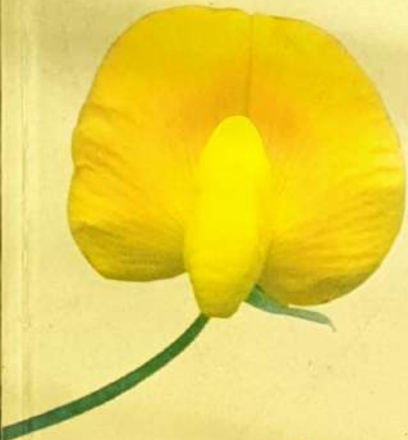
DGR

वार्षिक प्रतिवेदन

Annual Report

2009-10



मूँगफली अनुसंधान निदेशालय

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Directorate of Groundnut Research

P. B. No. 5, Jnuagadh - 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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Girnar 3: A new Spanish groundnut variety developed at DGR, Junagadh

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PREFACE

The year 2009 will long be remembered as one of the bad years for Indian agriculture as India suffered its worst drought since 1972. The delayed and scanty rains left the farmers high and dry in the affected areas. The Govt. of India was constrained to declare 161 districts as drought hit districts and the year 2009 as the drought year even as ten states in India declared 246 districts as drought-affected. Rainfall in 2009 was 29 per cent lower than nor nal.

The impact of the drought varied according to region, with the southern peninsula recording minus seven per cent while the northwest reported a deficit of 36 percent. For India's 235 million farmers, a bad monsoon spelt financial disaster because of lack of irrigation in most rural areas. Low rains ravaged India's rice, sugarcane and groundnut crops, and also disrupted the flow of water into the main reservoirs vital for hydropower generation and winter irrigation.

As for *kharif* groundnut crop, in 2009, only 44.47 lakh ha could be sown against 53.33 lakh ha in 2008. Among the major groundnut growing states, the worst hit states were Andhra Pradesh and Tamil Nadu. In Andhra Pradesh, in 2009 only 9.96 lakh ha could be sown against 14.99 lakh ha in 2008. In Tamil Nadu, only about a half (1.89 lakh ha) of the normal area (3.62 lakh ha) could be sown. In Gujarat, though there was no major reduction in groundnut area as sowing was completed in 16.58 lakh ha in 2009 against 17.91 lakh ha, yet the production was considerably down due to inadequate rains. The loss of groundnut area in other states is not as noteworthy. Although the final figures are yet to be declared, the total production of *kharif* groundnut for the year 2009 is expected to be down by 30%.

Notwithstanding the deficient rainfall, the DGR scientists continued to work with zest. Although the field experiments were affected a bit, the work in laboratory continued with full swing. In the year 2009-10, five young scientists joined the DGR after qualifying the ARS examination and one scientist joined at senior level. Thus, there was some respite from the earlier trend of departures alone from the DGR. With the joining of new scientists, their numbers grew and the strength reached slightly beyond 50% of the sanctioned positions. At AICRPG centres, due to erratic and scanty rains, sowing of field experiments was delayed at a few locations. During 2009-10, six new varieties developed through AICRP-G system were notified for release. Besides four varieties, one each developed by Tamil Nadu and Uttaranchal and two by Andhra Pradesh, were also notified.

The activities of infrastructure development continued will full swing and the extent of utilization of the allocated budget was 98.8% for plan and 100% for non-plan in respect of DGR. For AICRP-G (plan only) the utilization was 100%.

Breaking the previous trend, this report is being brought out well in time which indeed is highly gratifying.

The contents of this report have been contributed by the scientists and other officials of DGR. The painstaking efforts of Dr. R. Dey in compiling and editing are praiseworthy. Dr. K.K. Pal has rendered valuable help in designing the cover page and format for printing as well as overseeing the process of printing of this report. Several other officials have also helped in bringing out this report. The contribution of one and all is thankfully acknowledged.

J.B. Misra

(J.B. Misra)
Director

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Executive Summary

- 'Girnar 3', a Spanish bunch variety developed at DGR, Junagadh was released for commercial cultivation in the eastern states (West Bengal, Manipur, and Orissa) of India for *kharif* season.
- In *kharif* 2009, for incorporating tolerance of different biotic and abiotic stresses into the superior agronomic background, 19 fresh crosses were attempted.
- Twenty-seven new advanced breeding lines were developed in F_6 / F_7 generation in *kharif* 2009.
- For each of Spanish and Virginia types, preliminary yield evaluation trials and advanced evaluation trials were conducted in *kharif* 2009 season.
- In different yield evaluation trials, TG 37A, a variety that is now gaining popularity among the farmers of Saurashtra region, gave higher yield than that of the ruling variety GG 2.
- Two Spanish breeding lines PBS 15041 (1307 kg ha^{-1}) and PBS 16039 (1703 kg ha^{-1}) and two Virginia breeding lines PBS 21095 (1262 kg ha^{-1}) and PBS 25049 (1304 kg ha^{-1}) exhibited a higher pod yield potential than the best Spanish (TG 37A) and Virginia (GG 20) check varieties.
- In drought-nursery, a total of 323 breeding lines and varieties were screened under rain-fed conditions. At least, nine lines (PBS 21095, PBS 21087, PBS 16038, PBS 26019, PBS 26015, PBS 24022, PBS 11084, PBS 11058 and JUN 27) and a variety (Girnar 3) were adjudged to be promising as they all gave appreciable yields even under prolonged (40 days) end-of-the-season drought.
- A total of 15.60 q nucleus seed of two varieties (Girnar 2 and Girnar 3) was produced and supplied to SFCI, Hyderabad fetching a revenue of Rs. 1,90,998.
- Groundnut + cluster bean harboured significantly less population of jassids compared to other intercrops upto 60 DAS. Intercropping of groundnut with soybean resulted in least population of thrips upto 30 DAS.
- Among various biopesticides tested against sucking pests of groundnut, foliar spray of *Metarhizium anisopliae* (2 g L^{-1}) significantly reduced the population of jassids and thrips.
- Among Imidacloprid, Carbosulfan, Acetamiprid, Profenophos and Thiomethoxam tested for their efficacy against sucking pests of groundnut, seed treatment with Imidacloprid (0.0035%) + 2 sprays of 0.008% Imidacloprid (at 30 and 45 DAS) was found very effective in reducing jassids. The highest pod yield (3604 kg ha^{-1}) was obtained in this treatment.
- Seed treatment with Imidacloprid (70 % WS) @ 5 g kg^{-1} seed proved best in minimizing the jassids and thrips population. Imidacloprid (0.08%) sprays at 30 and 45 DAS proved best in reducing population of jassids and thrips.

- Out of seventeen genotypes screened against stem rot (*Sclerotium rolfsii*), four genotypes, *viz.* ICGV 86590, CS 19, CS 160 and CS 168 showed less than 20% stem rot incidence as against 43.4% in GG 2 and 50.0% in CS 168. Genotypes CS 164, CS 331, CS 334, CS 81, CS 104, CS 110, CS 272 and CS 316 showed immune reaction to the collar rot disease. Eight genotypes *viz.* CS 132, CS 68, CS 160, CS 245, CS 352, CS 78, CS 58 and GG 2 showed less than 20% collar rot incidence.
- Foliar application of *Trichoderma* isolate T-170 culture filtrate effectively reduced the aflaroot and collar rot diseases. The stem rot incidence was low in foliar spray of *Trichoderma* (T-170) spore suspension @ 1.5×10^6 CFU ml^{-1}.
- Severity of late leaf spot and rust diseases was reduced by foliar application of *Verticillium lecanii* culture filtrate (50% dilution) at 15 days interval from the day of appearance of diseases.
- Seed treatment with Tebuconazole (1.5 g kg^{-1}) + two foliar sprays of Tebuconazole (1 ml L^{-1}) significantly reduced the collar rot and stem rot incidences.
- Thirty Spanish groundnut cultivars were evaluated for photosynthetic efficiency *vis-à-vis* source-sink relationship and certain promising cultivars were identified.
- Relationship between photosynthetic efficiency and antenna efficiency of PS II ($r = 0.65^{**}$) was established by chlorophyll fluorescence parameters and then this relationship was used as a rapid and efficient tool for screening large number of segregating population/germplasm accessions, under field conditions.
- Roles of L-proline and reducing sugars in imparting drought tolerance were studied in both Virginia and Spanish types of groundnut cultivars.
- Root traits associated with drought tolerance and role of heat-shock proteins in imparting tolerance of high temperature stress was studied.
- Among seven carriers evaluated for application of a consortium of beneficial microorganisms, talcum powder was found to be the best with enhancement in pod yield of groundnut by 21%.
- Application of AM fungi, viz., *Glomus etunicatum*, *Glomus fasciculatum*, *Glomus mosseae* and *Gigaspora scutellospora* improved growth, yield and nutrient uptake of groundnut cultivar GG 2.
- Newly identified strain of groundnut rhizobia, RH11, enhanced the pod yield of groundnut cultivar Girnar 2 by 9% over the standard culture NC92.
- Seven DAPG-producing fluorescent pseudomonads were identified for having antifungal activities against major soil-borne fungal pathogens of groundnut.
- In large-seeded cultivars, application of appropriate quantities of P, K, B and Zn was found to be essential to ensure desirable seed size and quality.
- Ten high Fe and Zn containing cultivars were identified.
- For the NEH region six varieties (GG 7, GG 20, GG 13, TG 37A, ICGS 76 and CSMG 84-1) were identified as high-yielding and suitable.

- Intercropping groundnut with maize, rice, sesamum and/or mung could be successfully practiced in the NEH region.
- Among the large-seeded cultivars, BAU 13, ICGS 76, and NRCGCS 268, performed well in the NEH region with critical inputs like P, Ca, B and organic manures.
- The manure from piggery or poultry farms, vermi-compost (5 t ha^{-1}), and green leaves of *Gliricidia* and Subabul (10 t ha^{-1}) were found efficient as organic sources of nutrients.
- Application of 60 kg N, 100 kg P_2O_5, 125 kg K_2O, 200 kg Ca, 50 kg S, 60 kg Mg, 5 kg Zn and 2 kg B ha^{-1} significantly improved the pod yield and harvest index of the cultivars TG 37A, GG 7 and GG 20 in the experiment on 'fertilizer application for specific yield targets in groundnut'.
- The experiment on revalidation of fertilizer doses revealed that the application of 25 kg N, 80 kg P_2O_5 and 60 kg K_2O ha^{-1} significantly improved the pod yield and other yield attributes.
- Response to application of potassium was up to 60 kg ha^{-1} while the response to N and P application at higher levels (37.5 kg N and 80 kg P_2O_5 ha^{-1}) was not significant.
- In the permanent experiment on cropping systems, the groundnut (FYM+50% RDF)-wheat (FYM+50% RDF)-green gram cropping system recorded the significantly higher groundnut pod yield and total system productivity (4063 kg ha^{-1}). The soil fertility report showed that the organic carbon built (t ha^{-1}) was maximum in groundnut-wheat-green gram cropping system and the highest was recorded in the integrated nutrient management system (FYM + 50% RDF).
- The application of '2 kg CA + 2 t FYM ha^{-1}' resulted in significantly higher pod yield (3053 kg ha^{-1}) and net returns (Rs. 47027 ha^{-1}). The response was not appreciable with the increasing doses of CA (4 and 6 kg ha^{-1}).
- Various organic treatments did not differ significantly their effect on pod yield, however, the application of 10 t FYM ha^{-1} with biofertilizers (*Rhizobium* and PSB) and biopesticides (*Trichoderma* and castor cake) resulted in the highest pod yield (3528 kg ha^{-1}). The economic analysis based on groundnut selling price of Rs. 2 kg^{-1} pod, revealed that application of FYM + biofertilizers + biopesticides fetched the highest net returns (Rs. 54815 ha^{-1}).
- After nine years of experimentation, it was concluded that instead of taking single crop of groundnut in coastal areas of Saurashtra region, the farmers can take one more crop in *rabi* season for their economic benefit by using saline water (2-3 dS m^{-1}) for supplementary irrigation of *kharif* groundnut, and in *rabi* season, (4-6 dS m^{-1}) saline water can be used for irrigation of wheat, mustard and bajra crops for their optimum yields (about 1000 kg ha^{-1} of groundnut, 1500 kg ha^{-1} mustard, 3500 kg ha^{-1} wheat and 3300 kg ha^{-1} of bajra), whereas saline water was not suitable for irrigation of summer groundnut as there is buildup of high soil salinity.

