significant for SLA, PY, KY, HSSM and SMK. Interaction due to year x genotypes were significant for HSM and HSSM traits. PBS 25053 was found significantly superior in PY compared to the best check variety. For remaining traits none of the test entries were significantly superior over the respective best check variety (Table 9).



Table 9. Performance of selected advanced Virginia breeding lines for SCMR, SLA and yield traits in advanced yield evaluation trial (*kharif*2011 and 2012)

Genotypes	Traits							
	SCMR	SLA	PY	KY	HSM	HSSM	SMK	SOT
PBS 25049	35	163	1557	563	31	46	31	55
PBS 25053	33	171	1650*	884	33	47	39	67
GG 20	36	154	1421	872	44	60	50	72
Somnath	35	155	1420	742	40	57	34	66
Mean	34	165	1221	657	36	51	38	67
Range	29-39	135-199	870-1650	459-884	30-44	41-62	30-50	55-72
CD (5%)	5.1	30.2	228.4	198.1	2.6	4.5	9.6	6.1

Drought Screening Nurseries

In *kharif*2012, 210 advanced breeding lines were screened in two drought screening nurseries, 105 in each, in augmented RBD design using three checks (ICGS 76, ICGS 44 and Girnar 1) repeated three times. The crop was not given any supplementary irrigation and was grown under strictly rain-fed conditions. The season received rains which were almost normal in distribution except at the end of season when the crop experienced mild drought stress. The top ten ranking genotypes under rain-fed situations are enlisted in Table 10.

Table 10. Ten top ranking genotypes for pod yield under rain-fed conditions

Genotype	Drought nursery 1	Drought nursery 2	
	Pod yield (g plant ⁻¹)	Genotype	Pod yield (g plant ⁻¹)
PBS 16017	11.2	PBS 25049	28.6
JUN 27	10.9	ICGS 76	18.0
PBS 24022	10.7	PBS 25031	18.0
ICGS 76	10.1	PBS 14082	17.2
PBS 16045	9.9	Girnar 1	16.9
PBS 24073	9.8	PBS 15022	15.4
PBS 26020	9.7	PBS 25050	15.4
PBS 30001	9.7	PBS 25056	14.8
PBS 16004	9.6	PBS 15021	14.8
PBS 11073	9.5	PBS 25048	14.6
Girnar 1	9.3	PBS 26039	14.4



Genotypic responses for biochemical, physiological, biological nitrogen fixation and physical kernel-quality traits under water-deficit stress in advanced breeding lines of groundnut (*Arachis hypogaea* L.)

Sixteen groundnut genotypes were tested in summer 2012 under irrigated (Fig.3) and simulated water-deficit stress conditions (Fig.4). Observations on biochemical, physiological and biological nitrogen-fixation traits, and pod yield were recorded when the crop in the stressed plots was undergoing water-deficit stress at pod filling stage (71 to 89 days after sowing; DAS), and on yield traits after harvest of the crop which continues to undergo water-deficit stress at the time of maturity (99 to 111 DAS) also. Drought susceptibility index (DSI) was calculated on the pod yield basis. Soil samples were regularly collected at 0-5 cm and 5-10 cm depths to measure the soil-moisture content gravimetrically (Fig. 3). Soil temperature was recorded at 5 cm and 10 cm soil depths both under irrigated and stressed conditions at 8 am, 12 am and 4 pm (Fig. 4).

Except for relative water content (RWC), net assimilation rate (NAR) and SMK, highly significant genotypic differences were observed for all the traits studied. Barring crop growth rate (CGR), number of nodules, fresh and dry weights of nodules, SMK, KW and KW/KL, highly significant differences in variances due to irrigation treatments were found for all the traits studied. Genotypes x irrigation interactions were significant for SCMR, fodder yield (FY), leaf weight ratio (LWR), leaf growth rate (LGR), relative leaf growth rate (RLGR), active nodules, fresh and dry weights of nodules, proline, wax, chl_b, HSM, HSSM and seed length (SL).

Genotypes namely, PBS 16031, PBS 11084, PBS 14060, GG 2 and Girnar 3 were the top five for high pod yield (PY) across the irrigated and drought stress environments. In general, genotypes performing better under irrigated conditions also performed better under stress conditions as evident from the significant Pearson's correlation for PY ($r = 0.65$, $P < 0.01$) and HI ($r = 0.72$, $P < 0.01$). However, percent reduction in PY was independent of the yields obtained under irrigated conditions ($r = 0.017$), indicating that tolerance of water-deficit stress is a genotype-dependent trait. DSI revealed that the advanced breeding line PBS 15031 was the most tolerant one as it registered the lowest DSI followed by PBS 16038, and PBS 30055, PBS 16040 and GG 2. GG 2 is an old and still popular variety among the farmers of Saurashtra, and is known for tolerance of drought. PBS 16023 was adjudged to be the best genotype as it gave highest pod yield both under irrigated and drought stress conditions and ranked 6th in the increasing order of drought susceptibility index.

Among the physiological traits, there was substantial decrease in SLA, relative water content (RWC), leaf area ratio (LAR), crop growth rate (CGR), leaf growth rate (LGR) and relative leaf growth rate (RLGR); however, in case of net assimilation rate (NAR) majority of the genotypes registered several folds increase in response to the water-deficit stress. Yield traits also decreased substantially in response to the water-deficit stress.



In case of biochemical traits namely, contents of proline, epicuticular wax load (EWL), Chl a and Chl b, substantial increase was observed in response to water-deficit stress in majority of the genotypes).

Among the biological nitrogen fixation traits, substantial decreases were observed for number nodules and active nodules, and fresh weight of active nodules in majority of the genotypes. In case of dry weight of active nodules decrease was observed in ten genotypes, but six genotypes registered increase in response of water-deficit stress.

Among the physical-kernel quality traits, substantial decrease was observed in HKW in response to drought stress, though increase in IISM was recorded in one genotype PBS 16041.

Relationship of per cent change in the magnitude of different biochemical, physiological and biological nitrogen fixation traits in response to water-deficit stress with the DSI revealed that three traits namely, EWL ($r = -0.64, P < 0.01$), HI ($r = -0.60, P < 0.05$), RWC ($r = -0.63, P < 0.01$) and KL ($r = -0.50, P < 0.05$) were negatively associated.

Conclusion: The genotypes that deposit more EWL, and have least decrease in the HI and RWC in response water-deficit stress are likely to possess more tolerance of drought stress. At locations with known occurrence of drought at the end-of season, the genotypes with least DSI should be grown. Conversely, the genotypes with high yielding potential should be grown to maximize the yields under high input conditions.

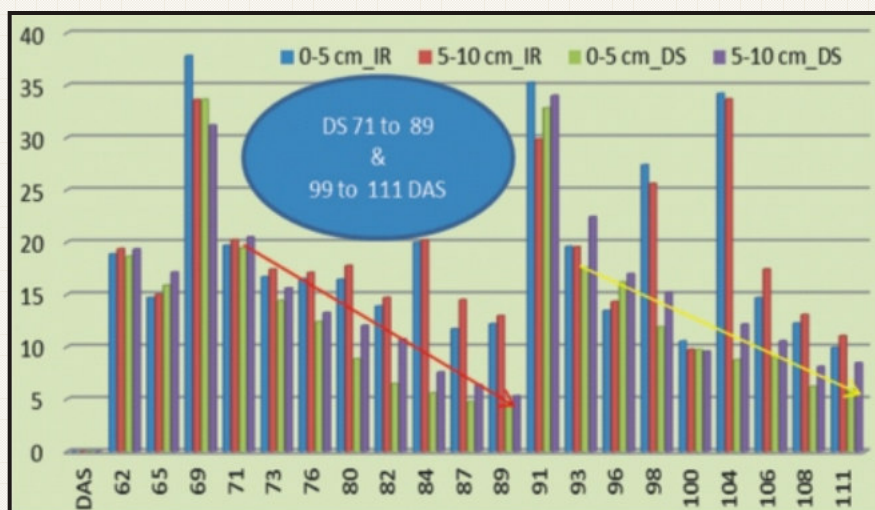


Fig. 1: Soil moisture content (%) of irrigated (IR) and stressed (DS) plots at 0-5 and 5-10 cm depths



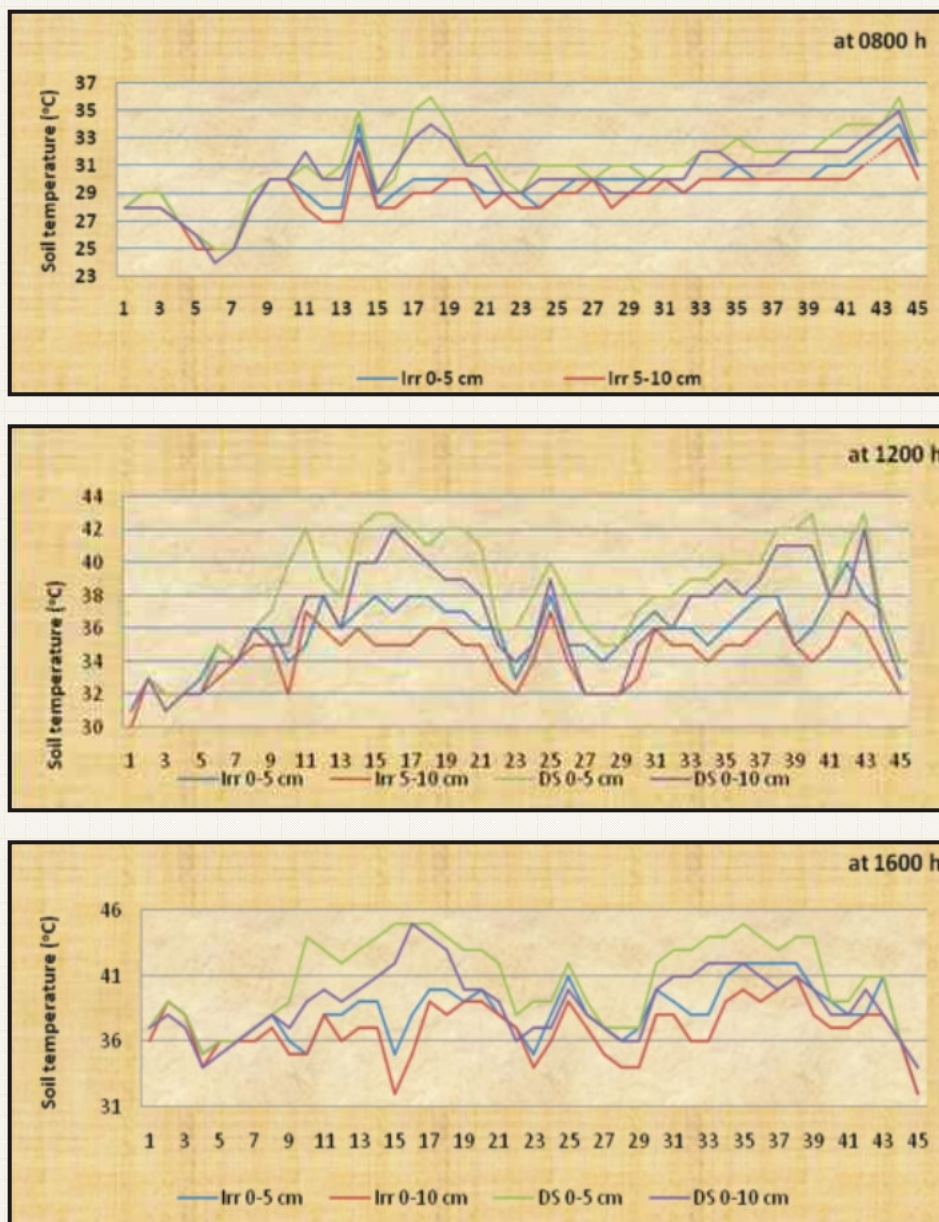


Fig.2. Soil temperature (°C) of irrigated (Irr) and stress (DS) plots at 0-5 cm and 5-10cm depths recorded at 0800, 1200 and 1600 h





Fig.3. Groundnut crop under simulated water-deficit stress



Fig.4. Groundnut crop under normal irrigated conditions



Evaluation of advanced breeding lines under irrigated and mid-season simulated drought situations

One hundred eighty eight advanced breeding lines derived from a cross TAG 24 x TMV2 NLM were sown in a split plot design with two irrigation treatments (irrigated and drought) as main plot treatments and 188 genotypes as sub-plot treatments in summer 2012. The plot size was 2-rows of 3-m each. Soil moisture content was recorded every alternate day at 0-5 and 5-10 cm soil depth, before and after irrigation. The soil temperature was recorded daily at 8 am, 12 am and 4 pm at 0-5 and 5-10 cm soil depth. Observations on 19 different traits namely, days to flower initiation (DFI) and 50% flowering (DF50), SCMR, specific leaf area (SLA), water saturation deficit(WSD), per hectare pod (PY) and kernel (KY) yields, shelling out turn (SOT), harvest index based on pod (HIp) and kernel (Hik) yields, 100-seed mass (HSM), 100-seed mass of sound mature kernels (HSMK), proportion of sound mature kernels (SMK), kernel length (KL), kernel width (KW), KW/KL, contents of oil, protein and moisture in kernel, were recorded following standard procedures (SLA was recorded after floating the plucked leaves in water for 3 hrs). Mid-season drought was imposed.

The ANOVA revealed that main plot treatments (irrigation treatments) were significant only for three traits (HSM, HSMK and Kernel length), though significant genotypic differences (subplot treatments) were observed for all the traits (18 traits), except WSD. Interactions of genotypes with the irrigation treatments (main plot x sub-plot) were significant for seven traits (DF50, SCMR, PY, KY, HSM, HSMK and protein content). Though imposition of drought stress did influence the expression of HSMK and Kernel length, but absence of interactions suggests that the drought stress had linear influence in the expression of these traits.

Genotypes were selected for the traits for which their performance was exceptionally high. In total 47 such genotypes were isolated from the total original 188 lot of genotypes. These comprised 11 of Spanish group and 36 Virginia group. The selected genotypes will be evaluated further in station trials.

Screening of genotypes for phosphorous (P) uptake (summer 2012)

Summer 2012

Twenty-four genotypes were screened for P-uptake during summer 2012. Experiment consisted of two treatments, i) T1: application of P @ 50 kg ha⁻¹ and (ii) T2: Without any application of P. Nitrogen @ 50 kg ha⁻¹ and Potassium 60 kg ha⁻¹ were applied in both the treatments. Samples of leaf, shoot and kernels were analyzed for P content. Analysis of variance indicated significant genotypic differences for the characters studied with exception of primary branches. Interaction between genotype and treatments was significant for hundred seed mass, kernel and pod yield, leaf-P and kernel-P. Under low-P conditions (T2), pod yield of NRCG 10078, followed by SP 250A were high while accumulation of shoot-P was highest in TPFPG 41 (Table 11).



Table 11. Yield performance and shoot-P content of selected groundnut genotypes in summer 2012

Genotypes	PY (g plant ⁻¹)		Shoot-P (mg g ⁻¹)	
	T1	T2	T1	T2
Girnar 3	19.6	14.7	1.0	0.8
NRCG 5007	17.2	12.3	1.2	0.8
NRCG 10078	30.0	26.4	1.0	1.4
NRCG 13182	16.7	16.9	0.6	1.5
NRCG 15049	18.0	21.8	1.2	0.9
TG 37 A	7.2	26.6	1.1	1.5
TPG 41	9.0	22.3	1.8	1.4
GG 5	15.8	13.7	1.4	1.9
Fe ESG 8	19.8	19.9	1.0	0.8
Fe ESG 10	25.4	22.4	1.0	1.1
SP 250 A	27.6	23.3	1.4	1.7
VRI 3	18.1	17.6	1.5	1.7
B 95	17.4	17.9	1.7	1.4
NRCG 162	11.5	12.0	1.7	2.2
CV (%)	23.8		22.7	

Kharif 2012

Twenty-three genotypes were screened for P-uptake in kharif 2012. Experiment consisted of three treatments, i) T1: application of P @ 50 kg ha⁻¹; (ii) T2: without any application of P and iii) T3: application of P @ 100 kg ha⁻¹. Nitrogen @ 50 kg ha⁻¹ and potassium @ 60 kg ha⁻¹ were applied in all the treatments. Shoot samples (collected 60 days after sowing) were analysed for P-content. The Shoot-P uptake was obtained as a product of shoot-P content (mg g⁻¹) and dry shoot biomass (g plant⁻¹). In T1, high pod yield was obtained from VRI 3, Girnar 3 and SP 250A. The differences due to genotypes, P-levels and genotype X P interactions were highly significant for pod yield and shoot-P uptake. The yield of genotypes NRCG 7085, NRCG 10126, FeESG8, FeESG10 was high under low-P conditions whereas genotypes TPG 41 and TG37A responded to high P-application (T3) by their high shoot-P uptake and high yield (Table 12).



Table 12. Yield performance and shoot-P content of selected groundnut genotypes in Kharif 2012

Genotypes	PY(g plant ⁻¹)			Shoot-P uptake (mg plant ⁻¹)		
	T1	T2	T3	T1	T2	T3
Girnar 3	6.0	2.4	4.1	26.7	24.8	32.9
NRCG 7085	1.4	2.3	1.9	25.8	28.9	29.6
NRCG 10078	4.9	2.5	4.7	32.2	33.8	40.0
NRCG 10126	4.3	5.4	2.8	24.7	28.9	26.3
NRCG 13182	5.1	4.7	3.9	47.1	51.3	43.7
TG 37 A	4.8	4.7	5.1	28.2	27.6	30.7
TPG 41	4.1	4.4	5.8	23.9	22.5	27.7
Fe ESG 8	2.0	5.5	2.4	29.5	36.1	27.2
Fe ESG 10	5.1	5.8	5.4	45.5	39.2	54.2
NRCG 1308	4.4	4.4	3.1	30.7	29.4	32.9
SP 250 A	6.0	4.4	4.1	43.8	41.6	43.0
VRI 3	6.3	1.6	4.7	37.5	41.5	43.9
B 95	5.8	2.2	3.5	32.6	32.0	40.9
GG 7	6.1	4.2	4.6	29.7	32.2	38.6
CV%	13.34			16.67		

Sub-project 2. : Breeding and genetic studies on tolerance of biotic stresses in groundnut

1. Crosses effected: Ten crosses were effected in *kharif* 2012 to develop improved varieties resistant/tolerant of major diseases (Table 1). Of these, five crosses were effected to study the genetics of foliar disease resistance, three for tolerance to stem rot and one cross each for imparting seed coat resistance to *A.flavus* and multiple tolerance to sucking pest. The number of harvested cross-pods varied from 43 to 125. In two crosses, ICGV 00350 x JSP 39 (125 cross-pods) and RHRG 06083 x ICGV 86031 (84 cross-pods), the number of probable cross-pods were relatively more. The success rate of the hybridisation programme ranged from 23.7% to 48.7%. High rate of success was observed in two crosses viz., TG 37 A x CS 19 (48.7%) followed by ICGV 00350 x JSP 39 (44.1%).



Table 1. Crosses were effected in *kharif* 2012

Cross	Objective	F ₁ pods harvested (Nos.)	Success rate (%)
BAU 13 x CS 196	Foliar disease resistance	47	26.5
CS 281 x CS 196	Foliar disease resistance	69	35.7
GG 20 x GPBD 4	Foliar disease resistance	45	27.9
GG 20 x CS 196	Foliar disease resistance	47	26.7
GPBD 4 x CS 196	Foliar disease resistance	57	25.4
GG 20 x CS 19	Tolerance of stem rot	43	23.7
TG 37 A x CS 19	Tolerance of stem rot	76	48.7
J 11 x GG 20	Resistance to <i>A. flavus</i>	64	25.0
ICGV 00350 x JSP39	Tolerance of stem rot	125	44.1
RHRG 06083 x ICGV 86031	High yield and multiple tolerance of sucking pests and resistant to PBND	84	28.6

2. Raising of F₁'s

Summer 2012: Ten crosses effected for developing resistant genotypes to collar rot, stem rot, *A. flavus*, PBND and sucking pests of groundnut during *kharif* 2011 were raised in summer 2012 to identify true F₁s. A total of 208 probable single plants have been identified as true hybrids in all the ten crosses. Number of true F₁s were maximum (35) in the cross ICGV 00350X J 11 and minimum (8) in Girnar 2 X OG 52-1 (Table 2).

Table 2. Details of F₁'s raised and true hybrids isolated in Summer 2012

Cross	Objective	F ₁ pods obtained (Nos.)	Success rate (%)	True hybrids isolated (Nos.)
GG 20 x J 11	For developing mapping population for <i>A. flavus</i>	52	20.3	24
ICGV 00350 x J 11	For developing Mapping population for <i>A. flavus</i>	160	53.1	35
GG 20 x CS 19	Tolerance to stem rot	50	19.5	21
TG 37A x CS 19	Tolerance to stem rot	80	49.7	10
GG 20 x OG 52-1	Tolerance to collar rot	55	18.6	25
Girnar 2 x OG 52-1	Tolerance to collar rot	44	21.4	8
TG 37A x Kadiri 3	High yield and tolerance to PBND	65	41.7	12
ICGV 00350 x R 8808	High yield and tolerance to PBND and leaf spot	122	55.5	30
SG 99 x ICGV 86031	High yield and multiple insect tolerance	41	18.8	16
Dh 86 x Girnar 1	High yield and tolerance to sucking pests	100	30.8	27
Total		769	32.9	208



3. Advancement of different filial generations

The breeding materials generated earlier were advanced to next higher filial generation in *kharif* 2012. Progenies of 57 crosses were advanced to different filial generations. The number of crosses in early generations (up to F_4) were 36 and in advanced generation, 21. In F_6 generation, 14 stable advanced breeding lines were identified of which 10 were of Spanish bunch and 4 were of Virginia botanical group.

4. Development and generation advancement of mapping populations

To develop mapping populations (GG-20 x J-11 and ICGV-00350 x J-11) for incorporating seed coat resistance to *A.flavus*, two crosses were effected in *kharif*- 2012 using J11 as a donor parent. Six mapping populations developed earlier for tolerance of stem rot and multiple diseases, were raised in different filial generations in *kharif*- 2012. Three populations in F_3 were for mapping stem rot resistant genes and three populations which were in F_4 generation were for mapping resistant genes of rust, LLS and PBND (Table 3)

Table 3. Mapping Populations (RILs) in different generations in *kharif* 2012

Generations	Cross	Purpose	RILs
F₃	GG 20 x CS 19	Tolerance of stem rot	359 (372)
	GG 20 x CS 75	Tolerance of stem rot	96 (300)
	GG 20 x CS 83	Tolerance of stem rot	245 (258)
F₄	JL 24 x VG 9816	Tolerance to multiple diseases	363 (380)
	GG 20 x CS 19	Tolerance of stem rot	134 (680)
	GG 20 x JSP39	Tolerance of stem rot	560 (566)

* Figures in parenthesis indicate the original number of RILs raised in *kharif* 2011 season

5. Yield evaluation of advanced breeding lines

A. Summer, 2012

Five Spanish advanced breeding lines (PBS 12180, 12181, 12183, 12185, 12186) along with two checks (TAG 24 and Dh 86) were evaluated for yield and its component traits in a randomised block design (RBD) with three replications. Analysis of variance indicated significant differences among the genotypes for all the traits. Among two checks, TAG 24 was found to be the best for flowering, pod yield/plant, pod yield (kg/ha) and sound mature kernels (%) (Table 4). The pod yield per plant (16.7g) and pod yield per ha (3702 kg) were high in TAG 24 and which out yielded all the test and other genotypes. Among the test genotypes, PBS 12181, for pod yield was found to be high yielding (3133.3 kg/ha).

The genotype PBS 12180 was found to be significantly superior over both checks variety for early flowering, 100-kernel weight (HKW) and 100 sound mature kernel weight



(HSMK). For early flowering, two advanced breeding lines (PBS 12183, PBS 12185) were also found significantly superior over both check varieties. One advanced breeding line PBS 12183 was found to be significantly superior over the best check for shelling outturn.

Table 4. Yield evaluation trial (Spanish) in summer 2012

Genotypes	DF	Pod yield		Shelling	HKW	HSMK	SMK
		Yield (g)/plant	Yield (Kg/ha)	outturn (%)	(g)	(g)	(%)
PBS 12180	43.7**	7.9	1743.9	69.1	69.7**	81.3***	48.7
PBS 12181	48.3	14.1	3133.3	65.0	27.3	36.0	48.0
PBS 12183	45.7**	9.9	2208.1	74.3*	31.0	39.7	51.7
PBS 12185	46.0**	12.4	2748.8	70.0	35.3	46.0	49.7
PBS 12186	48.7	12.1	2683.3	71.8	28.7	36.0	51.7
TAG 24	47.0	16.7	3702.4	68.0	41.7	52.3	58.3
Dh 86	47.3	15.2	3370.3	69.8	42.7	52.3	48.3
S.Em.±	0.44	1.31	291.51	1.81	1.97	1.38	1.97
CD (p=0.05)	1.38	4.04	898.30	5.59	6.07	4.25	6.06
CV (%)	1.66	18.0	18.04	4.50	8.64	4.87	6.69

*, ** Significance at P=0.05 and P=0.01 levels, respectively.

B. Kharif, 2012

Sixteen advanced breeding lines, five Spanish bunch and 11 Virginia bunch were evaluated for yield and its component traits in RBD with three replications. For the Spanish bunch advanced breeding lines, the check varieties were GG 7 and TG 37A while for Virginia, GG 20 and Somnath were used. For flower initiation, among the Spanish group, the check variety GG 7 was early (23 days) and none of the Spanish bunch advanced breeding lines was significantly superior to GG 7. Similarly in Virginia group, the check variety GG 20 was the earliest (25 days) and none of the advanced breeding lines were superior to GG 20.

For pod and kernel yields, the check variety GG 7 was the best (1826.2 kg pod and 1331 kg kernel/ha) in the Spanish group. While GG 20 was the best (1877.4 kg pod and 1338.7 kg kernel/ha) for both pod and kernel yields in Virginia group. None of the Spanish bunch advanced breeding lines were significantly superior over GG 7 for pod and kernel yield while one Virginia bunch advanced breeding line, PBS 22080 was significantly superior to GG 20 only for pod yield (2563.2 kg/ha). The duration for maturity among Spanish types ranged between 105 and 112 days whereas in Virginia types between 112 and 116 days (Table 5).



Table 5. Yield evaluation trial (Spanish and Virginia) in *kharif* 2012

Genotypes	FI	DFF	DM	PY (kg/ha)	KY (kg/ha)	SOT (%)	HKW (g)	HSMK (g)	SMK (%)
PBS 12180	24.3	30.3	104.7	1336.6	1005.4	75.1	25.5	35.2	66.3
PBS 12181	22.7	24.7	106.7	1438.8	1063.9	73.9	26.6	35.5	58.7
PBS 12183	24.3	28.0	108.7	1171.0	835.0	71.0	25.2	37.1	60.3
PBS 12185	22.7	24.7	110.3	1572.7	1101.7	69.5	30.7	48.0	43.0
PBS 12186	23.0	25.0	112.0	2189.8	1498.9	69.1	34.0	53.6	65.0
PBS 22075	28.7	35.3	115.0	1484.2	1005.1	67.0	30.5	46.8	43.0
PBS 22076	24.3	27.7	112.0	1583.2	1162.8	73.5	49.6	65.7	73.0
PBS 22077	25.0	28.0	112.0	1867.9	1326.8	70.6	47.2	70.1	67.3
PBS 22080	26.7	31.3	115.7	2563.2*	1736.6	67.8	38.5	54.8	53.0
PBS 22081	28.3	32.3	116.3	2109.1	1431.2	68.1	35.4	54.2	54.7
PBS 22082	28.7	36.0	112.7	1077.0	693.1	64.1	33.0	55.0	40.3
PBS 22083	28.7	32.3	113.7	1454.6	961.7	66.2	35.5	53.2	35.3
PBS 22084	29.0	34.3	112.3	1713.3	1097.4	64.2	33.3	51.4	31.7
PBS 22086	29.0	35.3	111.7	1513.6	978.0	64.7	39.0	58.0	31.3
PBS 22088	30.0	38.3	115.0	1234.1	781.8	63.3	42.9	70.1	55.3
PBS 22091	28.7	36.3	114.0	1463.2	1072.3	73.3	37.2	51.5	47.3
GG 7	23.0	26.7	113.3	1826.2	1331.0	73.0	44.2	58.7	81.3
TG 37 A	25.0	33.0	105.3	1416.5	950.0	66.2	36.9	54.8	57.7
GG 20	25.3	28.3	113.0	1877.4	1338.7	71.6	48.4	66.7	66.0
Somnath	27.0	32.3	116.0	1521.9	980.1	64.3	44.7	67.6	49.0
S.Em.±	0.92	1.60	2.21	212.48	147.89	1.71	1.66	2.43	4.21
CD (p=0.05)	2.65	4.58	6.33	608.62	423.62	4.91	4.77	6.96	12.06
C.V. %	6.11	8.93	3.42	22.71	22.92	4.32	7.81	7.73	13.51

*, ** Significance at P=0.05 and P=0.01 levels, respectively.

FI=Flowering initiation (Days), DFF=Days to 50% flowering (Days), DM=Days to maturity (Days), PY=Pod yield (kg/ha), KY=Kernel yield (kg/ha), SOT=Shelling outturn (%), HKW=100-kernel wt.in g, HSMK=Wt. Of 100-sound mature kernel in g, and SMK=Sound mature kernels in %

6. Development, and multiplication, distribution of breeding materials

A. Development of new advanced breeding lines in *kharif* 2012

A total 14 new advanced breeding lines were developed, of which 10 lines (PBS 12199, PBS 12200, PBS 12201, PBS 12202, PBS 12203, PBS 12204, PBS 12205, PBS 12206, PBS 12207, PBS 12208) belonged to Spanish and four lines (PBS 22104, PBS 22105, PBS 22106, PBS 22107) to Virginia group.



B. Multiplication of breeding materials:

i) Summer, 2012

A total of 33 Spanish advanced breeding lines were multiplied to obtain sufficient seeds for further evaluation and screening for different biotic stresses. Twenty- three new advanced breeding lines of Spanish and Virginia groups (12 Spanish and 11 in Virginia respectively) were multiplied.

ii) Kharif, 2012

A total of 38 advanced breeding lines (12 belonged to Spanish bunch and 26 belonged to Virginia) were multiplied to obtain sufficient seeds for screening for biotic stresses at hot spots.

C. Multiplication of AICRP-G lines

Seeds of five elite advanced breeding lines (PBS 22059, PBS 22066, PBS 22067, PBS 22062 and PBS 22063) were multiplied in the *kharif* 2012 to obtain sufficient seeds for evaluation at multi-locations under AICRP-G.

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

The breeding material (F_4 to F_5 generation) of four different crosses of two segregating generations was supplied to three AICRP-G centres to effect site specific selections against different biotic stresses during *kharif* 2012 (Table 8).

Table 6. List of segregating material supplied to different AICRP-G centres

Cross	Objective	Pod Wt. (g)	Centre
F_4 segregating material			
SGL 4233 x ICGS 44	Tolerance of collar and PBND	150	ARS, Durgapaura
GG 7 x SGL 4233	Tolerance of collar rot	150	ARS, Durgapaura
F_5 segregating material			
CSMG 2001-2 x TAG 24	Tolerance of PBND	150	ARS, Kadiri
JSP 39 x VG 9816	Multiple diseases resistance	150	ARS, Jalgaon

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

A. Summer 2012

A total of 208 M5 families of TAG 24; 38 stable advanced breeding lines of AICRP-G; 15 high yielding check varieties used as zonal check varieties in AICRP-G; 32 Spanish bunch germplasm accessions of mini-core collection along with three interspecific derivatives were screened in sick plots for tolerance of stem rot. The range in the incidence of



the disease in different genotypes were: wilting- 0-27%; mortality 0-24.2% and pod colonization at harvest was 25-100% indicating high incidence of the disease. Only one accession, NRCG 14499 showed a low level (25% of colonisation pods) of incidence compared to high level shown by other genotypes.

B. Kharif, 2012

A total of 378 genotypes comprising 102 elite breeding lines of AICRP-G; 28 advanced breeding lines of DGR; 60 mini-core germplasm accessions; 184 released varieties; 4 interspecific hybrid derivatives and 240 M₄ families of GG 20 were raised for screening for resistance to *Sclerotium rolfsii* in sick plots.

The pod infection was between 0% to 100% among the genotypes studied. Among the released varieties only one variety, Co-2 was free from the incidence of stem rot. While seven varieties Gg 16, ALR 1, LGN 2, R 9251, Dh 3-30, ICGS 37, and TG 26 recorded below 10% incidence of stem rot. Among the germplasm one accession NRCG 14396 recorded lower than 10% disease incidence. In case of four inter specific derivatives studied, NRCG CS 425 (11.1%) and VG 09074 (19.6%) recorded below 20% disease incidence. Among the mutant families, 3 families showed less than 10% incidence of stem rot.

9. Screening of genotypes for tolerance of collar rot under sick plot

Sixty mini-core germplasm accessions and three released varieties were screened against *A. flavus* under sick plot along with two known resistant varieties, OG 52-1 and JCG 88 in kharif 2012. The seedling mortality was observed in these genotypes after 30 days of germination.

The seedling mortality ranged from 0% (NRCG 14483) to 40.9% (NRCG14352). Four accessions, NRCGs 14339, 14372, 14373, 14469 recorded less than 10% seedling mortality. Among the reported sources of resistance (J 11, JCG 88, OG 52-1) the variety J 11 recorded 0% to 15% seedling mortality; JCG 88 0%-14%; and OG 52-1 recorded 4% to 8%.