- Under genus *Arachis*, 81 accessions belonging to sections *Arachis* (28), *Caulorhizae* (1), *Erectoides* (6), *Heteranthae* (1), *Procumbentes* (8) and *Rhizomatosae* (37) were maintained in the field gene bank.
- Seeds of 14 released varieties; seven identified for release, and two wild accessions were acquired from 7 AICRP-G centres for inclusion in the germplasm collection.
- For use in the crop improvement programme, 1656 germplasm accessions including the wild relatives of groundnut were supplied to 36 indenting scientists from various centres in the country.
- For two surrogate traits of WUE namely ^{13}C and ^{18}O, five promising accessions (NRCG 11915, NRCG 12568, NRCG 12965, NRCG 12274, and NRCG 12326) were identified.
- Among the Spanish bunch types, two varieties namely ICGV 86590 and DRG 12 identified for low ^{13}C values (18.86 and 18.94, respectively) can be used as donors for improving this trait as low ^{13}C value is considered a desirable trait.
- For conservation, 1118 new germplasm accessions were multiplied and 528 accessions were characterised for 30 different morpho-physiological traits.
- Two accessions, NRCG 14350 and NRCG 14409 which possessed a long (> 60 days) fresh seed dormancy and another two accessions with NBPGR, New Delhi, NRCG 14326 and NRCG 14336 with a fresh seed dormancy of 40 days were registered as a novel plant germplasm source of fresh seed dormancy.
- Nine transgenics were further confirmed by RT-PCR for the expression of the *mtlD* gene sequence.
- Three crosses were made for developing mapping populations for tolerance of stem rot.
- The mapping population of recombinant inbred lines from the cross TAG 24 X R 9227 was screened in a sick plot for tolerance of stem rot.
- The genotypes *viz.* TAG 24, R 9227, JL 24, ICGV 86590, GG 20, CS 83, CS 75 and CS 19, which were used for developing mapping populations, were analysed for their marker polymorphisms.
- The oil content of the kernels of the core germplasm collection (126 genotypes) was in the range of 39.2 to 50.7% with a mean of 42.6% while the protein content was in the range of 12.4% to 34.7% with a mean of 20.8%.
- Genotypic differences were observed in the oil and protein composition of groundnut kernels under drought stress. On the basis of these differences more sensitive and less sensitive lines were detected.
- A number of new and already available popular groundnut recipes were tried and their nutritive values were worked out.
- Seven proteolytic bacterial cultures, tolerant to high temperature, salinity and heavy metals, were isolated and evaluated.

- A highly efficient proteolytic isolate *Bacillus* sp. F1 was identified, which in slurry fermentation, produced 302.9 IU protease g^{-1} de-oiled groundnut cake after 48 h of incubation at 50°C.
- Seed infection and seed colonization of *Aspergillus flavus* were comparatively higher in the produce of *kharif* than those in summer produce.
- Population of *Aspergillus flavus* was low when groundnut was grown after rotation with garlic or onion or fallow land than after groundnut itself (groundnut-groundnut).
- Samples of groundnut, its by-products and value-added products from different industries showed that *Aspergillus flavus* population and aflatoxin contamination were higher in conditioned pods than in other samples. Maximum moisture content (11%) was recorded in conditioned pods where water was sprinkled to prevent the breakage of kernels during shelling. Sprinkling of water (conditioning of pods) facilitated further growth and infection of *A. flavus* and thereby increased aflatoxin contamination in the samples.
- For incorporating the trait of large-seed in the background of high yield potential, 10 fresh crosses were attempted. Segregating materials in different generations were advanced to the next respective filial generation. Selections were made for both or any one of pod size and pod yield. Ten advanced breeding lines possessing large-seed with or without high yield were identified.
- Twenty-nine advanced breeding lines were multiplied to get sufficient seeds for different station trials while 90 lines (14 Spanish, 76 Virginia) were maintained.
- Over two years (*kharif* 2008 and 2009), the pod (1761 kg ha^{-1}) and kernel (1201 kg ha^{-1}) yields of advanced breeding lines ICGV 97079 were significantly higher than the best check variety GG 20 (1408 kg pods ha^{-1} and 1026 kg kernels ha^{-1}).
- On the basis of observations on SLA and SCMR of 88 wild *Arachis* accessions, it was inferred that the SLA is influenced more by the environment than SCMR. Two accessions NRCG nos'11823 and 12036 were identified as stable for both SLA and SCMR and can be used as donors in breeding programmes.
- For introgression of desirable genes from wild species, fresh hybridization was done using the variety J 11 as the female parent and accessions of wild species belonging to *A. duranansis, A. appresipilla, A. regoni, A. diogoi, A. helodes, A. pussila, A. corentina, A. kemf- mercadoi* and *A. kretschmeri* as male parents.
- In *rabi* season at Raichur, 28 promising genotypes were screened for tolerance of PBND. Eight genotypes (NRCGCS nos' 50, 83, 103, 108, 164, 166, 205 and 221) showed 10-20% incidence of disease and were identified to be resistant to PBND. At Junagadh, under field conditions as many as 27 genotypes (NRCGCS nos' 19, 27, 70, 74, 77, 83, 85, 86, 124, 176, 180, 186, 195, 196, 222, 240, 242, 244, 247, 249, 280, 285, 296, 298, 349, 396, 363) were found to be immune to *Alternaria* leaf blight.

- Two genetic stocks "crinkle leaf white testa" and "crinkle leaf red testa" were registered with NBPGR, New Delhi as multiple phenotypic markers. Crinkle leaf is dominant over normal leaf, while both white and red testa colours are dominant over rose testa colour. Crinkle leaf and white or red testa colour in these two mutants segregate independently and hence are monogenic in nature.
- Two salt tolerant wild *Arachis* accessions of *A. glabrata* (NRCG 11832 and NRCG 11817) were subjected to DDRT analysis. Five, out of 400 polymorphic bands, were coded as GTRSS-1 to -5. Out of 94 matches of GTRSS-1 in the gene bank, four matches could be attributed to abiotic stress. GTRSS-5 showed similarity with Normalized cDNA library from the cotyledons and young leaves of peanut *Arachis hypogaea.*
- One susceptible and three resistant groundnut genotypes were analyzed using 56 random primers. Six primers, *viz.*, D 9, D 17, OPI 14, OPI 17, OPT 3 and OPT 8 produced a higher number of unique bands. These primers reproduced as many as 22 fragments of 100bp to 1200bp in 11 F_1 progenies of GG 2 and CS 19.
- Six generations (P1, P2, B1, B2, F1, F2) of the cross, ALR 2 x TG 37A were developed. The plants were separately harvested generation and replication-wise for analysis of fodder quality and to work out the pattern of inheritance of these traits.
- A total of 15 IVT I *rabi*-summer entries of AICRP-G, which were tested during 2008-09 at four main centers located at Vriddhachalam in Tamil Nadu, Dharwad in Karnataka, and Jalgaon in Maharashtra and Junagadh in Gujarat along with national and zonal check varieties, were harvested separately and analyzed for fodder quality.
- At all the four locations, the nitrogen content in the fodder of genotype, AG 2243 was the highest (mean value of 3.04%). Thus this genotype was superior to other genotypes in terms of both nitrogen content and stability of this trait. Hence, this can be used as a parent for improving nitrogen content in the fodder quality improvement programme.
- The heritability estimates for seven fodder traits over four locations indicated a very high value (0.82) for nitrogen content, while the neutral detergent fibre was found to be the least heritable. Other traits exhibited moderate heritability values.
- The Additive Main Effect and Interactive Multiplicative (AMMI) analysis for nitrogen content with data over four locations and 15 genotypes indicated that Dharwad was the most congenial location for realising high fodder quality and the genotypes, TG 60, AG 2244, UG 10 and CTMG 3 were the most stable genotypes for nitrogen content.

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

(CHUNI LAL, A.L. RATHNAKUMAR, VINOD KUMAR*, T.V. PRASAD**, P.C. NAUTIYAL AND A.L. SINGH)

*Up to September 2009; **Up to June 2009

Hybridization

During *kharif* 2009, 19 crosses were attempted to incorporate tolerance of different biotic and abiotic stresses and to develop mapping populations for stem-rot disease. From the 5330 buds, pollinated in different cross combinations, 1848 hybrid pods were harvested. The success rate of setting of hybrid pods from the number of pollinations attempted in a cross ranged from 20 to 58% in the crosses 'SGL 4233 x ICGS 44' and 'PBS 12160 x JL 286' attempted for incorporation of tolerance of PBND and tolerance of drought stress, respectively. Over all rate of success of crossing was 35%, which was fairly high compared to that of preceding two years.

Selections and generation advancements

Twenty F_1s and seven F_2s, developed during *kharif* 2008, were raised and true hybrids were identified on the basis of the hybrid vigor in F_1 and non-segregation observed in F_2 generations. In different filial generations (F_2 to F_6), 104 single plant selections were made in the crosses attempted in the previous years for incorporating tolerance of different biotic and abiotic stresses. In F_7 generation, 27 non-segregating new advanced breeding lines were identified.

Girnar 3 - a new variety released

The test entry PBS 12160, a Spanish type, was entered into AICRP-G trials in the year 2006. This entry was evaluated in Initial Varietal Trial stage-I in *kharif* 2006 and stage-II in *kharif* 2007. This entry was tested in Initial Varietal Trial (IVT) for Spanish groundnut in stage I (IVT I) and stage II (IVT II), respectively. This genotype gave the highest yields in Zone IV over two years, and hence was promoted to AVT. Based on its performance in this zone, it was identified in the Annual *kharif* AICRP-G Workshop (April 2009 at ANGRAU, Hyderabad) for submitting a proposal for release. This entry was subsequently proposed for release as 'Girnar 3' with a national identity number IC 571728 assigned by NBPGR, New Delhi. The Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agri-Horticultural Crops in its meeting held at Agartala (24-25 January, 2010) eventually recommended its release. This variety has been notified for commercial cultivation in the states of West Bengal, Orissa and Manipur vide "The Gazette of India, Extraordinary, Part II, Section 3, Sub-section ii No. 608, New Delhi, Thursday, April 1, 2010/Chaitra 11, 1932".