10. Screening of advanced breeding lines for seed colonization by *A. flavus*:

I. *in-vitro* seed colonization by *A. flavus*

A. Kharif, 2012

A total 46 advanced breeding lines with three check viz., J11 (seed coat resistant to *A. flavus*), GG 20 (a high yielding popular variety of Gujarat) and Girnar 2 (a DGR variety) have been screened *in vitro* for seed colonization at pod as well as kernel levels. The data of infection and colonization after harvest were recorded on dried pods as well as kernels. The results of screening at pod level indicated that in eight advanced breeding lines infection was lower than those of resistant check J 11 (16.7%). Similarly, screening at kernel level indicated that in five advanced breeding lines the infection was levels similar to that of resistant check J 11 (20%). In two advanced breeding lines, PBS 18057 and PBS 22064 pod and kernel infections were lower than those of the resistant check J 11.



B. Summer, 2012

A total 38 advanced breeding lines with two checks J11 (Seed coat resistant to *A.flavus*) and GG 20 were studied for *in vitro* seed colonization at pod as well as kernel levels. Pod and kernels were evaluated using modified progressive 1-4 Scale (Thakur *et al.*, 2003).

At pod level, four advance breeding lines (PBS 12181, 12183, 12186, and 18006) were at par with resistant check J 11 (1.2 of 1-4scale). Similarly at kernel level, ten advance breeding lines (PBS12009, 12032, 12067, 12171, 12175, 13020, 13021, 18038, 18045 and 18057) were also found at par or better than resistant check J 11 (recorded a disease score of 1.1 on a 1-4scale). *In vitro* seed colonization at kernel level indicated that four advanced breeding lines (PBS 12038, 12066, 12092 and 18029) were found their diseases score at par or below than resistant check J 11 (recorded a disease score of 1.2 on a 1-4scale at pod level and 1.1 of 1-4scale at kernel level). For pod as well as kernel levels, the colonisation of *A. flavus in vitro* was low even in the susceptible genotype GG 20 (recorded a colonisation score of 1.2 and 1.1 respectively). Hence, meaningful conclusion could not be drawn. This experiment will be repeated during summer 2013.

II. Pod and seed colonization by *A. flavus* under artificially inoculated and end-of-season moisture deficit stress conditions in field.

An experiment (RBD with three replications) was conducted in *kharif 2012* to ascertain the levels of infection of *A.flavus* in the pods and kernels of six large seeded varieties (Somnath, M 335, BAU 13, TKG 19A, TPG 41, Mallika); 3 seed coat resistant germplasm (PI 337394F, Ah 7223, UF 71513) and one variety (JCG 88) reported to be resistant to *A.flavus*; one germplasm derivative (RHRG 6083) along with a known seed coat resistant variety J11 and a susceptible variety GG 20 as checks. The material was evaluated for their reaction to *A. flavus* in artificially inoculated and end-of-season moisture deficit stress conditions.

After harvest, the pods were dried to optimum moisture levels (8%). The pod and kernel infection levels of *A. flavus* in these genotypes were estimated in lab conditions. The results indicated that at pod level *A. flavus* infection ranged from 0 (J11) to 97% (GG 20). Among the different categories of genotypes studied, the results indicated that the pod infection levels varied widely: in large seeded types the values recorded were 10% (Mallika) to 70% (M 335); in resistant germplasm accessions the range observed was 10% (UF 71513) to 27% (Ah 7223). Among the check varieties infection was very low in J 11 (0-7%) while in the susceptible check GG 20, the infection level varied from 26% to 97%.



At kernel level the infection ranged from 25% to 47% in the susceptible genotype, GG 20. In the resistant genotype J 11 these values ranged from 25% to 28% only. Interestingly, the variety JCG 88 which was reported to be resistant to *A. flavus*, there was only 25% of kernel infection. The kernel infection level varied from 25% (UF 71513) to 36.7% (PI 337394F) in the other categories studied.

11. Screening of advanced breeding lines for foliar disease resistance

A total 60 genotypes with two check viz., CS 85 (a foliar disease resistance interspecific derivative) and GG 7 (a high yielding popular variety of Gujarat) have been screened for foliar disease resistance during *kharif*, 2012 under natural condition. The study revealed only one genotype, PBS 12032 was found resistant (recorded a disease score <3 on a 1-9 scale) to leaf spot and rust on a modified 9 point scale. Seven genotypes viz., PBS 12038, 12066, 12067, 18064, 22008, 22050 and 22053 were found moderately resistant to both diseases and 17 and 5 genotypes were found moderate resistant to leaf spot and rust respectively on a 1-9 modified scale.



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

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Sub project 1 : Management of insect pests in groundnut based production system

(HARISH G, PRASANNA HOLAJJER, NATARAJA MV* AND POONAM JASROTIA**)

* Associated since January, 2012, ** Associated since August 2012

FIELD EXPERIMENTS

1 Effect of combinations of insecticides on sucking pests of groundnut (summer, 2012)

Four new combinations of insecticides were evaluated for their bio-efficacy against the sucking pests of groundnut. The insecticides were sprayed either once at 30 days after germination (DAG) or twice at 30 and 45 DAG. Combination of profenophos 40% + cypermethrin 4% @ 0.044% and acephate 25% + fenvalerate 3% @ 0.028% at 30 and 45 DAG were at par with the standard check (monocrotophos @ 0.04% at 30 & 45 DAG) in controlling the leafhopper population (1.8, 1.8 and 1.9 hoppers/ 5 sweeps, respectively). All the treatments were found effective in controlling the thrips population except quinolphos 28.5% + cypermethrin 1% @ 0.31% at 30 DAG, in which thrips population was maximum *i.e.*, 7.7 per 5 sweeps. Differences observed among treatment means for pod yield were not significant, the highest yield (3420.4 kg ha⁻¹) however was obtained in the treatment, chlorpyrifos 50% + cypermethrin 5% @ 0.055% at 30 DAG.

2 Effect of new insecticide molecules on insect pests of groundnut (summer, 2012)

Seven new insecticide molecules *viz.*, rynaxypyr 20SC, flubendiamide 480SC, thiodicarb 80DF, novaluran 10EC, acetamiprid 20SP, thiomethaxam 25WG, imidacloprid 0.008% were tested along with two standard checks *viz.*, monocrotophos 36SC and chlorpyrifos 20EC for their bio-efficacy against the sucking pests. The insecticides were sprayed at 30 and 45 DAG. All the new molecules were effective in controlling the leafhopper population. The lowest population (1.6 hoppers/5 sweeps) however, was observed in treatment, monocrotophos @ 0.04%. The treatments, acetamiprid @ 0.01% (1.3 per 5 sweeps), thiamethoxam @ 0.01% (1.9 per 5 sweeps), imidacloprid @ 0.008% (2.1 per 5 sweeps) and monocrotophos @ 0.04% (1.3 per 5 sweeps) were found effective in controlling the thrips population. The highest pod yield (2540 kg ha⁻¹) was observed in monocrotophos @ 0.04% treatment. The yield in the control plot was 1366 kg ha⁻¹.



3 Screening groundnut genotypes against sucking pests (summer, 2012)

Thirty eight groundnut genotypes were screened for resistance to insect pests of groundnut. Among these genotypes PBS12038, 12074, 12171, 12172 and 18062 were statistically at par with each other and recorded the lowest mean leafhopper population ranging from 4.7 to 8.3 hoppers per 5 sweeps. The genotypes, PBS12032, 12038, 12163, 12169, 12171, 12172, 12186, 13022 and 18064 were statistically at par with each other and recorded the lowest mean thrips population (8.6 to 11.1 thrips per 5 sweeps).

4 Effect of combination insecticides on sucking insect pests of groundnut (Kharif, 2012)

The four combinations of insecticides viz., profenophos 40% + cypermethrin 4% @ 0.044%, quinolphos 28.5% + cypermethrin 1% @ 0.31%, acephate 25% + fenvalerate 3% @ 0.028% and chlorpyrifos 50% + cypermethrin 5% @ 0.055% were evaluated for their efficacy on sucking pests. The mean leafhopper (2.6 hoppers/5 sweeps) and thrips (0.5 thrips/5 sweeps) populations after the first spray was lowest in acephate 25% + fenvalerate 3% @ 0.028%. Whereas the populations after the second spray with standard check, monocrotophos @ 0.04% was lowest for leafhopper (4.0/5 sweeps) and also thrips (3.8 thrips /5 sweeps). The population in the control was 28.2 hoppers and 10.1 thrips per 5 sweeps. Highest pod yield (2896 kg ha⁻¹) was recorded in treatment combination, quinolphos 28.5% + cypermethrin 1% @ 0.31% and was statistically superior over the untreated control (2384 kg ha⁻¹).

5 Effect of new insecticide molecules on sucking pests of groundnut (Kharif, 2012)

Seven new insecticide molecules viz., rynaxypyr 20SC, flubendiamide 480SC, thiodicarb 80DF, novaluran 10EC, acetamiprid 20SP, thiomethoxam 25WG, imidacloprid 0.008% were tested along with two standard checks viz., monocrotophos 36SC and chlorpyrifos 20EC for their bio-efficacy against the sucking pests. The mean leafhopper and thrips population after the two sprays was found to be lowest in Thiamethoxam @ 0.01% (1.4 hoppers and 2.3 thrips per 5 sweeps,) which was statistically at par with Imidacloprid @ 0.008% (1.7 hoppers and 3.5 thrips per 5 sweeps). The highest pod yield (2839 kg ha⁻¹) was observed with Thiamethoxam @ 0.01% which is superior over the untreated control (2224 kg ha⁻¹).

STORAGE EXPERIMENTS

1. Comparative response of certain groundnut genotypes to bruchid, *Caryedon serratus* Oliver in storage

Ten groundnut genotypes were screened for resistance to bruchids. The number of eggs laid, adults emerged and the per cent kernel damage differed non-significantly. However groundnut cultivar, Girnar-2 exhibited lowest pod (57.9%) and kernel (64.5%) damage.



2. Evaluation of effectiveness of different storage bags to minimize the infestation of *C. serratus*

Four types of bags viz., lino bag, fertilizer bag, gunny bag, and plastic super grain bags were evaluated for their effectiveness to reduce *C. serratus* damage to groundnut pods. Amongst tested bags, super grain bag effective with pod damage less than 50% for a storage period of four months.



Lino bag



Fertilizer bag



Gunny bag



Super grain

3. Effect of some essential oils on bruchid beetle, *C. serratus* in storage

Four essential oils viz., castor, eucalyptus, neem and pongamia were evaluated for their bio-efficacy against bruchid, *C. serratus* under storage conditions at two different doses (5 and 10 % v/w). The lowest numbers of eggs (2.3 per 100 g pods) were observed with neem oil 10% (v/w) and was statistically at par with castor oil 10% (v/w) (2.5 eggs per 100 g pods) and superior over untreated control (68.2 eggs per 100 g pods). The adult emergence was observed nil with castor oil, eucalyptus oil, neem oil and pongamia oil at 10% (v/w) concentration. Groundnut pods treated with castor oil, eucalyptus oil, neem oil and pongamia oil at 10% (v/w) and neem oil at 5% (v/w) concentrations recorded zero damage (per cent) to pods and kernels.

Sub-project 02. : Integrated management of major diseases (ELS, LLS, rust, collar stem rot, PBNB) of groundnut

(THIRUMALAISAMY P.P. AND KULDEEP SINGH JADON)

1. Screening of genotypes for *Sclerotium* stem rot

Among twenty genotypes screened for resistance to *Sclerotium* stem rot in summer 2012, the disease incidence was low (5%) in genotypes CS 405 and CS 407 whereas disease incidence was high in CS 412 (56%). Among sixteen genotypes screened in *kharif* 2012, the disease incidence was much low in genotype CS 319 (15%) compared to check variety GG 20 (40%).



2. Effects of arbuscular mycorrhizal fungi on *Sclerotium* stem rot

Compared to control (42.0%), the incidence of stem rot (8.8%) was low in plots where an arbuscular mycorrhizal fungus was applied in seed furrow @100 g/m² area (~ 100 spores/g soil). Further, plant height (cm), secondary and tertiary roots (no.), root nodules (no.) and root volume (cc) at harvest were enhanced in arbuscular mycorrhizal fungi treated plots (50.7, 16.8, 86.0 and 2.7, respectively) compared to those of untreated plots (43.8, 15.5, 68.0 and 1.9, respectively).

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

For the management of *Sclerotium* stem rot, isolates of *Trichoderma* (T-170 and Dharwad), *Pseudomonas* (DGR and TNAU- Pf-1) and their combinations were used. Incidence of stem rot was in the range of 2.5 to 18.9% in summer, and 18.7 to 26.3% in *kharif* experiments.

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

Among different tillage (harrow, cultivator, mouldboard and disc) and cultural practices (soil solarisation, and sowing in flat bed and raised bed), the lowest disease incidence (3.1%) was recorded with the soil solarisation using transparent polythene sheet compared to sowing in furrows (19.3%).

5. Management of foliar diseases in groundnut using fungicides

In summer 2012, among fifteen fungicides used for managing foliar, on a modified 1-9 scale the lowest severity of *Alternaria* blight (3.3) was recorded in two sprays of pyraclostrobin 5% + metiram 55% @ 0.98% (Cabrio) at 45 and 60 DAS. A similar efficiency was observed with two sprays of tebuconazole 50%+trifloxystrobin 25% @ 0.01% (Nativo). The disease severity in control was 7.0.

Among fifteen fungicides used for managing the leaf spots (early and late) and rust in *kharif* 2012, on modified 1-9 scale the lowest severity of leaf spots (3.3) and rust (4.0) was recorded with two sprays of difenoconazole @ 0.025% at 45 and 60 DAS. A similar efficiency was seen with in pyraclostrobin 5% + metiram 55% (Cabrio) @ 0.98 (leaf spots 4.0 and rust 4.0). The disease severities of leaf spots and rust were 9.0 and 7.3, respectively.

6. Survey on major diseases of groundnut in the Saurashtra region

In summer 2012, the survey of diseases of groundnut was conducted in the districts of Junagadh, Rajkot, Jamnagar and Porbander. The incidence of soil borne diseases (stem rot and collar rot) was below 5% in the farmers' fields. The *Alternaria* leaf blight was seen in all the farmer's fields but severity was high wherever cotton was grow in the vicinity.



In *kharif* 2012, survey was conducted in the districts of Junagadh, Rajkot, Bhavnagar, Amreli, Porbander and Jamnagar. Soil borne diseases *viz.*, collar rot, stem rot and afla root were severe at 35-40 days old crop. The incidence of collar rot was up to 30% in many farmers' field. Simultaneous growth of *Aspergillus niger* and *A. flavus* on the diseased plants was observed in many fields. The early leaf spot and rust began to appear on 40 day old crop and severity of foliar diseases increased in the later stage of crop.

Sub-project 3.: Survey, damage functions and management strategies for plant parasitic nematodes in groundnut

(PRASANNA HOLAJJER AND HARISH G.)

1. Evaluation of entomopathogenic nematodes, *Steinernema carpocapsae* and *Heterorhabditis* sp. for their virulence against *Spodoptera litura*

A study was undertaken to evaluate the virulence of two entomopathogenic nematodes (EPNs) (*Steinernema carpocapsae* and *Heterorhabditis* sp.) against larvae of *S. litura*. The 3rd and 4th instar larvae of *S. litura* were exposed to infective juveniles (IJs) of EPNs @ 2, 5, 10, 20 and 40 IJs cm⁻² under laboratory condition. After 48, 72 and 96 h of inoculation, LC₅₀ (no. of IJs per cm⁻² for 50% larval mortality) of *S. carpocapsae* strain for 3rd instar larvae was 49, 5 and 4 cm⁻²; and for 4th instar was 253, 7, 2 cm⁻²; respectively. However, the LC₅₀ of *Heterorhabditis* sp. for 3rd instar larvae was 74, 5 and 2 cm⁻²; and for 4th instar larvae was 55, 4, 2 respectively, after 48, 72 and 96 h of inoculation. The reproductive potential of nematode was not affected by dose. However, *Heterorhabditis* sp. produced more IJs per larva (12101-18420) as compared to *S. carpocapsae* (7250-12333I). The study revealed that both the species of EPNs are virulent and can cause 50% mortality at 2 IJs cm⁻² *in-vitro*.

2. Effect of selected essential oils on root-knot nematodes

In-vitro nematicidal activity of oils (*Pongamia pinnata* and *Eucalyptus globules*) was evaluated against root-knot nematodes, *Meloidogyne arenaria* and *M. incognita* at five concentrations (500, 1000, 2000, 3000 and 4000ppm). The mortality of nematodes increased with increase in concentration and exposure period. The maximum mortality (100%) of *M. arenaria* (J2) was observed at concentration of 4000ppm with *Eucalyptus* oil after 72h exposure period and at the same concentration mortality of *M. incognita* (J2) was 81.5 %. Whereas oils of *Pongamia* caused 100% mortality in *M. arenaria* after 72 h exposure at the concentration of 3000 and 4000 ppm and at the same concentrations, the mortality of *M. incognita* was 70.8 and 82.4 % respectively.



3. Relative damage potential of *Meloidogyne arenaria* and *M. incognita* on groundnut.

The relative damage potential of root-knot nematodes, *Meloidogyne arenaria* and *M. incognita* infecting groundnut were compared in 15-cm-diameter earthen pots. Two levels of each nematode (low = 100 J₂/100 cm³ of soil; high = 1000 J₂/ 100 cm³ of soil) were used in eight replicates along with uninoculated control. Significantly higher number of gall and egg-mass were produced in the treatment with high level of *M.arenaria* inoculation compared to other treatments. No significant differences in nematode population were observed at the time of harvest irrespective of nematode species and inoculation level. Observations on plant growth characteristics revealed that significantly shortened root length, lower fresh root and dry root weights in the treatment with high level of *M. arenaria* compared to other treatments.

4. Differential response of oxidative stress in leaves of groundnut due to *M. arenaria* and *M. incognita*

Effect of root-knot nematodes, *M. arenaria* and *M. incognita* on generation of damaging reactive oxygen species such as hydrogen peroxide (H₂O₂), super oxide radicals and lipid peroxidation was estimated in groundnut leaves. The infection of root-knot nematode, *M. arenaria* at high level (1000 J₂/ 100 cm³ of soil) resulted in significantly increased H₂O₂ (109.53g⁻¹ fresh weight), super oxide radical (1.35g⁻¹ fresh weight) and TBARS content (23.27g⁻¹ fresh weight) compared to 68.25, 0.37 and 15.53g⁻¹ fresh weight respectively in un-inoculated control.



PROJECT 03 : PHYSIOLOGICAL STUDIES ON ENVIRONMENTAL STRESSES IN GROUNDNUT

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

* On study leave since August 01, 2012

A. Photosynthetic efficiency and productivity in groundnut under water deficit stress

During Summer 2011-12 water deficit (WD) condition was imposed in field in six Spanish groundnut cultivars between beginning of bloom to beginning of seed (WD I) and beginning of seed to beginning of maturity (WD II) by withholding irrigation from 31 - 62 DAS and 62 - 87 DAS, respectively. Pod and haulm yield decreased due to water deficit stress at pod development stage but not at pegging stage. Varietal difference for yield was observed with highest yield in ICGS 44 followed by SG 99 in WD I. The pooled analysis of data showed increase in pod yield from 244 g in well irrigated to 280 g m⁻¹ under water deficit condition during R1-R5 indicating that water deficit stress during this period was not detrimental and was rather beneficial as it resulted increasing in yield. The highest yield under WD condition was found in ICGS 44 (330 g m⁻²) followed by SG 99 (306 g m⁻²). The WD condition between R5-R7 adversely affected pod yield which decreased to 184 g m⁻² with the lowest yield in DRG 1 (143 g m⁻²). Variety ICGS 44 gave the highest yield (206 g m⁻²) and SG 99 (191 g m⁻²) over the years.

B. Effect of high temperature stress in groundnut

During summer 2012 an experiment with 10 groundnut cultivars (ICGS 44, SG 99, ICGV 86031, TPG 41, TAG 24, DRG 1, AK 159, GG 7, JL 24 and TG 37A) was conducted to study the effect of temperature by resorting to staggered sowing (early, normal and late) and sampling at 50% flower initiation stage. The weekly mean of day/night temperature at the time of flowering was 35.5/17, 37.5/22.5 and 39/25.5 °C respectively for early, normal and late sown crops. This situation exposed the plants three different temperature regimes at a particular growth stage. Early sowing prolonged the period to attain 50% flowering by 10 days compared to normal and late-sown plants. Germination percentage was also low in early as well as late sown crop compared to normal sowing time.

With increase in mean day/night temperature membrane stability reduced in all the cultivars. Average membrane stability index (MSI) decreased from 88% to 74% with increase in 2/2.5 °C mean day/night temperature, respectively. Membrane lipid peroxidation measured in terms of TBARs content also showed partial destabilization of membrane (increase from 0.94 to 1.39 TBAR content g⁻¹FW). Production of H₂O₂ increased under high temperature stress with an average increase from 104 to 139 µmol g⁻¹ FW in all the cultivars. However, the genotype TG 37A (0.99 µmol g⁻¹ FW) and JL 24 (1.21 µmol g⁻¹ FW) performed best with least increase in H₂O₂ content.



Accumulation of various osmolytes like proline, glycine betaine and trehalose was higher with the concomitant increase in mean day/night temperature and on an average proline content increased from 60.7 to 71.8 mg g⁻¹ DW. Activity of different antioxidant enzymes like superoxide dismutase, catalase, peroxidase and glutathione reductase increased in almost all the cultivars with increase in mean day/night temperature.

C. Chlorophyll fluorescence and photosynthesis in groundnut under heat stress

The rate of photosynthesis in groundnut at 45 DAS was higher when the crop was sown at mid sowing time. There was no significant variation in chlorophyll fluorescence parameters in groundnut varieties under staggered sowing. However, the actual efficiency of photosynthesis was highest when the crop was sown at regular sowing time (first week of February) which is generally followed in the Saurashtra region, but, there was no difference in non-photochemical quenching among the crops grown at different sowing time. The SPAD value was lowest at 45 DAS in the crops sown at regular sowing time which was different from other sowing times. Similarly, the highest SLA was found in crop sown at the regular time. The pod yield was highest when the crop was sown 20 days before regular sowing time. Highest yield was realised in variety ICGS 44 if sown at early as well as regular sowing time.

D. Amelioration of water deficit stress with application of salicylic acid

In an experiment in summer 2012, effect of salicylic acid to ameliorate water deficit stress was studied with six cultivar viz., SG 99, TAG 24, ICGV 86031, AK 159, DRG 1 and ICGS 44, and four levels viz. 0 (T₁), 0.5 (T₂), 1.0 (T₃) and 2.0 ppm (T₄) of salicylic acid treatment as a foliar spray along with a set of control (T₁). Imposition of water deficit stress on an average resulted in 40% loss of yield in all the cultivars with highest loss in AK 159 (50.3%) and least in TAG 24 (23.9%). Application of salicylic acid @ 2.0 ppm can reduce the average yield loss from 40 to 19%.

E. Role of osmolytes in water deficit stress

In summer 2012, the role of osmolyte accumulation in tolerating water deficit stress in groundnut was studied in several cultivars grown under water deficit condition in summer 2012 in concrete block with three water regimes viz. T₁ (100% irrigation), T₂ (50% irrigation) and T₃ (25% irrigation). Osmolytes such as proline and trehalose were estimated in these 3 different treatments in which greater accumulation of osmolytes was observed in the leaves of stressed plants than those of normal ones. Proline content ranged between 0.087 and 0.618 mg g⁻¹ and trehalose content 14.21 and 81.71 mg g⁻¹. Accumulation of proline and trehalose varied with genotypes and maximum proline accumulation was seen in Girnar 2 and minimum in Kadiri 9 in crop raised at 25% irrigation. Maximum trehalose in AK 159 and minimum in JL 501 in 25% irrigation.



F. Screening of groundnut cultivars under well watered and water deficit condition

Thirty six groundnut varieties of Spanish and Virginia were grown under three different irrigation regimes. A significant effect on physiological parameters was observed. The crop raised at 25% irrigation showed highest rate of photosynthesis in variety TPG 41 ($28.9 \mu \text{mol m}^{-2} \text{s}^{-1}$) followed by GG7 ($28.0 \mu \text{mol m}^{-2} \text{s}^{-1}$). Limited water supply increased SCMR value and SLA. Interestingly, a marginal increase in yield was observed when the crop was given 50% irrigation. At 25% irrigation the lowest yield was in TMV 13 (78.4 g m^{-2}) and LGN1 (93.2 g m^{-2}) and the highest yield was observed in variety GG2 (301 g m^{-2}) followed by SG 99 (296.3 g m^{-2}) and VRI 2 (273.4 g m^{-2}).

G. Assessment of PWP in groundnut

The relationship between relative water content (RWC) and permanent wilting was studied in 21 Spanish groundnut cultivars by imposing 60 days of progressive stress (DPS) by withholding irrigation 24 days after emergence (DAE). Even after 60 DPS, the RWC was above 70 in 13 out of 21 cultivars. Visual wilting of plants (VW_p) at 60 DPS showed significant differences in the extent (%) of plant population on the verge of permanent wilting—the maximum in GG 2 (42%) and the minimum in ICGV 86590 (5%). Seven days after relief of stress, the permanent wilting of plants (PW_p) was only 4% in TPG 41 and ICGV 86590. It was concluded that the lower limit of RWC in groundnut leaves causing permanent wilting though varied with cultivars, the groundnut plants could survive moisture deficit up to 70% RWC and further reduction enhanced the chances of permanent wilting. A strong inverse relation between RWC at 60 DPS and VW_p ($r = 0.74$) and RWC at 60 DPS and PW_p ($r = 0.76$) with $R^2 = 0.55$ and 0.58 respectively, indicated that RWC at the 60 DPS determines the mortality of groundnut plants undergoing severe moisture deficit stress.

H. Studies on salinity stress in groundnut

In kharif 2012, screening of 42 cultivars and 15 germplasm lines was carried out for salinity tolerance in concrete block with with control (S_0), 2 (S_1) and 4 (S_2) dS m^{-1} salinity levels. Soil salinity adversely affected germination percentage and early establishment of the crop in all the genotypes. On an average more than 40% reduction in germination and early crop establishment was observed at 2 dS m^{-1} salinity level, whereas at 4 dS m^{-1} salinity level only two genotypes i.e. Somnath and NRCG 357 showed nearly 50% germination.

I. Studies on oxidative stress in groundnut

In a pot experiment in kharif 2012, effect of water deficit stress on 6 genotypes (two each from SB, VB and VR habitat group) for variation to tolerance of oxidative stress under limited (50%) and well watered condition. At flowering stage, on an average the leaf water potential decreased from -10 bars in well watered plants to -17 bars in limited water condition. The decrease was more pronounced at pod development where more than 100%



reduction was observed in limited watered plants. Among these, TPG 41 followed by CSMG 84-1 showed less reduction in leaf water potential compared to well-watered plants. Increase in H_2O_2 content under stress at pod development stage. Similarly, superoxide radicals content and lipid peroxidation was also more under stress condition. On an average content of SORs was more in Spanish genotypes (TPG 41 and JL 286) under water deficit stress compared to Virginia genotypes (GG 11 and CSMG 84-1). Activity of antioxidant enzymes viz. SOD, CAT, POD, GR and APX increased under water deficit stress.

J. Screening for drought tolerance in groundnut (kharif 2012)

The SLA in 48 groundnut varieties during post flowering was low ($144 \text{ cm}^2 \text{g}^{-1}$) in rain-fed than in protective irrigation ($180 \text{ cm}^2 \text{g}^{-1}$). The SCMR was 37.5 in well watered to 41.5 in rain-out-shelters and 39.5 in rain-fed crop, whereas it decreased to 34.1 under high moisture stress. The pod yield in groundnut ranged from 58 g m^{-2} to 232 g m^{-2} in rain-fed condition and 61 g m^{-2} to 272 g m^{-2} in high soil moisture stress condition. The plant height was 49.1 cm in well watered crop reduced to 42.0 cm under mid-season drought in rain-out-shelters. During screening for drought stress in thirty six groundnut varieties, late season drought has reduced the pod yield to 150 g m^{-2} from 186 g m^{-2} in well watered crop, per plant to 12.2 from 14.4 in well watered crop and the dry matter per plant to 5.15 from 6.14 g in well watered crop.

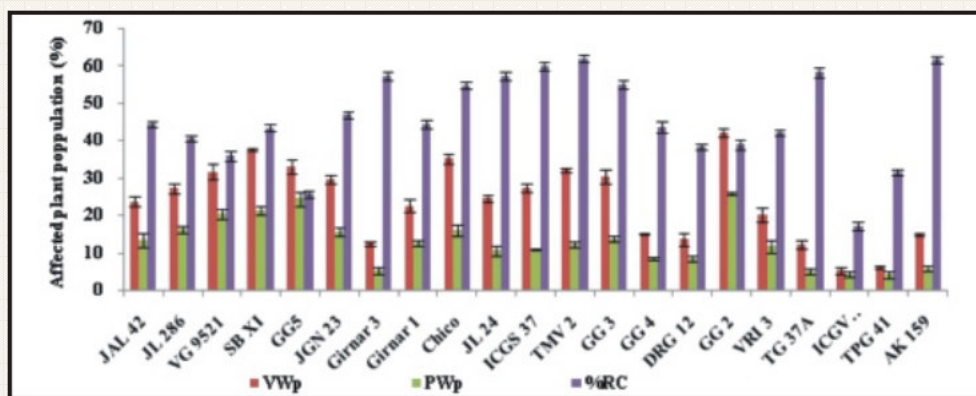


Figure 1. Visually wilted plants (VW_p), permanently wilted plants (PW_p) and rejuvenation capacity of groundnut after 60 days of progressive stress (DPS) in groundnut genotypes



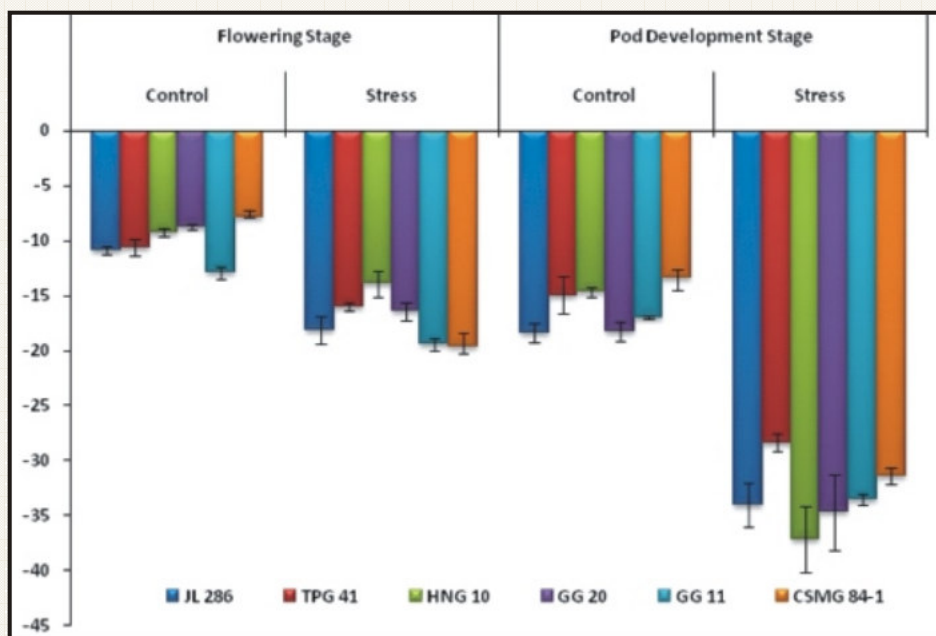


Figure 2. Reduction in leaf water potential (bar) in groundnut cultivars due to water deficit stress



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

(K.K. PAL AND R. DEY)

A. Evaluation of DAPG-producing fluorescent pseudomonads (summer and *kharif*, 2012)

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

Application of *Pseudomonas putida* DAPG1, DAPG5, and DAPG6 through seed treatment significantly enhanced pod yield of cultivar TG 37A during summer 2012 (Table 1). There was also significant improvement in haulm yield, root and shoot length; root and shoot dry weight; shelling out-turn and 100 kernel mass of groundnut, cultivar TG 37A by inoculation of *P. putida* DAPG1 and DAPG5 isolates over un-inoculated control.

Table 1. Evaluation of the effect of DAPG-producing fluorescent pseudomonads on the growth and yield of groundnut cultivar TG 37A (summer & *kharif* 2012)

Treatments	Summer		<i>Kharif</i>	
	PY (kg/ha)	HY (kg/ha)	PY (kg/ha)	HY (kg/ha)
Uninoculated (control)	2699	5075	2333	5387
DAPG1	3019	5787	2314	5315
DAPG2	2866	5375	2551	5922
DAPG3	2639	5760	2281	5777
DAPG4	2839	5262	2702	5757
DAPG5	3013	5902	2369	5550
DAPG6	2926	5392	2372	5265
FP98	2859	5550	2813	5770
CD (0.05)	182	385	128	260

In *kharif* season, application of pod and haulm yield was enhanced significantly by application of *Pseudomonas putida* DAPG2, *Pseudomonas putida* DAPG4 and *Pseudomonas fluorescens* FP98 (Table 1).



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

A field trial was conducted during the summer 2012 to study the effects of inoculation of AM fungi on the growth and yield of cultivar TG 37A. Four AM fungal cultures viz., *Glomus etunicatum*, *Glomus fasciculatum*, *Glomus mosseae*, and *Gigaspora scutellospora* were evaluated. Inoculation with *Glomus mosseae*, *Glomus etunicatum* and *Glomus fasciculatum* enhanced the pod (7-16%) and haulm yield (6-8%); root and shoot length; root and shoot dry weight; and shelling out-turn significantly over uninoculated control (Table 2). Hundred-seed-mass also increased significantly with the application of *G. fasciculatum* and *Gigaspora scutellospora*. An increase in root volume was observed in all the treatments. VAM-root colonization also enhanced significantly.

Table 2. Effect of inoculation of AM fungi on the growth and yield of groundnut cultivar TG 37A (summer 2012)

AM fungi	PY (kg ha ⁻¹)	SL (cm p ⁻¹)	IIY (kg ha ⁻¹)	Root Volume (cc)
<i>G. etunicatum</i>	2439	38.5	6073	6.7
<i>G. fasciculatum</i>	2442	37.6	5977	7.1
<i>G. mosseae</i>	2635	38.9	5947	6.6
<i>G. scutellospora</i>	2138	38.5	6043	6.8
Uninoculated (control)	2270	34.9	5627	5.5
CD (5%)	149	1.69	320	1.1

C. Evaluation of new strains of groundnut rhizobia

A field trial was conducted during *kharif* 2012 to evaluate the newly isolated *nod nif* competitive strains of groundnut rhizobia. Six strains viz., RH17, RH29, SRR7, RH11, PAS17-2, and RH20 having additional traits like production of siderophore and IAA like substances, were tested along with standard culture NC 92. The inoculation with the newly isolated strains of groundnut rhizobia RH17, SRR7, RH11, RH29 and PAS17-2 significantly enhanced the pod yield of cultivar TG 37A. The strain RH17 was adjudged the best (Table 3). Besides, plant growth, haulm yield, nodule number and biomass, shelling out-turn, etc. also improved.



Table 3. Evaluation of the effect of newly isolated groundnut rhizobia on growth and yield of groundnut

Treatments	PY (kg ha ⁻¹)	HY (kg ha ⁻¹)	HSM (g)
Uninoculated (control)	1909	5577	36.7
RH29	2134	5880	38.3
SRR7	2091	5802	37.2
RII17	2371	5907	37.6
RH11	2126	5832	40.9
RH20	2011	5582	38.0
NC92	1937	5740	37.1
PAS17-2	2182	5902	39.3
CD (0.05)	142	NS	1.6

D. Testing of DAPG-producing fluorescent pseudomonads for suppression of soil-borne fungal pathogens (*kharif*2012)

Some fluorescent pseudomonads are known to produce 2, 4-diacetylphloroglucinol (2, 4-DAPG) which is antifungal and inhibits the soil-borne fungal pathogens. To develop suppressive soils for fungal pathogens, twelve DAPG-producing fluorescent pseudomonads, highly antagonistic to *A. niger* and *S. rolfisii*, were evaluated in field condition for their potential in development of suppressive soils for management of *S. rolfisii* and *A. niger*. Application of DAPG-producing fluorescent pseudomonads effectively checked plant mortality (35-42%) due to stem rot in plots which were treated with both pathogen and DAPG-producing fluorescent pseudomonads whereas the mortality was quite high (70%) in the plots which were treated with only pathogens.

The analysis of data on yield and yield parameters indicated that besides checking the incidence of stem rot of groundnut, there was significant improvement in the yield of groundnut due to application of different DAPG-producing fluorescent pseudomonads. Application of DAPG2, DAPG3, DAPG4, DAPG7 and FP20 significantly enhanced the pod yield of cultivar GG 20 (normalized data as per standard plant stand/ha) with maximum yield of 4435 kg/ha (20% over uninoculated control) obtained with the application of *Pseudomonas putida* DAPG4 (Table 4). All yield with other treatments was at par with that of control. Application of *Pseudomonas putida* DAPG3 and DAPG7 improved the maximum number of yield parameters.



Table 4. Evaluation of the effect of DAPG-producing fluorescent pseudomonads on the growth and yield of cultivar GG 20, kharif 2012

Treatments	SL (cm/p)	PY (kg/ha)	Shelling out-turn (%)	HKM (g)
Uninoculated (control)	67.3	3671	70.7	45.5
Patho. (P)	65.1	3669	69.6	45.0
P+DAPG2	69.5	3959	70.7	46.5
P+DAPG3	70.5	4358	73.1	46.3
P+DAPG4	70.7	4435	74.7	48.1
P+DAPG7	70.9	4244	73.8	48.1
P+FP20	71.5	4208	72.3	47.4
P+FP46	70.1	3936	70.4	46.5
P+FP86	73.1	3721	71.5	44.9
P+FP93	69.0	3902	70.1	47.3
P+FP94	69.8	3816	74.5	47.8
P+FP121	69.8	3867	72.3	44.7
P+FP133	70.7	3743	71.9	47.3
P+FP82	70.7	3750	72.2	46.2
CD (0.05)	2.7	286	2.2	2.2

E. Deposition of 16S rRNA sequences with NCBI

Twenty-five 16S rRNA sequences of different PGPR and rhizobia were submitted to NCBI. The accession numbers assigned to each of these sequences are given in table 5.

Table 5. Details of the deposition of 16S rRNA sequences with NCBI

Sr. No.	Identity of the culture	Accession Number
1	<i>Pseudomonas putida</i> strain DAPG7	JX514402
2	<i>Sinorhizobium americanum</i> strain NRCG4	JX514403
3	<i>Pseudomonas putida</i> strain DAPG3	JX514404
4	<i>Rhizobium</i> sp. IGR40	JX514405
5	<i>Pseudomonas</i> sp. NRCG22	JX514406
6	<i>Pseudomonas putida</i> strain DAPG4	JX514407
7	<i>Pseudomonas putida</i> strain DAPG2	JX514408
8	<i>Enterobacter cloacae</i> strain ACC6	JX514409
9	<i>Pseudomonas gessardii</i> strain BIIU1	JX514410
10	<i>Enterobacter ludwigii</i> strain ACC3	JX514411
11	<i>Pseudomonas putida</i> strain DAPG6	JX514412
12	<i>Pseudomonas putida</i> strain S1(2)	JX514413
13	<i>Pseudomonas putida</i> strain DAPG5	JX514414



Sr. No.	Identity of the culture	Accession Number
14	<i>Pseudomonas fluorescens</i> strain S1(7)	JX514415
15	<i>Rhizobium</i> sp. NRCG8	JX514416
16	<i>Pseudomonas aeruginosa</i> strain BM6	JX514417
17	<i>Rhizobium</i> sp. IGR6	JX514418
18	<i>Psychrobacter alimentarius</i> strain ACC2	JX514419
19	<i>Enterobacter cloacae</i> strain NRCG9	JX514420
20	<i>Enterobacter cloacae</i> strain C185	JX514421
21	<i>Pseudomonas aeruginosa</i> strain ACC7	JX514422
22	<i>Enterobacter cloacae</i> strain BM8	JX514423
23	<i>Enterobacter ludwigii</i> strain NRCG12	JX514424
24	<i>Pseudomonas putida</i> strain DAPG1	JX514425
25	<i>Pseudomonas putida</i> strain S1(6)	JX514426



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

(A.L. SINGH, ANITA MANN*, K.A. KALARIA,
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* Associated since June 2012

1. Nutritional requirement of groundnut genotypes differing in seed-size

A field experiment was conducted to study the requirement of macronutrients (P and K) and micronutrients (Zn and B) for 50 groundnut genotypes differing in their seed size. Genotypes were supplied with various combinations of nutrients ($P_{50} + K_{100}$, $P_{50} + K_{100} + 2 \text{ kg ha}^{-1} \text{ Zn} + 1 \text{ kg ha}^{-1} \text{ B}$). A large variation in the response, depending upon the seed size, was observed and the genotypes NRCG 11057, ICGV 86590, NRCG 12085, 11073, and 2063 were found to be highly responsive to all these nutrients. However the genotypes NRCG, 7599, 11057, 11535, 2063, JSP 19 and JL 24 showed better response to B and Zn. The large seed-sized groundnut showed high P and Ca in their seed and shell than the small seed sized genotypes. Application of B and Zn, resulted in their contents in seed and shell with a more pronounced effect in large seeded genotypes. The application of P, K, Zn and B increased pod yield by increasing both length and width of the pods as well as seeds.

2. Seed treatment with Mo and its compatibility with *Bradyrhizobium*, *Trichoderma* and Bavistin

Studies conducted in micro-plots indicated that seed treatment with Mo (ammonium molybdate at 0.5 kg/ha) along with or without fungicides and biofertilizers (Bavistin, *Trichoderma* and *Rhizobium*), there was a significant improvement in yield of all the four cultivars (TG 37A, GG 7, ICGS 76 and GG 20) responded to Mo. In general application of Mo exerted a synergistic effect with Bavistin and *Bradyrhizobium* and hence can be recommended for use along with Bavistin was found superior to *Trichoderma*.

During summer 2012, the activities of soil enzymes (dehydrogenase, acid phosphatase, alkaline phosphatase and urease) were estimated from the soils of root zone of groundnut cultivars at two growth stages (60 DAS and 90 DAS) to assess the treatment and varietal differences. Except alkaline phosphatase, activities of other enzymes increased from 60 DAS (vegetative stage) to 90 DAS (pod development stage) over four treatments and four cultivars under study. Combined application of Bavistin-Rhizobium-Mo enhanced the soil dehydrogenase, alkaline phosphatase and urease activities (Fig. 1). Hence this treatment can be considered the best to maintain soil biological health. The activities of soil enzymes were higher with ICGS 76 and TG 37A than with GG 7 and GG 20 (Fig. 2).



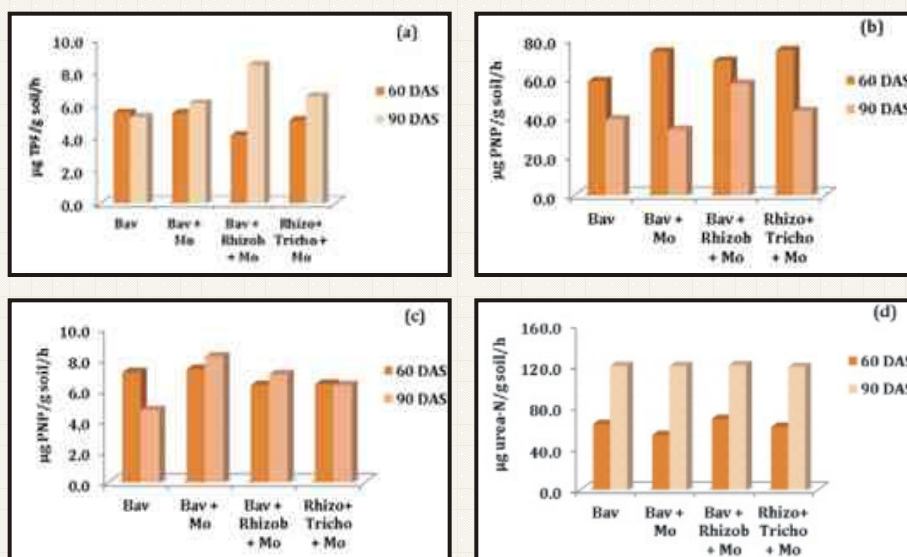


Fig.1. Changes in soil (a) dehydrogenase, (b) alkaline phosphatase, (c) acid phosphatase and (d) urease activities of two growth stages (60 DAS and 90 DAS) under application of Mo and different seed treatments (TPF = Triphenylformazan; PNP= p-nitrophenol)

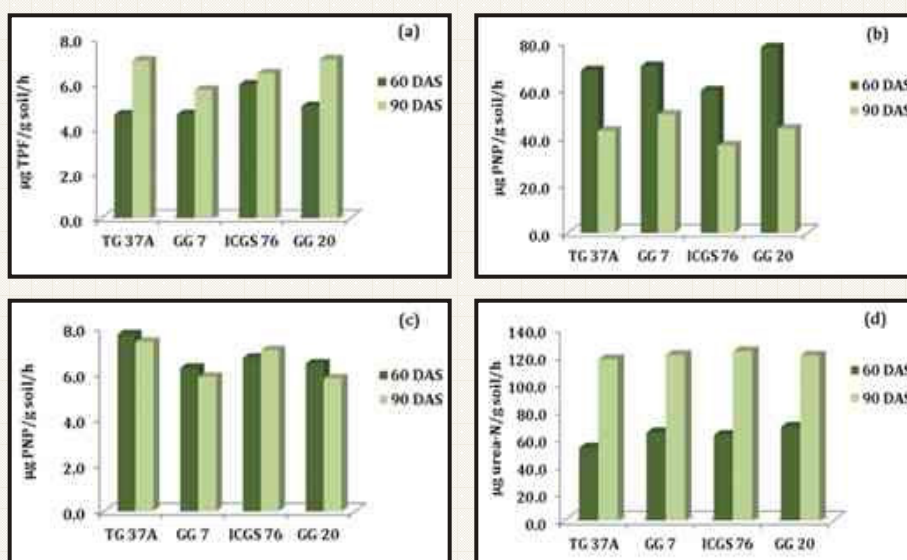


Fig.2. Changes in soil (a) dehydrogenase, (b) alkaline phosphatase, (c) acid phosphatase and (d) urease activities of two growth stages (60 DAS and 90 DAS) growing four groundnut cultivars (TPF = Triphenylformazan; PNP= p-nitrophenol)



Table 1. Soil enzymatic activities under Mo and different seed treatments in four groundnut cultivars

Soil enzymes activities at various growth stages												
Treatments	Dehydrogenase			Acid Phosphatase			Alkaline Phosphatase			Urease		
	(mg TPF/g soil/h)			(µg PNP/g soil/h)			(µg PNP/g soil/h)			(mg urea/g soil/h)		
	60DAS	90DAS	mean	60DAS	90DAS	mean	60DAS	90DAS	mean	60DAS	90DAS	mean
Bavistin	0.059	0.056	0.057	0.364	0.178	0.271	0.302	0.274	0.288	0.209	0.296	0.253
Bavistin+ Mo	0.058	0.065	0.062	0.320	0.495	0.412	0.571	0.090	0.331	0.192	0.296	0.244
Bavistin+	0.044	0.090	0.067	0.218	0.322	0.270	0.476	0.416	0.446	0.217	0.298	0.257
Rhizobium+ Mo												
Rhizobium+	0.054	0.069	0.062	0.245	0.283	0.264	0.450	0.217	0.334	0.205	0.295	0.250
Trichoderma+Mo												
Varieties												
TG 37A	0.049	0.075	0.062	0.392	0.358	0.375	0.450	0.246	0.348	0.192	0.292	0.242
GG 7	0.049	0.061	0.055	0.230	0.291	0.261	0.519	0.326	0.422	0.209	0.297	0.253
ICGS 76	0.064	0.069	0.066	0.287	0.366	0.327	0.292	0.130	0.211	0.206	0.301	0.253
GG 20	0.053	0.075	0.064	0.246	0.262	0.254	0.539	0.296	0.417	0.215	0.296	0.256

TPF=Triphenyl formazan; PNP=p-nitrophenol

3. Basic studies on nutrient efficient lines

The cation and anion contents of leaf sap and root exudates and yield potential of 26 groundnut varieties representing both nutrient efficient and inefficient ones were studied. The varieties were grown in field during summer. Wide variations were observed in the root exudates and leaf sap of groundnut. There was a positive indication of high cation contents and high yield. The cation and anion contents were generally lower in the inefficient cultivars.

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

The mini-core germplasm identified by ICRISAT comprising 181 accessions were screened for their fertilizer response and kernel micronutrient densities in kharif season, where the pod yield ranged from 35 g m⁻² to as high as 350 g m⁻² with an average yield of 130 g m⁻² without fertilizers and 150 g m⁻² with fertilizers. Most genotypes responded well to fertilizer application but many were nonresponsive due to their poor yielding capacities. In summer season, the net photosynthetic rate (P_N) in these genotypes ranged from 14.5-40.8 with a mean value of 28.5 µmol CO₂ m⁻² s⁻¹, conductance (g_s) 0.13-0.7 with mean value of 0.43, the transpiration rate 4.0-14.8 with mean value of 9.6 µmol m⁻² s⁻¹, the WUE 1.7- 5.2 with mean of 3.0 and the SCMR 30-43 with mean of 38. A good correlation was observed between g_s and P_N (0.640**), between Tr and g_s (0.453**) and between P_N and Fv/Fm (0.223**).

5. Studies on response of groundnut cultivars to applied Zn

In a field study, 187 groundnut cultivars were grown under unfertilized and fertilized conditions. NPK and Zn were applied to study the response on pod yield and micronutrient enrichment in kernels. There was a large variation in pod yield and



with an average of 1100 kg /ha and all the cultivars did not respond to the fertilizers and Zn. The yield increased to 1350 kg pod /ha with application of fertilizers and further to 1400 kg pod /ha with application of fertilizer and Zn. When screened for iron chlorosis, among these cultivars, 16 were found tolerant, several moderately tolerant, and 21 sensitive.

6. Screening groundnut cultivars for high Zn content in seed

Seed samples of 110 groundnut cultivars were analyzed for Zn and Fe, as well as many other nutrients. Analysis of seed samples from two seasons revealed that the Zn concentration in seed was in the range of 28-73 mg kg⁻¹ with a mean value of 49- mg kg⁻¹. of these, the high Zn containing (more than 55 ppm) were: 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.

7. Zinc Biofortification in groundnut:

In a study conducted on 60 groundnut cultivars, three spray applications of aqueous solution of 0.2 % zinc sulphate on the foliage, at 40, 55 and 70 DAE, influenced yield and yield attributes, checked over growth of the foliage and increased the seed Zn content.

The mean Zn concentrations in seeds of 60 groundnut cultivars was 50 mg kg⁻¹ (range of 32-67 mg kg⁻¹) which with spray increased to 58 mg kg⁻¹ (range: 40-70).

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

8. Screening of genotypes and studies on mechanism of iron-deficiency chlorosis

For identifying iron-efficient genotypes, 114 groundnut genotypes, mostly advanced breeding lines, and some released varieties were screened. The leaves of all genotypes were evaluated for visual chlorotic rating (VCR) at 10, 20, 30 and 65 days after emergence during the crop season. The intensity of chlorosis of top five leaves was measured by determining the visual chlorotic rating (VCR) score on a 1-5 scale (i.e., 1=normal green leaves with no chlorosis, 2= green leaves but with slight chlorosis on some leaves, 3= moderate chlorosis on several leaves, 4= moderate chlorosis on most of the leaves, 5= sever chlorosis on all leaves) and the percentage of plants showing deficiency symptoms. First reading showed the seed borne character of tolerance/susceptibility to Fe-deficiency. Cultivar ICGV 86031 was used as Fe-chlorosis tolerant check whereas NRCG 7472 was used as the susceptible check. Out of 114 genotypes, 22 were grouped as tolerant, 48 as moderately tolerant, 32 normal and 12 sensitive. Chlorophyll content (Chlorophyll *a*, *b*, carotenoids and total chlorophyll) and SPAD meter reading were estimated in the youngest fully emerged leaves. The SPAD reading was in the range of 18.4 to 43.0. Chlorophyll content was in the range of 67.7- 574.7 µg/gfw among different genotypes. The chlorophyll content ranged was highest in PBS 12171 while lowest content in PBS 14042.



Table 2. Categorization of groundnut cultivars for their iron- chlorosis tolerance

Tolerant	Moderately tolerant	Normal	Sensitive
PBS 12169, 12171, 12175, 12183, 13021, 16040, 16044, 19020, 19021, 19024, CS 349, CS 369, Gimar 2, ICGV 00348, RG 425, RG 510, TPG 41, HNG 69, SG 99, GPBD 4, VJ 9521, CSMG 9510	PBS 12032, 12163, 12167, 12168, , 12172, 12180 bold, PBS 13003, 13020, 13022, 14083, 16035, 18037, 18045, 18062, PBS 19018, PBS 19022, PBS 19023, PBS 19027,CS 280, CS 287, CS 291, CS 298, CS 401, CS 240, Gimar 3, Mallika, T 28, TMV 3, JL 501,TG 37 A, GG 13, MII 2, LGN 2, Kadri 9, GG 16, Chintamani, DG 4-3, Kokan Tapora, Kadiri Harithandra, ICGV 00351, TMV 1, GG 5, GG 20.CSMG 84-1, M 37, DRG 17, JCG 88	PBS 12009, 12018, 12029, 12038, 12066, 12067, 12074, 12092, 12116, 12181, 12185, 12186, 18029, 18033, 18035, 18038, 18057, 14135, CS 296, GG 8, TMV 4 VG 9816, R 2001-3, GPBD 5, VRI 16, JGN 23, LGN 1, ICGV 0350, TMV 13, AK 159, VRI 3, GG 7	NRCG 162, 7472, ICGV 91114, JL 286, Kadri 6, JGN 3, CS 332, PBS 18064, 18055, 18004, 18006, 14042

To know the mechanism of tolerance, the Fe^{2+} content and nitrate reductase (NR) activity were studied, the total Fe^{2+} content was highest (109 mg Fe^{2+} /g d.wt) in GG 8 while it was lowest (34.9 mg Fe^{2+} /g d.wt.) in leaves SG 99 showing their tolerance level to iron-chlorosis. Similarly, the activity of NR was also maximum in GG 8 (64 $\mu\text{g NO}_2/\text{g.h}$) and minimum (9.01 $\text{NO}_2/\text{g.h}$) in TMV 3. The protein content was maximum in genotypes with lesser chlorosis and lower protein content was observed in genotypes with higher chlorosis value.

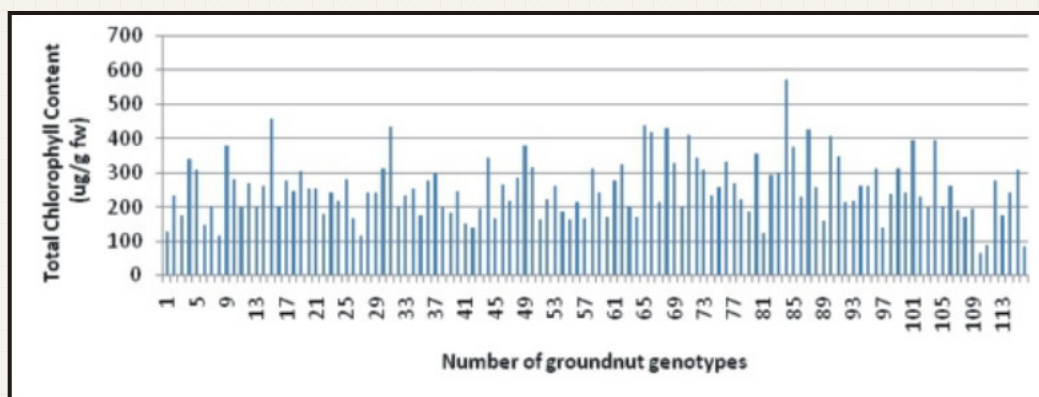


Figure 1. Total chlorophyll content of groundnut genotypes.



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

(N.K.JAIN, H. N. MEENA, DEBARATI BHADURI, K. K. PAL, AJAY SATHI, RAMA. JAT* AND R.S. YADAV**)

* Associated since May, 2012; ** Associated since April 2012

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

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

During summer 2012, a validation trial consisting of four treatment combinations i.e. FYM @ 2 t+2 kg citric acid ha⁻¹, 250 kg SSP+2 kg citric acid ha⁻¹, recommended dose of fertilizers and farmer's practice were taken. Application of FYM @ 2 t+citric acid @ 2 kg ha⁻¹ significantly improved pod yield by 27.6 and 18.5% and haulm yield by 30.0 and 24.1% over the recommended dose of fertilizers and farmer's practice, respectively.

Thus, on the basis of 3 years results (2009-11) as well as validation trial conducted during summer 2012, it could be concluded that application of 2 t FYM+2 kg citric acid ha⁻¹ improved both pod and haulm yields and also better economic returns. Compared to initial status, availability of phosphorus also improved after harvest of groundnut under all the treatments except control.

2. Sulphur-management in summer groundnut-maize cropping system

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

Summer 2012: All the treatments had significant effect on pod and haulm yields of groundnut over the absolute control. Application of sulphur through cosavet and SSP significantly increased pod and haulm yields over gypsum. However, there was no significant difference between cosavet and SSP treatments. Maximum net returns (₹ 93439 ha⁻¹) and benefit cost ratio (3.47) also accrued with 40 kg S ha⁻¹. S-use efficiency and apparent S-recovery decreased with increase in sulphur levels and were found



maximum with 20 kg S ha⁻¹. However, there was no significant effect of sources and levels of sulphur on organic carbon, nitrogen, phosphorus and potassium status of soil. But sulphur status was significantly higher in plots receiving gypsum and 40 kg S ha⁻¹ over cosavet-and-SSP and 20 kg S ha⁻¹, respectively. But in absolute control plots significantly lower S content was found compared to rest of the treatments.

Kharif 2012: All the treatments applied to summer groundnut had significant residual effect on grain and stover yields of maize over absolute control. Application of sulphur through cosavet and SSP (applied to groundnut) significantly increased grain and stover yields of succeeding maize over gypsum. The successive higher level of sulphur fertilization to groundnut up to 40 kg ha⁻¹ significantly improved grain yield by 7.1% and stover yield by 9.2% over 20 kg S ha⁻¹ and thereafter, there was no significant improvement was observed. Application of 75% of recommended dose of sulphur to maize significantly enhanced grain yield by 9.3% and stover yield by 6.7% over control and was at par with 100% RDS. After harvest of maize, significantly lower available nitrogen and sulphur status was recorded under the absolute control over rest of the treatments.

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

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

Application of 37.5 kg N ha⁻¹ significantly increased pod and haulm yields over RDF i.e. 25 kg N ha⁻¹ which was found at par with 50 kg N ha⁻¹. Similarly, with each successive increase in phosphorus levels, significant improvement in pod and haulm yields up to 30.8 kg P ha⁻¹ and further, a non-significant increase was observed at the higher level. Similarly, application of potassium significantly enhanced pod and haulm yields up to 24.9 kg K ha⁻¹. A similar trend was seen in all growth and yield parameters. Soil fertility status also improved significantly due to addition of nutrients.

On the basis of three-year experiment, it could be concluded that application of 37.5 kg N, 30.8 kg P and 24.9 kg K ha⁻¹ was effective in improving groundnut yield as well as soil fertility status.

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

The experiment was conducted during summer 2012 to study the effect of irrigation intervals and fertigation on productivity of groundnut and thus work out fertilizer and water savings under drip irrigation. The experiment consisted of two irrigation intervals i.e. 4-day intervals (10-day intervals in F₁) and 6-day intervals, (15-day intervals in F₁), allotted to main plots and four fertigation schedules (100% NPK in furrows with check basin method



of irrigation, 50, 75 and 100% NPK through drip), allotted to sub-plots, was laid out in split plot design with three replications.

Application of irrigation either at 4- or 6-day intervals through drip (10- or 15-day intervals under check basin irrigation) did not affect pod yield, haulm yield, net returns and benefit cost ratio of groundnut significantly. Thus, there will be saving of 2.3% water under drip and 21.7% water under check basin method of irrigation, if irrigated at 6-day intervals through drip and 15-day intervals through check basin method of irrigation. Overall, there will be saving of about 48% water with drip irrigation.

Both pod and haulm yields of crop fertilized with 75% NPK through drip were enhanced significantly by 17.9 and 9.9%, respectively over 50% NPK through drip and were at par with 100% NPK through drip and 100% NPK placed in furrows with check basin irrigation. Thus, there would be saving of 25% NPK over RDF. However, the interaction between irrigation intervals and fertigation schedules on pod and haulm yields were not found significant.

There was no significant effect of irrigation intervals and fertigation schedule on organic carbon, nitrogen, phosphorus and potassium status of soil after harvest of groundnut.

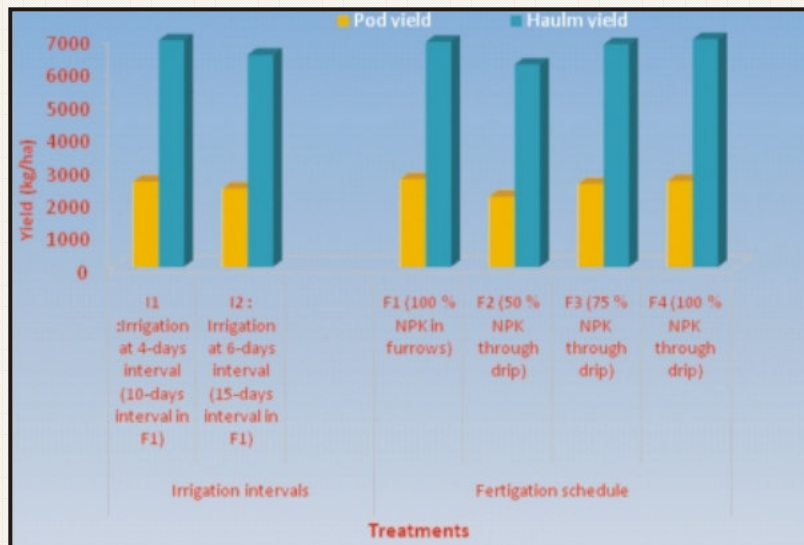


Fig.1. Effect of irrigation intervals and fertigation on productivity of groundnut





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

The experiment was conducted in summer 2012 to study the use of polythene mulch, application of hydrogel and nutrient management on productivity of groundnut. The experiment, consisting of two mulching treatments i.e. with and without (main plots), three levels of hydrogel i.e. 0, 2.5 and 5.0 kg ha⁻¹ (sub-plots) and three nutrient management schedules i.e. organic, inorganic and integrated nutrient management (sub-sub plots) was laid in split-split plot design with three replications.

With the use of polythene mulch, pod and haulm yields of groundnut increased significantly to the tune of 33.5 and 21.5%, respectively compared to no use of mulch.

Application of hydrogel up to 2.5 kg ha⁻¹ significantly improved both pod and haulm yields over the control and with higher levels, however, there was no significant response recorded. The improvement in pod and haulm yields was 6.5 and 6.9% over control, respectively. Furthermore, integrated use of organic manures, inorganic fertilizers and biofertilizers also improved pod and haulm yields significantly by 9.7 and 7.6% over organic manures and 11.2 and 10.8% over inorganic fertilization, respectively.

The interaction effect of polythene mulch x hydrogel x nutrient management schedule was significant on net returns wherein maximum net returns (85099 ha⁻¹) were obtained with combined use of polythene mulch, 2.5 kg ha⁻¹ hydrogel and integrated management schedule.

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

The experiment was undertaken during summer 2012 in a randomized block design with three replications in 8 m x 5 m net plot size. The treatments comprised:

- T₁ Control
- T₂ 10 t FYM ha⁻¹
- T₃ 25:50:00 kg NPK + 5 t FYM + 500 kg gypsum ha⁻¹
- T₄ Farmer's practices (45-70-40 NPK kg ha⁻¹)
- T₅ 40-60-60 kg NPK (Urea-SSP-MOP) ha⁻¹
- T₆ 40-60-60 kg NPK (Urea-DAP-MOP) + 250 kg gypsum ha⁻¹
- T₇ 40-60-60 kg NPK (AS-SSP-MOP) ha⁻¹
- T₈ 40-60-60 kg NPK (AS-DAP-MOP) + 250 kg gypsum ha⁻¹
- T₉ 40-60-60 kg NPK (Urea-SSP-MOP) + 10:2:1 kg Fe Zn B ha⁻¹
- T₁₀ 40-60-60 kg NPK (Urea-DAP-MOP) + 250 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹



T₁₁ 40-60-60 kg NPK (AS-SSP-MOP)+10:2:1 kg Fe Zn B ha⁻¹

T₁₂ 40-60-60 kg NPK (AS-DAP-MOP)+ 50 kg gypsum +10:2:1 kg Fe Zn B ha⁻¹

T₁₃ RDF + 5 t FYM +500 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹

T₁₄ 10 t FYM +10:2:1 kg Fe Zn B ha⁻¹

Pod yield of groundnut increased significantly with the application of 40-60-60 kg NPK (AS-SSP-MOP)+10:2:1 kg Fe Zn B ha⁻¹ (T₁₁) over rest of the treatments except T₃, T₉, T₁₀, T₁₂ and T₁₃ while haulm yield improved significantly with the application of RDF + 5 t FYM +500 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹ (T₁₃) over rest of the treatments except T₂, T₃, T₉, T₁₀, T₁₁, T₁₂ and T₁₄.

7. Soil test based fertilizer recommendations for balanced fertilization in groundnut

An experiment was conducted during summer, 2012 with groundnut variety TG 37A as a test crop. Before raising the test crop, maize was grown as an exhaust crop to create various fertility gradients. The experiment comprising 24 treatment combinations of N, P, and K including absolute control plots, was laid out in randomized block design. Sources of N, P, K used were urea, SSP and MOP. Three different levels of N (N₁= 25, N₂= 37.5, N₃= 50 kg ha⁻¹), P (P₁= 50, P₂= 75, P₃= 100 kg ha⁻¹) and K (K₁=30, K₂=45, K₃=60 kg ha⁻¹) were randomized as 72 different combinations (including control) to develop STCR-based fertilizer equation. Soil samples were collected after harvest of crop for analysis of soil nutrient balance in terms of soil available N, P and K. To estimate plant uptake, seed and leaf samples were analysed to assess the plant nutrient (N, P, K) status.



Fig. Field performance of (a) control (N₀P₀K₀) plots and (b) higher doses of nutrients (N₂₅P₇₅K₄₅) applied plots



8. Yield responses:

Control- Among the control ($N_0P_0K_0$) plots lowest yield was recorded in strip II (8.54 q/ha), followed by strip I (10.39 q ha⁻¹) and strip III (11.12 q ha⁻¹).