Figure 1. 'Girnar 3'- a new release from DGR

Maintenance breeding

Maintenance of advanced breeding lines

In *kharif* 2009, 558 advanced breeding lines developed to meet different objectives of the project were raised for maintenance (Table 1). These included 48 advanced breeding lines developed for high water-use-efficiency, and 50 mutants of variety Girnar 1.

Table 1. Particulars of advanced breeding lines maintained and multiplied in *kharif* 2009

Purpose	Spanish	Virginia	Total
Tolerance of different abiotic stresses	136	195	331
Tolerance of different biotic stresses	40	48	88
Total	**176**	**243**	**419**
Girnar 1 Mutants	-	-	50
WUE lines	-	-	47
Other genotypes	-	-	42
Total			**558**

Maintenance of DGR varieties

Basic seed production of pre-release variety Girnar 3

Seeds of pre-release variety Girnar 3 collected individually from 1451 plants were sown in plant-to-row progenies of basic seed (Fig. 2). Rigorous roguing was done both at vegetative and reproductive stages of the crop and also at the time of harvest and thus 175 kg basic seed was produced. During summer 2009, a severe incidence of leaf blight (*Alternaria* sp.), a hitherto uncommon disease of groundnut was observed in DGR farm and also in the farmers' fields. A row of single plant progeny, which was later identified as rogue and subsequently removed from the Girnar 3 seed plot, was found to be severely infected with this disease. The plants of Girnar 3, growing in the vicinity of this infected material, however remained free from infection and thus exhibited near immunity against this disease (Fig. 3).

Figure 2. 'Girnar 3'- a rich harvest from the seed plots

Figure 3. An off type plant (leaves with lesions) susceptible to *Alternaria* sp. amidst the plants of 'Girnar 3'

Maintenance of Nucleus Seed Production of DGR Groundnut varieties

In *kharif* 2009, 25 kg nucleus seed of Girnar 1 (now out-of-cultivation) and 875 kg nucleus seed of Girnar 2 (released in 2008 for northern states) was produced. In summer 2009, 175 kg basic seed of Girnar 3 (a variety identified in April 2008 and notified in April 2009 for Orissa, West Bengal and Manipur states) was produced and then further multiplied in *kharif* 2009 to produce 675 kg of nucleus seed.

Screening for tolerance of drought stress

Junagadh location has been characterized for occurrence of end-of-season drought. A nursery for screening for drought tolernce is established every *kharif* season to screen all the advanced breeding lines developed for tolerance of drought under natural situations. In *kharif* 2009, a total of 323 advanced breeding lines comprising both Spanish and Virginia types and also Girnar 1, Girnar 2 and Girnar 3 (DGR varieties) were sown in single rows each of 5 m length. As no protective irrigation was provided, the crop remained rain-fed only. The location received 829.6 mm rainfall in 29 days from June to November. The major chunk of it was received in July (660 mm in 17 days) coupled with reduced average sunshine hours in this month. In September only 10.4 mm rainfall was received in 2 days and in November only 5 mm in a single day. In October, no rain was received. Thus, the crop experienced a protracted spell of drought. The plant population and pod yield for each row (genotype) were recorded and the yield expressed as g plant^{-1}. The pod yield was in the range of 0.72 g plant^{-1}

(PBS 14072) to 9.26 g plant^{-1} (PBS 21095). The yield of the best 10 breeding lines was in the range of 7.0 g to 9.26 g plant^{-1} where Girnar 3 and JUN 27 ranked 4th and 9th. The entry JUN 27 is being tested in AICRP-G trials for tolerance of end-of-season drought and Girnar 3 is the latest release from the DGR (Table 2). When pod yields expressed as per plant basis were approximated on unit area basis for comparison with Spanish and Virginia groups, it was revealed that a Spanish line PBS 16038 topped the list with a pod yield of 1759 kg ha^{-1}, followed by Girnar 3 which gave 1672 kg ha^{-1}.

Table 2. Top ten groundnut genotypes for pod yield under end-of-the-season drought conditions

Genotype	Habit group	Pod yield (g plant^{-1})
PBS 21095	Virginia	9.26 (1544)
PBS 21087	Virginia	8.36 (1393)
PBS 16038	Spanish	7.91 (1759)
Girnar 3	Spanish	7.52 (1672)
PBS 26019	Virginia	7.38 (1229)
PBS 26015	Virginia	7.30 (1217)
PBS 24022	Virginia	7.28 (1213)
PBS 11084	Spanish	7.01 (1557)
JUN 27	Virginia	7.00 (1556)
PBS 11058	Spanish	7.00 (1555)

Values in parenthesis are approximated to express yield on unit area basis (kg ha^{-1})

Station trials for yield evaluation

Advanced breeding lines developed for tolerance of different biotic and abiotic stresses were evaluated under preliminary yield evaluation trial for one year and advanced yield evaluation trials for two years in trials which were conducted separately for Spanish and Virginia groups. Observations were recorded on surrogates of water-use efficiency (SCMR and SLA) and yield and yield component traits (pod yield, PY; kernel yield, KY; biological yield, BY; 100-seed mass HSM; weight of 100-selected mature kernels, HSMK; sound mature kernels, SMK; shelling turnover, ST; and harvest indices for yields of pod (HI_p) and kernel (HI_k). In *kharif* 2009, the groundnut crop experienced prolonged end-of-the-season drought a characteristic feature of this region and as such in general the yields were low, though a protective irrigation was given to all the yield evaluation trials. The trial-wise observations are discussed.

Preliminary yield evaluation - Spanish type

Nine advanced breeding lines of Spanish type along with three check varieties (GG 2, GG 7 and TG 37A) were evaluated for yield and yield related traits, besides surrogates of water-use efficiency (SLA and SCMR) in a replicated complete block design with three replications with a plot size of five rows each of 5 m length. The planting geometry was 10cm within a row (plant-to-plant) and 45 cm between the rows. Analysis of variance indicated highly significant differences due to genotypes. When genotypic means were compared it was observed that GG 2 recorded the highest SCMR among the check varieties, whereas for the remaining traits, GG 7 was adjudged to be the best. TG 37A was found to be the best check variety for pod and kernel yields, and SLA. TG 37A has gained popularity among the farmers of Saurashtra region and is replacing the old and most popular Spanish groundnut variety GG 2. The results of the experiment indicated that the variety TG 37A has an edge over GG 2 for yield. The advanced breeding line PBS 11088 was found to be significantly superior for SCMR over the respective best check varieties, however, this line was not found promising for yield and the related traits. For pod and kernel yields, only one advanced breeding line, PBS 15041, gave significantly superior yields over the best check variety. This line had also the highest ST, which was significantly higher than GG 7, the best check variety for this trait. The other advanced breeding line, which gave significantly higher ST, was PBS 15038. For HSM and HSMK, only PBS 15045 was found to be significantly superior to the best check variety. None of the advanced breeding line was found significantly superior over the best check variety for SMK (Table 3).

Table 3. Performance of advanced Spanish breeding lines for morpho-physiological and yield attributes in preliminary evaluation trial (*kharif* 2009)

Genotypes	SCMR	SLA ($cm^2 g^{-1}$)	PY ($kg\ ha^{-1}$)	KY ($kg\ ha^{-1}$)	HSM (g)	HSMK (g)	SMK (%)	ST (%)
Test entry								
PBS 11088	31*	177	711	485	25	31	39	68
PBS 14073	26	203	940	540	24	28	25	57
PBS 14074	25	198	1099	611	27	33	33	55
PBS 14076	28	184	891	503	22	28	22	56
PBS 15032	29	187	706	474	29	34	40	67
PBS 15038	25	220	937	687	24	29	38	73*
PBS 15041	24	202	1307*	960*	30	37	41	74*
PBS 15045	32	162	1170	741	36*	43*	41	63
SE 8	30	175	732	474	31	38	38	65
Check								
GG 2	28	196	587	398	22	27	33	67
GG 7	26	192	858	599	33	39	46	70
TG 37 A	28	174	1052	685	30	36	37	65
CV (%)	8.6	7.0	13.5	14.9	6.8	3.9	16.9	1.8
CD (5%)	2.8	15.9	148.4	106.2	2.3	1.6	7.3	1.4

Advanced yield evaluation trial - Spanish group

Single- year-evaluation

Fifteen groundnut genotypes comprising twelve advanced breeding lines of Spanish type and three check varieties (GG 2, GG 7 and TG 37A) were evaluated for their performance in *kharif* 2009 under rainfed conditions. The material was grown in a replicated complete block design with three replications. The plot size was of five rows- each of 5 m length. Seeds were sown to maintain a plant-to-plant distance of 10 cm within a row and rows were spaced at 45 cm from each other. Analysis of variance indicated highly significant differences due to genotypes for all the traits studied. Among the three check varieties GG 2 was found to be the best check variety for surrogates of WUE (SCMR and SLA) and ST; GG 7 for HI_k, HKW, HSMK and SMK; and TG 37A for PY , KY, BY, and HI_p. On comparing the genotypic means of the advanced lines it was observed that most of the lines were significantly superior over the best check variety for SCMR and PBS 16039 for SLA. For

Table 4. Performance of advanced Spanish breeding lines for morpho-physiological and yield attributes in advanced trial (*kharif* 2009)

Genotype	SCMR	SLA ($cm^2 g^{-1}$)	PY ($kg ha^{-1}$)	KY ($kg ha^{-1}$)	BY ($g plant^{-1}$)	HI_P (%)	HI_k (%)	HSM (g)	HSMK (g)	SMK (%)	ST (%)
Test entry											
PBS 11077	30	197	1299	778	20	29	18	29	32	21	60
PBS 11084	31*	160	1417	854	27*	24	15	31	40	25	60
PBS 14060	31*	167	1471	27	25*	26	18	34	46*	34	70
PBS 14064	26	182	843	550	20	19	12	29	36	40	65
PBS 14065	26	207	1126	646	21	23	13	31	39	35	57
PBS 14066	28	191	1071	637	19	25	15	28	36	40	59
PBS 14067	25	186	1141	657	19	27	16	30	38	40	57
PBS 16026 A	33*	165	1348	832	19	32	20	31	41	27	62
PBS 16026 B	31*	165	617	334	19	15	8	23	30	25	54
PBS 16039	34*	151*	1703*	1067*	25*	31	20	35	44*	28	63
PBS 16044	34*	165	1066	717	21	23	15	25	35	35	67
PBS 19017	32*	170	846	579	24*	16	11	31	43	28	68
Check											
GG 2	27	187	737	529	18	19	13	23	30	33	72
GG 7	25	196	1110	788	17	31	22	32	41	40	71
TG 37 A	26	191	1375	904	20	32	21	29	39	32	66
CV (%)	8.8	16.9	15.7	15.4	14.8	15.7	16.4	9.4	5.4	13.4	1.9
CD (5%)	3.0	35.6	212.6	132.2	3.7	4.6	3.1	3.3	2.4	5.1	1.4

pod and kernel yields only PBS 16039 outperformed the best check variety. This advanced breeding line was also superior over the best check for biological yield and HSMK. Three more advanced breeding lines (PBS 11084, PBS 14060 and PBS 19017) were found to yield significantly superior biological yields over the best check variety. In case of HSMK, PBS 14060 also recorded significantly superior performance over the best check variety. For rest of the traits no advanced breeding line was found superior over the best check variety (Table 4).