Nitrogen- Treatment N_{50} in strip II gave highest yield response (36.22 q/ha) across the three strips and also in strip III (30.62 q ha⁻¹) while for strip I, $N_{37.5}$ produced maximum yields (34.23 q ha⁻¹, respectively).

Phosphorus- For P-fertilizer, highest yield responses obtained up to P_{75} and both strip I and II showed maximum responses in this treatment (34.23 and 36.22 q ha⁻¹, respectively)

Potassium- K application up to 60 kg ha⁻¹ produced maximum yields for both strip I (34.23 q ha⁻¹) and strip II (36.22 q ha⁻¹).

So best treatment combinations as revealed from the yield responses were $N_{37.5}P_{75}K_{60}$ (34.23 q ha⁻¹) for strip I, $N_{50}P_{75}K_{60}$ (36.22 q ha⁻¹) for strip II and $N_{50}P_{100}K_{45}$ (30.62 q ha⁻¹) for strip III

9. Relationship among yield, yield attributes, soil and fertilizer nutrients and uptake:

Significant correlations of pod yield with haulm yield; both no. of pods and no. of branches with pod weight; and plant height with root length. Uptake of different nutrients was positively correlated with each other like nitrogen uptake with phosphorus uptake ($r = 0.514^{**}$), nitrogen uptake with potassium uptake ($r = 0.674^{**}$) and phosphorus uptake with potassium uptake ($r = 0.488^{**}$). Whereas nitrogen, phosphorus and potassium uptake had positive relationships with pod yield ($r = 0.578^{**}$, 0.677^{**} , 0.558^{**} , respectively) and haulm yield ($r = 0.787^{**}$, 0.338^{**} and 0.716^{**} , respectively).

10. Computation of Nutrient Requirement (NR) and Contribution from soil (Cs):

Basic parameters to develop targeted yield equations and fertilizer recommendations have been computed as NR for N, P, K were 6.67, 0.51 and 2.22, respectively and Cs (%) for N, P, K were 56.6, 68.3 and 17.8, respectively.

11. Persistence of pendimethalin and imazethapyr in groundnut field

A field experiment was conducted during summer 2012 to determine the persistence of pendimethalin and imazethapyr in the soil of groundnut fields and their effect on soil biochemical reactions.

It was found that the dissipation of pendimethalin was faster than that of imazethapyr. The half-life ($T_{1/2}$) of pendimethalin was 17.7 and 21.5 days for recommended and double the recommended dose respectively. Residue of pendimethalin was found up to



45 days for the recommended dose application and up to 60 days in the double dose. The rate of dissipation of imazethapyr was a little slower; the half-life ($T_{1/2}$) of imazethapyr was 30.1 and 33.4 days for recommended and double the recommended dose respectively. For both the doses the residues were found up to 60 day. Treatment with pendimethalin only at the recommended dose had a significant incremental effect on ammonium-N ($\text{NH}_4^+\text{-N}$) from 7 day and up to 90 days. Imazethapyr treatment at recommended dose had no significant effect on ammonium-N content on any days of sampling. However, its adverse effect was observed on ammonium-N at double the recommended dose on 1-15 day sample. The effect of herbicide treatment on nitrate ($\text{NO}_3^-\text{-N}$) was not significant at any days of sampling. Pendimethalin at recommended dose resulted in a indicated a significant increase in available phosphorus on sample drawn on 7th days and it continued up to 45 days and thereafter there was no change. Application of pendimethalin at double the recommended dose lowered the available phosphorus during 15 to 45 day of sampling. Imazethapyr, at recommended dose resulted in significant increase in available phosphorus in samples drawn 7-15 day. Imazethapyr, at double the recommended dose increased available phosphorus in sample drawn on 7th days. These results of the present investigation thus revealed that the application herbicides have only temporary effects on available ammonium, nitrate-N and available phosphorus. Whenever the availability of ammonium-N, nitrate-N and phosphorous was adversely affected, it recovered within a few days or weeks.

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

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

Results of *kharif* 2012 revealed that pod and haulm yields of groundnut, raised under polythene mulch, improved significantly by 14.4 and 31.7%, respectively over control (no mulch). Polythene mulch also significantly increased net returns. However, benefit cost ratio was not affected due to mulch treatment. Alkaline phosphatase enzyme activity was significantly higher under polythene mulch while acid phosphatase and dehydrogenase enzyme activities did not differ significantly.

Furthermore, pod and haulm yields improved significantly by 11.4 and 16.0%, respectively with the application of 75% RDF through drip over its preceding level and were at par with rest of the treatments. Thus, there will be saving of 25% RDF with drip



fertigation over RDF with check basin method. Application of 100% RDF in furrow fb check basin method, being at par with 75% RDF through drip, gave significantly higher net returns over other treatments. Maximum benefit cost ratio was also recorded under this treatment. Alkaline phosphatase activity was significantly higher in control i.e. 100% RDF as furrow placement with check basin method and was at par with 75% RDF through drip while acid phosphatase and dehydrogenase activities did not differ significantly. Mulching treatment by fertigation schedule interaction was not significant.

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

The experiment was conducted during *kharif* 2012 in a randomized block design with three replications in 5 m x 8 m net plot size. The experiment comprised 14 treatments namely:

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

Application of 20-40-30 kg urea + DAP + MOP + 250 kg gypsum + 10:2:1 kg Fe Zn B ha⁻¹ (T₁₀) recorded significantly higher pod yield (1616 kg ha⁻¹) except T₉, T₁₁, T₁₂, T₁₃, T₁₄ and T₃.

However, haulm yield was significantly higher (3595 kg ha⁻¹) in treatment T₃ i.e. 12.5:25:0 kg recommended NPK + 5 t +500 kg gypsum ha⁻¹ which was at par with T₉, T₁₀, T₁₁, T₁₂, T₁₃ and T₁₄.



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

The experiment was initiated during *kharif* 2010. It comprised two irrigation schedules, one fully irrigated and another rainfed (without any protective irrigation), which both were allotted to main plots and four levels of hydrogel (0, 1.5, 2.0 and 2.5 kg ha⁻¹), allotted to sub plots and was laid out in split plot design with three replications. The crop was raised with recommended package of practices.

Irrigation schedule did not affect yield attributes, pod and haulm yields significantly (Table 1).

Application of hydrogel @ 1.5 kg ha⁻¹ significantly improved pod and haulm yields by 9.6 and 16.4%, respectively over no use of hydrogel and was at par with application of hydrogel @ 2.0 and 2.5 kg ha⁻¹.

However, irrigation schedules by levels of hydrogel interaction on pod and haulm yields was not significant.

Table 1. Effect of hydrogel on yield of irrigated and rainfed crop (*kharif*, 2012)

Treatments	Pod yield (kg ha ⁻¹)	Haulm Yield (kg ha ⁻¹)
Irrigation schedule		
Full irrigation (with protective irrigation) (I ₁)	2209	2519
Rainfed (without protective irrigation) (I ₂)	2105	2284
CD (P=0.05)	NS	NS
Hydrogel (kg/ha)		
Control (H ₀)	2046	2122
1.5 (H ₁)	2242	2469
2.0 (H ₂)	2307	2500
2.5 (H ₃)	2031	2515
CD (P=0.05)	161	255

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

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

Results of *kharif* 2012 revealed that application of 25 kg N, 26.4 kg P and 24.9 kg K ha⁻¹ significantly improved the pod and haulm yields over RDF (12.5 kg N and 17.6 kg P ha⁻¹). However, the interaction effect of nitrogen, phosphorus and potassium on yield was not significant.



On the basis of three years' pooled data, it could be concluded that although application of 25 kg N, 26.4 kg P and 24.9 kg K ha⁻¹ significantly and considerably improved the productivity of *kharif* groundnut over RDF, the interaction of nitrogen by phosphorus by potassium on yield was not significant.

16. Effect of land configuration and application of mulch on groundnut productivity

A field experiment was initiated during *kharif* 2012 to study the effect of land configuration and mulching (polythene sheet 5 μ) on productivity of groundnut. It comprised seven treatments viz., conventional system, broad bed-and-furrow (BBF 100-50 cm), ridge-and-furrow system, raised (narrow) bed-and-furrow (60-30 cm), conventional system with mulch, raised bed-and-furrow with mulch and ridge-and-furrow system with mulch, was laid out in randomized block design with four replications. The crop was raised with recommended package of practices. Groundnut cultivation under raised bed-and-furrow with polythene mulch significantly improved the pod and haulm yields over all the other land configuration treatments with or without mulch, except conventional system with mulch. The increase in pod yield was 18.6, 43.7, 48.5, 13.4, 8.3 and 21.6% and haulm yield by 18.1, 43.6, 34.1, 16.0, 9.1 and 14.3% over conventional system, broad bed-and-furrow (BBF 100-50 cm), ridge-and-furrow system, raised (narrow) bed-and-furrow (60-30 cm), conventional system with mulching and ridge-and-furrow system with mulching, respectively. Maximum P and K uptake was also recorded under raised bed-and-furrow with mulch treatment over all the other treatments. Minimum available phosphorus was recorded in raised bed-and-furrow with mulch while available N, available K, pH and EC did not undergo any significant change.

17. Effect of herbicides on soil enzymatic activities and their persistence in groundnut field

In *kharif*, 2012, a field experiment was conducted to study the effect of herbicides on pod yield of groundnut as well as their persistence and effect on soil enzymatic activities in black soil at Junagadh. A total of 14 treatments were tested in randomized block design with three replications. The treatments included application of two pre-emergent herbicides i.e. pendimethalin and oxyfluorfen, two post-emergence herbicide imazethapyr and quizalofop-*p*-ethyl at their half-recommended dose (HRE), recommended dose (RE) and double of the recommended dose (DRE), weed-free control and un-weeded check.

All the herbicide treatment resulted in significantly higher pod yield over the un-weeded check. The highest pod yield was obtained with pre-emergence spray of oxyfluorfen (@ RE and HRE) and pendimethalin (@RE). Among herbicide treatments only quizalofop-*p*-ethyl (post-emergence spray at 20 DAS; @ HRE) gave significantly lower yield over weed-free control. Dissipation of pendimethalin and oxyfluorfen, imazethapyr followed the first order reaction kinetics. Relatively a shorter half-life (number of days) was observed for pendimethalin (13.6-20.1 days) and oxyfluorfen (21.5-27.4 days) than that of imazethapyr (30.7-40.1 days). Residue of quizalofop-*p*-ethyl was found in the soil samples drawn 4 hours after spray and the day next. There was no detectable residue in the samples drawn on 7th day and up to harvest.



There was an increase in the soil microbial biomass carbon (MBC) with the increasing dose of application of pre-emergent herbicides (pendimethalin and oxyfluorfen) in all the treatments compared to weed-free control and un-weeded check. In case of pendimethalin, there was a significant initial increase in soil MBC on 7 day onwards after application up to 30 days for HRE, up to 45 days for RE and up to 60 days for DRE and thereafter there was no change and the MBC was generally higher in the treated plots compared to both control and un-weeded check. Whereas in case of oxyfluorfen the increase was noticed during 15-30 days for both HRE and RE and 7-30 days for DRE. Application of pendimethalin at RE increased the fluorescein diacetate activity (FDA) during 7-45 days and this activity remained significantly higher throughout from 7 days onwards at DRE. Oxyfluorfen application at RE and DRE increased the FDA activity during 7-60 days. Application of both the herbicides at HRE dose did not have any significant effect on FDA at any stage of the sampling. However, there was a significant decrease in soil dehydrogenase (DHA) activity at RE and DRE in respect of both the herbicides.

MBC decreased with the application of post-emergent herbicides viz., imazethapyr and quizalofop-p-ethyl at RE and DRE but this effect was not significant at HRE. Imazethapyr decreased MBC during 7-45 days when applied at RE but there was a continuous decrease when applied at DRE. With application of quizalofop-p-ethyl, at RE, there was a little initial positive effect on MBC and subsequently there was a greater inhibitory effect; at DRE there was only an inhibitory effect. At HRE, imazethapyr did not have any effect on FDA but a strong inhibition was observed at both RE and DRE with a progressive decrease with the increasing dose. Quizalofop-p-ethyl exerted a little stimulatory effect on FDA activity at HRE but both RE and DRE exerted an inhibitory effect. Imazethapyr application at all the doses, decreased DHA during 7 to 15 days after application for HRE and RE but a progressive decrease was seen throughout the sampling period for DRE. However, there was no significant effect on DHA by any dose of quizalofop-p-ethyl and show little inhibiting action at DRE. The results of the present investigation reveal that the use of herbicides may have only a transient stimulating or inhibitory effects on MBC, FDA and DHA and also that the duration of effect depends on the type and dose of the herbicides. Whenever any activity was adversely affected, it recovered within a few days or a couple of weeks for HRE and RE but takes much longer a duration in case of DRE. Therefore, frequent application of herbicides in higher doses is likely to adversely affect the soil health.



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

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* Associated since April, 2012

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

After the harvesting of groundnut in kharif 2012, rabi-summer cluster bean was sown by using saline irrigation water having salinity of 0.5, 2, 4 and 6 dS m⁻¹. The salinity buildup in soil at harvest of cluster bean with use of different irrigation water salinity levels was 2.80, 5.22, 7.15 and 8.98 dS m⁻¹, respectively. A decreasing trend was observed (Table 1) in fresh pod and dry fodder yield of cluster bean with increasing level of soil (2.80 to 8.98 dS m⁻¹) and water (0.5 to 6.0 dS m⁻¹) salinity. The fresh pod and dry fodder yield of cluster bean were significantly lower in all the treatments as compared to those of fresh irrigation water (i.e., control) but the fresh pod yield was at par up to 2.0 and 5.22 dS m⁻¹ water and soil salinity, respectively. Available nitrogen, phosphorus and potassium also decreased with increase in salinity levels while significant increase in availability of sodium was recorded with increase in soil and water salinity. Similar trends were observed with different nutrient concentrations in different plant parts of the cluster bean.

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

EC _{iw} (dS m ⁻¹)	EC _e (dS m ⁻¹)	Plant height (cm)	Root length (cm)	Plant stand (no. ha ⁻¹)	Dry plant weight(g)	Fresh pod yield (kg ha ⁻¹)	Dry fodder yield (kg ha ⁻¹)
0.5	2.80	90	13.87	70333	27	16981	3185
2.0	5.22	69	13.27	60667	21	15145	2517
4.0	7.15	67	11.33	50667	16	11829	1408
6.0	8.98	45	12.20	37000	12	5584	891
CD (P=0.05)	2.09	21.6	NS	5522	4.6	2254	217

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

The experiment was conducted during summer 2012 to ameliorate the effect of salinity by the application of potassium fertilizer. The treatment consisted of three levels of salinity (0.5, 2 and 4 dS m⁻¹) and two levels of potassium (0 and 30 kg ha⁻¹) in two different cultivars (GG 2 and TG 37A). The results revealed decrease in pod and haulm yields of



groundnut with successive increase in water salinity up to 4 dS m⁻¹, but significant reduction in pod (37.2%) and haulm (27.3%) yields were seen with application of 4 dS m⁻¹ saline water as compared to control (0.5 dS m⁻¹) (Table 2). Further, cultivar TG 37A was found to be more tolerant to water salinity with 33.3% and 9.2% higher pod and haulm yield over GG 2, respectively. The application of potassium @ 30 kg ha⁻¹ improved the pod and haulm yield of groundnut by 6.9% and 11.7% respectively indicating ameliorative effect of potassium on salinity stress.

Table 2: Effect of saline irrigation water and application of potassium on yield of summer groundnut

ECiw (dS m ⁻¹)	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Salinity levels		
0.5	2302	3505
2	2173	3308
4	1446	2549
CD (P=0.05)	149	252
Variety		
TG 37 A	2369	3271
GG 2	1579	2970
CD (P=0.05)	122	206
Potassium levels (kg ha⁻¹)		
0	1,904	2927
30	2,044	3314
CD (P=0.05)	122	206

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

Kharif groundnut was taken in 2012 to test the performance of two released varieties namely TG 37A and GG-2 using normal seeds and seeds from **salinity** conditioned crop in four salinity levels of saline irrigation water with 0.5, 2, 4 and 6 dS m⁻¹, respectively. Two lines of five meter rows of each variety (fresh and induced tolerance) were sown in this experiment. It was observed that the pod yield of both the varieties were at par up to 2 dS m⁻¹ irrigation water salinity but significant difference was recorded at a water salinity of 4 and 6dS/m in comparison to water salinity of 0.5 dS m⁻¹ control (Table 3). The loss of pod yield was 5.9, 37.2 and 81.8% respectively compared to control at different irrigation water salinity levels. Further, the significant difference in pod and haulm yield were also recorded within the varieties with significantly higher pod and haulm yield in GG 2 (1293 kg ha⁻¹) over TG 37A (952 kg ha⁻¹). The reduction in pod and haulm yield of TG 37A was 26.4 and 33.7% over GG 2, respectively. However, the normal seeds performed better than salinity induced groundnut seeds. The reduction in pod and haulm yield of salinity induced seed was 29.9 and 27.2% over the normal seed, respectively. Almost a similar trend was observed for other yield contributing characters also.



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

ECiw (dS m ⁻¹)	Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
Salinity levels		
0.5	1632	2599
2	1536	1959
4	1024	1657
6	297	859
CD (P=0.05)	308	114
Groundnut variety		
TG 37A	952	1411
GG 2	1293	2127
CD (P=0.05)	85	160
seed Type		
Fresh seed	1320	2047
Salinity induced seed	925	1491
CD (P=0.05)	114	110



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

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

1. Field maintenance of wild *Arachis* germplasm

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

2. Acquisition and distribution of germplasm accessions

During 2012, fourteen inter specific derivatives (VG 0401, VG 0410, VG 0411, VG 0430, VG 0437, VG 0438, VG 0439, VG 0448, VG 09410, VG 09405, VG 09406, VG 1002, VG 1005, VG 1009) and five accessions/cultivars have been newly acquired. A few seeds of seven amphidiploids namely: *Arachis cardenasii* x *Arachis villosa*; *Arachis batizocoi* x *Arachis kuhlmannii*; *Arachis correntina* x *Arachis helodes*; *Arachis helodes* x *Arachis pusilla*; *Arachis duranensis* x *Arachis stenosperma*; *Arachis duranensis* x *Arachis cardenasii*; *Arachis stenosperma* x *Arachis cardenasii* were also acquired.

A total of six hundred accessions were supplied to 28 groundnut scientists of DGR (573), SAUs (25) and others (2) for crop improvement programme to identify promising lines for WUE, diseases and nematode tolerance, large seeded types and for using in crossing programmes.

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

Eighty-four accessions and advanced breeding lines having desirable morpho-physiological traits which were identified earlier were multiplied during summer 2012. Two released varieties (TG 26 and Somnath) were multiplied for seed enhancement. In *kharif*, 1424 accessions were multiplied for seed enhancement. These included: voucher samples (284), DGR mini-core collection (167), exotic accessions (59), new germplasm accessions (47), accessions repatriated from ICRISAT (223), released varieties (173), large-seeded accessions (30), 28 accessions having low carbon isotope discrimination ($\Delta^{13}\text{C}$) and others (413).

Multiplication of a total of two thousand accessions, received from NBPGR, were also arranged at five AICRP-G centres (TNAU, Vridhachalam, ANGRAU Kadiri, UAS Dharwad, MPKV Rahuri and JAU Junagadh).

4. Characterisation of germplasm

a. Reference collection for water use efficiency

Out of 5577 accessions (5000 general; 184 ICRISAT mini core; 129 DGR mini-core; 54 having diverse canopy architecture; and 213 stable water-use efficient breeding lines)



evaluated for different traits, 189 accessions have been used for developing the reference/composite collection (core group). These accessions/lines belong to *fastigiata*, *vulgaris*, *hypogaea* (semi-spreading) and *hypogaea* (spreading) botanical types. Based on various morpho-physiological traits such as specific leaf area or leaf thickness, canopy dimensions (spread and height), leaf folding and changes in leaf angles during mid-day stress, stomatal density on the upper and lower surfaces of the leaf, and canopy and leaf temperatures, chlorophyll contents, SPAD chlorophyll meter readings, leaf desiccation rate, leaf RWC and water potential, and parameters of chlorophyll fluorescence, and root traits such as root length primary and secondary, and root length density at different soil depths under normal and water deficit conditions a reference set of 189 accessions representing maximum genetic variability among all the traits studied has been developed under the externally funded project on, "Evaluation of Groundnut Germplasm for Morphological, Physiological and Molecular Characters/Traits Associated with Drought Tolerance for Enhancing Productivity in Rain-dependent System" under NFBSRA.

This reference set has extensively been characterised for 13 qualitative and 24 quantitative traits in *kharif* 2012. The variability for the yield and its components indicated that the days to maturity ranged from 101 (NRCG 12922) to 128 days (NRCG 14356); pod yield from 0.5 g (NRCG 14451) to 13.8 g plant⁻¹ (JUG 27) closely followed by NRCGs' 5405 and 12177 (12.3 g plant⁻¹). Hundred Seed Mass ranged from as low as 18.0 g (ICG 4747) to as high as 60.2 g (NRCG 12177). Shelling out-turn ranged from 52.1% (NRCG 12581) to 81.5% (NRCG 10541).

b. Large seeded accessions

Twenty-eight large seeded accessions belonging to the *ssp hypogaea* along with two check varieties M13 and GG 20 were characterised for 16 yield and its component traits in *kharif* 2012. The design adopted was a randomized block design with two replications. The days to maturity of these accessions ranged from 117 (NRCGs' 4775, 12083, 12447) to 122 (NRCGs' 12056, 12107, 12806). Pod yield ranged from 2.9 g (NRCG 12499) to 12.1 g plant⁻¹ (NRCG 272). Hundred Seed Mass ranged from 34.8 g (NRCG 12499) to 59.8 g (NRCG 12107). Shelling out-turn ranged from 57.2% (NRCG 12447) to 78.6% (NRCG 12107). Although the accession, NRCG 12107 was late maturing but the shelling outturn and HSM were high.

c. Characterisation of mini-core accessions of the subspecies *fastigiata*

Sixty mini-core accessions belonging to the subspecies *fastigiata* were characterised for 13 traits during summer and *kharif* 2012. The design adopted was augmented block design. The duration of maturity ranged from 98 days (NRCG 14493) to 105 days (NRCGs' 14329, 14407, and 14477). The other accessions which exhibited early maturity (99 days) were NRCG 14399 and NRCG 14425. The pod yield was highest



(15.0 g plant⁻¹) in NRCG 14433 and lowest (2.3 g plant⁻¹) in NRCG 14385. Hundred Seed Mass ranged from 20.0 g (NRCG 14425) to 51.0 g (NRCG 14461). Shelling out-turn ranged from 51.0% (NRCG 14482) to 75.8% (NRCG 14405).

While in *kharif*, the duration of maturity ranged from 103 days (NRCG 14425) to 115 days (NRCGs' 14329, 14363, and 14420). The accessions NRCG 14329 was found to be late maturing consecutively in both summer and *kharif* seasons. The pod yield was highest (12.5 g plant⁻¹) in NRCG 14480 and lowest (1.7 g plant⁻¹) in NRCG 14381. Hundred Seed Mass ranged from 20.5 g (NRCG 14368) to 49.4 g (NRCG 14329). One accession NRCG 14425 exhibited low hundred seed mass both in summer (20.0 g) and *kharif* (24.0 g) seasons. Shelling out-turn ranged from 60.0% (NRCG 14485) to 79.1% (NRCG 14387). The shelling outturn of the accession NRCG 14405 was high in both summer (75.8%) and *kharif* (77.1%) season.

5. Evaluation of genotypes with low carbon isotopic discrimination (¹³C), for yield and physiological traits under moisture deficit conditions during summer 2012

Twenty-eight genotypes comprising 12 varieties, 7 from ICRISAT mini-core collection and 9 from subset of DGR working collection all which exhibited low ¹³C values (around 18.0) were studied for 16 yield component traits, physiological traits (SLA and SCMR), and biomass production under moisture deficit and irrigated conditions in summer 2012. The check varieties used were GG 2 and ICGV 87846. This experiment has been carried out over two years during summer seasons while over one year in *kharif* season. The pooled results are provided below.

The changes in SLA studied at 10, 20 and 30 days after imposing the moisture deficit stress (DAIS) over those of regularly irrigated indicated that the SLA decreased initially (10 DAIS) irrespective of the genotypes. The reduction in SLA after 10 DAIS ranged from 0.7% (GG-2) to 19.5% (Kadiri-3). This trend, however, got changed 20 DAIS in that the reduction in SLA was the least (0.1) in TG 1 to and highest (12.6%) in TMV 10. Interestingly six genotypes exhibited increase in SLA which ranged between 1.3% (T64) to 11.5% (DSG 1).

ANOVA worked out for pod yield and its related traits revealed that there were significant differences among the genotypes for all the yield traits during each year and over years. The days to maturity among the released varieties under irrigated condition ranged from 106 (DRG 12) to 121 days (DSG 1). While under moisture deficit stress conditions, the days to maturity was unaffected (106 days) in case of DRG 12. On the contrary, the maturity was delayed in the variety TG 1 by 6 days under moisture deficit stress conditions.

The pod yield plant⁻¹ was the lowest in the variety TMV 10 under both irrigated (3.0 g) and moisture deficit stress (1.2 g) conditions. The pod yield was the highest (18.8 g plant⁻¹) in the variety BG 2 under irrigated condition. While under moisture deficit stress condition the check variety ICGV 86764 recorded the highest pod yield (8.1 g plant⁻¹) followed by GG 2 (7.3 g plant⁻¹).



Hundred seed mass ranged from 34.6g (TMV 10) to 53.8g (T 64) under irrigated conditions. Whereas under moisture deficit stress condition the values ranged from 24.5g (DSG 1) to 29.2g (T 64). While the shelling outturn was 54.6% in TG 1 and 68.6% in DRG 12 under irrigated condition. While the shelling outturn was as low as 40.4% in GAUG 10 and as high as 67.8% in TMV 10 under moisture deficit conditions.

Among the germplasm accessions evaluated, the duration of maturity under regularly irrigated conditions ranged from 110 days (NRCG 404) to 118 days (NRCG 14432). While under the moisture deficit stress conditions, the duration was rather unaffected (110 days) in case of NRCG 404. While two accessions NRCG 14342 and NRCG 12138 matured late (116 days).

The pod yield plant⁻¹ was the lowest (2.5g) in NRCG 14352 and highest (10.5g) in NRCG 14395 under irrigated condition. Whereas under moisture deficit stress condition it was the lowest (0.7 g) in NRCG 14390 and highest (5.5g) in NRCG 14355. Hundred seed mass ranged from 26.0g (NRCG 11924) to 55.2g (NRCG 14395) under irrigated conditions. While under moisture deficit stress condition the values ranged from 20.4g (NRCG 12393) to 31.0g (NRCG 12138). The shelling outturn was as low as 47.5% in NRCG 14395 and 62.6% in NRCG 11942 under irrigated condition. It was very low (31.4%) in NRCG 14442 and highest (51.3%) in NRCG 11924 under moisture deficit stress conditions.

While in *kharif*, only 16 yield related traits were studied as moisture deficit stress could not be imposed at specific stages of crop growth as can be done in summer season. The duration of maturity in released varieties was 112 days in GG 2 and 123 days in BG 2. Pod yield ranged from 5.3 g (DSG 1) to 10.7 g plant⁻¹ (T 64). Hundred Seed Mass ranged from 31.3 g (DSG 1) to 48.3 g (TG 1). Shelling out-turn ranged from 64.9% in TG 1 and 73.3% in DRG 12.

Among the germplasm accessions duration of maturity ranged from 119 days (NRCG 11924) to 124 days (NRCG 666). Pod yield ranged from 2.3 g (NRCG 14390) to 15.8 g plant⁻¹ (NRCG 8963). Hundred Seed Mass ranged from 25.2 g (NRCG 666) to 48.3 g (NRCG 8963). Shelling outturn ranged from 54.6% (NRCG 666) to 72.6% (NRCG 11942). The germplasm accession NRCG 666 was a poor yielder in spite of its late maturity and had shrivelled seeds thus leading to poor shelling outturn.

6. Screening of Valencia accessions for table purpose

From 2000 Valencia accessions available in the working collection, 200 accessions were short-listed based on minimal passport data. These accessions belonged to 15 different countries. These accessions were screened visually at the time of harvest for better pod features and pod yield. On the basis of high yield, 51 accessions were short-listed and evaluated in a replicated randomised block design for sixteen agronomic and yield traits during summer and *kharif* 2012.



In summer 2012, duration of maturity of the accessions ranged from 123 days (NRCGs' 14328, 143332 and 14481) to 130 days (NRCG 14775). Pod yield ranged from 3.2 g (NRCG 14243) to 13.3g plant⁻¹ (NRCG 14163). The accession NRCG 14163 over two summer seasons recorded the highest pod yield of 13 g plant⁻¹. Hundred Seed Mass ranged from 27.0 g (NRCG 14328) to 58.0 g (NRCG 14765). Shelling out-turn ranged from 49.0% (NRCG 14328) to 88.8% (NRCG 14484).

While in *kharif*, these 51 accessions were evaluated in a replicated randomised block design for fourteen agronomic and yield traits. The duration of the accessions were early than those of summer season and ranged from 105 days (NRCG 14344) to 118 days (NRCG 14815). Pod yield ranged from 1.3 g (NRCG 14445) to 8.1 g plant⁻¹ (NRCG 14274). Hundred Seed Mass ranged from 18.2 g (NRCG 14451) to 58.4 g (NRCG 14332). Shelling out-turn ranged from 58.3% (NRCG 14815) to 72.5% (NRCG 14163).

8. Screening of germplasm against soil borne pathogens

a. For tolerance of stem rot (*Sclerotium rolfsii*)

Thirty two Spanish bunch germplasm accessions of mini-core collection in summer 2012 and 60 mini-core germplasm accessions; 184 released varieties and 4 interspecific hybrid derivatives in *kharif* 2012 were screened for tolerance of stem rot in sick plot.

The accession, NRCG 14499 recorded a low level (25%) of incidence in summer as against 25-100% level of incidence in various genotypes. In *kharif* 2012, the accession NRCG 14396 recorded below 10% disease incidence. In case of four inter specific derivatives screened, NRCG CS 425 and VG 09074 recorded below 20% incidence.

b. For tolerance of collar rot (*Aspergillus niger*)

In *kharif* 2012, 60 mini-core germplasm accessions and three released varieties were screened against *A. flavus* in a sick plot along with two known resistant varieties, OG 52-1 and JCG 88 in *kharif* 2012. The seedling mortality was observed in these genotypes after 30 days of germination.

The seedling mortality ranged from 0% (NRCG 14339) to 40.9% (NRCG14352). Four accessions, NRCGs 14339, 14372, 14373, 14469 recorded less than 10% seedling mortality. Out of 12 mutant GG 20 families, one family was found free of seedling mortality.



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

(RADHAKRISHNAN T., LUKE RATHNAKUMAR, CHUNI LAL, S. K. BERA, ABIR KUMAR* AND GYANPRAKASH MISHRA**)

*On study leave since 1st August 2012; **Associated since May, 2012

1. Genetic transformation

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

Forty-five days old transgenic plants having *mtlD* transgene in T₂ generation were evaluated for their tolerance to water deficit stress. The stress was imposed by withholding the irrigation and subsequently stress was released after 24 days of withholding irrigation when non-transformed plants started visible wilting by adding 100 mL of water in each pot.

Twelve independent *mtlD* transgenic lines developed from the cultivar GG 20 and the wild type (WT; GG 20) lines were evaluated for water-deficit stress tolerance. The effect of water-deficit stress on shoot growth was recorded both before and after imposing the stress. There was apparent retardation in the rate of increase in shoot length under water-deficit stress. Under stress, the mean increase in shoot-length in the wild type was only 10.8% while it was as high as 35.6% in transgenics. This clearly indicated the tolerance in terms of shoot elongation of the transgenic to water-deficit stress conditions.

The mean relative water content (RWC) of transgenic and wild type plants was higher in well-watered condition as compared to those in water-deficit stress condition. The range of RWC in well-watered and water-deficit stress conditions was 87.88-70.50% and 80.83-38.31% respectively. The highest RWC in the well-watered and water-deficit stress condition was in MTD.9.10.7 and MTD.5.4.3, respectively. Both in well-watered and water-deficit stress conditions RWC was higher in all the 12 transgenic lines as compared to WT. Due to stress, transgenic lines had less reduction of RWC as compared to the WT.

The total chlorophyll content in both transgenic and wild type plants under well-watered and water-deficit stress condition was recorded both before imposition and after release of the stress. The chlorophyll content of transgenic plants was higher compared to the wild type in both water-deficit stress and well-watered conditions. There was a reduction in the chlorophyll content of both transgenic and WT plants under stress conditions. The extent and pattern of decrease in the chlorophyll content in both transgenic and WT was similar.

The cell-membrane leakage in the transgenic and WT plants was assayed using the leaf disc method. Among the transgenic and WT, the mean injury was highest in the WT both



in well-watered (60.82%) and water-deficit stress condition (85.45%). In well-watered and water-deficit stress conditions the electrolytic leakage was minimum in transgenic lines MTD.7.6.5 (27.76%) and MTD.5.2.3 (50.42%) indicating a better membrane stabilization property in the *mtlD* transgenics.

Among the transgenics and WT, mean per cent injury was found to be much less in transgenic lines as indicated by less reduction of electrolytic leakage as compared to that in WT in well-watered and water-deficit stress conditions. However, the rate of injury between the transgenic and WT plants appeared to be similar. The cell membrane leakage increased with increasing water-deficit stress conditions.