Two-year-evaluation

Eleven Spanish advanced breeding lines were evaluated for two consecutive *kharif* seasons in, 2008 and 2009 along with three check varieties GG 2, GG 7 and TG 37 A. For SCMR and SLA, variations due to genotypes and years were significant, but interactions between year and genotypes were non-significant. In case of PY and KY, variations both due to genotypes and genotype x year were significant. For the remaining traits, variations due to all the components (year, genotype and genotype x year) were significant. None of the test

Table 5. Performance (pooled over two years) of advanced Spanish breeding lines for morpho-physiological and yield attributes (*kharif* 2008 and 2009)

Genotypes	SCMR	SLA ($cm^2 g^{-1}$)	PY ($kg ha^{-1}$)	KY ($kg ha^{-1}$)	HSM (g)	HSMK (g)	SMK (%)	ST (%)	HI_k (%)
Test entry									
PBS 11077	29	187	1054	617	30	34	37	58	16
PBS 11084	31	167	1181	693	31*	41*	34	58	16
PBS 14060	30	165	1272	837	34*	44*	40	65	15
PBS 14064	26	193	1031	653	28	35	53*	64	19
PBS 14065	27	203	964	501	28	33	45	51	14
PBS 14066	30	188	1175	617	26	32	51	53	16
PBS 14067	28	193	1092	556	27	34	49	51	14
PBS 16026 A	33*	160*	1139	662	29	37	37	57	18
PBS 16026 B	34*	163*	661	325	22	27	33	49	9
PBS 16039	34*	155*	1320	807	34*	42*	41	61	19
PBS 19017	31	172	903	574	33*	42*	49	64	13
Check									
GG 2	28	190	654	428	21	27	39	65	15
GG 7	28	194	1139	727	29	35	46	64	20
TG 37 A	28	182	1237	756	29	36	46	60	19
CV (%)	8.9	12.8	20.8	21.0	7.8	5.9	16.8	4.7	18.4
CD (5%)	2.2	18.8	180.7	107.7	1.8	1.7	5.9	2.3	2.4

entries could out perform TG 37A which gave the highest yield. Though statistically at par with the check variety TG 37A, the test entry PBS 16039 recorded numerically higher pod and kernel yields (Table 5). This test entry also possessed low SLA and high SCMR, the traits that are understood to impart enhanced water-use efficiency. PBS 16039 has medium bold kernels as indicated by its HSM and HSMSK values.

Preliminary yield evaluation trial - Virginia group

Along with two check varieties (GG 20 and Somnath), 17 advanced breeding lines of Virginia bunch type were evaluated for yield and yield related traits, and also the surrogates

Table 6. Performance of advanced Virginia breeding lines for morpho-physiological and yield attributes in preliminary evaluation trial (*kharif* 2009)

Genotypes	SCMR	SLA ($cm^2 g^{-1}$)	PY ($kg ha^{-1}$)	KY ($kg ha^{-1}$)	HSM (g)	HSMK (g)	SMK (%)	ST (%)
Test entry								
PBS 21091	31	181	660	452	28	32	38	69
PBS 21095	34	168	1262*	682	38	43	31	54
PBS 21096	37*	150	1079	774	37	44	33	71
PBS 25015	33	170	918	597	31	33	30	65
PBS 25017	33	170	826	549	32	38	39	66
PBS 25047	33	149	1149	790	31	36	29	69
PBS 25049	34	144	1304*	855*	32	37	29	66
PBS 25051	31	160	711	461	28	33	30	64
PBS 25053	30	149	902	587	29	36	27	[illegible]
PBS 26025	31	164	482	274	28	34	25	[illegible]
PBS 14075	30	177	925	538	26	31	23	[illegible]
PBS 14077	31	166	761	519	28	34	29	[illegible]
PBS 15037	32	160	669	450	29	35	29	[illegible]
PBS 15039	39*	137*	599	415	30	37	35	[illegible]
PBS 15040	37*	144	604	407	27	35	28	[illegible]
PBS 15042	35*	150	1068	693	31	36	30	[illegible]
PBS 15043	34	149	669	451	34	40	42	[illegible]
Check								
GG 20	31	159	1027	725	39	46	43	[illegible]
Somnath	33	166	819	514	35	36	28	[illegible]
CV (%)	5.1	8.8	16.3	16.8	8.9	12.6	20.7	[illegible]
CD (5%)	2.0	16.4	165.1	111.2	3.2	5.4	7.6	[illegible]

(SLA and SCMR) of WUE in a replicated complete randomised block design with three replications. The plot size was of five rows- each of 5 m length. Seeds were sown to maintain a plant-to-plant distance of 10 cm within a row and rows were spaced at 60 cm from each other. Analysis of variance indicated highly significant differences due to genotypes for all the traits except SMK. The check variety GG 20 was adjudged the best check for all the traits studied, except SCMR, for which Somnath was found to be superior to GG 20. Compared with the best check variety, the advanced breeding line PBS 25049 gave significantly higher PY and KY. Another advanced breeding line PBS 25095, though gave significantly higher pod yield than the check variety, its kernel yield was not significantly higher than the best check as its ST was too low (54.0%). Four advanced breeding lines namely, PBS 21096, PBS 15039, PBS 15040 and PBS 15042 gave significantly superior SCMR over the best check variety and PBS 15039 also had superior SLA (Table 6). For the remaining traits HSM, HSMK, SMK and shelling turnover none of the advanced breeding lines could outperform GG 20, the best check variety which is currently popular among the farmers of Saurashtra for *kharif* season.

Advanced yield evaluation trial - Virginia bunch type

Single- year-evaluation

Twenty-two groundnut genotypes comprising twenty advanced breeding lines and two check varieties (GG 20 and Somnath) were evaluated for their performance in *kharif* 2009 under rainfed conditions. All the twenty-two genotypes were grown in a replicated complete block design with three replications. The plot size was five rows each of 5 m length. Seeds were sown to maintain a plant-to-plant distance of 10 cm within a row with a row to row spacing of 60 cm. The differences due to genotypes for all the traits studied were highly significant. The check variety GG 20 was found to be the best for the traits namely, PY and KY, harvest indices for pod and kernels, HSMK and ST. The check variety Somnath was superior to other check variety for SCMR, SLA, BY, HSM and SMK. The breeding line PBS 22042 and PBS 22053 performed significantly superior over the best check variety for SCMR and another two advanced breeding lines PBS 21085 and PBS 24091 were found significantly superior to best check variety GG 20 for both PY and KY. Also, the HI of the advanced breeding line PBS 21085 for both pod and kernel were significantly higher than the best check GG 20. The advanced breeding line PBS 24091 recorded significantly higher HSM and SMK over the best check variety. PBS 22042 was also superior for ST (Table 7). For biological yield and HSMK, however, none of the advanced breeding lines outperformed the best check varieties.

Table 7. Performance of advanced Virginia breeding lines for morpho-physiological and yield attributes in advanced trial (*kharif* 2009)

Genotypes	SCMR	SLA ($cm^2 g^{-1}$)	PY ($kg\ ha^{-1}$)	KY ($kg\ ha^{-1}$)	BY (g plant-1)	HI_p (%)	HIk (%)	HSM (g)	HSMK (g)	SMK (%)	ST (%)
Test entry											
PBS 21084	30	156	1145	765	26	27	18	33	45	27	67
PBS 21085	33	153	1875*	1219*	29	39*	25*	38	45	29	64
PBS 21086	33	148	1212	789	26	28	18	33	46	25	65
PBS 21087	32	150	1198	769	29	24	16	33	45	33	64
PBS 22042	36*	157	969	709	24	25	18	29	35	42	73*
PBS 22053	36*	149	1244	891	25	30	22	35	43	29	71
PBS 22059	29	202	1253	778	32	24	15	32	39	15	62
PBS 22062	29	183	1133	715	28	25	16	29	38	21	63
PBS 22063	32	171	1091	681	29	23	15	29	37	28	62
PBS 22064	30	184	1134	708	31	22	14	32	38	17	62
PBS 22065	27	191	1006	617	31	20	12	28	34	17	61
PBS 22066	29	190	1309	815	32	27	17	31	37	17	62
PBS 22067	29	195	1262	802	31	25	16	31	40	26	64
PBS 22074	32	163	1297	922	29	27	19	37	48	45	71
PBS 24090	33	171	1287	903	33	24	17	40	52	45	70
PBS 24091	31	168	1490*	1054*	36	26	18	44*	51	48*	71
PBS 24092	33	162	1262	891	26	29	20	37	46	41	71
PBS 24093	35	151	1350	922	28	29	20	40	51	40	68
PBS 24100	29	161	646	420	30	16	10	30	38	33	65
PBS 29100	30	182	905	587	30	18	12	32	41	39	65
Check											
GG 20	30	176	1128	792	27	25	18	39	51	31	70
Somnath	34	153	832	522	30	17	11	39	48	38	63
CV (%)	6.8	9.0	22.9	24.0	19.1	27.9	28.3	10.0	6.7	23.7	3.0
CD (5%)	2.5	17.6	315.9	219.7	6.5	8.1	5.5	4.0	3.4	8.6	2.3

Two- year evaluation

Eleven advanced breeding lines of Virginia groundnut were evaluated alonwith two check varieties GG 20 and Somnath in *kharif* 2008 and 2009. Coefficients of variation were found to be low to moderately high for different traits studied. None of the test entries surpassed the best check variety GG 20 for PY and KY; however, two test entries were found to be statistically at par with the GG 20 for these traits. SCMR of PBS 22042 was superior while the seed size was superior in PBS 24091 (Table 8).

Table 8. Performance (pooled over two years) of advanced Virginia breeding lines for morpho-physiological and yield traits (*kharif* 2008 and 2009)

Genotypes	SCMR	SLA (cm^2 g^{-1})	PY (kg ha^{-1})	KY (kg ha^{-1})	HSM (g)	HSMK (g)	SMK (%)	ST (%)	HI_k (%)
Test entry									
PBS 21084	30	176	1231	814	36	46	35	66	18
PBS 21085	31	173	1562	1014	37	46	35	64	21
PBS 21086	31	165	1108	720	34	45	33	65	18
PBS 21087	30	170	1103	703	33	44	36	64	16
PBS 22042	36*	180	1464	1078	29	36	50	74	22
PBS 22053	33	175	1145	820	36	45	43	71	20
PBS 24090	31	188	1368	958	42*	53	51	70	17
PBS 24091	28	194	1440	1009	44	53	49	70	16
PBS 24092	31	185	1366	966	40	49	49	71	19
PBS 24093	30	185	1514	1055	43	54	52	70	19
PBS 24100	27	182	904	590	31	40	41	65	3
Check									
GG 20	29	194	1479	1032	41	53	48	70	19
Somnath	33	172	1168	695	39	48	37	61	13
CV (%)	9.6	7.4	23.6	25.0	9.2	7.4	16.9	4.4	25.0
CD (5%)	2.6	11.8	272.4	197.0	3.1	3.1	6.5	2.7	3.9

Evaluation of early-maturing advanced breeding cultures of Spanish type for their suitability for summer cultivation

Sixteen advanced breeding lines were evaluated in a complete randomized block design in summer 2009 along with four checks (GG 2, TAG 24, TG 26 and Dh 86). The advanced breeding lines comprised 12 selections derived from a single cross 'Chico x R 33-1', while the remaining four were from other different cross combinations. Seeds of each genotype were sown in five rows each of five-meter length and replicated thrice. The observations were recorded on different biometrical parameters (Table 9). As Chico and R 33-1, the early maturing Spanish and Virginia cultivars, respectively, were the parents of most of the test entries, the objective of the experiment was also to find out early maturing line(s) for summer situations thus reduce the total requirement of water of summer groundnut crop besides facilitating harvest before onset of early monsoon. Analysis of variance revealed highly significant differences due to genotypes for all the traits studied.