The leaf water potential of wild-type and transgenic plants overexpressing *mtlD* was determined under both well-watered and water-deficit-stress conditions. Among the transgenic and WT, the osmotic potential was highest in both well-watered and water-deficit-stress conditions in MTD.2.41.5 and MTD.1.26.2 as compared to that of WT.

Ability of transgenic plants to maintain a higher osmotic potential compared to that of WT indicated that the water uptake capacity of transgenic plants improved due to the *mtlD* gene. The mean increase in osmotic potential in transgenics was recorded 57% as compared to 47% in WT. Due to water-deficit stress, substantial accumulation of proline was observed in both transgenic as well as WT. In comparison to the initial values, the proline content was doubled in the wild types while it was 3.5 times in transgenics.

In transgenic plants mannitol concentration in well-watered and water-deficit stress conditions was in the range of 4.7-1.2 $\mu\text{g g}^{-1}$ and 5.5-2.2 $\mu\text{g g}^{-1}$ fresh weight (FW) of leaf respectively. The highest mannitol levels in the well-watered and water-deficit-stress condition was in MTD.1.26.1 (4.66 $\mu\text{g g}^{-1}$ FW) and MTD.1.26.2 (5.49 $\mu\text{g g}^{-1}$ FW), respectively. All the 12 transgenic lines, expressed the *mtlD* gene in both well-watered and water-deficit stress conditions and thus were having high mannitol content. Reverse transcriptase PCR (RT-PCR) of the T_2 plants confirmed the expression of the transgene. As the expression of *mtlD* driven by CaMV35S promoter, its expression was not modulated by the stress.

The transgenics plants exhibited improved physiological and biochemical parameters for tolerance to salinity and water-deficit stress.

ii. Transformation of groundnut (cv. GG 20) with the plant defensin *Rs-AFP2* (*Raphanus sativus* Anti Fungal protein 2 and *Tfgd2* (*Trigonella foenum graecum* defensin 2) genes

Quantitative (real-time) PCR was carried out for 8 homozygous transgenic T_2 lines to determine the expression of *defensin* transcript. The $2^{-\Delta\Delta C_T}$ method was used to calculate relative changes in expression of *defensin*. Amplicon abundance was monitored in real-time by measuring SYBR[®] Green fluorescence. The level of *defensin* transcripts in T_2 plants was normalized with reference to *18S rRNA* taken as an internal control.



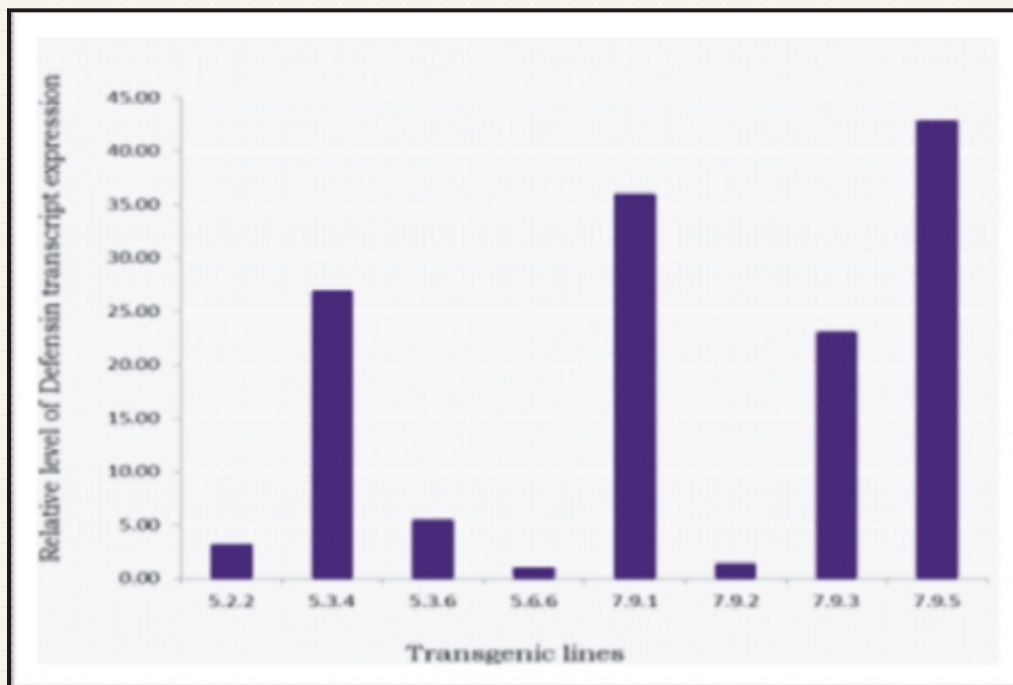


Fig 1. Histogram of the relative expression of defensin transcript in the 8 T_1 transgenic groundnut lines. The level of defensin transcript in T_1 plants was normalized with reference to 18S rRNA taken as an internal control. *The calibrator whose relative expression is arbitrarily set as equal to one is defined as the sample giving the highest ΔC_T value which corresponds to the lowest level of transcripts. The quantification of the relative transcript levels was performed using the comparative $\Delta\Delta C_T$ method.

The relative expression of *defensin* transcript in transgenic lines is shown in the fig 1. The bars denote the fold expression compared to the lowest expressing plant 5.6.6 (calibrator). As can be seen in the figure 1 the expression of transgenic plant no. 7.9.2 was almost similar to reference calibrator while in two transgenic lines, 5.3.4 and 7.9.3, expression was 26 and 23 times respectively. In transgenic lines 7.9.1 and 7.9.5 also expression was 36 and 42 times that of reference calibrator.

2. Marker assisted breeding

Validation of SSR markers linked to the rust and late leaf spot (LLS) diseases resistance in groundnut

Different known linked SSR markers for rust and LLS in groundnut were to validate these markers in different known resistant and susceptible genetic lines available at DGR, Junagadh. These include cultivated varieties, advanced breeding lines and in the



selected wild species of groundnut. In this study, 100 diverse genotypes (grouped as rust/LLS resistant and susceptible varieties, advanced breeding lines, promising crosses and wild species) were used for marker validation using fourteen SSR markers, earlier identified as linked to rust and LLS resistance in groundnut by several researchers were selected and tested.

Out of 33 rust resistant varieties, except for five, linked marker amplification was recorded. However, all the markers could be validated for four susceptible varieties. In case of LLS and rust, very few linked-markers could be validated for resistant varieties but for susceptible varieties, except one, validation for all other markers was perfect (Fig. 2).

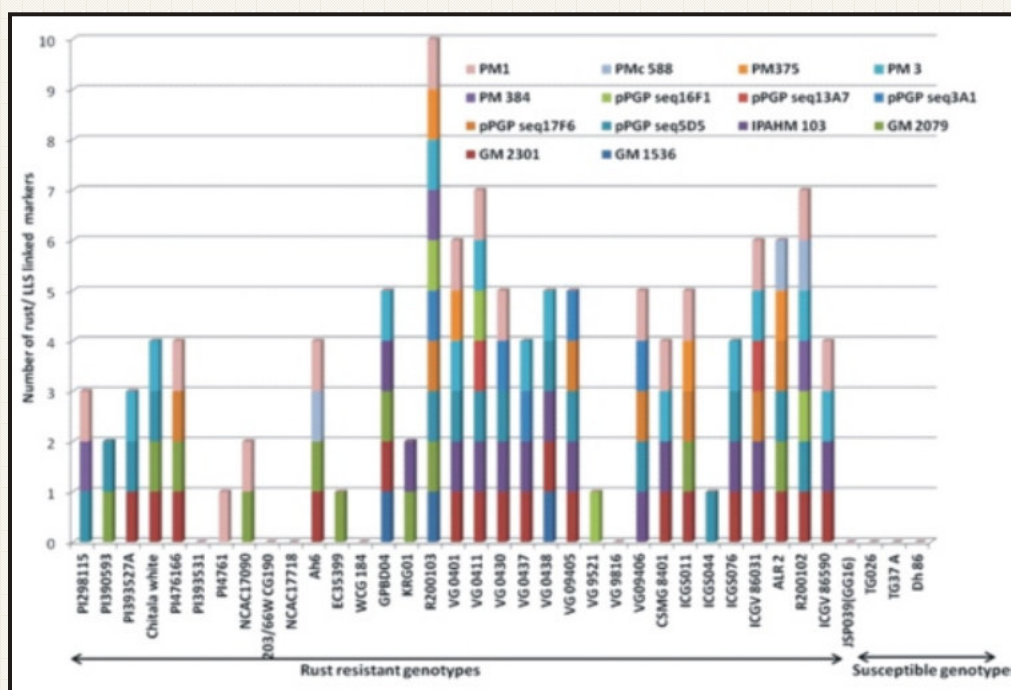


Fig. 2. Marker association in known rust resistant and susceptible varieties

Among fourteen promising breeding lines and crosses, all the genotypes were positive for one or the other marker (Fig. 3). Very poor marker validation was observed for wild relatives as out of 32 only 12 wild species amplified 09 linked markers.



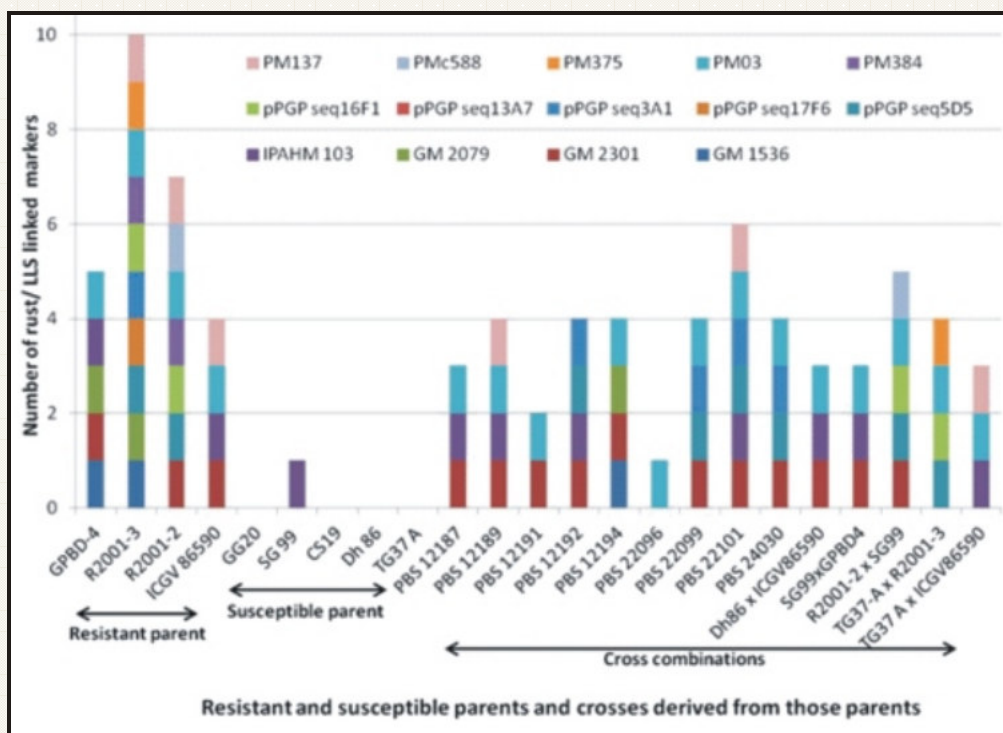


Fig. 3. Marker association and its transfer from rust/LLS resistant and susceptible parents to their crosses in advanced generations

For ascertaining the location of molecular markers on the linkage groups, the integrated map of Gautami et al. (2012) was used. Maximum number of markers linked with the foliar diseases, were found on linkage group 03 which is found most promising for future fine mapping and cloning of genes.



PROJECT 10. ASSESSMENT AND ENHANCEMENT OF QUALITY IN GROUNDNUT GENOTYPES

(S.K. BISHI* AND M.K. MAHATMA**)

*On study leave since 1st August 2012, **Associated since July 2012

Kernel samples of 44 popular groundnut cultivars were analysed for oil content and sugar profiling including raffinose family oligosaccharide (RFO) to identify suitable cultivars for confectionary purpose. Among various oligosaccharides estimated by ion chromatography, sucrose was the predominant sugar, and was followed by RFO's. Sucrose content among cultivars ranged from 6.50% (ICGS 76) to 2.6% (Kadiri-3). RFO content ranged from 0.12 to 0.76 % with maximum in TG 26 (0.76 %) and minimum in AK 265 (0.12). The maximum oil content was observed in AK-156 (54.7%), AK-256 (53.8%) and AK 303 (53.6%). Groundnut oil consisted about 97.40 % of total fatty acids as oleic, linoleic, palmitic and stearic acid. The variability in these four major fatty acids was significant among cultivars evaluated which ranged from 37.5 to 61.6% for oleic, 22.4 to 41.4% for linoleic, 10.4 to 16.7% for palmitic and 1.7 to 4.2% for steric acids. For confectionary purpose it is desirable to have groundnut with low oil, high sucrose, high oleic acid, high O/L ratio and low total RFO's content. This results of analysis indicated that cultivars M 13, M 548 and ICGS 76 have low oil and high sucrose contents with favourable fatty acid composition. The seeds of cultivars GG 14, GG 16 and GG 21 had low saturated fatty acid, high oleic acid, low linoleic acid and high O/L ratio.

Table 1. Oil, oligosaccharides and fatty acids profiles of 44 popular groundnut cultivars

	Oil (%)	Sucrose (%)	Raffinose (%)	Stachyose (%)	Verbascose (%)	RFOs (%)	Myoinositol (%)	Palmitic Acid (%)	Stearic Acid (%)	Oleic Acid (%)	Linoleic Acid (%)	O/L
SB	50.30	4.56	0.04	0.42	0.02	0.48	0.08	14.74	2.87	41.81	37.91	1.12
VB	51.10	4.58	0.05	0.39	0.02	0.46	0.08	12.67	2.56	51.82	30.37	1.80
VR	48.25	5.37	0.06	0.46	0.02	0.54	0.08	11.90	2.07	55.70	28.03	2.05
Valencia	50.43	3.86	0.07	0.31	0.00	0.39	0.17	13.79	2.34	40.49	40.74	0.99

RFO's = Raffinose family oligosaccharides, O/L = Oleic/linoleic acid ratio

Effect of water deficit stress on nutritional quality of groundnut

Twelve genotypes were grown in field under well-watered and water deficit stress conditions were analysed. Under water deficit stress condition sucrose concentration decreased (31-87%) in leaves of all genotypes while myo-inositol increased (1.09 fold-2.77 fold)



almost in all genotypes. However, sucrose concentration increased (15-28%) in the kernels of all genotypes except JL-286. Fatty acid profiles of these samples revealed that O/L ratio (9-32%) decreased in all genotypes under stress condition. Stearic acid levels also decreased in all genotypes under stress condition while palmitic acid levels increased in seven genotypes.

Quality analysis of large-seeded and confectionery type groundnut

Total free amino acids and total phenol content of 97 samples of large seeded groundnut genotypes were determined. Total free amino acids were found in the range of 0.37 (PBL5 22) – 3.39 (PBL5 109) mg/g while total phenol contents were ranged from 1.76 (PBL5 39) to 7.64 mg/g (PBL5 51)

Evaluation of quality in cultivars, breeding material and germplasm collection

Oil content of 150 groundnut samples from different section of DGR and 100 samples from different AICRP-G centres were measured by standard solvent extraction method. Around 2500 samples from different sections of DGR were analyzed for oil, protein and moisture content by NIR spectroscopy

Influence of abiotic and biotic stresses on metabolomes of groundnut

The sugar profiling and activities of various enzymes related to phenylpropanoid pathway were assessed at 30 DAS in 15 groundnut genotypes for stem rot resistance. Highest sucrose concentration was found in leaves of genotype R2001-2 (26.3 mg/g fw) which showed 84% disease incidence while lowest content was observed in leaves of CS-319 (3.6 mg/g fw) which showed 15% disease incidence. PPO, PAL, C3II activities were varied in all genotypes. The experiment is still in progress.

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

Concluded



**PROJECT 12. PREVENTION AND MANAGEMENT OF MYCOTOXIN IN
GROUNDNUT**

(P. P. THIRUMALAI SAMY AND KULDEEPSINGH JADON)

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

Soil population of *A. flavus*, infection on pods and kernels, and aflatoxin contamination of kernels were estimated in a cropping system of rotation of *kharif* groundnut with maize, sorghum, groundnut, or fallow in summer.

In summer crop of groundnut in rotation with different crops and fallow, the population of *A. flavus* was smaller in soil after harvest compared to that of before sowing. The population of *A. flavus* was smaller prior to sowing than that recorded after harvest in *kharif*. The decrease in soil population of *A. flavus* in summer could be attributed to rise in soil temperature and rotation of groundnut with non-host crops.

A. flavus infection on pods was higher than on seeds in summer as well as in *kharif*. The estimated infection on pods, kernels and aflatoxin contamination were 71.7%, 8.3% and 46 ppb, respectively.

The aflatoxin contamination in kernels varied widely among the samples and the treatments (crop for rotation or fallow). In general, although rotation with crops or fallow reduced the population of *A. flavus* in soil, there was no reduction in the level of aflatoxin contamination.

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

For developing technologies for producing aflatoxin free groundnuts, an experiment was done by incorporating salts (common salt, rock salt and baking soda) at different concentrations (1, 2, 3, 5, 10, 15, 20 and 25%) in the *Aspergillus* growth media. Incorporation of common salt or rock salt (20%) in potato dextrose broth adversely affected the germination of spores and also growth of colonies. Incorporation of baking soda, however, proved to be equally effective even at much lower a concentration (2%).



PROJECT NO 13. IMPACT ASSESSMENT OF IMPROVED GROUNDNUT PRODUCTION TECHNOLOGIES: SUSTAINABLE LIVELIHOOD APPROACH

(NARAYANANG., MURLIDHAR MEENA AND A.P. MISHRA)

Impact assessment scale

Based on the concept of total factor productivity an impact assessment instrument was developed by introducing certain modifications in the earlier version. A greater emphasis was given to reliance on new technologies; impact of market on choosing groundnut crop, other competitive crops in *kharif* season, information processing behavior of farmers and, level of adoption of crop management practices has been included.

Summer 2012

During summer 2012, as many as 91 on-farm trials (OFT) were conducted for validation of improved production technologies in farmers' fields. For this purpose Farmers were selected from four talukas viz., Kodinar (30 farmers), Una (30 farmers), Sutrapada (20 farmers), and Talala (11 farmers). Along with the seeds of varieties TG 37 A, TPG41, and GG2; other inputs for one acre farm land were supplied. These included urea 20kg, SSP 125Kg, MOP 20kg, ZnSO₄ 4kg (containing 12% Zn), Agricol (11%) 4 kg, Carbendazim (50%) 100g, FYM enriched PGPR 5 Kg, *Trichoderma viride* 600 gm.

The taluk-wise data on maximum, minimum, and average yield obtained with the improved practice and also with that of farmer's practice is given in Table 1 beside the data on economic potential of the improved practice vis-à-vis farmer's practice.



Table 1. Component: Improved Technology
Taluk: Kodinar

	Pod Yield (kg/ha)		Haulm Yield (kg/ha)		Cost of cultivation (Rs/ha)		Gross return (Rs/ha)		Net Return (Rs/ha)		BCR	
	TP	TP	TP	TP	TP	TP	TP	TP	TP	TP	TP	TP
Maximum	2840	2220	3700	3175	31460	28280	98680	68680	67220	40400	3.13	2.42
Minimum	1960	1600	2825	2540	29900	27240	72010	53800	42110	26560	2.40	1.97
Average	2501	1978	3337	3005	30682	27830	86713	61417	56031	33587	2.82	2.20
Taluk: Sutrapada												
Maximum	2450	2120	4513	3770	28000	27000	76808	66462	48808	39462	2.74	2.46
Minimum	1700	1480	3170	2808	25000	24500	53142	46265	28142	21765	2.12	1.88
Average	2093	1765	3561	3046	26385	25895	65511	55258	39127	29363	2.48	2.13
Taluk: Talala												
Maximum	2373	1950	4210	3041	26500	25800	64915	52786	38415	26986	2.44	2.04
Minimum	2050	1660	3397	2552	24800	24100	55994	44944	31194	20844	2.25	1.86
Average	2216	1799	3768	2814	25700	25000	60726	48798	35026	23798	2.36	1.95
Taluk: Una												
Maximum	3261	2632	3942	3396	37065	32454	114135	92120	77070	59666	3.07	2.83
Minimum	2500	2091	3375	2750	33442	25744	95235	73185	61793	47441	2.84	2.84
Average	2963	2316	3693	3026	35906	29357	103690	81081	67784	51723	2.88	2.76



In *Kharif* the validation of improved groundnut production technologies in farmers' fields were taken up in 8 taluks of Junagadh district. These includes in addition to the taluks taken up for the summer, Maliya, Keshod, Menderda, and Veraval. The inputs supplied are kept same as it in summer except urea. In its place ammonium sulphate was given. Survey was conducted to examine the socio-economic and psychological profile of OFT farmers and non-OFT farmers. The results obtained were presented below.

Majority of the farmers (67 per cent) using information technology tool viz. mobile, Television and other source of information's such as Shopkeeper, Private agency (Agro service centre), State Department of Agriculture, KVK, State Agricultural University but rarely found using (18.14 per cent) Radio, Neighbour, DGR. Further more than two third (83.33 per cent) of farmers having their own farm implements such as seed drill, multi tool bar, sprayer but tractor and thresher usage is concerned majority of the farmers hires.

Almost all OFT and Non- OFT farmers revealed that source of irrigation in *kharif* is mainly from rainfall and open well. 100 per cent OFT and Non-OFT farmers adopted seed treatment, its compulsory practice among the groundnut growers.

Non-OFT farmers used gypsum extensively than OFT farmers this may be due to hands on training given at the time of sowing. For *kharif* cultivation, both the groups of farmers not aware about varieties other than GG 20. Almost all the farmers used higher seed rate (75 Kg/ha). Majority (68.89 per cent) of farmers doing 3 hand weeding Practice in groundnut crop. Major fertilizer application is concerned majority (62.22 per cent) of farmers using DAP followed by SSP fertilizer in the study area. It was observed that more pest and diseases attacks observed at 5th week from the date of sowing in *kharif* season. It is interesting to note that on the very 2nd day farmers are doing plant disease management after observing the pests and diseases attacks.

As far as the marketing is concerned majority (68.89 per cent) of the farmers sale their groundnut produce in yard followed by sale of farm gate. Majority of farmers perceived that the quality of groundnut is good after using inputs provided in the OFT. It was observed that mainly on the basis of farmers need the selection of particular crop enterprise takes place. Majority (86.67 per cent) OFT and Non-OFT farmers have always self-confidence to have final decision.

The productivity and profitability obtained by the farmers who undertaken OFT in their field and non-OFT farmers has been given in the Table 2.



**Table 2. Component: Improved Technology
Taluk: Una**

	Pod Yield kg/ha		Haulm Yield kg/ha		Cost of cultivation (Rs/ha)		Gross return (Rs/ha)		Net Return (Rs/ha)		BCR	
	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP
Maximum	3750	2750	1500	1500	22675	15765	93750	64360	83540	53900	4.13	4.08
Minimum	1250	1250	1000	1000	10210	10425	35600	30750	20210	17482	3.49	2.95
Average	2440	2000	1310	1150	13408	12677	58492	47996	45048	35345	4.36	3.79
Taluk: Kodinar												
Maximum	4000	3000	5000	5000	29500	27500	105250	85200	81135	69120	3.57	3.10
Minimum	1250	1125	2500	1250	14630	14330	29000	24575	13290	8835	1.98	1.71
Average	2980	2475	3700	3200	20450	18763	64875	54589	43842	35302	3.17	2.91
Taluk: Veraval												
Maximum	3000	2500	5000	5000	27683	18981	65500	59000	37817	40145	2.37	3.11
Minimum	1875	1875	2500	3750	24377	18855	41812	44062	17435	25100	1.72	2.34
Average	2625	2082	4000	4000	26581	18932	57604	49354	31023	30421	2.17	2.61
Taluk: Maliya												
Maximum	2125	1875	3000	1000	18395	19195	55312	46875	37392	28130	3.01	2.44
Minimum	750	750	2500	1000	16045	17745	24750	24000	8705	6105	1.54	1.35
Average	1355	1307	2550	1000	17697	18283	36287	34845	18590	16562	2.05	1.91



Taluk: Keshod												
Average	812	750	1500	1250	17732	16002	20575	18156	2842	653	1.16	1.13
Taluk: Mendaria												
Maximum	1500	1230	2500	5000	24101	15000	43500	44500	19399	32350	1.80	2.97
Minimum	1500	300	2500	1250	14430	12150	43500	28500	19399	13980	3.01	2.35
Average	1500	1834	2500	2450	16510	13650	43500	38500	19399	24850	2.63	2.82
Taluk: Talala												
Maximum	1250	875	2500	2500	15200	15080	30500	23000	15475	8880	2.01	1.53
Minimum	1000	375	1750	1250	12730	14120	25500	11350	12770	830	2.00	0.80
Average	1156	563	2312	2000	14491	14712	28212	15525	13721	812	1.95	1.06
Taluk: Sutrapada												
Maximum	2750	2250	5000	3750	30962	29145	60000	51375	37005	30505	1.94	1.76
Minimum	750	375	750	1250	9930	9930	15600	9812	505	355	1.57	0.99
Average	1650	1355	2750	2425	20763	18979	37021	30746	13510	9493	1.78	1.62

Note: IP, improved practice; FP, farmer's practice

EXTENSION ACTIVITIES

Visit of farmers

This year (2012-13), a total of 1063 farmers in 25 different groups and as many as 333 students belonging to different agricultural universities visited DGR. Thus during the year altogether 1396 visitors from various states viz. Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Haryana, Uttar Pradesh visited the DGR. The visits were sponsored by State Departments of Agriculture or State Agriculture Universities concerned. These visitor-groups were taken round field experiments, technology park, laboratories, museum, library etc. and interaction meetings with the scientists were also arranged.

Training programmes organized for farmers

During year (2012-13), 6 trainings were conducted at DGR. There was a one-day training programme for inter-state visiting farmers on improved groundnut production technologies. A one-day training programme organized on 20th December 2012 for 30 farmers of Rajasthan. The training coordinated by Dr. Narayanan G. and covered topics like the role of DGR in development of groundnut varieties, improved agronomic practices, major pest and diseases and their management, conservation agriculture besides organized visits to field and museum.

Four three-day training programmes were organized on a common title "Technological interventions for improving groundnut productivity in tribal belts of Gujarat". The first batch of 45 farmers from Navsari district was imparted training on 24-26 December 2012, the second batch of 30 farmers from Vyara district 15-17 January 2013, the third batch of 35 farmers from Bharuch district on 31st January- 2 February 2013, and the fourth batch of 33 farmers from Junagadh district on 05-07 February 2013. Out of four, two trainings each were coordinated and co-coordinated by Mr. Murlidhar Meena and Dr. Narayanan G. A training manual prepared in Gujarati language was provided to the trainees.

For 25 farmers from Khargone district of Madhya Pradesh, another three-day training programme "Technical interventions for improving groundnut productivity among tribal farmers of district Khargone" was organized on 20-22nd March 2013. The training coordinated by Mr. Murlidhar Meena and co-coordinated by Mr. Nataraja, MV and the topics covered included among others improved agronomic practices, use of polythene sheet as mulch, management of major pests and diseases, minimizing the risk of aflatoxin-contamination, application of micro-nutrients, prospects of value-addition. The need for and prospects of mechanization of groundnut production and improved post-harvest management, marketing of produce and opportunities and challenges in ground cultivation. A training-manual prepared in Hindi was given to each of the trainees.



Farm Innovators Day: 15th September 2012

For the first time DGR celebrated the 'Farm Innovators Day'. More than 750 groundnut growers from Saurashtra region participated in the day-long programme. The farmers-scientists interaction was organized in such a manner that the farmers could interact freely for as long a duration as needed to clear their doubts. The speakers were drawn from grass-root level, extension workers and experts. Competitive programmes for the farmers on varietal identification and methods productivity improvement was an attraction for several farmers. The winning and participating farmers were also given away the prizes. An exhibition on DGR's achievements was also arranged. This event was widely covered by both electronic and print media.

Media Meet

On 28th September 2012, the Directorate of Groundnut Research (DGR) under the sponsorship of NAIP sub-project on “mobilizing mass media support for sharing agro-information” has convened a media meet. The objective was to create awareness among the stakeholders of groundnut including farmers, exporters and agro-industries people about three newly developed eco-friendly and economically viable technologies by the DGR. The title of the meet was “DGR technologies” for commercialization, while the 'DGR technology' word being the brand name. Three press notes were simultaneously released for the wider reach of people. Each press note was printed in Hindi, Gujarati, and English and circulated amongst media personnel. The first press note titled 'DGR technology for industrial production of Enzyme *cellulase*'. In the press note it was stated that by investing a sum of ₹ 10 to 50 lakhs for the infrastructure, one can produce Enzyme *cellulase* from groundnut shell and can earn good profit. The second press note titled 'Biofertilizer mixture for enhancement of groundnut yield – An opportunity for commercialization'. About 20% yield increase can be obtained in the groundnut, if this biofertilizer is applied in the field. For its commercial production the DGR is ready to share the technology with interested persons. Third press note released under the title 'DGR develops new “Girnar” series of groundnut varieties'. Information on “Girnar2” and “Girnar3” varieties were shared with media persons and emphasised for wider publicity among groundnut growing community. This event was covered in eight print and two electronic media in the subsequent days. Farmers and industrial persons contacted the DGR for further information.



PROJECT 14. BREEDING FOR LARGE-SEEDED AND CONFECTIONERY GROUNDNUT

(M. C. DAGLA, RADHAKRISHNANT., A. L. RATHNAKUMAR, CHUNILAL, S. K. BISHI*, M. K. MAHATMA**, NARENDRA KUMAR AND AJAY B. C.)

*On study leave since 1st August, 2012; **Associated in this project since July 2012

Hybridization (*Kharif*-2012)

Nineteen crosses were attempted to incorporate large seed size coupled with high yield and other confectionary traits (high O/L ratio, high protein and low oil content). A total of 3328 buds were pollinated and 838 probable hybrid pods were harvested with 25% success.

Table 1. Crossing programme in *Kharif*-2012

Cross	Purpose	Bud Pollinated (No.)	F ₁ pods (No.)	Success rate (%)
TPG 41 x S 230	Large kernel with high O/L ratio	289	83	28.7
ICGV 97079 x Dh 3-30	High yield with low oil content	392	108	27.6
GPBD 4 x Dh 3-30	Kernels with high protein and low oil contents	275	82	29.8
ICGV 97079 x MH 4	High yield and short duration	422	90	21.3
Gangapuri x M 13	Large kernels with high sugar content	98	30	30.6
MTI 4 x M 13	Large kernels and short duration	99	4	4.0
BAU 13 x CS 281	Large kernels	288	51	17.7
BAU 13 x GG 20	High yield and large kernels	197	53	26.9
BAU 13 x GPBD 4	Large kernels with high protein content	245	46	18.8
CS 281 x GG 20	Large kernels and high yield	210	71	33.8
CS 281 x GPBD 4	Large kernels with high protein content	298	91	30.5
BAU 13 x NRCG 14492	Large kernels	63	21	33.3
NRCG 14492 x BAU 13	Large kernels	94	20	21.3
Gangapuri x NRCG 14492	Kernels with high sugar content	145	57	39.3
NRCG 14492 x Gangapuri	Kernels with high sugar content	146	17	11.6
CS 281 x Chico	Large kernels	29	9	31.0
Chico x CS 281	Large kernels	4	2	50.0
ICGV 07368 x Chico	Large kernels	30	1	3.3
Chico x ICGV 07368	Large kernels	4	2	50.0
Total		3328	838	25.2

Identification of true hybrid plants (*Summer*-2012)

Eleven crosses generated during *kharif*-2011 were raised along with their seven parents and 170 true hybrid plants identified and pods were harvested for further advancement.



Table 2. True hybrids identified and selected as single plant in F_1 generation.

Crosses	Purpose	SPP*
GG 20 x GPBD 4	High yield and high protein content	14
TPG 41 x S 230	Large kernels with high O/L ratio	36
GPBD 4 x S 230	Kernels with high protein content and high O/L ratio	13
ICGV 97079 x Dh 3-30	High yield, and kernels with low oil content	25
GPBD 4 x Dh 3-30	Kernels with high protein and low oil content	14
S 230 x Dh 3-30	Kernels with high O/L ratio	7
ICGV 97079 x MH 4	High pod yield	28
GG 20 x MH 4	High pod yield and short duration	9
GPBD 4 x MII 4	Kernels with high protein content and short duration	6
S 230 x MH 4	Kernels with high O/L ratio	16
Dh 3-30 x MH 4	Kernels with low oil content	2
Total		170

*SPP: Single Plant Progeny

Generation advancement (*Kharif-2012*)

The F_2 generations of 11 crosses were sown and true F_2 s (segregating) were identified and advanced. The selected crosses were cross-wise bulk-harvested for advancing to next generation. Twenty crosses in F_3 were sown and progenies were harvested in bulk. Seven crosses in F_4 were advanced. Similarly, 5 crosses were advanced from F_5 to F_6 generation and one cross was rejected due to its poor performance.

New advanced breeding lines (*Kharif-2012*)

In F_6 generation, nine crosses were sown and among these, one cross was rejected because of its very poor phenotypic performance. Among the remaining eight crosses, one line was selected and identified as Spanish and 17 lines were selected and identified as Virginia. Single plant has been selected for development of each ABL (Advanced Breeding Line) and will be multiplied in next season for making sufficient seeds to conduct their evaluation trial.