When genotypic means were compared for the traits studied. The variety Dh 86 was found to be the best check for days to 50% flowering, and pod and kernel yields, whereas for the remaining traits, TAG 24 was the best check variety. An advanced breeding line PBS 11056 recorded significantly higher and the SE 09 significantly lower values for SCMR and days to maturity, respectively, over the best check variety TAG 24. The highest pod (3119 kg ha^{-1}) and kernel (2033 kg ha^{-1}) yields were recorded in the advanced breeding line SE 25, though these values were at par with the best check Dh 86. For rest of the traits, none of the test entries performed better than the respective best check variety (Table 9). An advanced breeding line SE 22 was found to bear exceptionally high number of pods (up to 185 pods $plant^{-1}$; Fig. 5) but size of the pod and filling was poor.

Figure 5. 'SE 22' an advanced breeding line with a large number of pods (up to 185 pods $plant^{-1}$)

Table 9. Statistical attributes of the promising genotypes identified in summer 2009

Trait	Mean	Range	CV (%)	CD (5%)	Best check		Promising breeding lines	
					Identity	Value	Identity	Value
Days to flower	28	25-30	5.8	2	TAG 24	26	-	-
Days to 50% of plants to flower	44	37-48	4.6	3	Dh 86	37	-	-
SCMR	36	34-44	4.0	2	TAG 24	40	PBS 11056	44*
SLA (cm2g^{-1})	164	140-181	6.1	15	TAG 24	140	-	
Days to maturity	104	96-110	1.0	3	TAG 24	100	SE 09	96*
PY (kgha^{-1})	2542	2026-3119	15.3	593	Dh 86	2919	SE 25	3119
KY (kgha^{-1})	1716	1342-2033	16.5	433	Dh 86	1915	SE 25	2033
HIp (%)	36	22-47	16.4	9	TAG 24	47	-	-
HIk (%)	24	14-34	19.1	7	TAG 24	34	-	-
HSM (g)	32	20-40	14.7	7	TAG 24	40	-	-
HSMK (g)	42	28-54	12.4	8	TAG 24	50	-	-
ST (%)	68	61-73	5.2	5	TAG 24	72	-	-

*significant at $p = 0.05$

Advanced breeding lines in AICRP-G Trials

JUN 27: A water-use efficient line was tested in IVT I and IVT II in special feature trials of AICRP-G formulated to evaluate groundnut material for drought situations. This genotype was found promising at locations characterized for occurrence of early- and end-of -the-season droughts. It was further tested in *kharif* 2008 and 2009 seasons under ADVRT trials for these situations.

PBS 30051: A mutant of 'Girnar 3' was evaluated under IVT I and IVT II of Spanish groundnut in *kharif* seasons of 2008 and 2009 but this mutant could not qualify for the next stage of testing *i.e.* advanced varietal trials.

PBS 30086: A mutant of 'Girnar 3' was evaluated under IVT I of Spanish groundnut in the *kharif* 2009 season.

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

A mapping population comprising 188 RILs derived from a cross TAG 24 x TMV2 NLM and developed for surrogates (SLA and SCMR) of water-use efficiency, was sown in a non-replicated single row for want of sufficient seed in summer 2009. Observations were recorded on the second full-opened leaf from the top of five randomly selected plants on SCMR and SLA at 55th day after sowing. Besides, SLA was also recorded on three randomly selected plants on whole plant basis at 55th day after sowing. Plot yield was recorded and expressed as g plant^{-1}. Harvest index was calculated for pod yield (HIp). The values of descriptive statistical parameters were calculated (Table 10).

The data on SCMR, SLA and PY was subjected to simple linear regressions analysis. The negative relationship, observed between SLA and SCMR, when recorded on 2nd fully

Table 10. Descriptive statistics for non-replicated data on various traits in a mapping population (188 RILs) for surrogates of WUE

Trait	Mean	Std. Dev.	Min.	Max.	Percentiles 25th	50th (Median)	75th
SCMR1	37	3	31	44	36	37	39
SCMR2	38	3	30	49	6	38	40
SLA1 ($cm^2 g^{-1}$)	154	25	123	408	142	152	164
SLA2 ($cm^2 g^{-1}$)	138	14	98	200	129	138	147
SLA3 ($cm^2 g^{-1}$)	143	16	104	196	134	143	152
PY (g plant^{-1})	9	3	3	19	7	9	11
HIp (%)	28	9	7	47	21	28	34

opened leaf from the apex at 55th DAS (Fig. 6a to 6b) was much stronger compared to other stages/conditions. The analysis indicated that the association between PY and SLA was negative while it was positive between PY and SCMR. The association between PY and SCMR was, however, stronger than that between PY and SLA.

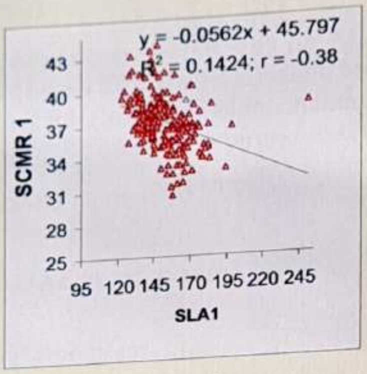

Figure 6a

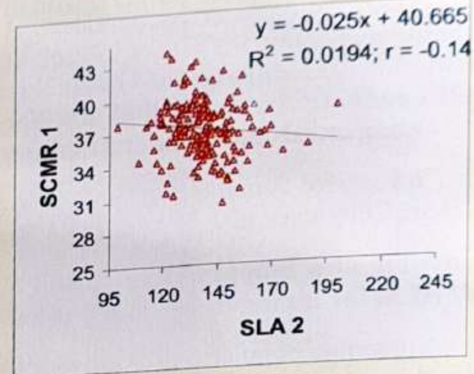

Figure 6b

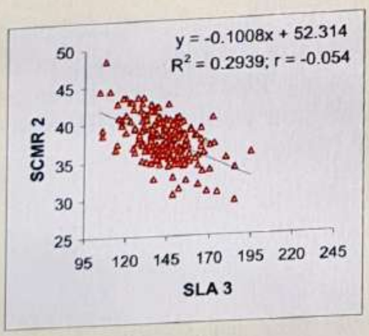

Figure 6c

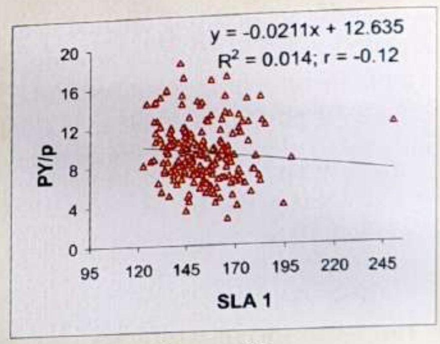

Figure 6d

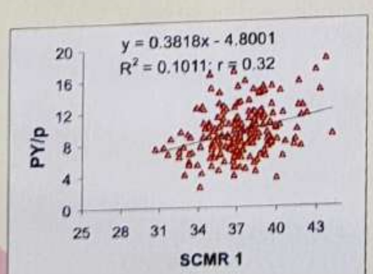

Figure 6e

Fig. 6a to Fig. 6c: Relationships of SLA and SCMR

Fig. 6d to Fig.6e: Relationships of SLA and SCMR with pod yield (g $plant^{-1}$)

SLA 1 and SCMR 1: Observations on SLA and SCMR recorded on 55th day on 2nd fully opened leaf from the apex.

SLA 2: Observations on SLA recorded on 55th day on all leaves of a plant.

SCMR 2 and SLA 3: Observations on SLA and SCMR on 2nd fully opened leaf from the apex recorded at harvest

Sharing of Segregating/Advanced Breeding Materials with AICRP-G centres

Produce of segregating material of 23 crosses in different generations (F_3 to F_5) harvested at DGR in *kharif* 2008 were supplied to the AICRP-G centres for evaluation in kharif 2009 at respective locations and a total of 219 location-specific selections were made (Table 11).

Table11. Particulars of crosses developed at DGR and evaluated at AICRP-G centres

Objective	Number	Centre of evaluation
Tolerance of drought stress	14	Jalgaon
Tolerance of stem rot	5	Jalgaon, Dharwad, Junagadh
Tolerance of foliar diseases	1	Aliyarnagar, Dharwad, Junagadh
Others	3	Junagadh, Anand

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

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

Integrated Pest Management (IPM) in groundnut based inter cropping system

An experiment on integrated pest management (IPM) in groundnut based intercropping system was conducted during *kharif* 2009. In a replicated trial (plot size 6 x 5 m and row to row spacing 45 cm), nine intercrops *viz.*, sunflower (local), castor (GAUCH 4), pigeon pea (BDN 2), soybean (local), green gram (K 851), cluster bean (local), Bt cotton (MRC 6301), desi cotton (Deviraj) and hybrid cotton (G Cot 10) were evaluated in a row-to-row ratio of 3:1. For groundnut, clusterbean, green gram and soybean the plant to plant spacing within a row was 10 cm, for pigeon pea and sunflower 30 cm and for castor and cotton 60 cm. For groundnut, cultivar GG 20 was used. The results indicated that up to 60 DAS, compared to other intercrops and sole groundnut crop, cluster bean harboured significantly small population of jassids. In case of thrips, compared to sole groundnut crop, upto 30 DAS, 'groundnut + red-gram' harboured a largest population while soybean harboured the smallest population. Even at 45 and 60 DAS, the population of thrips remained low in 'groundnut + soybean'. The pod yield of groundnut was significantly influenced by intercropping. The maximum pod yield was obtained in sole groundnut crop. Among the intercrops, the highest grain yield was recorded in 'groundnut + sunflower' (1080 kg ha^{-1}), followed by 'groundnut + cluster bean' (1048 kg ha^{-1}). Intercropping of groundnut with hybrid cotton gave the highest CBR of 5.51 (ICBR 1:2.14) while the CBR with red gram was 5.27 (ICBR 1: 2.04) compared to 2.58 CBR with sole groundnut crop (ICBR 1:1).

Evaluation of efficacy of bio-pesticides for controlling sucking insect pests

The efficacy of various biopesticides against sucking pests of groundnut was compared with the chemical insecticide monocrotophos (0.04%), which supported the lowest population of jassids and thrips (3.10 and 6.83 per 5 sweeps, respectively). None of the biopesticides was found superior to chemical control using monocrotophos. Among the biopesticides, the fungus *Metarhizium anisopliae* (2 g L^{-1}) was found to be the best treatment with a population of jassids and thrips (4.77 and 9.50 per 5 sweeps, respectively). Spray application of fungus *Verticillium lecanii*, however, recorded the highest pod yield (1713 kg ha^{-1}) as compared to control (1205 kg ha^{-1}), which was not sprayed with any pesticide.