Spanish yield evaluation trial (Summer-2012)

Yield evaluation trial for Spanish type was conducted during summer-2012. There were six ABLs and two checks TPG 41 and TG 37A. Data were recorded for yield parameters and some quality traits required for confectionary purpose. Enough genetic variability was found for all the studied traits except kernel yield.

Being a large seeded Spanish variety, TPG 41 was used as reference for all the traits. PBS 19018 was found to be superior to check for total dry matter production, pod yield, harvest index and number of pods per plant. PBS 19020 was superior for total dry matter and haulm yield, hundred kernel weight, kernel count and hundred sound mature



kernels weight. PBS 19021 was found to be superior to TPG 41, only for kernel count and hundred sound mature kernel weight, while PBS 19022 was superior for total dry matter production, pod yield, harvest index, hundred kernel weight, kernel count and hundred sound mature kernel weight. PBS 19023 was found to be superior to check for dry matter production, pod yield, hundred kernel weight, kernel count and hundred sound mature kernels weight. PBS 19024 was superior for dry matter production, haulm yield and pod yield. For shelling and sound mature kernel none of the genotypes was found superior to check.

Spanish yield evaluation trial: Pooled analysis over two years (Summer-2011 and 2012)

The yield trial of six ABLs and two checks (TPG 41 and TG 37 A) was conducted for the last two years (Summer-2011 and Summer-2012). In general, in Spanish group there are small numbers of large-seeded varieties. So far, at least ten Spanish large-seeded advanced breeding lines have been developed. Among these, six lines were tested for two subsequent summer seasons. Pooled analysis indicated that two advanced breeding lines, PBS 19018 and PBS 19022 surpassed the standard check TPG 41 for pod yield. Other quality traits like hundred kernel weight and kernel count exceeded the value of these traits in check.

Virginia yield evaluation trial (Kharif-2012)

Virginia yield evaluation trial was conducted during *kharif*-2012. There were fifteen Virginia ABLs and three checks GG 20, BAU 13 and M 13. Data were recorded for yield parameters and a few quality traits for confectionary purpose. Enough genetic variability was observed for all the studied traits except days to maturity. For pod yield, GG 20 was the best check, and though one ABL (PBS 29148) surpassed this check, the difference was not significant.

Spanish yield evaluation trial (Kharif-2012)

In an evaluation of seven Spanish ABLs and one check TPG 41, it was found that there was enough genetic variability for all the traits studied. For pod yield, only one ABL (PBS 19024) surpassed the check significantly.

Screening of Spanish mini core germplasm for confectionary traits (Kharif-2012)

Total 60 lines (56 germplasm and 4 checks) were screened for confectionary traits. Enough genetic variability was found for pod yield, HKW, HSMK, KL, KW and KL:KW ratio, oil and protein contents. Genotypes NRCG14500 was identified for high protein content (33%), NRCG 14470 for low oil content (48%), and NRCG14430 for high shelling (73%).

Screening of Valencia mini core germplasm for confectionary traits (Kharif-2012)

Total 28 lines were screened for confectionary traits. Enough genetic variability was found for pod yield, HKW, HSMK, KL, KW and KL: KW ratio, oil and protein contents. Genotypes NRCG14379 was identified for high shelling outturn (72%), NRCG14470 for low oil content (47%), and NRCG14448 for high protein content (31%).



PROJECT 15.**UTILIZATION OF WILD *ARACHIS* GENE POOLS FOR GROUNDNUT IMPROVEMENT**

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

I) Evaluation of interspecific derivatives**a) Yield evaluation of Virginia bunch genotypes**

- Selected Virginia bunch (VB) genotypes were evaluated for yield and related traits during kharif 2011 and kharif 2012. Twenty-six promising VB genotypes along with check variety (GG-20) were evaluated in RBD with three replications. Significantly higher pod yield was recorded in the genotype NRCGCS-414 than check variety along with >70% shelling out turn and >90% sound matured kernels weight based on pooled analysis over two seasons. Genotype NRCGCS-414 shall be recommended for AICRP testing.

b) Yield evaluation of Spanish bunch genotypes

- Selected Spanish bunch (SB) genotypes were evaluated for yield and related traits during kharif-2011 and also during rabi-2012. Five promising SB genotypes along with four checks were evaluated in RBD with three replications. None of the genotypes out performed the checks in yield.

c) Yield evaluation of large kernel size mutants

- Groundnut mutants with small and large kernels were developed by chemical mutagenesis of NRCGCS-281, an advanced pre-breeding line with large kernel size and deep pod constriction. Forty large/small kernel size mutants bred true along with NRCGCS-281 were characterized during summer and rainy seasons in 2012. On the basis of pod yield per plant, mutants 281-21-1, 281-21-2, 281-25-4, 281-22, 281-25-3 and 281-21-3 were found superior than NRCGCS-281, while for HSM none of these mutants exceeded the NRCGCS-281.

II) Advancement of segregating progeny**a) RILs developed from cross between GG-20 and CS-19**

- Recombinant inbred lines developed from a cross between GG-20 and CS-19 were sown for advancement during summer season. Two hundred and seventy eight RILs (F_{5-6}) were sown in two lines of five metre bed. Heterozygous plants were roughed out to attain homogeneity among progenies. Post harvest observations were recorded. Pod yield /10 plants ranged from 8 to 200 g with an average of 141 g indicating wide variability among RILs progenies. Similarly, hundred seed mass and shelling out turn ranged from 32 to 66 g and 47 to 84 per cent, respectively.



b) RILs developed from cross J11 X *A. pusilla*

- During kharif season the segregating progenies (F_{5-6}) developed from a cross between J-11 and *A. pusilla* were advanced to next generation. Hundred and forty-six segregating progenies along with checks were sown in single line of five metre bed following recommended crop management practices. Initial screening of these RILs under natural field conditions was not any avail due to poor incidence of foliar as well as soil borne diseases. However, lines with higher SCMR along with low SLA were identified from these RILs.

c) Segregating progenies

- Segregating progenies (F_{5-6}) developed from OG52-1 x CS-19 and ICGV-86590 x CS-19 and OG52-1 x ICGV-86590 were sown for advancement during summer and also during kharif. Four hundred and two lines were sown in single line of five metre bed during summer 2012 season. Segregating lines were advanced to next generation. Yield and related traits were recorded at harvest. Pod yield per line ranged from 17-900 g with an average of 257 g. Similarly, hundred kernels mass and shelling out turn ranged from 24-62 gram and 56-79 per cent, respectively.
- These 402 lines were further evaluated during kharif season. Each line was sown in single line of five metre bed. Among 15 checks used, cultivar GJG-31 was found superior and was followed by TG37A. Thirty genotypes were found superior to check TG37A based on pod yield plant⁻¹. Besides segregating populations of 'J11 X *A. pusilla*', 'J11 x *A. diogeni*', 'J11 x *A. appressipila*', 'J11 x *A. duranensis*', 'J11 x *Kretschmeri*' and 'J11 x *A. kempff-marcadori*' were advanced from F₂ to F₃ generation and bulked.

III) Advanced interspecific breeding lines recommended for multi-locations testing under AICRP

- Interspecific genotypes NRCGCS-253, NRCGCS-287 and NRCGCS-401 were found superior to check. Seeds of these three lines were multiplied during summer 2012 and supplied for testing under AICRP during kharif 2012.
- In addition, Seeds of an interspecific genotype NRCGCS-425 were multiplied during summer season and supplied to AICRP-G centers for testing under advanced varietal trial (AVT). Based on the performance in initial varietal trial (IVT) over two years the NRCGCS-425 was promoted to AVT. Similarly, seeds of NRCGCS-369, NRCGCS-264, NRCGCS-349, NRCGCS-240, NRCGCS-298, NRCGCS-291 and NRCGCS-280 were also multiplied during rainy 2012 season for AICRP testing during rainy 2013.



IV) Hybridization

- Back crossing was done using triploid and pentaploid hybrids during rainy season under field conditions. Probable cross pods were harvested and will be sown in the next rainy season for second back-crossing (table-1). In addition inter-varietal crosses were made to develop RILs for improving harvest index (NRCG-4747 X TMV 2 NLM), tolerance of salinity (NRCG-4659 X NRCGCS-237) and resistance to peanut bud necrosis disease (JL-24 X NRCGCS-86).

Table 1. Particulars of hybridization made during rainy season and cross pod harvested

Cross	No. of pollinations attempted	No. of cross pods harvested
GG2 X 3x of (J11 X <i>A. pusilla</i>)	377	157
GG2 X 3x of J11 X (<i>A. kempff-marcadoi</i>)	417	200
GG2 X 3x of J11 X (<i>A. diogoi</i>)	380	207
GG2 X 5x of J11 X (<i>A. Kempff-marcadoi</i>)	189	99
NRCG-4747 X TMV2 NLM	100	30
JL-24 X NRCGCS-86	299	197
NRCG-4659 X NRCGCS-237	13	10

V) Maintenance of genetic Stocks

- Maintained and multiplied 42 wild *Arachis* species for regular use in on going interspecific breeding programme.
- Maintained and multiplied 34 groundnut mutant stocks collected from various sources and registration secured for multiple disease resistant interspecific breeding lines for their conservation and use
- Maintained and multiplied 435 interspecific pre-breeding groundnut genotypes developed in the section for resistance to various biotic and abiotic stresses.
- Maintained 75 interspecific breeding lines resistant to various diseases and supplied to indenters.

VI) Identification of SSRs linked with with kernel mass

- Groundnut mutants with small and large kernel were developed by chemical mutagenesis of NRCGCS-281, an advanced pre-breeding line with large kernel size and deep pod constriction. Four large (HSM: 68.1 g, 66.5 g, 63.4 g and 64.0 g) and eight small kernel size (HSM: 25.7 g, 31.7 g, 33.8 g, 32.1 g, 37.8 g, 31.0 g, 38.7 g and 36.3 g) genotypes which bred true and also NRCGCS-281 were subjected to molecular analysis using 35 SSRs.



- The PIC value of 28 polymorphic SSRs ranged from zero to 0.91 with an average of 0.63. The MI value of primers ranged from zero to 85.5 with an average value of 43.4. Twenty-eight polymorphic primers discriminated 13 *genotypes into two clusters*. All genotypes grouped into a single cluster (denoted as cluster-I) except NRCGCS-281-7.
- AMOVA among two groups detected 15% ($P < 0.025$) of total variation associated with high hundred seed mass (HSM). Kruskal-Wallis ANOVA detected significant association of six primers (TC3A12, TC4G02, TC9B08, PM478, TC9H09, and TC3D04) with higher HSM. These six primers had higher number of alleles per locus along with higher polymorphic per cent, PIC and MI values and showed significant association with HSM by simple regression analysis. Among these six primers, TC3A12 and TC9H09 explained 28.2% ($P = 0.006$) and 12.1% ($P = 0.003$) of phenotypic variations, respectively due to high HSM. Out of these two, TC3A12 amplified an allele of approximately 400bp in genotypes with high HSM which did not amplify in genotypes with low HSM. Thus, TC3A12 was able to discriminate the pooled DNA of genotypes with high HSM from the pooled DNA of genotypes with low HSM.
- The association of locus TC3A12₄₅₀ with HSM was further validated in genotypes with different genetic background to test its reliability as a marker. For this purpose, four varieties with high HSM and one variety with low HSM of diverse genetic background were used to check the presence of allele. The TC3A12 primer amplified the 400bp allele in three varieties with high HSM but did not show an amplification in variety with low HSM.

VII) Molecular diversity in interspecific derivatives of groundnut resistant to peanut bud necrosis disease (PBND) using SSRs

- Screening of 435 peanut genotypes along with susceptible check variety KRG-1 under field conditions over two seasons resulted in identification of additional sources of resistance to PBND. Based on mean disease incidence over two seasons, 115 genotypes were found resistant to highly resistant. Of these 42 scored less than 1% disease incidence, while 73 genotypes scored less than 5% disease incidence. Susceptible check variety KRG-1 scored more than 60% disease incidence. The genotypes which showed less than 5% incidence were used for molecular analysis using SSR markers.
- All 20 SSRs were highly polymorphic ($>50\%$) in cultivated groundnut and the polymorphism ranged from 57 to 100% with an average polymorphism of 92.2 %. The PIC value ranged from 0.5 to 0.91 with an average of 0.80. Marker index (MI) of SSR markers ranged from 43.3 to 92.0 with an average of 75.8.



- Cluster analysis based on Jaccard's similarity coefficient classified the peanut genotypes into three major clusters. The dendrogram indicated that majority of the genotypes clustered in the range of 0.59 to 0.92 similarity coefficient indicating presence of wide variability among the genotypes studied. Susceptible cultivar KRG-1 was discriminated from resistant genotypes NRCGCS-28 and NRCGCS-86 by eight SSR markers. This grouping of genotypes was further confirmed with Principal coordinate analysis (PCoA). Groupings of genotypes identified by PCA were comparable to those of identified by UPGMA cluster analysis. More than 26% of genetic variation was explained by the first 2 coordinates. The first and second coordinates explained 16.6% and 10.3% variations with Eigen value of 1.76 and 1.09, respectively.
- Further, three populations identified by UPGMA and PCA were subjected to analysis of molecular variance (AMOVA) to know the variability among the groups. The three populations showed significant variation ($P < 0.001$), with 96% of the variation attributed to within populations and 4% attributed to among populations.
- NRCGCS-28, NRCGCS-86 and KRG-1 grown in glass house were tested for resistance to PBNB artificially using sap inoculation method followed by ELISA. Tested genotypes were found positive to PBNV, however were resistant to PBNB with 8% and 9% disease incidence, respectively. In contrast, 70% disease incidence was recorded in the susceptible genotype KRG-1. Incubation period for appearance of disease symptom were also longer in case of NRCGCS-28 as well as NRCGCS-86 and shorter in case of KRG-1. The registration of genotype NRCGCS-86 as multiple disease resistant groundnut germplasm has been secured with NBPGR, New Delhi.

VIII) Variable changes in genome size associated with different polyploid events in *Arachis hypogaea*

- Using *Allium cepa* ($2C = 33.5 \mu g$) as an internal standard flow cytometry of propidium iodide stained nuclei of *Arachis* species gave sharp peaks with low coefficients of variation ($< 4\%$ of the $2C$ peak). Observed mean $2C$ -values were 4.69pg, 6.41 pg, 8.44pg and 11.90pg in diploid, triploid, tetraploid and pentaploid, respectively. Across the ploidy levels, $2C$ value differed significantly and an approximately 1.15-fold increase in $2C$ value was observed in pentaploid genome over its diploid one. Maximum deviation was observed in tetraploid and deviation was less in artificial triploid and pentaploid. However, C -value is positively correlated with ploidy level.
- Fertile pollen count varied from 25 to 90 among ploidy level, although variation was not significant between diploid and tetraploid as well as triploid and tetraploid. Fertile pollen count was lowest in pentaploid and it was highest in diploid. Fertile



pollen count is positively correlated with ploidy level. Diploid, triploid and tetraploid were fertile and produced profuse pods. On the other hand pentaploid was sterile as it did not produce any pods under natural field conditions even after two years.

- Pollen diameter varied significantly among ploidy levels except between triploid and pentaploid. Pollen diameter did not increase in relation to increase in ploidy. Pollen diameter was shorter in diploid and was longer in pentaploid. Pollen diameter was significantly correlated with ploidy level.
- Stomatal density though varied between ploidy levels but the variation was not commensurate with genome size. It was lowest in pentaploid and highest in triploid, although range was wider in higher ploidy levels than diploid. Stomatal density was significantly correlated with ploidy level. Length of stomata increased with the increase of ploidy level. The range of length of stomata in pentaploid was distinct to that of the lower ploidy levels and there was a considerable overlapping in the ranges of length of stomata among diploid, triploid and tetraploids. Length of stomata was significantly correlated with ploidy level.
- SCMR varied with ploidy level. Lowest SCMR value was observed in diploid and highest in tetraploid. Increase in SCMR value was not commensurate with ploidy levels, although there was a considerable overlapping in the range of SCMR among the ploidy levels. SCMR was significantly correlated with ploidy level.
- SLA also varied with ploidy levels. It was lower in triploid and pentaploid, while it was higher in diploid and tetraploid. A considerable overlapping was observed in the range of SLA of different ploidy levels. SLA was significantly correlated with ploidy level.
- RWC varied between diploid and higher ploidy levels, although no significant variation was observed among triploid, tetraploid and pentaploid. RWC was lowest in diploid and highest in pentaploid. There was a considerable overlapping in ranges of RWC of different ploidy levels. RWC was significantly correlated with ploidy level.
- Leaf length/width ratio varied between diploid and higher ploidy levels, although no significant variation was observed among triploid, tetraploid and pentaploid. Similarly, range of leaf length/width was wider as well as considerably overlapping among triploid, tetraploid and pentaploid. Leaf length/width was significantly correlated with ploidy level.
- Leaf thickness was lower in diploid and increased in relation to ploidy level. Unlike leaf thickness, thickness of palisade tissue was lower in diploid and increased with increase in ploidy level. Both leaf thickness and thickness of palisade tissue were found positively correlated with ploidy level.



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

(MURLIDHAR MEENA, NARAYANANG AND, A.P. MISIRIA)

(A) Price transmission in groundnut oil markets in India

An analysis of data on monthly peanut oil wholesale price from January 1992 to December 2011 of Chennai, Hyderabad, Kolkata, Mumbai, Rajkot and Delhi revealed that Chennai market expressed relatively a wider wholesale price variation compared to prices in Rajkot and Delhi markets, while price fluctuations in Hyderabad, Kolkata and Mumbai markets were more or less similar. The wide variation in prices in Chennai market represents a regional effect in consumer preferences for edible oils. It may also be due to more substitution option (other-then peanut oil oils) for consumers. Highest average wholesale price of ₹ 5,652 was in Delhi, followed by Rajkot market and the least price was the Chennai market. Hyderabad and Kolkata market had same average wholesale price of groundnut oil (Table-1).

Table 1. Average wholesale prices in six Indian markets and their coefficient of variation (₹ Qt⁻¹)

Location	Minimum	Maximum	Mean	'γ'
Chennai	2242	9999	4732	35.3
Hyderabad	2470	9100	4878	30.9
Kolkata	2470	9100	4878	31.0
Mumbai	2460	9700	5084	30.84
Rajkot	2900	10867	5270	33.7
Delhi	2833	11000	5652	32.6

Augmented Dickey Fuller (ADF) and Phillip-Peron (PP) tests results (Table-2) revealed that none of the price series was stationary at the level and they become stationary at the first difference. It confirmed that all the price series were integrated of the order one [I(1)], when linear trend was excluded from the unit root test. The result obtained, confirmed the precondition for co-integration i.e. non-stationary at level and integrated of same level. It means that there is long-run or equilibrium relationship in peanut oil wholesale prices observed in different markets during the study period.



Table 2. Result of Augmented Dickey-Fuller and Phillips-Perron Test

Location of market	Level Probability		First Difference Probability	
	ADF Test	PP Test	ADF Test	PP Test
Chennai	0.65	0.78	0.00	0.00
Delhi	0.75	0.76	0.00	0.00
Hyderabad	0.31	0.31	0.00	0.00
Kolkata	0.54	0.50	0.00	0.00
Mumbai	0.31	0.31	0.00	0.00
Rajkot	0.66	0.63	0.00	0.00

Johansen co-integration was used to judge extent of price transmission in the integrated markets. The result revealed that all the six markets were integrated with one or more markets in long-run (Table 3). There was long-run equilibrium between Hyderabad and Chennai; Chennai and Mumbai; Chennai and Rajkot; Delhi and Kolkata; Hyderabad and Rajkot; and Mumbai and Rajkot. The results showed that Rajkot market is the major player among the peanut oil markets since Rajkot region is the main peanut producing hub in India. As eastern part of the country is not the traditional grower of peanut, Kolkata market depends on Delhi market means Kolkata market is having long-run relationship with the Delhi market. The coefficients of the long-run co-integration for different pairs of markets (Chennai-Hyderabad; Mumbai-Chennai; Rajkot-Chennai; Rajkot-Hyderabad; Kolkata-Delhi and Mumbai-Rajkot) are highly statistically significant at less than 1% level, implying that there is a long-run relationship among these pairs of markets (Table 4). The coefficient varied from -1.3 (Rajkot-Hyderabad) to -0.75 (Mumbai-Rajkot), here negative sign of co-efficient indicates that market converges to equilibrium in long-run.

Table 3. Pair-wise Co-Integrated Wholesale Markets

Market	Chennai	Delhi	Hyderabad	Kolkata	Mumbai	Rajkot
Chennai	1	NO	YES	NO	YES	YES
Delhi	NO	1	NO	YES	NO	NO
Hyderabad	YES	NO	1	NO	NO	YES
Kolkata	NO	YES	NO	1	NO	NO
Mumbai	YES	NO	NO	NO	1	YES
Rajkot	YES	NO	YES	NO	YES	1



Table 4. Cointegration Equations for Peanut Oil Wholesale Prices

Cointegration Equation:	CIIE(-1)_HYD(-1)	MUM(-1)_CHE(-1)	RAJ(-1)_CHE(-1)	RAJ(-1)_HYD(-1)	KOL(-1)_DEL(-1)	MUM(-1)_RAJ(-1)
Coeff.	-1.17	-0.84	-1.08	-1.30	-0.99	-0.77
S.E	-0.03	-0.04	-0.05	-0.05	-0.06	-0.05
t-stat	[-35.86]	[-20.28]	[-21.91]	[-23.72]	[-17.90]	[-17.18]
C	24.31	-26.42	-3.85	25.61	-7.64	-26.38

Note: C denotes intercept. Figures in parenthesis are t-values. CIIE, HYD, MUM, RAJ, KOL, DEL represents Chennai, Hyderabad, Mumbai, Rajkot, Kolkata and Delhi markets respectively.

(B) Impact of trade liberalisation on groundnut area, production and productivity in India

In India, groundnut is cultivated on large areas in Gujarat, Tamil Nadu, Andhra Pradesh, Rajasthan, Karnataka and Maharashtra which collectively account for about 93% of area and equal extent of production. In 2010-11, the total cropped area (kharif + rabi-summer) was 5.9 million hectare with production of 8.3 million tonne. Time series data from 1980-81 to 2010-11 on groundnut area, production and productivity was analysed using growth rate and instability analysis and was compared with those of total nine oilseed crops. The study period was divided into six equal sub-periods, viz. 1980-81 to 1984-85, 1985-86 to 1989-90, 1990-91 to 1994-95, 1995 to 1999-00, 2000-01 to 2004-05 and 2005-06 to 2009-10 to for analysing the performance during different sub-periods.

During the whole period of study, the Indian oilseeds sector underwent several ups and downs. The maximum compound annual growth rate (CAGR) of 14.6% was observed in production and this was followed by yields (8.7%) and area (5.4%) in pre-liberalisation period (1985 to 1990's). This could be attributed to a positive impact of Technology Mission on Oilseeds and Pulses (TMOP) launched by Govt. of India in 1986 (Table-5). There was not any observable negative growth in history of Indian oilseeds sector prior to trade liberalisation but as soon as Indian market was opened for international players, a negative growth was often observed in both area and production. There was relatively a higher instability in oilseeds production and yield than in area. This was possibly due to fact that oilseeds in India are cultivated generally (three-fourths of area) under low input rain fed conditions. The growth performances during different sub-periods indicated that there was a higher growth in area, production and yields during pre-liberalisation phase than in post-liberalisation phase thereby indicating a negative impact of liberalisation on oilseeds sector as a whole. In post-liberalisation phase, however, instability in oilseeds area, production and yield was much higher which implied that in this globalized economy, the performance of oilseed crops became highly sensitive to international markets and changing trade policies.

In case of groundnut area, a positive growth was recorded in pre-liberalisation phase up-to 1989-90 and subsequently a continuous negative growth was observed during the post-liberalisation period. Groundnut production in the country also recorded a negative



growth during 1995 to 2000 (6.69%) and 2005 to 2010 (3.77%) which was a combined effect of negative growth in area as well as yield. In other post-liberalisation periods, a positive growth in production could be attributed to a positive growth in yield. The highest positive growth (15.2%) was recorded in groundnut production between 1985 and 1990 because of policy and support intervention by Govt. of India i.e. an effect of TMOP. Conversely, the adverse impact of liberalisation was reflected in the negative growth in post liberalisation era. During the study-period, relatively a higher instability was observed in post-liberalisation period. In groundnut, the highest index of instability was for production (0.47) and this was followed by yield (0.45) and area (0.13). Comparatively a greater uncertainty was observed in groundnut than all the nine oilseeds put together which highlights the vulnerability of groundnut to international markets and trade policies. Erratic rainfall resulting in frequent droughts of various spells groundnut growing areas are the main reason for this instability in area, production and productivity as nearly 80% area under groundnut lies in rain-fed conditions. Least instability in production (0.13) and yield (0.15) was observed during 1991-95 which could be ascribed to a positive impact of TMOP.

Table 5. Compound annual growth rate (CAGR) and instability analysis of area, production and yield of nine oilseeds and groundnut in India

Periods	Nine oilseeds					
	Area		Production		Yield	
	CAGR (%)	Instability index	CAGR (%)	Instability index	CAGR (%)	Instability index
1980-85	1.34	0.05	7.21	0.22	5.80	0.17
1986 -90	5.38	0.04	14.59	0.15	8.72	0.13
1991 -95	1.32	0.06	4.28	0.04	2.88	0.06
1996-00	-1.37	0.04	-1.14	0.15	0.24	0.12
2000-05	4.32	0.08	7.83	0.31	3.36	0.28
2006 -10	-1.02	0.04	-1.02	0.18	0.01	0.15
Periods	Groundnut					
	Area		Production		Yield	
	CAGR (%)	Instability index	CAGR (%)	Instability index	CAGR (%)	Instability index
1980-85	1.21	0.06	4.96	0.31	3.71	0.26
1986 -90	6.22	0.11	15.19	0.26	8.46	0.18
1991 -95	-1.54	0.05	2.44	0.11	4.03	0.15
1996-00	-2.05	0.05	-6.69	0.32	-4.71	0.28
2000-05	-0.17	0.06	2.58	0.45	2.76	0.45
2006 -10	-3.17	0.13	-3.77	0.47	-0.66	0.36



Research Highlights of AICRP on Groundnut- 2012-13

Crop Improvement

- ◆ In *kharif* 5419 accessions during and in rabi-summer 1123 accessions during *rabi*-summer were maintained.
- ◆ At Dharwad, two interspecific hybrid populations (pre-bred) comprising 97 and 84 lines were screened for tolerance of stem rot (*Sclerotium rolfsii*). Of these 181 lines screened, 52 lines (26 each) were found to be tolerant to *S. rolfsii*.
- ◆ At Vridhachalam, promising pre-breeding lines (interspecific derivatives) have been identified for earliness (<110 days) in Virginia bunch types; drought tolerance; fresh seed dormancy (>20 days); and resistance to foliar diseases (rust and LLS) in *kharif* season.
- ◆ At various AICRP-G centres, 225 single-crosses in *kharif* and 142 in *rabi*-summer were made for developing high-yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses.
- ◆ In *kharif*, progenies of 1190 crosses were advanced to their respective next filial generations and very large number (16648) of selections were made. The selections comprised of 12154 single plants and 4494 progeny bulks. In *rabi*-summer progenies of 593 crosses were advanced to their respective next filial generations and a large number (7547) of selections were made at 13 AICRP-G centres. The selections comprised of 6467 single plants and 1080 progeny bulks.
- ◆ A total of 26 genotypes in *rabi*-summer and 78 genotypes in *kharif* were evaluated in the three tier system i.e. Initial Varietal Trial-I, Initial Varietal Trial-II and Advanced Varietal Trial-I across 30 locations.
- ◆ In *kharif* season, in Zone V (southern peninsular region) one Spanish bunch test genotype, JL 777 was found superior for both pod (2733 kg/ha) and kernel (1816 kg/ha) yield over those of the best zonal check, R 2001-3. This genotype exhibited numerical superiority in six out of ten locations over the best check and hence was promoted to AVT.
- ◆ In zone III (Madhya Pradesh and Northern Maharashtra) the genotype, JL 776 recorded 16% higher kernel yield over the best check variety, GG 8 across different stages of testing and hence it is proposed for identification.
- ◆ For the year 2011-12, against an indent of 25501.60 q of groundnut breeder seed a production target of 18114.80 q comprising 61 groundnut varieties was set. At 22 breeder seed producing centres seed production was taken up both in *kharif* and *rabi*-summer and thus a total of 17241 q of breeder seed was produced.



Crop Production

i) Post-emergence herbicide for rainfed groundnut

- ◆ Although, the weed free check (manual weeding) was found most economical for realization of high groundnut productivity but often labourers are not available. Combined application of pre (pendimethalin 30 EC @ 1 kg a.i. ha⁻¹) and post-emergence herbicides (quizalofop ethyl 5 EC @ 50 a.i. ha⁻¹ at 20 DAS or Imazethapyr 10 WC @ 75g a.i. ha⁻¹ at 20 DAS) and one hand weeding at 45 DAS was as effective as weed free check in terms of weed control as well as economics.

ii) Packages for organic groundnut

- ◆ Application of FYM @ 7.5 t ha⁻¹ enriched with bio-fertilizers – bio-pesticide @ 2.0 kg ha⁻¹ each and seed treatment with bio-fertilizer + bio-pesticides + PGPR + *Trichoderma* @ 200 g ha⁻¹ each + foliar application of *panchagavya* at 45 DAS was the most productive and economically viable option for organic groundnut cultivation.

iii) Nutrient management in groundnut + Bt-cotton intercropping system

- ◆ At Dharwad, application of 75% recommended doses of fertilizers (RDF) to groundnut and 100% RDF to Bt-cotton crop was found to be profitable over other fertilizer management practices in groundnut-Bt-cotton (3:1) intercropping. The groundnut-Bt-cotton (3:1) intercropping system was much more remunerative compared to sole groundnut or Bt-cotton crop.
- ◆ At Junagadh, application of 100% RDF to groundnut and 100 % RDF to Bt-cotton crop was more profitable over other fertilizer management practices in groundnut-Bt-cotton (3:1) intercropping system. The groundnut-Bt-cotton (3:1) intercropping system was more remunerative as compared to sole groundnut or Bt-cotton system.

iv) Management of sulphur and calcium through application of gypsum in rain-fed groundnut

- ◆ Application of gypsum @ 600 kg ha⁻¹ was found to be most appropriate dose in enhancing economically higher groundnut productivity at both Aliyarnagar and Bhubaneswar. Basal application of gypsum was as effective as to application in two splits i.e. 50% as basal and remaining 50% at flowering (45 DAS) at Aliyarnagar but at Bhubaneswar application in split dose was found superior.
- ◆ At both Chinthamani and Durgapura, application of gypsum @ 800 kg ha⁻¹ was found most appropriate dose for economically higher groundnut productivity. Further, application in split halves as basal and remaining 50% at flowering (45DAS) or 100% at flowering (45 DAS) was found better than 100% gypsum application as basal at Chinthamani.



- ◆ Basal application of entire dose of gypsum, however, was found better than split application at Durgapura.
- ◆ At Jalgaon, application of gypsum @ 400 kg ha⁻¹ was found most suitable for economically higher groundnut productivity. Application in split doses half as basal and half at later stage gave better results.
- ◆ At Junagadh application of gypsum @ 400 kg ha⁻¹ as basal was found most appropriate gypsum dose for economically higher groundnut productivity.
- ◆ At Mohanpur, application of gypsum @ 600 kg ha⁻¹ is the most appropriate dose for economically higher groundnut productivity. Further, application either in two split halves, 50% as basal and 50% at flowering (45 DAS) or 100% at flowering (45 DAS) was better than 100% basal application.

vi) Tillage and sowing methods for groundnut in rice-groundnut system in rabi-summer

The following land preparation and sowing methods were optimized:

- ◆ Land preparation with rotavator and use of seed cum fertilizer drill method of sowing at Jagtial
- ◆ Land preparation with conventional tillage or rotavator with any method of sowing at Shirgaon
- ◆ Paired row (20/30 x 20 cm) method of sowing with any tillage options at Bhubaneswar

vii) Production maximization in groundnut through nutrient management practices during rabi-summer

The following nutrient management practices for rabi-summer groundnut cultivation were identified:

- ◆ 100% RDF as basal + 50% RDF as top dressing at 30 DAS + FYM @ 7.5 t ha⁻¹ or RDF (75%) as basal + RDF (75%) as top dressing at 30 DAS along with 7.5 t ha⁻¹ of FYM at Aliyarnagar
- ◆ 100% recommended dose of fertilizers at the time of sowing + 50% of the RDF at 30 DAS along with FYM @ 7.5 t ha⁻¹ at Bhubaneswar, Chintamani, Junagadh, Rahuri and Shirgaon
- ◆ 150% RDF as basal or top dressing of NPK fertilizers at 30 days after groundnut sowing applied in different proportions (i.e., 50 or 75% of RDF) at different fertilizers rates (100% to 150% RDF) or 75% RDF as basal and 75% RDF as top dressing 30 days after sowing at Dharwad



- ◆ RDF (75%) as basal + RDF (75%) as top dressing at 30 DAS + FYM @ 7.5 t ha⁻¹ at Jagtial
- ◆ RDF (150%) as basal+ FYM @ 7.5 t ha⁻¹ or RDF (100%) as basal + RDF (50%) as top dressing at 30 DAS+ FYM @ 7.5 t ha⁻¹ or RDF (100%) as basal+ FYM @ 7.5 t ha⁻¹ at Jalgaon
- ◆ RDF (150%) as basal + FYM @ 7.5 t ha⁻¹ or RDF (75%) as basal + 75% RDF at 30 DAS + FYM @ 7.5 t ha⁻¹ or RDF (75%) as basal + 25% at 30 DAS + FYM @ 7.5 t ha⁻¹ or RDF 150% as basal or RDF 100% basal – 50% at 30 DAS + FYM @ 7.5 t ha⁻¹ or RDF 75 % as basal – 75% at 30 DAS or RDF 100% basal + FYM @ 7.5 t ha⁻¹ at Kadiri
- ◆ RDF (100%) as basal + FYM @ 7.5 t ha⁻¹ or RDF (150%) as basal at Mohanpur
- ◆ 150% RDF (25:50:75 NPK kg ha⁻¹) along with FYM @ 7.5 t ha⁻¹ at Vriddhachalam
- ◆ RDF (100%) as basal + FYM @ 7.5 t ha⁻¹ or RDF (100%) as basal + RDF (50%) as top dressing t 30 DAS + FYM @ 7.5 t ha⁻¹ at Vyara have been optimized.