Evaluation of new insecticides against sucking pests

Five new insecticides *viz,* Imidacloprid, Carbosulfan, Acetamiprid, Profenophos and Thiomethoxam were tested for their efficacy against sucking pests of groundnut. The results indicated that seed treatment with Imidacloprid (0.0035%) followed by two sprays of

0.008% Imidacloprid (30 and 45 DAS) was very effective in controlling the population of jassids compared to control and other treatments. The treatment also gave the highest pod yield (3604 kg ha^{-1}).

Screening of groundnut varieties and genotypes for their relative resistance to damage by *Caryedon serratus*

Spanish bunch: In a lab experiment, 21 groundnut varieties were screened for damage by *C. serratus*. Eggs laid on pods were counted and loss of pod weight was also worked out. The oviposition (mean number of eggs) was in the range of < 40 in Dh 8 to 91 in ICGS 1. The minimum weight loss was (< 30%) observed in DRG 12 while the maximum (> 75%) in SB 11.

Virginia bunch and Virginia runner: Out of twenty varieties screened, the minimum (< 40) oviposition (mean number of eggs) was recorded in Chandra, RS 1 and ICGS 5, while the maximum (133) was in ICGS 76. The loss in pod-weight was in the range of 46.1% in ICGS 5 to (93.5%) in ICGS 76.

Twenty-one inter-specific breeding lines developed at DGR along with cultivar GG 2 were screened for extent of damage by *C. serratus* under laboratory conditions. Minimum oviposition was recorded in the breeding line CS 298 (> 40 mean number of eggs) as compared to CS 289 and CS 301 (112 mean no. of eggs). However, the minimum per cent pod weight loss was in CS 108 as compared to CS 102, 243, 253, 254, 273, 287, 290, 296 and CS 301.

Efficacy of seed-treatment with insecticide (Imidacloprid) in controlling sucking pests

Among the six levels of Imidacloprid (70 % WS), the treatment @ 5 g kg^{-1} seed proved to be the best in controlling the populations of both jassids and thrips (2.02 and 3.19 per 5 sweeps, respectively) as compared to untreated control (6.9 and 10.1, per 5 sweeps, respectively).

Evaluation of new insecticides on sucking pests through seed-treatment

The results indicated that all the new molecules were effective in controlling the populations of jassids and thrips. Among these new molecules, treatment with Fipronil @ 1 mL kg^{-1} seed was found to be the best in controlling jassids (1.46 per 5 sweeps) and treatment with Thiomethoxam @ 1g kg^{-1} seed proved to be the best in controlling the population of thrips (3.93 per 5 sweeps) compared to control (6.2 and 10.9 per 5 sweeps, respectively). However, compared to control (1241 kg ha^{-1}), the highest pod yield (1655 kg ha^{-1}) was recorded in treatment with Imidacloprid (@ 2g kg^{-1} seed).

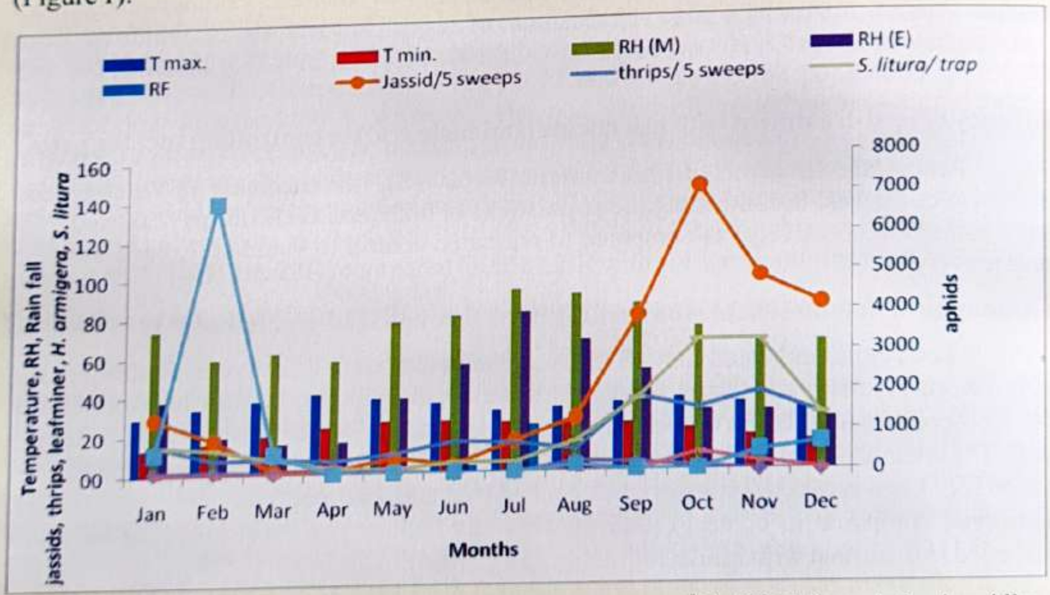
Evaluation of new insecticides against sucking pests of groundnut

Six new insecticides *viz,* Imidacloprid, Carbosulfan, Acetamiprid, Profenophos, Thiomethoxam and Monocrotophos were tested for their efficacy of controlling the sucking pests of groundnut. The population of jassids and thrips were monitored before and after spray of insecticides. Two modes of spray were used for each insecticide: single spray at 30

DAG and two sprays, first at 30 DAG and another at 45 DAG. Unsprayed plots were treated as control plot. Thus there were thirteen treatments. Among the treatments evaluated, two sprays of 0.08% Imidacloprid (at 30 and 45 DAG) harboured the lowest populations of jassids (0.62 per five sweeps) and thrips (4.46 per five sweeps) while the populations of these insects in control were 8.02 and 18.65 per 5 sweeps, respectively. The highest pod yield of 3604 kg ha^{-1} was also recorded in this treatment. The yield of the control plot was 2397 kg ha^{-1}.

Monitoring of insect pests

Monitoring was done in the groundnut crops sown at monthly intervals. For monitoring *Helicoverpa armigera*, *Spodoptera litura* and *Aproaerema modicella* pheromone traps were used; for aphids (*Aphis craccivora* and *Hysteroneura setariae*) cylindrical sticky trap was used; and for jassids and thrips sweep-net was used. Among the sucking pests, the populations of jassids and leaf miner were the largest during October (143 5 sweeps^{-1}, 456 trap^{-1}, respectively) and of thrips during November (39 5 sweeps^{-1}). Maximum population (65 trap^{-1}) of *Spodoptera* was recorded during October and November. The population of *Helicoverpa* remained small (below 4 trap^{-1}) throughout the year (Figure 1).



(T_{max} = maximum temperature (°C); T_{min} = minimum temperature (°C); RH (M) = relative humidity in morning (%); RH (E) = relative humidity in evening (%); RF = rainfall (mm)

Figure 1. Parameters of weather *vis-a-vis* population of insect pests during 2009

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

Screening of genotypes for resistance of stem rot under field conditions during summer

A total of 31 genotypes were evaluated for incidence of stem rot (*Sclerotium rolfsii*) *vis-a-vis* pod yield. The incidence of stem rot was recorded before and after harvest. Observation on pod yield (g $3m^{-1}$ row) was also recorded. The results indicated that the incidence of stem rot varied from 0.0 to 66.7%. The highest incidence of stem rot was in CS 301 whereas genotypes CS 296, CS 266, CS 263, CS 292, CS 109, OG 52-1, CS 280, CS 287, ALR 2 and CS 273 were free from stem rot. The highest pod yield (327 g $3m^{-1}$ row) was recorded in GG 2 followed by CS 266 (247 g $3m^{-1}$ row) and CS 253 (199 g $3m^{-1}$ row) with stem rot incidence of 15, zero and 39.6%, respectively.

Screening of genotypes for resistance to soil borne fungal diseases under artificially inoculated conditions during summer

For tolerance of stem rot (*Sclerotium rolfsii*), 17 genotypes were evaluated under artificially inoculated conditions in concrete blocks. Out of these, four genotypes, *viz.* ICGV 86590, CS 19, CS 160 and CS 168 showed less than 20% stem rot incidence compared to 43.4% in GG 2 and 50.0% in CS 168. The pod yield was highest in CS 168 (50 g $2m^{-1}$ row) followed by GG 2 (43 g $2m^{-1}$ row).

Also, 20 genotypes were evaluated for resistance to collar rot pathogen (*Aspergillus niger*). The genotype CS 164, CS 331, CS 334, CS 81, CS 104, CS 110, CS 272 and CS 316 showed no visible symptoms of collar rot. Eight genotypes *viz.* CS 132, CS 68, CS 160, CS 245, CS 352, CS 78, CS 58 and GG 2 showed less than 20% incidence. The highest incidence was recorded in CS 113 (39.6%) followed by CS 76 (31.0%) and CS 85 (30.0%).

Biological control of soil borne and foliar fungal diseases during *kharif*

A field experiment was conducted during *kharif* 2009 to study the effect of application of *Trichoderma* isolate T-170 enriched in castor cake and *Verticillium lecanii* in various combination to soil or as foliar spary on soil borne and foliar fungal diseases of groundnut. The cultivar GG 20 was used in the experiment and observations on foliar fungal diseases *viz*. ELS, LLS, rust and soil borne diseases *viz*. collar rot, stem rot and pod rot were recorded. The various treatments were as under:

- T_1 : Soil application of *Trichoderma* isolate T-170 enriched in castor cake (@ 5 kg ha^{-1}(*Trichoderma* multiplied in sorghum grain medium was mixed with 100 kg castor cake ha^{-1} and then incubated for 10 days before application)
- T_2 : Soil application of castor cake @ 500 kg ha^{-1} (1.125 kg $plot^{-1}$)
- T_3 : Foliar spray of *V. lecanii* culture filtrate at 50% dilution- two sprays at 15-day interval (1st spray at appearance of disease; 2nd spray 15 days after the 1st spray)

T_4 : Foliar application of *Trichoderma* isolate T-170 culture filtrate (50% dilution)
T_5 : Foliar spray of *Trichoderma* isolate T-170 spore suspension @ 1.5 x 10^6 CFU ml^{-1}; 3 sprays starting at 1st appearance of disease at 15-day intervals
T_6 : T_1 + T_3
T_7 : T_2 + T_3
T_8 : T_1 + T_4
T_9 : T_2 + T_4
T_{10} : T_1 + T_5
T_{11} : Control

Observations on foliar fungal diseases were recorded by adopting a 1-9 modified scale, while in case of soil borne diseases incidence was expressed as per cent. Foliar application of culture filtrate of *Trichoderma* isolate T-170 was effective in controlling aflaroot and collar rot diseases. The disease incidences of aflaroot and collar rot reduced to 0.7 and 2.6%, respectively from 2.4% and 5.0% respectively as observed in the control. The stem rot incidence was low (1.8%) in treatment receiving foliar spray of *Trichoderma* isolate T-170 spore suspension @ 1.5 x 10^6 CFU ml^{-1} (3 sprays at 15-day intervals starting at the 1st appearance of disease) compared to high (5.1%) incidence in control. There was a significant reduction in the severity of late leaf spot (LLS) due to foliar spray of culture filtrate of *Verticillium lecanii* at 50% dilution at the first appearance of the leaf spots followed by two sprays at 15-day intervals. Soil application of castor cake @ 500 kg ha^{-1} plus two foliar sprays of culture filtrate of *V. lecanii* at 50% dilution at 15-day intervals reduced the incidence of rust disease to 3.2% from 5.3% observed in the control.