Crop Protection

Plant Pathology

a) *Rabi*-summer 2012

1. Disease situation

- ◆ On a 1-9 scale, Late leaf spot (LLS) was severe in Aliyarnagar (6-8), Vriddhachalam (6-9), Dharwad (2-7) and Bhubaneswar (5-7); early leaf spot was recorded at moderate level in Kadiri (1-5); rust was severe in Aliyarnagar (6-7), Dharwad (2-8) and Bhubaneswar (2-6) and leaf spots and rust were not noticed at Junagadh and Jalgaon. Alternaria blight, however, was noticed up to 7 score in Junagadh.
- ◆ Stem rot was recorded in most of the fields in Dharwad, Jalgaon and Raichur and dry root rot was recorded in many fields of Kadiri. Low incidence of collar rot was seen in many fields of Mohanpur, Bhubaneswar, Jalgaon and Junagadh.
- ◆ Moderate infection of PBNB was observed in Kadiri and Raichur areas in a moderate form. Bacterial pod rot was observed at Bhubaneswar only.

2. Disease Resistance

a. Resistant germplasm and inter-specific derivatives

- ◆ At Aliyarnagar, among the inter-specific derivatives, VG 0430, 0437, 052, 0517, 9402, 9406, 1004, 1005 1007, 1008 and 1015 recorded below 5% (2 score) severity of rust.



- ◆ At Vriddhachalam, among the 47 inter-specific derivatives screened, six entries viz., VG 455, VG 517, VG 519, VG 707, VG 1002 and VG 1003 showed resistance to LLS.
- ◆ At Kadiri, least thrips damage was seen in VRI (GN)-6, and the entries showing < 5% PBNB were CSMS 884 (VR), CSMG-84-1(VR), VG-0433, HNG-10 and Chandra. Incidence of dry root rot was < 5.0 % in Co-1, GG2, GPBD-4, VRI (GN)-6, Kadiri 9, S-230, VRI-5, K-1470 (FDR) and K1482 (FDR). The entries Co-1, GG2, GPBD-4, VRI (GN)-6, SBX1, DRG-12, Gangapuri, Kadiri 9, TAG 24, SG 84, ICGV 00350 and INS-I-2010-9 were free from stem rot.
- ◆ Two genotypes viz., Chandra and VG 0433 were found resistant to PBNB consistently in two *rabi* seasons. The genotypes Chitra, S-230 and VG-0433 scored low incidence of dry root rot. The genotypes GPBD 4, GG 2 and Gangapuri were free from stem rot during 2010-11 and 2011-12.
- ◆ At Jalgaon, RHRGS-785 recorded < 5% incidence of stem rot and seven entries viz., JL-776, JL-777, RHRGS-785, WRGS-1, WRGS-15, JL-785 and JL-800 recorded < 10% incidences of collar rot and stem rot.
- ◆ At Raichur, among twenty promising inter-specific derivatives screened for resistance to PBNB, eleven entries viz., CS-51, CS-54, CS-55, CS-77, CS-86, CS-92, CS-104, CS-120, CS-202, CS-246 and CS-262 were found resistant (<5%).

3. Management

a. Integrated Management of PBNB

- ◆ Both PBNB and thrips damage were reduced by adopting practices of module III (Jowar-4 rows as a border crop + seed rate @ 200 kg/ha + seed treatment with gaucho 600 FS@ 1 ml/kg seed + foliar spray using Thiocloprid 480 SC@ 150 ml/ha at 20 - 25 DAS followed by acetamiprid 20 SP @ 100g/ha at 35-40 DAS) in Kadiri and Jalgaon whereas, module II (Jowar-4 rows as a border crop + seed rate @ 200 kg/ha + seed treatment with Imidacloprid 200 SL @ 2 ml/kg seed + foliar sprays using Dimethoate @ 1 L/ha at 25 DAS followed by Imidacloprid @ 200 ml/ha at 40 DAS) was found very effective in managing PBNB at Raichur.

b. Management of Alternaria leaf blight

- ◆ Mancozeb was found the best for managing Alternaria leaf blight and followed by tebuconazole, propiconazole and copper oxychloride at JAU, Junagadh. All the treatments were significantly effective in managing alternaria leaf blight as compared to the control.



b) Kharif 2012

1. Disease situation

- ◆ The highest stem rot incidence was observed at Dharwad (51.0%) which was followed by Junagadh (30.0%), Jalgaon (30.0%), Mohanpur (20.3%), Kadiri (16.0%) and Bhubaneswar (12.5%). The highest collar rot incidence was recorded at Hanumangarh (25.6%) which was followed by Jalgaon (17.0%), Junagadh (11.6%), Kadiri (10.0%) and Mohanpur (4.6%).
- ◆ Kadiri centre recorded high incidence of dry root rot in most of the entries (max. 24.0%). Though most of the entries were infected with LLS and rust the highest LLS and rust (7-9) were recorded from Aliyarnagar followed by Dharwad, Vridhachalam Jalgaon and Bhubaneswar. PBNB was recorded from Raichur only (max. 40%).

2. Management

a) Integrated management of late leaf spot and rust diseases

- ◆ Seed treatment with mancozeb (2.0 g/kg) + two sprays of hexaconazole @ 0.1% at 45 and 60 DAS was found to be highly economical and effective in reducing late leaf spot and rust diseases and this was followed by seed treatment with tebuconazole 1.5 g/kg + two sprays of tebuconazole @ 0.1% at 45 and 60 DAS.

b) Disease management for organic groundnut cultivation

- ◆ Seed treatment with *T. viride* @ 10 g/kg seed + furrow application of *T. viride* @ 4 kg enriched with FYM @ 250 kg/ha + foliar application neem seed kernel extract @ 5% at 30 and 45 DAS was effective in controlling stem rot.
- ◆ Seed treatment with a mixture of *T. viride* and *P. fluorescens* @ 10 g each/kg seed + combined furrow application of *T. viride* and *P. fluorescens* @ 2 kg each enriched with FYM @ 250 kg/ha + foliar application of mixture of both @ 2 kg each/ha at 30 and 45 DAS was effective in reducing collar rot).

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

- ◆ Groundnut in rotation with different crops and fallow reduced the population of *A. flavus* in soil after harvest during summer. Whereas, in *kharif*, the population of *A. flavus* was lower before sowing compared to that after harvest.
- ◆ The rise in soil temperature and rotation with non-host crops/fallow during summer may be reasons for decreasing population of *A. flavus* in soil. *A. flavus* infection on pods was higher than on seeds, and around 10% infection on pods and kernels was recorded in all the centers.



- ◆ In Raichur and Kadiri, upto 30% infection on pods and kernel was recorded. The aflatoxin contamination in kernels varied widely with samples within the treatment. In general it was observed that rotation with crops and fallow reduced the population of *A. flavus* in soil, but not the aflatoxin contamination in groundnut

Entomology

- ◆ Incidence of major pests of groundnut was recorded at different stages of crop growth during Kharif and Rabi-summer seasons. These include thrips, leafhopper, *Spodoptera* and leaf miner.
- ◆ Among major pests, the incidence of sucking pests; thrips and leafhopper varied from moderate to high at different centres. The incidence of *Spodoptera* was high at Jagital during both the seasons while at other centres it was either moderate or low.
- ◆ Various genotypes tested under AICRP-G were screened for thrips and *Spodoptera* by most centres. At few centres, screening was also done for leafhopper, leafminer and *Helicoverpa*. A few tolerant and resistant genotypes were also identified.
- ◆ Population dynamics of *Spodoptera* and leaf miner were recorded by using pheromones traps during *kharif* and *rabi*-summer seasons. In *kharif*, the population of *Spodoptera* peaked during 32th to 37th standard week at most of centres, while in *rabi*-summer it peaked during 10th to 13th standard week. During *kharif*, the *Spodoptera* appeared late at Jalgaon (42nd) and Tirupati (42nd), and Raichur (52nd) centres.
- ◆ Population of leaf miner during *kharif* peaked during 39th standard week at Kadiri while at Tirupati it peaked during 29th week. During *rabi*-summer, the pest population was highest during 5th and 14th standard weeks at Kadiri. However, at Vriddhachalam it was during the 6th standard week.
- ◆ Population dynamics of thrips fauna and PSND/PBND incidence on groundnut was determined in *kharif*. Although, thrips were found to damage the crop during the early stages of crop growth yet no or very low incidence of PSND/PBND was observed.
- ◆ Among the new insecticides tested, thiodicarb, flubendiamide, rynaxypyr, profenophos and novaluran were found promising for controlling defoliator populations while at Raichur, profenophos, spinosad, flubendamide and rynaxypyr were found effective in lowering leaf miner population.
- ◆ For managing sucking pests, fipronyl, thiamethoxam, triazophos, acephate, imidacloprid were effective against thrips while acephate, triazophos and imidacloprid were effective against whitefly.
- ◆ Various IPM modules were employed for pest management. At all the centres, the IPM module evaluated gave higher yield and higher gross income.



Front Line Demonstrations (FLDs)

Rabi-summer 2011-2012

- ◆ A total of 315 FLDs were allotted to 17 AICRP-G centers located in nine states. However, only 295 FLDs, could be conducted.
- ◆ The FLDs were conducted on Improved Variety (IV), Whole Package (WP), Integrated Pest Management (IPM), Integrated Pest and Disease Management (IPDM), Integrated Disease Management (IDM), Integrated Nutrient Management (INM), Integrated Weed Management (IWM), and Plant Growth Promoting Rhizobacteria (PGPR).
- ◆ The result showed with WP recorded an average pod yield of 2532 kg/ha compared to 2028 kg/ha with farmers practice. The pod yield increased by 25% with improved practice over farmers practice. The average haulm yield was 4497 kg/ha with improved practice compared to 3688 kg/ha with farmers practice. The haulm yield with improved practice increased by 24.4% over farmers practice.
- ◆ The average cost of cultivation and average gross returns with improved practice was ₹ 36836/ha and ₹ 103194/ha respectively whereas, in farmers practice it was ₹ 32516/ha and ₹ 82023/ha respectively. Thus with adoption of whole package the gross returns increased by 25.9%.

Kharif 2012

- ◆ During *kharif* 2012 a total of 515 FLDs were allotted but only 410 FLDs could be conducted.
- ◆ The results of 340 FLDs showed that with the use of IV an average pod yield of 2035 kg/ha could be realised compared to 1638 kg/ha with farmers practice. Thus pod yield increased by 24.2% with the use of improved variety over local varieties. The average haulm yield was 3717 kg/ha with improved practice compared to 3135 kg/ha with farmers practice. Increase in the haulm yield with improved variety was 20.2% over the local varieties.
- ◆ The average cost of cultivation and average gross returns with improved variety were ₹ 30851/ha and ₹ 91877/ha respectively whereas, the corresponding values in farmers practice were ₹ 28507/ha and ₹ 72723/ha respectively. The gross returns increased by 26.1% per cent.



EXTERNALLY FUNDED PROJECTS

1. ALL INDIA NETWORK PROJECT ON SOIL BIODIVERSITY BIOFERTILIZERS

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

Funding agency: ICAR

Duration: 01.04.2007-31.03.2013

Total fund: ₹ 30.00 lakh

Objectives:

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

Achievements:

- ◆ To evaluate the diversity of rhizobia in all the cultivated legumes in India, cultures have been received from different centres, purified and maintained as lyophilized and glycerol stock. The 16S rRNA of 177 isolates belonging to groundnut, soybean, chickpea, methi, berseem, blackgram, etc. were PCR amplified, and 65 sequenced.
- ◆ One hundred and seventy-seven isolates have been characterized for *nif* and *nod* functions so far out of 206 isolates received from other centres. Among these one hundred thirty one were found *nif*⁺.
- ◆ Besides, 23 additional groundnut rhizobial isolates, tolerant to 5-10% of NaCl, were isolated from Kutch region of Gujarat and purified.

2. EXPLORING BACTERIAL AND ARCHAEBACTERIAL DIVERSITY IN KUTCH ECO-REGION OF GUJARAT FOR AGRICULTURAL AND INDUSTRIAL APPLICATIONS

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

Funding agency: ICAR through AMAAS project

Duration: 01.04.2007-31.03.2013

Total fund: ₹ 53.10 lakh

Objectives:

- ◆ Survey, isolation and characterisation of important bacteria from salt affected areas and salterns of Kutch eco-region of Gujarat
- ◆ Identification of potent salt tolerant strains of bacteria suitable for groundnut cultivation in salt affected areas of Kutch eco-region



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

Achievements

- ◆ The intracellular solutes of *Haloferax volcanii* H1 grown at three different concentrations of salts (10%, 20% and 30%) were analysed by IIPLC. IIPLC analysis of solutes for major sugars, ectoins, hydroxyl ectoins and amino acids revealed that there was no significant accumulation of any sugars or sugar alcohols that could be detected by HPLC. There was a significant change in the amino acid composition with respect to salinity. At 10% NaCl concentration there was accumulation of tyrosine and leucine at much more higher concentration than other amino acids. At 20% NaCl concentration, leucine was the most dominant amino acid and at 30% of NaCl concentration, the situation dramatically changed and accumulation of histidine, tyrosine and phenylalanine increased significantly as compared to other amino acids.
- ◆ To understand the mechanisms of osmotolerance in *Haloferax volcanii* H1, differentially expressed transcripts were isolated by DDRT-PCR and sequenced. The transcripts were isolated by growing *H. volcanii* H1 at 10, 20 and 30% of NaCl concentration. Sequencing and blast comparison of the transcript revealed the possible involvements of a number of hypothetical proteins in imparting extreme osmotolerance in *Haloferax volcanii* H1. In majority of the cases the proteins involved at different levels of osmolarity were different.
- ◆ The genomes of haloarchaeon 3A1-DGR, *Bacillus* sp. SB49, *Bacillus megaterium* MSP20.1 and *Bacillus* sp. NSP22.2 were sequenced for comparative analysis of the genomes for identification of gene(s) tolerant to salinity. Novel haloarchaeon 3A1-DGR genome has 112 contigs, 79 scaffolds, 2797 ORFs, GC content of 69.09%, 37 tRNA genes and is 2848455 bp in length besides capable of growing at saturated NaCl concentration. Contrary to 3A1-DGR, *Bacillus* sp. SB49 has 3709667 bp in length, 61 tRNA genes, 3915 ORFs, 44 contigs and 12 scaffolds with GC content of 37.46%. The subsystems of haloarchaeon 3A1-DGR and *Bacillus* sp. SB49 were also identified and compared. Whereas 25 ORFs in 3A1-DGR were involved in stress response, it was 88 ORFs in *Bacillus* sp. SB49.



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

(CCPI: K.K. PAL)

Funding agency: NAIP

Duration: 09.01.2009-31.12.2013

Total fund: ₹ 85.17 lakhs

Objectives:

- ◆ Diversity analysis and identification of *Bacillus* and predominant genera from various extreme environments
- ◆ Study of diversity of *Bacillus* and other predominant genera in crop association under extreme environment and its validation
- ◆ To understand the mechanisms of adaptation in *Bacillus* and mining of relevant genes
- ◆ Selection of novel strains of *Bacillus thuringiensis* and other *Bacillus* species with insecticidal properties and isolation of novel *cry* and other insecticidal genes

Achievements:

- ◆ Osmolytes produced at different levels of osmolality (0-35% NaCl) by *Salinibacillus aidingsensis* SB47 and *Bacillus* sp. SB49 were purified and identified by XRD and HPLC. At lower levels of osmolality, accumulation of trehalose and glycerol were detected. At higher levels of osmolality, accumulation of serine, a branched chain amino acid, was detected.
- ◆ To understand the possible mechanism(s) of osmotolerance in *Bacillus* sp. SB49, the organism was cultivated at 0, 20 and 35% of salts for isolating differentially expressed proteins by 2D electrophoresis. Ten differentially expressed proteins were isolated from *Bacillus* sp. SB49 which were expressed only at 20% of NaCl as compared to those expressed without application of any salts. All the 10 proteins were successfully identified by MALDI-TOF/TOF as cysteine synthase A (33 KD, PI:5.1), DEAD-like helicase (94.7KD, PI:5.7), GTP pyrophosphokinase (24.7 KD, PI:6.6), Nitrilase/cyanide hydratase (33.2KD, PI:5.8), hypothetical protein (137.4 KD, PI:6.5), pyruvate dehydrogenase (40.6, 5.3), lysidine synthase (53.4KD, PI: 8.6), Aspartyl/glutamyl-tRNA(Asn/Gln) amidotransferase (53.4 KD, PI:5.0), electron transfer flavoprotein (34.6KD, PI:5.7), etc.
- ◆ By fluorescent DDRT-PCR, 423 differentially expressed transcripts (expressed only when 20% of NaCl was applied in the growth medium) were obtained



from *Bacillus pumilus* SB49 and 173 of them were sequenced. Analysis of the sequence data revealed the expression of a number of uncharacterised/unknown proteins at 20% NaCl concentration as compared to those expressed without the presence of salts. This indicated the possible involvement of new proteins/genes in imparting osmotolerance in *Bacillus* sp. SB49.

- ◆ To understand the mechanisms of osmotolerance in extreme halophilic bacilli on evolutionary perspective and isolation of relevant genes by comparative genome analysis, four bacterial whole genomes have so far been sequenced. These are *Salinibacillus aidingensis* MSP4 (minimum requirement of NaCl for growth: 10% and can grow upto 20% NaCl; scaffolds 21; contigs 77; genome size: 7387864 bp; ORFs: 7663); *Bacillus* sp. NSP2.1 (Sensitive to salinity; scaffolds: 25; contigs: 107; genome size: 5426897 bp; ORFs: 5558); *Bacillus* sp. NSP9.1 (can grow upto 15% NaCl; scaffolds: 8; contigs 33; genome size: 4511959 bp; ORFs: 4887); and *Bacillus* sp. SB47 (minimum requirement of NaCl for growth: 5% and can grow upto saturated level of NaCl; scaffolds: 10; contigs 33; genome size: 4464274 bp; ORFs: 4684).

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

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

Funding agency: NAIP

Duration: 04.05.2009-31.03.2014

Total fund: ₹ 97.59 lakh

Objectives:

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

Achievements:

- ◆ To understand the mechanisms of extreme osmotolerance and isolation of relevant genes in a unique fungus *Aspergillus sydowii* BF5, which can grow at saturated NaCl condition, DDRT-PCR technique was employed using Gene Hunter protocol. Eventually 493 differentially expressed transcripts were



obtained after covering around 70% of the mRNA obtained from two different conditions viz. 0% and 20% of NaCl. So far 326 transcripts have been re-amplified and 256 were sequenced.

- ◆ Analysis of the sequence data, received thus far, indicated the differential expression of a number of genes coding hypothetical proteins (25 in number) at 20% of NaCl as compared to that expressed without salt. The information of the gene(s)/sequences responsible for coding hypothetical proteins have been collected from relevant genome databases (genome sequences of *Aspergillus niger*, *Aspergillus terreus*, etc.) as no sequence information of *Aspergillus sydowii* BF5 was available. The size of the coding sequences varied from 0.204 KB to 5.259 KB. Using the primer combinations, 20 genes encoding conserved/predicted/hypothetical proteins were amplified of amplicon size between 448 bp to 3216 bp. Among them three amplicons (450 bp, 900 bp and 1400 bp) have been successfully cloned to pUC18 for studying the expression and their validation.

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

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

Funding agency: ICAR through NFBSFARA

Duration: 01.06.2011-31.05.2016

Total fund: ₹ 249.2690 lakh

Objectives:

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

Achievements:

- ◆ One hundred thirty-one bacterial and 20 fungal endophytes were isolated from root, stem and seeds of groundnut cultivars Girnar 2, TG37A (tolerant to moisture deficit stress), GG2 (tolerant to salinity), J11 (seed coat resistance to *A. flavus*), ICGS11, SG99 and few germplasm accessions like NRCG 12431, 12962, 12732 (all tolerant to moisture deficit stress), etc. Among the bacterial root endophytes of groundnut, organisms belonging to *Bacillus* (like *Bacillus*



endophyticus REN56) and *Bacillus* derived genera were predominant. Two actinomycetes *Dietzia* sp. and *Cohnella* sp. were also identified. Bacterial stem endophytes of groundnut includes isolates of *Alcaligenes faecalis*, *Kocuria palustris*, *Brevundimonas* sp., *Pantoea agglomerans*, *Pseudomonas aeruginosa*, *Enterobacter ludwigii*, *Enterobacter cloacae*, *Staphylococcus* sp., and a number of isolates of *Bacillus* and *Bacillus* derived genera. The seed endophytes were identified as *Bacillus subtilis*, *Bacillus firmus*, *Pseudomonas* sp., *Bacillus tequilensis* and *Pseudomonas aeruginosa*.

- ◆ Seventeen of the 72 bacterial, fungal and actinomycetes endophytes of groundnut so far identified here have also been reported as endophytes of other crops and plant species. None of the identified endophytes in groundnut have been reported to play role in alleviating abiotic stresses in other plants including agricultural crops. Therefore, scope exists for unravelling the roles of these endophytes in alleviating abiotic and biotic stresses in groundnut and also for understanding the mechanism(s) of beneficial associations.

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

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

Funding agency: ICAR through NFBSFARA

Duration: 01.08.2012-31.07.2015

Total fund: ₹ 54.4743 lakh

Objectives:

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

Achievements:

- ◆ For isolation of microorganisms from the rhizosphere and rhizoplane of naturally adapted plants including grasses of the Rann of Kutch of Gujarat, surveys were conducted and 24 soil and plant samples were collected during 2012-13. To gain insight into the physiological, biochemical and molecular bases of interaction of microorganisms in helping the naturally adapted plant species in the Rann of Kutch and possibility of using them in sustaining the stresses, 171 bacterial, 33 archaeal and 20 fungal isolates were isolated.



- ◆ The population of bacteria, fungi, archaea, etc. were determined in the rhizosphere and rhizoplane. Population varied among the plant species and across locations of the samples. While population of bacteria varied from 1×10^4 - 18.3×10^6 cfu/g in the rhizosphere across plant species, it was 4×10^3 - 7.3×10^6 cfu/g in the rhizoplane. Seedling bioassays are being conducted after standardizing the technique for *Sporobolous* spp. and *Dicanthium* spp. in petri dishes.

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

(PI: N. K. JAIN, COPIs: H. N. MEENA AND Koushik CHAKRABORTY)

Funding agency: Department of Science and Technology, New Delhi

Duration: 21.12.2010 to 20.12.2013

Fund: ₹ 45.25 lakhs

Objectives

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

Achievements

- ◆ Soil organic carbon stock in Saurashtra region ranged from 12.4 to 13.1, 11.1 to 13.1 and 8.7 to 12.3 Mg ha⁻¹ in surface (0-15 cm), middle (15-30 cm) and bottom (30-60 cm) soil layers, respectively under various land use patterns averaged over nine soil types. The mean SOC stocks of surface, middle and bottom soil layers were 12.7, 12.0 and 10.8 Mg ha⁻¹, respectively. The mean maximum SOC stock (37.9 Mg ha⁻¹) was found in shallow to medium black (sand stone) soil.
- ◆ Groundnut-pod equivalent yield differed significantly due to various conservation practices and groundnut-based cropping systems. Significantly



higher groundnut-pod equivalent yield (3635 kg ha^{-1}) was obtained in groundnut-wheat (ZT)-*Sesbania* (GM) cropping system and was at par with all groundnut-wheat cropping systems with and without conservation tillage and green manuring.

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

(PI: N.K. JAIN, Co PI: H.N. MEENA)

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

Duration: 04.02.2011 to 03.02.2013

Total Fund: ₹ 05.68 lakhs

Objectives

- ◆ To study the performance of 'Allwin Top Drip Special' in comparison to recommended sources of NPK in groundnut.
- ◆ To evaluate the effect of 'Allwin Top Drip Special' on growth, yield and economics of groundnut.
- ◆ To find out the fertilizer and water savings.

Achievements

- ◆ Application of Allwin Top Drip Special @ 226.5 kg ha^{-1} through drip significantly improved productivity and oil yield of groundnut over rest of the treatments.
- ◆ Maximum net returns (₹ 50 894 ha^{-1}) were also realized under this treatment. Its application through drip saved 36-38% irrigation water compared to check basin method of irrigation.

9. OVER EXPRESSION OF PR 10 GENE CLONED FROM SALT TOLERANT CELL LINES OF *ARACHIS HYPOGAEA* IN GROUNDNUT CULTIVARS FOR ABIOTIC STRESS TOLERANCE

(PI: SK BERA; COPI: NB SARIN, JNU, N. DELHI)

Funding Agency: DBT, New Delhi

Duration: 2009-2013

Total Funds: ₹ 31.99 Lakhs

Objectives:

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



Achievements

- ◆ Cultivar GG-20 was used for transformation with PR10 gene besides GG 2 and TAG 24. Higher regeneration frequency (>80%) was observed in GG 20 than GG 2 and TAG 24.
- ◆ Embryo development occurred in 500 out of 800 de-embryonated cotyledons cultured.
- ◆ Three hundred and ten putative transgenics were out of 900 shoots were hardened and shifted to glass house.
- ◆ PCR confirmation for integration of PR10 gene in these putative transgenics is in progress.

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

(CCPIs: JB MISRA; T RADHAKRISHNAN; SK BERA; SK BISHI;
K CHAKRABORTY)

Funding Agency: ICRISAT, Hyderabad

Duration: 01.01.2011 to 31.03.2015

Total Funds: ₹ 40.50 Lakhs

Objective:

- ◆ Conduct of high / low oil content groundnut varietal trial (HLOGVT) (52 entries and 12 checks) under two conditions, irrigated and imposed drought.

Achievements:

- ◆ Five groundnut varieties possessing high O/L ratio along with high oil content developed, evaluated and recommended for national testing.
- ◆ The estimates of oil content from the produces ranged from 49-57% while the protein content varied from 27-33.
- ◆ The allele-specific PCR was used in the identification of hybrids in the MABC for high O/L content. SSR primers polymorphic in parental combinations were identified and will be used in the MAS for high oil crosses.
- ◆ Mapping high oil content: The F_1 generation is raised, confirmed with SSRs and selfed to harvest F_2 seed.



11. ICAR NETWORK PROJECT ON TRANSGENIC CROP

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

Funding Agency: ICAR, New Delhi

Duration: 2011-12

Total Funds: ₹ 06.94 Lakhs

Objective

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

Achievements:

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

i) *AtDREB1a*

Dehydration tolerance analysis

- ◆ Three transgenic lines (1T₂ and 2 T₃ lines) were subjected to 0, 10, 15, 20% Polyethylene glycol (PEG 6000) and 0, 100, 150, 200 mM NaCl stress separately along with wild type plants.
- ◆ The morphological, physiological and biochemical analysis showed that transgenic plants are more tolerant to both the types of stresses as compared to wild type control.
- ◆ For developing groundnut having transgenic resistance to defoliating insect especially *Spodoptera litura*, the gene construct *cry1Fa1* was used.

ii) *cry1Fa1*

- ◆ Ten plants from 2 events were bio-assayed for insect feeding (*Helicoverpa* and *Spodoptera*). Promising events which had minimum damage were identified. The larval mortality also was assayed.
- ◆ These events were assayed for quantitative expression of transgene by qPCR and events with high level of expression of the transgene were identified

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

(NODAL OFFICER: CHUNI LAL)

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

Funding Agency: ICAR, New Delhi



Summary

- ◆ Seed production of DGR varieties 'Girnar 2' and 'Girnar 3' and BARC variety 'TG 37A' was taken up in summer 2012. In *kharif* 2012 seed production programme of DGR varieties only viz. 'Girnar 2' and 'Girnar 3' was taken up.
- ◆ To make up for the production deficits of *kharif* season, compensatory seed production was taken up in summer 2013 season.
- ◆ A total quantity of 51.69 q seed of different classes of three new generation groundnut varieties was sold for ₹ 373199/-.
- ◆ In summer 2012 seed production of 'Girnar 2' variety was taken up in 0.65 ha; 'Girnar 3' in 1.75 ha and 'TG 37A' in 0.3 ha to produce seed of different classes of these varieties. At harvest 4 q of nucleus seed and 11 q of breeder seed of 'Girnar 2'; 15.25 q breeder seed of 'Girnar 3'; and 3.3 q truthfully labelled seed of 'TG 37A'.
- ◆ In *kharif* 2012, seed production of 'Girnar 2' variety was taken up in 1.65 ha; and that of 'Girnar 3' in 1.5 ha. The production realized was 6.60 q breeder seed of 'Girnar 2' and 15.0 q breeder seed and 1.5 q nucleus seed of 'Girnar 3'.
- ◆ In addition, 19.9 q TFL seed of BARC variety 'TG 37A' was also produced.
- ◆ Compensatory seed production programme of three varieties 'Girnar 2', 'Girnar 3' and 'TG 37A' was taken up in summer 2013 in 2.9 ha to produce seed of different classes (nucleus, breeder and truthfully labeled). Early sowing of summer seed crop of variety 'Girnar 2' was done in the month of January under polythene mulch to ensure germination at the prevailing low temperature. The crop stand and growth was excellent under polythene mulch and a good harvest of this crop is expected.
- ◆ A total 51.69 q seed of different classes of three new generation groundnut varieties was sold which generated a revenue of ₹ 373199/-.
- ◆ An expenditure of ₹ 570356/- was incurred under this project of annual budget of ₹ 7.0 lakhs received from the Directorate of Seed Research, Mau during the period under report (1.4.2012-31.3.2013). In addition the entire budget (₹ 2.0 lakhs) received under the Tribal Sub Plan was utilized.



Demonstrating seed treatment with Rhizobium and PSM to tribal farmers



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- ◆ Chakraborty, K., Singh, A.L., Bhaduri, D. and Sairam, R.K. 2013. Mechanism of salinity stress tolerance in crop plants and recent developments. In: Advances in Plant Physiology (Ed. A. Hemantranjan) Vol. 14 pp. Scientific Publishers (India), Jodhpur.
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- ◆ Pal, K.K., Dey, R. and Tilak, K.V.B.R. 2013. Microbiology education for biotechnology industry. In 'Evolving Corporate Education Strategies for Developing Countries: The Role of Universities' (Eds. BPR Narasimharao, KS Rangappa and TU Fulzele), IGI Global Publications, Hershey PA 17033, USA, pp. 209-227.



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- ◆ थिरुमलाईसामी, पी.पी., जादोन, के.एस. और मीणा, एच.एन. 2012. अफ्लाटोक्सीन मुक्त मूँगफली उत्पादन के लिये उन्नत कृषि पद्धतियां. प्रशिक्षण पुस्तिका. संयुक्त रूप से कृषि एवं प्रसंस्कृत खाद्य उत्पाद निर्यात विकास प्राधिकरण, नई दिल्ली ; मूँगफली अनुसंधान निदेशालय, जूनागढ़ और भारतीय तिलहन एवं उत्पाद निर्यात संवर्धन परिषद, मुंबई द्वारा प्रकाशित

Award/Recognition

AL Singh

- ◆ Served as vice-president Indian Society for Plant Physiology during 2012.

NK Jain

- ◆ Elected as Councilor from Gujarat for Indian Society of Agronomy for the biennium 2013-14.

GP Misra

- ◆ Received 'Pran Vohra Award' from "Indian Science Congress Association" (ISCA), Kolkata, in 100th Indian Science Congress at University of Calcutta, Kolkata, 3-7 January, 2013.

Koushik Chakraborty

- ◆ Received "ISCA Young Scientist Award" in Agriculture and Forestry Sciences Section from "Indian Science Congress Association" (ISCA), Kolkata, in 100th Indian Science Congress at University of Calcutta, Kolkata, 3-7 January, 2013.

Radhakrishnan T

- ◆ Member, IMC, DOR, Hyderabad (22 June and 6 Feb 2013)
- ◆ Member expert committee at Saurashtra University, March 28, 2013



Recognition

- ◆ Junagadh Agricultural University, Junagadh- 362 001, Gujarat has recognized following scientists of this directorate for 'PG Teaching and MSc/PhD Guide' (vide its letter No. No. JAU / DR / PGT / T-6 / ACA / 301-1-360 /2013, Junagadh dated: 01/04/2013)
- ◆ Dr AL Singh, Dr. Chuni Lal, Dr KK Pal, Dr NK Jain, Dr R Dey, Dr MK Mahatma, Dr Gyan P Mishra, Dr RA Jat, Dr Poonam Jasrotia, Dr. Anita Mann and Dr RS Yadav.

Meetings/ Trainings Organized/ Attended

Trainings organised/ conducted

- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़ कृषि विश्वविद्यालय तथा भाभा परमाणु अनुसंधान केन्द्र द्वारा संयुक्त रूप से जूनागढ़ कृषि विश्व विद्यालय में आयोजित दो दिवसीय 'राष्ट्रीय वैज्ञानिक संगोष्ठी', (दिनांक 14-15 फरवरी 2013).