Integrated disease management during *kharif*

A field trial in RBD with four replications and six treatments was conducted during *kharif* 2009. Observations on major foliar fungal diseases *viz*. ELS, LLS, rust and soil borne diseases *viz*. collar rot, stem rot and pod rot were recorded. The cultivar GG 20 was used in the experiment. The various components of IDM were as under:

T_1: Seed treatment with *Trichoderma* (10 g kg^{-1}) + two foliar sprays of Hexaconazole (1ml L^{-1})
T_2: Seed treatment with Mancozeb (3 g kg^{-1}) + two foliar sprays of Hexaconazole (1ml L^{-1})
T_3: Seed treatment with Tebuconazole (1.5 g kg^{-1}) + two foliar sprays of Tebuconazole (1ml L^{-1})
T_4: Soil application of *Trichoderma* (4.0 kg ha^{-1}) + castor cake (250 kg ha^{-1}) + two foliar sprays of Hexaconazole (1ml L^{-1})
T_5: Seed treatment with *Trichoderma* (10 g kg^{-1}) + T4
T_6: Control

In case of two foliar sprays, the first was done at the appearance of foliar disease and the second fifteen days after the first.

Seed treatment with Tebuconazole (1.5 g kg^{-1}) + two foliar sprays of Tebuconazole (1ml L^{-1}) brought about significant reduction in the incidences of collar rot and stem rot. The incidences of foliar diseases namely ELS, LLS and rust diseases was low in the treatment receiving soil application of *Trichoderma* (4.0 kg ha^{-1}) + castor cake (250 kg ha^{-1}) + two sprays of Hexaconazole (1ml L^{-1}) as compared to control.

Evaluation of new fungicides against soil borne diseases

A field experiment was conducted during *kharif* 2009 in RBD to see the effect of systemic fungicides as seed treatment. The fungicide treatments with Hexaconazole (2ml kg^{-1}), Hexaconazole (1ml kg^{-1}) + Captan (3g kg^{-1}), Carbendazim + Mancozeb (SAF) (3g kg^{-1}), Tebuconazole (1.5g kg^{-1}), Propiconazole (2ml kg^{-1}), Difenconazole (2ml kg^{-1}), Vitavax (2g kg^{-1}), Carbendazim (2g kg^{-1}), Mancozeb (3g kg^{-1}) and Captan (3g kg^{-1}) were compared with untreated control.

Out of various types of treatments, the plants from the seeds treated with Tebuconazole (1.5g kg^{-1}) suffered the lowest (2.94%) of stem rot (cf 6.1% in control) whereas the plants from the seeds treated with Carbendazim + Mancozeb (SAF) (3g kg^{-1}) showed the lowest (0.9%) incidence of aflaroot (cf 3.1% in control).

Screening of genotypes for resistance to stem rot under concrete block sick soil condition

Out of 16 genotypes screened for resistance to stem rot disease, the incidence of disease was below 20% in three genotypes *viz.* CS 315, CS 256 and CS 25 whereas the highest incidence of 75% was observed in CS 158.

Screening of genotypes under artificially inoculated conditions for resistance to collar rot

Out of 20 genotypes/cultivars screened for resistance to collar rot in sick soil (in concrete blocks), 16 genotypes were identified as resistant as they showed below 20% disease incidence. The prominent genotypes among these were CS 334, CS 164 and CS 245 which showed disease incidences of 3.3, 7.1 and 9.8%, respectively.

Promising genotypes for resistance to stem rot under field condition (4^{th} year screening)

Seventeen genotypes were screened for resistance to stem rot disease under field conditions. The disease incidence was in the range of 16.3 to 50.0%. The genotype CS 303 showed the least incidence of disease (16.3%), followed by CS 285 (22.2%), Code 1-1 (22.9%) and CS 294 (23.6%).

PROJECT 03: PHYSIOLOGICAL STUDIES ON ENVIRONMENTAL STRESSES IN GROUNDNUT

(P.C. NAUTIYAL, RADHAKRISHNAN T. AND S.K. BISHI)

Evaluation of groundnut cultivars for photosynthetic efficiency

Trials were conducted during three contrasting cropping seasons (*kharif*, summer and *rabi*) with 30 Spanish groundnut cultivars. It was observed that there exists a wide genetic variability in single-leaf carbon exchange rate (CER) and its association with various morphological and physiological parameters including pod yield and yield components. The CER was found to be inversely associated with specific leaf area (SLA). Direct association between CER and the number and size of reproductive sink and the inverse association between CER and the difference between the temperatures of leaf and air, especially during pegging stage, indicated that in groundnut, the source was not limiting the productivity. Hence, it was inferred that in groundnut as the sink-size increases the CER also increases. Out of 30 cultivars, one cultivar showed stability for pod yield while another one showed for total biomass. Cultivars with desirable agronomical traits were identified for their use as donor parent in crop improvement programme. High broad-sense heritability (h^2 >0.75) was observed in certain traits *viz*., CER, g_s, plant height, specific leaf area, pod yield, total biomass, HI and 100-kernel mass. The positive associations between number of pods and pod yield ($r = 0.76^{**}$), harvest index (HI) and pod yield ($r = 0.79^{**}$), and pod yield and shelling turnover ($r = 0.51^{**}$), indicated that these traits were the potential determinants of productivity. Thus, for enhancing groundnut productivity in semi-arid tropics, traits like early leaf area cover, high CER, large sink-size, high HI, high shelling turnover and increased stability of total biomass and pod yield need to be incorporated in cultivars.

In addition, chlorophyll fluorescence was recorded in 28 Spanish and 20 Virginia cultivars under normal irrigation (100% cpe) and water-deficit stress (withholding irrigation between 60 and 80 DAS) conditions. The observations were recorded between 75 and 77 DAS. On the day of observation, the soil-moisture content was 19% under normal irrigation and 10% under water-deficit stress. Leaf RWC was recorded immediately after fluorescence measurements. Wide genetic variation was observed in the parameters of chlorophyll fluorescence, both under normal and water deficit stress. Cultivars showing highest reduction or increase were identified (Table 1). In general, leaf temperature increased significantly under water-deficit stress and the highest increase (difference between leaf and air temperature, T) by 3.5°C was observed in cvs. GG 5, ICGV 86590, JAL 42, Chico, TMV 2, DRG 12 and TPG 41 while the least increase was observed in the cvs. Girnar 1, VG 9521, TAG 24, and ICGS 37. This indicated that the cultivars showing the least increase are better equipped with the leaf cooling mechanism (perhaps by maintaining higher rates of transpiration).

Under the water-deficit conditions; the decrease in maximum quantum yield of PS II (Fv/Fm) was less in Chico, JL 286, and GG 6, while it was more in DRG 12, ICGS 37 and TG 26. The stability of the thylakoid membrane (F_0/F_m) was high in DRG 1, ICGS

44, AK 159, and Girnar 1 and low in GG 6, JAL 42, TAG 24, and TG 37A. The reduction in quantum yield of PS II (PS II) was less in ICGS 44, VG 9521, DRG 1, and ICGS 11, while it was more in SG 99, JL 24, and GG 2. The reduction in total biomass was more in GG 4, Girnar 1, SG 99 and JL 42 and less in ICGS 11, ICGV 86031, SB XI and TMV 2. On the other hand, reduction in pod yield was less in SG 99, TG 37A, ICGS 11 and VG 9521 and more in

Table 1. Cultivars with high or low reduction/increase in the parameters of chlorophyll fluorescence, T, RWC and biomass under water-deficit stress

Parameter	Least change (reduction/increase)	Maximum change (reduction/increase)
Thylakoid membrane stability	DRG 1, ICGS 44, AK 159, Girnar 1	GG 6, JAL 42, TAG 24, TG 37 A
Quantum yield of PS II	ICGS 44, VG 9521, DRG 1, ICGS 11	SG 99, JL 24, Chico, GG 2,
Electron transport rate	VG 9521, ICGS 44, TG 26, DRG 1	JAL 42, SG 99, JL 24, SG 99, JL 24
Photoche mical quenching	VG 9521, ICGS 86031, ICGS 44, DRG 1	GG 2, Chico, JL 24, GG 5, TAG 24
Non-photochemical quenching	Chico, TPG 41, JL 286, AK 159	ICGS 11, ICGS 44, DRG 12, TG 26
Transpiration	SB XI, VG 9521, TPG 41, SG 99, TG 26	ICGS 11, GG 3, JL 24, GG 4, ICGS 37
T	Girnar 1, TAG 24, ICGS 37, VG 9521	GG 5, JL 24, DRG 12, TMV 2,
RWC (%)	GG 2, JAL 42, JL 24, ICGV 86590	TG 37A, TMV 2,
		DRG 1, JL 286, TAG 24, Chico
SLA	GG 5, ICGS 11, TAG 24, ICGS 44	ICGV 86590, TG 26, Chico,JL 286
Biomass	ICGS 11, ICGV 86031, SB XI, DRG 12, TMV 2	GG 4, ICGV 86590, SG 99, Girnar 1, JL 24, JAL 42
Pod yield	SG 99, TG 37A, ICGS 11, VG 9521	Chico, GG 4, ICGV 86031, GG 5, JL 286

Chico, GG 4, ICGV 86031, GG 5 and JL 286.

The association observed between CER and antenna efficiency of PS II ($r = 0.65^{**}$) could be utilized as a tool to measure photosynthetic efficiency in large number of segregating population/germplasm accessions under field conditions rapidly.

Physio-chemical characterization of Spanish and Virginia type groundnut cultivars for drought tolerance

In *kharif* season, 20 Virginia and 28 Spanish type groundnut cultivars were analyzed during the stage of pod development for drought tolerance under water-deficit (natural drought) and irrigated (100% cpe) conditions. Different plant parts i.e. leaf, stem, and root were sampled and analysed for free amino acids, proline, total phenols, reducing sugars and methanol soluble and insoluble proteins. Observations on physiological parameters such as specific leaf area (a surrogate trait for water-use efficiency), relative water content, harvest index and total biomass were recorded. Biochemical parameters were analyzed to study the effect of drought like conditions (during pod development) on the quality of seed or kernel. Observations on crop yield and yield related attributes were recorded at the final harvest. Results showed wide genetic variability among both Virginia and Spanish types in all the physiological and chemical parameters studied. For example, cultivars varied in their water-use efficiency and retention of leaf relative water content under both normal irrigation and water-deficit conditions. Under water-deficit conditions, concentration of L-proline, free amino acids and phenols increased in all the parts of plant in all the cultivars. Reducing sugars, however, increased only in leaf and decreased in stem and root. The methanol soluble proteins also increased in different parts of plants except in seeds where it decreased. Various correlations between physiological and chemical parameters and also between different chemical and yield attributes were established. It was felt that proline in stem plays some role in imparting drought tolerance in groundnut. Hence, along with the changes in reducing sugars and phenols in leaf, the changes in stem proline content may be studied further. Thus in Spanish type, on the basis of changes in proline in stem and reducing sugars and phenols in leaf, cultivars TG 37A, JL 286 and ICGS 37 could be termed drought tolerant while, JL 24, TAG 24 and SG 99 drought susceptible. Likewise, in Virginia type, GG 16 and Somnath were identified as drought tolerant and ICGV 86325 and GG 20, as drought susceptible.