Dr Radhakrishnan T

- ◆ Short training programme on 'Protection of Plant Varieties & Farmers' rights, and DUS testing' sponsored by PVP&FR was organised during 10-11 May, 2012.
- ◆ Two Awareness-cum-training programme on 'Protection of Plant Varieties & Farmers' rights' were conducted on 18th and 19th March 2013.

Dr KK Pal and Dr Rinku Dey

- ◆ Entrepreneurs-DGR Interface meeting: Interface meeting of Entrepreneurs conducted on 5th January 2013 for demonstrating enzyme technology (cellulase) to entrepreneurs. Thirty entrepreneurs attended the meeting.

Dr MC Dagla

- ◆ The 'Hindi Chetna Maas-2012' was organized in which competitions were held for Essay Writing, General Hindi Knowledge, Extempore, Speech, Debate, Noting and Drafting, and Antaaksharee.

Meetings/ Trainings / Attended

Dr AL Singh

- ◆ National Seminar of Plant Physiology on "Physiological and molecular approaches for development of climatic resilient crops" from 12-14 Dec 2012 at ANGRAU, Hyderabad, India and gave a lead lecture on 'Recent Advances in Plant Nutrition'.



Dr Radhakrishnan T

- ◆ Meeting of the Directors and the Head of divisions at NAS Complex, New Delhi on March 11, 2013.
- ◆ IMC meeting of DGR on March 02, 2013.
- ◆ Annual review meeting of the PPV&FR authority at IIVR, Varanasi on February 28, 2013.
- ◆ Discussion meeting of High oil project at ICRISAT on February 07, 2013.
- ◆ IMC meeting of DOR at DOR Hyderabad on June, 22 and February 06, 2013.
- ◆ Review meeting of the transgenic network project at IARI, New Delhi from 15-16 January 2013.
- ◆ Cost committee meeting of National Fund for Project budget finalization at KABI, New Delhi on December 24, 2012.
- ◆ Expert committee meeting of National Fund for Project presentation at KABI, New Delhi on November 30, 2012.
- ◆ Project preparation workshop at NAARM, Hyderabad from 19-21 November 2012.
- ◆ DBT task force for meeting for Project presentation at DBT, New Delhi on October 8, 2012.
- ◆ Annual review meeting of the PPV&FR authority and the Plant Genome Savior Community Award NAS Complex, New Delhi on May 21, 2012.
- ◆ QRT meeting at Regional Agricultural Research Station (RARS), Tirupati, ANGRAU from 24-26 April 2012)
- ◆ QRT meeting at OUAT, Bhubaneswar on April 09, 2012.
- ◆ Annual review meeting of project “Development and promotion of promising varieties / lines with high yield and high oil content with enhanced O/L ratio for enhancing production and quality of groundnut oil in drought-prone environments to boost the income of small and marginal groundnut farmers in India” at Regional Agricultural Research Station (RARS), Tirupati, ANGRAU on April 23, 2012.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़: जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित ‘कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका’ पर दो दिवसीय ‘संगोष्ठी’ (दिनांक 14-15 फरवरी 2013)

Dr Chuni Lal

- ◆ Workshop on Public Purchase Management for Goods, Works and Consultancy organized by DGR on 16-20 April 2012





- ◆ Annual Review Meeting of ICAR seed project held on 25-26 July, 2012 at NASC Complex, New Delhi
- ◆ Plant Breeders' Meet chaired by the DG ICAR on 3rd and 4th May, 2012 at NBPGR, New Delhi
- ◆ Three-day workshop on reservation policy held at Jaipur on 6-8 September, 2012
- ◆ VI-ICLGG held at Hyderabad on 2-7 July, 2012
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)

Dr KK Pal

- ◆ Entrepreneurs-DGR Interface meeting: Interface meeting of Entrepreneurs conducted on 5th January 2013 for demonstrating enzyme technology (Cellulase) to entrepreneurs. Thirty entrepreneurs attended the meeting.
- ◆ Meeting of QRT of AMAAS project and presented the progress made at DGR, Junagadh from 2006 to 2012 held at NASC Complex, N. Delhi on 19.2.2013.
- ◆ National Symposium on "Biotic and abiotic stresses in plants under changing climate scenario" from 29-30 November 2012 at Dept. of Plant Pathology, Uttar Banga Krishi Viswavidyalaya, Coochbhar, West Bengal and made oral presentation of research paper.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)

Dr NK Jain

- ◆ Workshop on Public Purchase Management for Goods, Works and Consultancy, held at DGR, Junagadh during 16-20 April, 2012.
- ◆ *Kharif* Groundnut Workshop held at Regional Research Station, ANGRAU, Tirupati during 24-26 April, 2012.
- ◆ Refresher Course on Agricultural Research Management of Directly Recruited Principal Scientists/Sr. Scientists, held at NAARM, Rajendranagar, Hyderabad, during 5-18 June, 2012.



- ◆ Review Meeting of Programme Advisory and Monitoring Committee of National Programme on Carbon Sequestration Research, held at Andhra University, Vishakhapatnam, A.P. during 19-20 July, 2012.
- ◆ *Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods"*, held during 26-29 November, 2012 at IARI, New Delhi.
- ◆ Review Workshop of PME Cells of ICAR Institutes, held at National Dairy Research Institute, Karnal during 8 December, 2012.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़: जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)
- ◆ Meeting of Directors, Project Coordinators and Heads of Crop Science Division, held during 11 March, 2013 at New Delhi.

Dr R Dey

- ◆ RFD meeting at Directorate of Maize Research, Pusa, N. Delhi on 14th January 2013 to finalize Draft RFD 2013-14 of Directorate of Groundnut Research, Junagadh
- ◆ 'General Management Programme for Scientists' at Administrative Staff College of India (ASCI), Hyderabad from 17-28 September 2012.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़: जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)

Dr SK Bera

- VI-International Conference on Legume Genetics and Genomics, 2-7 October 2012 at Hyderabad, India.
- National Seminar on Plant Genetics Research for Eastern and North-eastern India, May 11-12, 2012, Umiam, Meghalaya.

Dr RS Yadav

- Workshop on Public Purchase Management for Goods, Works and Consultancy at DGR, Junagadh from 16th to 20th April, 2012.



- मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)

Dr MK Mahatma

- Chemist Conclave" held at IARI, New Delhi during 14-15 January, 2013

Dr GP Mishra

- 100th Indian Science Congress at Kolkata from 4-7 January, 2013.
- 'Results Framework Document (RFD) meeting' at Directorate of Maize Research (DMR), Pusa, New Delhi on 14th January, 2013.
- 'Capacity Building Workshop on Development of Digital Knowledge Repository of Oilseed Crops' at ICRISAT, Andhra Pradesh, from 24 to 25 January 2013.
- मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)
- Training – cum – awareness programme on "Protection of plant varieties and farmers' rights" on 18-19 March, 2013.
- Worked as invigilator in the ICAR NET and ARS (Preliminary Exam) examination which was held on February 24, 2013 at Junagadh Agricultural University, Junagadh.

Dr RA Jat

- "Third International Agronomy Congress on "Agriculture Diversification, Climate Change Management and Livelihoods" at IARI, New Delhi from 26th to 29th November 2012.
- मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013)

Dr Anita Mann

- ♦ General Management Programme for Scientists (sponsored by Department of Science and Technology) from Sep 17-28, 2012 (12 days) held at Administrative Staff College of India (ASCI), Bella Vista, Hyderabad.



Dr Poonam Jasrotia

- ◆ Workshop as a resource person on “Good Agricultural Practices (GAP) and Production of Aflatoxin-Free Groundnuts at KVK Kodinar on September 7, 2012.
- ◆ NAIP sponsored subject training on "Bioinformatics: methods and approaches for insect research" from 19th November to 1st December, 2012 at National Bureau of Agriculturally Important Insects (NBAII), Bangalore.
- ◆ Refresher course on “Agricultural Research Management” during January 7-19, 2013 at National Academy of Agricultural Research Management (NAARM), Hyderabad.
- ◆ National Workshop on “Foresight and Future Pathways of Agricultural Research through Youth in India” as resource person during March 1-2, 2013 at NASC Complex, New Delhi.

Dr Ajay BC

- ◆ Training course on “Techniques in Molecular Biology” from 3rd to 23rd May 2012 organized at the Dept. Of Plant Biotechnology, University of Agricultural Sciences, GKVK, Bengaluru – 560065, Karnataka, India.
- ◆ ICAR-CAFT Training on “Quantitative genetics in the era of Genomics” from 16th November to 6th December 2012 organized at Centre for Plant Breeding and Genetics Tamil Nadu Agricultural University Coimbatore – 641 003 TAMIL NADU, India

Dr K Chakroborty

- ◆ Workshop on “Public purchase management for goods, works and consultancy” organized by DGR, Junagadh from 16-20 April, 2012.
- ◆ Media meet on “DGR technologies for commercialization’ of NAIP sub-project on “Mobilising mass media support for sharing agro-information” organized by DMAPR, Anand at DGR, Junagadh on 28th September, 2012.
- ◆ National Symposium on “Biotic and Abiotic Stresses under Changing Climate Scenario”, organized by UBKV, Cooch Behar (W.B.) from 29-30 November, 2012.
- ◆ “The 100th Indian Science Congress” organized by University of Calcutta, Kolkata from 3-7 January, 2013.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित ‘कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका’ पर दो दिवसीय ‘संगोष्ठी’ (दिनांक 14-15 फरवरी 2013).



Dr HN Meena

- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़: जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013).
- ◆ Workshop on Public Purchase Management for Goods, Works and Consultancy at DGR, Junagadh from 16th to 20th April 2012.
- ◆ Monitoring of AICRP-G trial at ARS Manpuri and monitoring of breeder seed production of Chitra at Degh farm, Kanpur from 19th to 23th September, 2012.

Dr Debarati Bhaduri

- ◆ "100th Indian Science Congress" at University of Calcutta, Kolkata from 3-7th January, 2013.
- ◆ NNRMS, ISRO (Dept. of Space) sponsored 21-days training programme on 'Application of Remote Sensing and GIS in Natural Resource Management' at NBSS&LUP, Nagpur 12th February to 4th March, 2013.

Dr Ajoy Saha

- ◆ Short course on Food pollutant evaluation for food safety and quality at IIHR, Bangalore from 4th -13th September, 2012.
- ◆ "Chemist Conclave"-Brainstorming session at IARI, New Delhi from 14th -15th January, 2013.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़: जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित 'कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका' पर दो दिवसीय 'संगोष्ठी' (दिनांक 14-15 फरवरी 2013).

Dr KA Kalariya

- ◆ National Seminar of Plant Physiology held at ANGRAU, Hyderabad 12-14 December, 2012
- ◆ Media meet on "DGR technologies for commercialization' of NAIP sub-project on "Mobilising mass media support for sharing agro-information" organized by DMAPR, Anand at DGR, Junagadh on 28th September, 2012.
- ◆ Short training programme in PPV & FR and DUS Testing held at DGR, Junagadh 10-11 May, 2012



- ◆ Workshop on “Public purchase management for goods, works and consultancy” organized by DGR, Junagadh from 16-20 April, 2012.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़: जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित ‘कृषि, खाद्य एवं स्वास्थ्य संवर्धन में नाभिकीय प्रौद्योगिकी की भूमिका’ पर दो दिवसीय ‘संगोष्ठी’ (दिनांक 14-15 फरवरी 2013).

Dr MC Dagla

- ◆ Annual Review Meeting for Breeder Seed Production on 12th March, 2013 at NBPGR, New Delhi.
- ◆ Meeting on Strategies for improvement of SRR of Oilseeds for 12th Plan on 13.03.2013 at Krishi Bhawan, New Delhi.
- ◆ Monitoring in Zone-III (Jalgaon, Rahuri and Akola) was done for AICRP-G trials, and breeder seed production programme of centres.
- ◆ 21 days CAFT training programme on “Quantitative genetics in the era of genomics” held at TNAU, Coimbatore from 16th November 2012 to 6th December 2012.

Dr Narendra Kumar

- ◆ Workshop on “Public purchase management for goods, works and consultancy” held at Directorate of Groundnut Research, Junagadh from 16-20 April, 2012.
- ◆ Mobilising mass media support for sharing agro-information media meet at DGR, Junagadh on 28th September, 2012.
- ◆ VI International Conference on Legume Genetics and Genomics at Marriott Hotel, Hyderabad from 02-07th October, 2012.
- ◆ FGI EXPO-AGRO SUMMIT-2013 at Vadodara, Gujarat from 03-05th January 2013.
- ◆ National Scientist Seminar on “Role of nuclear technology in agriculture, food and health management at Junagadh Agricultural University, Junagadh from 14-15 February, 2013.

Dr Narayanan G

- ◆ Annual *Kharif* groundnut researchers group meeting, Kharif Groundnut Workshop, RARS, ANGRAU, Tirupati, April 24-26, 2012
- ◆ Protection of plant varieties & Farmers right, DUS testing, Sponsored by the protection of plant varieties and Farmers right authority, On 10-11 May 2011 at DGR, Junagadh





- ◆ Workshop on Good Agricultural Practices (GAP) for production of Aflatoxin free groundnut, on 05 June 2012 at Directorate of Groundnut Research, Junagadh.
- ◆ Institutional innovation in Agri-Extension for inclusive growth, Organized at National Academy of Agricultural Research Management, Hyderabad during 1-7, August 2012
- ◆ “KM Portal Oilseeds” Two day workshop on Knowledge repositories, Held at ICRISAT, Hyderabad on 24-25 January 2013.

Mr Harish G

- ◆ International Conference on Insect Sciences. February 14-17, 2013, UAS, GKVK, Bangalore.

Mr Nataraja MV

- ◆ ICAR–CII (Confederation of Indian Industries) meet held at Ahmedabad on 16th April, 2012
- ◆ 2 days short training programme on “Protection of Plant Varieties & Farmers' rights, and DUS testing” at this Directorate from 10th to 11th May, 2012
- ◆ Seminar on “GCMS/LCMS” by Agilent Industries held at this Directorate on 24th May, 2012
- ◆ Workshop on “Good Agricultural Practices for production of Aflatoxin free groundnut” held at this directorate on 5th May, 2012
- ◆ 21 days training “Taxonomy on insects and mites” at Department of Entomology, University of Agricultural Sciences, Bangalore from 25th July to 14th August, 2012
- ◆ “International Conference on Plant Health Management for Food Security” held at Hyderabad from 28th to 30th November, 2012
- ◆ IV International Insect Science Congress on “Exploring the Incredible Insect World” held at Bengaluru from 14-17th February, 2013

Mr MD Meena

- ◆ Foundation course for Agriculture Research Service (FOCARS) at NAARM Hyderabad from 15th September to 13th December 2011.
- ◆ Professional attachment training at NCAP, New Delhi from 23rd January to 21 April, 2012.
- ◆ Short training programme on Protection of plant varieties and Farmers rights and DUS testing organized at Directorate of Groundnut Research, Junagadh from 10-11th May, 2012.
- ◆ Developing Agriculture Commodity Outlook Models for policy analysis at NCAP from 15-24th March, 2012.
- ◆ MDP workshop on supply chain management in Agriculture at NAARM, Hyderabad from 15-19th October, 2012.



- ◆ Training programme on Data analysis using SAS at MPAUT, Udaipur from 14-20th January, 2013.
- ◆ “Agriculture technology week” organised by KVK, Ambuja cement foundation Ambujanagar (Kodinar) from 7-11th January, 2013.
- ◆ मूँगफली अनुसंधान निदेशालय, जूनागढ़; जूनागढ़ कृषि विश्वविद्यालय, जूनागढ़ तथा भाभा परमाणु अनुसंधान केन्द्र, मुंबई द्वारा संयुक्त रूप से जूनागढ़ में आयोजित ‘कृषि, खाद्य एवं स्वास्थ्य संवर्धन मे नाभिकीय प्रौद्योगिकी की भूमिका’ पर दो दिवसीय ‘संगोष्ठी’ (दिनांक 14-15 फरवरी 2013).

Scientist on deputation

Dr P.P. Thirumalaisamy, Scientist, Plant Pathology of this directorate attended the 'Working group meeting on groundnut bacterial wilt and *Sclerotium* stem rot diseases' which was held in Bangkok, Thailand (11-12 December, 2012). The meeting was organized by ICRISAT, Oil Crops Research Institute, Wuhan, of the Chinese Academy of Agricultural Sciences, Beijing; and FCRI, Bangkok, of the Department of Agriculture, Thailand. A total of 15 partners from the NARS of China, India, Indonesia, Thailand and Vietnam, who represent major groundnut-growing regions of Asia, took part in this meeting. A draft work plan was prepared focusing on developing integrated disease management strategies, improving diseases screening techniques, identification of resistant sources, understanding soil microbe population dynamics, germplasm exchange etc.



Participants of the Working Group meeting held in Bangkok



Staff list on 31.03.2013

1.	Dr. J.B. Misra	Director
2.	Dr. A.L. Singh	Pr. Scientist, (Plant Physiology)
3.	Dr. T. Radhakrishnan	Pr. Scientist (Plant Breeding)
4.	Dr. A.L. Rathnakumar	Pr. Scientist (Plant Breeding)
5.	Dr. N.K. Jain	Pr. Scientist (Agronomy)
6.	Dr. S.K. Bera	Pr. Scientist (Genetics & Cytogenetics)
7.	Dr. Chuni Lal	Pr. Scientist (Plant Breeding)
8.	Dr. K.K. Pal	Pr. Scientist (Microbiology)
9.	Dr. Rinku Dey	Pr. Scientist (Microbiology)
10.	Dr. A.P. Mishra	Sr. Scientist (Agril. Statistics)
11.	Dr. R.S. Yadav	Sr. Scientist (Soil Science)
12.	Dr. R.A. Jat	Sr. Scientist (Agronomy)
13.	Dr. G.P. Mishra	Sr. Scientist (Plant Breeding)
14.	Dr. Anita Maan	Sr. Scientist (Plant Physiology)
15.	Dr. Poonam Jasrotia	Sr. Scientist (Entomology)
16.	Dr. M.K. Mahatama	Sr. Scientist (Biochemistry)
17.	Dr. H.N. Meena	Scientist (Agronomy)
18.	Dr. Manesh Chandra Dagla	Scientist (Plant Breeding)
19.	Sh. Abhay Kumar	Scientist (Plant Biotechnology)
20.	Sh. Sujit Kumar Bishi	Scientist (Biochemistry)
21.	Dr. P.P. Thirumalaisamy	Scientist (Plant Pathology)
22.	Shri Harish G.	Scientist (Agril. Entomology)
23.	Dr. Narendra Kumar	Scientist (Plant Breeding)
24.	Dr. Koushik Chakraborty	Scientist (Plant Physiology)
25.	Dr. Debarati Bhaduri	Scientist (Soil Science)
26.	Dr. Kuldeep Singh Jadon	Scientist (Plant Pathology)
27.	Dr. Prasanna Holajjer	Scientist (Nematology)
28.	Dr. Kuldeep Singh Kalariya	Scientist (Plant Physiology)
29.	Dr. Ajay B.C.	Scientist (Plant Breeding)
30.	Sh. Nataraja M.V.	Scientist (Entomology)
31.	Dr. Ajoy Saha	Scientist (Agril. Chemicals)
32.	Dr. Narayanan G.	Scientist (Agril. Exten.)
33.	Sh. Murlidhar Meena	Scientist (Agril Economics)
34.	Dr. R.S. Tomar	Farm Superintendent (T-6)
35.	Ms. S.M. Chauhan	Technical Officer, (T-9)



36.	Sh. V.K. Sojitra	Technical Officer, (T-6)
37.	Sh. H.B. Lalwani	Technical Officer, T(7-8)
38.	Sh. D.M. Bhatt	Technical Officer, T(7-8)
39.	Dr. D.L. Parmar	Technical Officer, (T-9)
40.	Sh. H.M. Hingrajia	Technical Officer, (T-6)
41.	Sh. N.R. Ghetia	Technical Officer, T(7-8)
42.	Sh. P.V. Zala	Technical Officer, T(7-8)
43.	Sh. Ranvir Singh	Technical Officer, (T-6)
44.	Dr. S.D. Savaliya	Technical Officer, (T-6)
45.	Sh. V.G. Koradia	Technical Officer, T(7-8)
46.	Sh. P.K. Bhalodia	Technical Officer, T(7-8)
47.	Dr. H.K. Gor	Technical Officer, T(7-8)
48.	Dr. J.R. Dobaria	Technical Officer, T(7-8)
49.	Dr. M.V. Gedia	Technical Officer, T(7-8)
50.	Sh. P.R. Naik	Technical Officer, (T-6)
51.	Mrs. V.S. Chaudhari	Technical Officer, (T-6)
52.	Sh. Virendra Singh	Technical Officer, (T-6)
53.	Sh. B.M. Chikani	Technical Officer, (T-6)
54.	Sh. D.R. Bhatt	Technical Officer, (T-6)
55.	Sh. R.D. Padvi	Technical Officer, (T-5)
56.	Sh. H.V. Patel	Technical Officer, (T-5)
57.	Sh. C.B. Patel	Technical Officer, (T-5)
58.	Sh. J.G. Kalariya	Tractor Driver (T-5)
59.	Sh. K.H. Koradia	Driver (T-5)
60.	Sh. A.M. Vakhariya	Photographer, (T-5)
61.	Sh. G.J. Solanki	Tech. Astt. (T-4)
62.	Sh. P.B. Garchar	Ele. (T-4)
63.	Sh. N.M. Safi	Driver (T-4)
64.	Sh. A.D. Makawana	Tech. Astt. (T-3)
65.	Sh. R.S. Garhwal	Tech. Astt. (T-3)
66.	Sh. Lokesh Kumar	Tech. Astt. (T-3)
67.	Sh. Anil Kumar Maurya	Tech. Astt. (T-3)
68.	Sh. G.G. Bhalani	Driver (T-3)
69.	Sh. B.M. Solanki	Driver (T-3)
70.	Sh. Pitabas Das	T-2



71.	Sh. Darvesh Kumar	Administrative officer
72.	Sh. R.T. Thakar	AAO
73.	Mrs. Rosamma Joseph	PS
74.	Sh. Y.S. Kariya	PA
75.	Sh. L.V. Tilwani	PA
76.	Mrs. Santha Venugolan	Astt
77.	Mrs. M.N. Vaghasia	Astt.
78.	Sh. R.D. Nagwadia	Astt.
79.	Sh. M.B. Kher	Security Supervisor
80.	Sh. H.S. Mistry	UDC
81.	Sh. C.G. Makawan	UDC
82.	Sh. P.N. Solanki	LDC
83.	Sh. N.M. Pandia	SSS
84.	Sh. D.M. Sachaniya	SSS
85.	Sh. R.B. Chawada	SSS
86.	Sh. C.N. Jethwa	SSS
87.	Sh. M.B. Shaikh	SSS
88.	Sh. K.T. Kapadia	SSS
89.	Sh. J.G. Agrawat	SSS
90.	Sh. V.N. Kodiatar	SSS
91.	Sh. R.P. Sondarwa	SSS
92.	Sh. G.S. Mori	SSS
93.	Sh. V.M. Chawada	SSS
94.	Mrs. D.S. Sarvaiya	SSS
95.	Sh. N.G. Vadher	SSS
96.	Sh. P.M. Solanki	SSS
97.	Sh. B.J. Dabhi	SSS
98.	Sh. C.G. Moradia	SSS
99.	Sh. Dharmesh A. Makawan	SSS
100.	Sh. Jay R. Purohit	SSS

Sanctioned strength employees on position and their category-wise distribution as on 31.03.2013.

Category	Sanctioned	On position	General	SC	ST	OBC
Scientific	39 + 1RMP	33	21	04	03	05
Technical	40	37	22	03	05	07
Administrative	17	12	06	03	00	03
SSS	19	18	04	04	03	07
Total	115+01	100	53	14	11	22

Discipline and grade –wise sanctioned scientific position

Discipline	Scientist	Sr. Scientist	Pr. Scientist	Total
Agril. Economics	01	-	-	01
Agril. Entomology	02	01	-	03
Agril. Extension	01	-	-	01
Agril. Statistics	-	01	-	01
Agronomy	01	01	01	03
Biochemistry(PS)	01	01	-	02
Biotechnology(PS)	02	01	-	03
Genetics & Cytogenetics	01	01	-	02
Microbiology	01	01	-	02
Plant Breeding	06	02	01	09
Plant Pathology	02	02	01	05
Plant Physiology	02	01	-	03
Soil Science (Pedology)	01	01	-	02
Agril. Engineering	01	-	-	01
Nematology	01	-	-	01
Total	23	13	03	39

Transfer

Sr.No.	Incumbent	Transferred from	Transferred to	With effect from
1.	Shri G.C. Prasad, FAO	DGR, Junagadh	NBSS& LUP, Nagpur	18.08.2012
2.	Sh.V.K.Jain.T-5	DGR, Junagadh	CS & WCR & TI, Kota	31.08.2012
3.	Sh. S.M. Sahare, A.O.	DGR, Junagadh	NRC for Grapes, Pune	22.06.2012



Financial up gradation

- ◆ DPC held on 09.05.2012 for Technical staff benefit to 07 employees Category II
- ◆ DPC held on 08.05.2012 for Technical staff benefit to 03 employees Category III
- ◆ DPC held on 29.10.2012 for scientific staff consideration for clearance of probation period benefit to eight employees
- ◆ DPC held on 28-29, Jan. 2013 for Tech. staff benefit to 03 employees

- ◆ DPC held on 19.12.2012 for Admn. Staff benefit to 01 employees
- ◆ DPC held on 27.11.2012 for Admn. Staff benefit to 01 employees
- ◆ DPC held on 16.03.2012 for Admn. Staff benefit to 01 employees

Appointment

- ◆ Shri J. R. Purohit and Shri D. A. Makwana joined as SSS on 17th September, 2012 on compassionate ground.

Retirement

- ◆ Shri J.B. Bhatt, AAO w.e.f. 30.11.2012

Demise

- ◆ Sh. Alji D. Makawan, SSS on 27.05.2012.

MEETING

IRC Meeting (14-16 May, 2012)

The 59th meeting of Institute Research Committee were held from 14th to 16th May 2012. This meeting was chaired by Dr. J.B. Misra, Director, DGR. During the meeting, project-wise progress of research work was reviewed and the technical programmes for ensuing seasons were finalised. The PIs of various research projects presented the highlights of work done in their respective projects and then proposed the future plans of work. The plans of work were discussed thoroughly and modified wherever required before being approved by the house. The Chairman mentioned that many new scientists had joined the institute and accordingly work plan have to be finalised for the new scientists as well as new projects have to be formulated for the 12th plan. The house discussed the titles for the projects to be taken up during the 12th plan. Other issues like growing labour problem, etc., were also discussed.

RAC Meeting (13-14 April, 2012)

The 14th RAC meeting was held on 13th and 14th April 2012. This meeting was chaired by Dr. J. H. Kulkarni. The other members who attended the meeting were Dr. B.B. Singh, ADG (O&P), Dr. G.S. Jadhav, ex-Director Instruction, MAU, Parbhani, and Dr. A.M. Parakhia, Director (Extension), JAU, Junagadh. Presentations on ongoing research projects were made by the PIs or co-PIs. Each presentation was discussed thoroughly and if required, the work plan was modified keeping in view the remarks of the RAC. In their concluding remarks the Chairman and the members while appreciating the good work that has been done at DGR also pointed out the need for reorienting the research work on certain aspects.



Research Advisory Committee and DGR scientists



**QRT meeting (July 14, 2012)**

For a critical appraisal of performance of DGR and AICRP-G for the period 2007-11 and also the relevance of continuation of these schemes, the Quinquennial Review Team (QRT) appointed by Council held its final meeting on July 14 2012 at Junagadh. The QRT comprised a Chairman, Dr DM Hegde, Ex-PD, DOR; five members: Dr SN Nigam, Principal Groundnut Breeder, ICRISAT; Dr SS Mehetre, Director of Research, MPKV, Rahuri; Dr DV Singh, Plant Pathology, IARI; and Dr Padma Raju, Director of Research, ANGRAU, Hyderabad; and one Member Secretary, Dr Radhakrishnan T, Principal Scientist DGR.

This was the final QRT meeting which was interfaced with Institute Management Committee (IMC) meeting. The Chairman QRT, while apprising the members of IMC of his general views on the importance and relevance of continuation of both DGR and AICRP-G, also sought suggestions from the members of IMC for improving the congeniality and performance of these schemes.



General Information

Institute Management Committee (IMC)

Chairman

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

Members

- ♦ Director of Agriculture (Gujarat), Krishi Bhavan, Sector-10A, Gandhinagar, Gujarat
- ♦ Director of Agriculture, Chepauk, Chennai-600 005, Tamil Nadu
- ♦ Dr. K.L. Dobariya, Research Scientist (Groundnut), Junagadh Agricultural University, Junagadh – 362 001, Gujarat
- ♦ Ms. Heerbai Ben Lobi, Jambur, Talala, Junagadh, Gujarat
- ♦ Sh. J.K.B. Gundc, Post Pattan Kodoli, Hatkanaglc, Kolhapur- 416 202, Maharashtra
- ♦ Dr B.B. Singh, ADG (OP), ICAR, Krishi Bhavan, New Delhi – 110 114
- ♦ F&AO, CIRCOT, Mumbai (ex-officio)
- ♦ Dr. A. Henry, Project Coordinator (NNRPL), Central Arid Zone Research Institute, Jodhpur – 342 003, Rajasthan
- ♦ Dr. Radhakrishnan, T, Principal Scientist, DGR, Junagadh
- ♦ Dr. S.R. Bhatt, Principal Scientist, NRC for Plant Biotechnology, IARI, New Delhi – 110012
- ♦ Dr. (Mrs.) M. Sujatha, Principal Scientist, DOR, Hyderabad – 500 030

Member Secretary

- ♦ Administrative Officer, DGR, Junagadh (ex-officio)

Research Advisory Committee

Chairman

- ♦ Dr. J.H. Kulkarni, Ex-Vice Chancellor, UAS, Dharwad, 'Suggi', Alur Compound, 3rd Cross, Sadhanker, Dharwad – 580 008, Karnataka

Members

- ♦ Dr. S.N. Nigam, Principal Groundnut Breeder, ICRISAT, Patancheru - 502 324, AP
- ♦ Dr. V. Muralidharan, Professor (Oilseeds), TNAU, Coimbatore - 641 003, TN
- ♦ Dr. G.S. Jadhav, Ex-Director Instruction, MAU, Parbhani, Aurangabad- 431 003, Maharashtra
- ♦ Dr. A.M. Parakhia, Director (Extension), Junagadh Agricultural University, Junagadh – 362 001, Gujarat





- ◆ Dr. G.V. Subbaratnam, Retd. Professor of Entomology, ARI Campus, ANGRAU, Rajendranagar, Hyderabad – 500 030, AP
- ◆ Dr. J.B. Misra, Director, DGR, Junagadh- 362 001, Gujarat
- ◆ Assistant Director General (O&P), ICAR, Krishi Bhavan, New Delhi – 110 114
- ◆ Shri M.K. Mankad, Progressive Farmer, KVK, Gundala Road, Kutch- 370 421 Gujarat
- ◆ Shri H.B. Zala, Progressive Farmer, Vadhavi, Junagadh, Gujarat

Member Secretary

- ◆ Dr. S.K. Bera, Principal Scientist (Cytogenetics), DGR, Junagadh

Institute Research Committee

Chairman

- ◆ Director, DGR, Junagadh

Members

- ◆ All Scientists of DGR, Junagadh

Member Secretary

- ◆ Dr Rinku Dey, Principal Scientist, DGR, Junagadh

Institute Joint Staff Council

Chairman

- ◆ Dr J.B. Misra, Director, DGR, Junagadh- 362001, Gujarat

Members: Staff side

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

Members: Office side

- ◆ Dr.Chuni Lal, Principal Scientist, DGR
- ◆ Dr. R. Dey, Principal Scientist, DGR
- ◆ FAO
- ◆ AO



FINANCE AND ACCOUNTS

EXPENDITURE STATEMENT FOR THE YEAR 2012-13

DGR-Main Unit

₹ In lakhs

S. No.	Budget Head	NON Plan			Plan		
		BE	RE	Expenditure	BE	RE	Expenditure
1	Establishment Charges	449.00	600	599.84	0	0	0.00
2	Wages	19.00	58	58.16	0	0	0.00
3	Loans & Advances	10.00	6	3.16	0	0	0.00
4	Pension	0.00	21	21.37	0	0	0.00
5	T.A.	7.00	7	7.00	12	12	11.99
6	Recurring Contingencies	85.50	81	80.63	291	224	224.04
7	Works	5.00	0	0.00	80	0	0.00
8	Equipments	10.00	10	9.99	288	167	167.49
9	Furniture	0.00	0	0.00	15	4	3.81
10	IT	0.00	0	0.00	10	0	0.00
11	Books	0.00	0	0.00	12	10	10.06
12	IIRD	0.00	0	0.00	12	8	7.60
Total		585.50	783	780.15	720	425	424.99

AICRP-G

₹ In lakhs

S. No.	Budget Head	RE 2012-13	Expenditure
1	Pay and Allowances	876.09	875.87
2	TA	6.90	6.90
3	Contingency	48.45	48.45
4	Non Recuring Contigencies	14.16	14.16
5	HRD	0.00	0.00
6	Need Based Research	0.00	0.00
7	Pay And Arrear (VI Pay Comm.)	0.00	0.00
8	TPS	10.60	10.82
Total		956.20	956.2



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: 0285-2675831 (residence)

EPABX : 0285-2672461/2673041

Administrative officer : 0285-2672843

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



हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agr'search with a human touch