Root architecture under normal and water-deficit stress

Root architecture has been shown to play an important role in crop performance, particularly under water scarcity environments. Groundnut crop is mostly grown under rain-dependent conditions (about 80% area) and so far little is known on the genetic control of root traits. This study summarizes the results of the experiment on selected Spanish and Virginia cultivars varying in specific leaf area (SLA) *vis-à-vis* WUE. The experiment was conducted in both summer and rainy-seasons, under normal and water-deficit stress conditions. Significant genetic variations were observed in all the root traits, i.e. primary root length (cm), secondary root length (cm), root dry weight (expressed as g plant^{-1} and also as g m^{-2}soil), root volume (ml plant^{-1}), root weight density (g m^{-3}soil), primary and secondary root length density (cm m^{-3}soil), root weight density (g m^{-3}soil), specific root length (cm g^{-1} m^{-2} soil), and root shoot ratio. Under water-deficit stress, the cultivar Girnar 1 showed the least reduction in root length, root length density, total root dry weight during different stages of root growth while the cultivars JL 24 and ICGV 86031 showed the least reduction in root weight (g plant^{-1}) at 80 DAS. Under water- deficit stress conditions, the root growth was hampered, in terms of both root: shoot ratio, and number of roots in different soil layers. Root volume also changed significantly. In rainy season, the root traits showed genetic diversity. Thus the cultivars may be selected either for rain-dependent or irrigated conditions on the basis of relative advantages of the root profiles (Fig. 1). Thus, the genetic variability in root traits could be utilized in selecting and improving drought tolerance for different agro-climatic conditions.

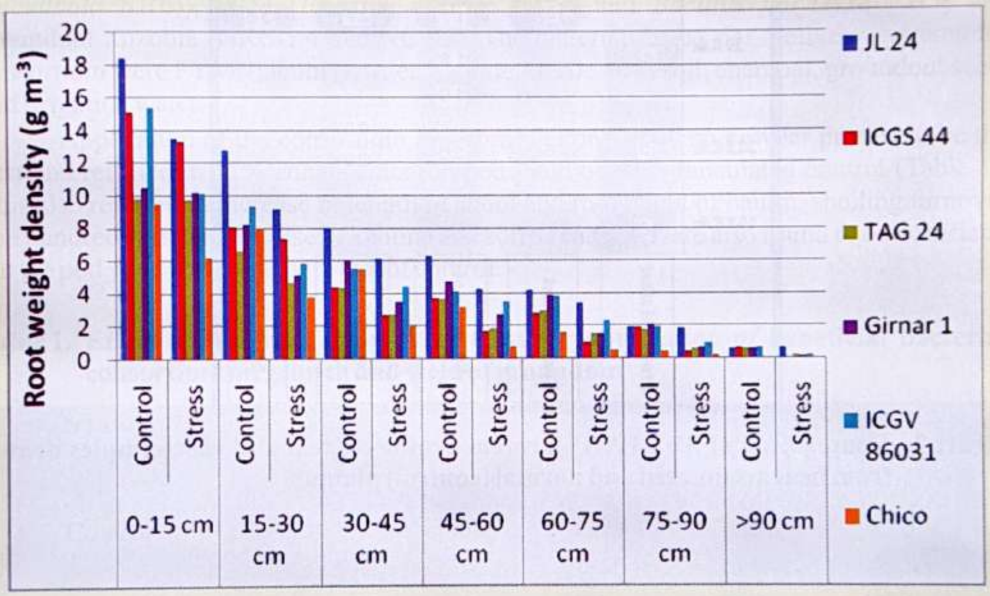


Figure 1. Root weight density in six groundnut cultivars in different soil depths under control (100% cpe) and water-deficit stress (50% cpe)

Cross tolerance

The SDS-PAGE was performed to isolate heat shock proteins in groundnut leaf and root parts. Heat shock treatments were given to 30 day old plants by the following two different methods:

i) The plants were exposed to 40°C for one hour,
ii) The plants were sequentially exposed for one hour each at the temperatures of 35°C, 37°C, and 40°C and finally to 45°C.

After giving the heat shock treatment, differences in the band patterns of stressed and control plants for both low (14 to 40 KDa and high (>40 to 98 KDa) molecular weight proteins in SDS-PAGE were discernible (Fig. 2).

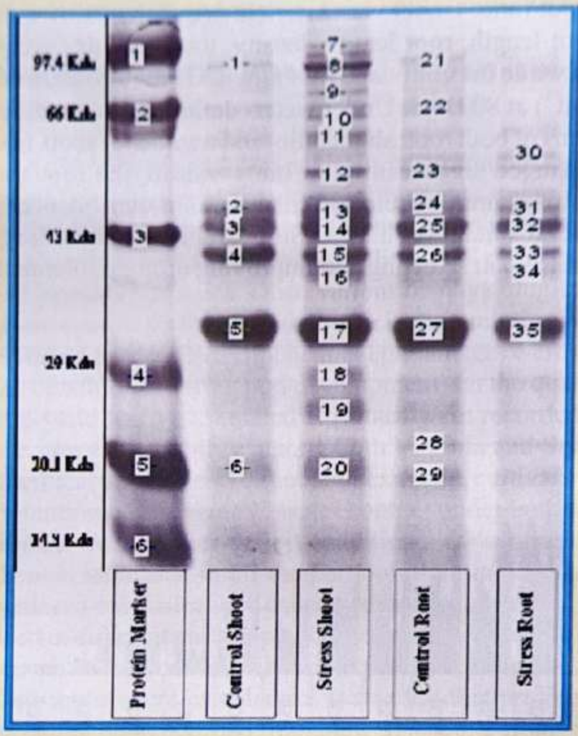


Figure 2. Comparison of SDS-PAGE protein profiles of leaf and root samples drawn from heat acclimated and normal (control) plants

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

(K.K. PAL AND R. DEY)

Consortium of beneficial microorganisms

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

Different delivery systems of a consortium of beneficial bacteria were evaluated in a field trial with groundnut cultivar GG 2 during summer season. The beneficial bacterial consortium consisted of PGPR (*Pseudomonas fluorescens* BHU1 and *Pseudomonas maculicola* S1(6)), PSM (*Pseudomonas* sp. BM8 and *Bacillus polymyxa* H5) and groundnut rhizobia (NRCG 4 and NC 92). The material for carrier /delivery systems for consortium were FYM, talcum powder, kaoline, sterile farm soil, charcoal, groundnut seed, and irrigation water.

Application of the consortium as a formulation in talcum powder proved to be the best and resulted in 21% enhancement in pod yield over un-inoculated control (Table 1). This also resulted in increase in length of shoot and root, yield of haulm, shelling turnover and hundred kernel mass. Use of kaoline and soil as carriers were also found to be beneficial but the pod yield was at par with that of control.

Table 1. Effect of different delivery systems for application of beneficial bacterial consortium on growth and yield of groundnut

Treatment	SL (cm p^{-1})	HY (kg ha^{-1})	PY (kg ha^{-1})	Shelling turnover (%)	HSM (g)
Control	30.8	3007	1990	70.3	43.6
Seed	32.0	3310	1955	73.0	45.8
FYM	31.2	3233	2070	70.5	43.1
Talcum	35.7	3360	2425	73.8	47.4
Irrigation	30.0	3233	2086	73.0	45.2
Kaoline	30.4	3017	2143	71.7	43.8
Soil	31.1	2920	2142	71.5	42.8
Charcoal	33.5	3073	2080	72.8	46.1
CD (5%)	1.66	311	262	1.26	2.21

In the trial conducted in *kharif* 2009 with cultivar Girnar 2, FYM was adjudged to be the best carrier and resulted in enhancement in pod yield by 18% over the uninoculated control. Use of farm soil as carrier resulted in 15% enhancement of pod yield while enhancement of pod yield by application of consortium through seed coating was 12%.

AM fungi

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

A trial was conducted in pots with groundnut cultivar GG 2 during the summer and *kharif* seasons of 2009 to study the effects of inoculation of AM fungi on the growth and yield. Four AM fungal cultures *viz*., *Glomus etunicatum*, *Glomus fasciculatum*, *Glomus mosseae*, and *Gigaspora scutellospora* were used. Inoculation with different AM fungi (1500-2000 chlamydospores 100^{-1} g soil) significantly improved the growth of groundnut cultivar GG 2 in terms of biomass of shoot and root, number and mass of nodules, and pod-yield. An increase in root volume was also observed which was in the range of 13.5% with *G. mosseae* to 47% with *G. etunicatum*. Inoculation with AM fungi enhanced the pod yield from 11% with *G. scutellospora* to 21% with *G. etunicatum* (Table 2).

During *kharif* 2009, inoculation with *Glomus etunicatum*, *Glomus mosseae* and *Gigaspora scutellospora* significantly improved root volume, pod yield and VAM root colonization.

Table 2. Effect of inoculation of AM fungi on the growth and yield of groundnut, cultivar GG 2 in pots (summer 2009)

Treatment	PY ($g\ p^{-1}$)	SL (cm)	RL (cm)	RV ($cc\ p^{-1}$)	NN ($n\ p^{-1}$)	NDW ($mg\ p^{-1}$)
Control	3.14	25.9	51.2	17.33	57.9	31.0
G. etunicatum	3.81	27.9	54.6	25.00	77.5	46.2
G. fasciculatum	3.50	26.9	51.7	23.00	70.0	51.2
G. mosseae	3.57	26.7	55.9	19.67	79.1	44.6
G. scutellospora	3.47	28.4	54.1	21.33	74.9	48.6
CD (5%)	0.22	1.3	NS	2.05	9.6	5.2

Role of rhizodeposition

Influence of groundnut genotypes on soil microbial population

The effect of groundnut genotypes on microbial population in rhizosphere of groundnut was studied by using two parental lines *viz*. GG 2 and ICGV 86031 and their six progenies. Population dynamics of different groups of microorganisms, recorded at seven DAE and subsequently at seven-day intervals in the rhizosphere of parental lines and their progenies, indicated that the population of cyanogenic fluorescent pseudomonads was high in the rhizospheres of progenies giving low yields compared to the population in the rhizosphere of the high-yielding parental lines. The population of cyanogenic fluorescent pseudomonads increased appreciably with the increase in crop-duration.

Table 3. Population densities of pseudomonads in the rhizosphere of groundnut genotypes (summer 2009)

Genotype	Pseudomonad population ($X10^5$ CFU g^{-1})							
	14 DAE		21 DAE		28 DAE		35 DAE	
	Flu	NF	Flu	NF	Flu	NF	Flu	NF
JUG 22	13.0	5.2	4.3	8.9	5.8	6.2	13.2	10.9
JUG 24	10.8	3.2	4.2	2.9	3.9	1.7	4.2	4.9
JUG 48	13.3	4.5	3.1	2.8	12.5	2.9	6.9	4.3
JUG 43	21.5	1.7	40.6	11.8	9.1	8.7	16.4	0.8
JUG 46	12.9	1.2	15.3	7.6	4.0	2.2	8.5	4.1
JUG 47	15.5	2.0	10.7	8.0	7.9	8.7	4.6	2.95
GG2	8.1	3.8	2.5	0.7	8.2	4.9	2.6	3.8
ICGV 86031	15.7	2.6	7.4	6.8	6.2	3.6	10.7	1.2

A similar trend was observed for the population of bacteria and pod yield in *kharif* 2009. The population of cyanogenic fluorescent pseudomonads was high in the rhizosphere of genotyopes giving lower yields compared to yields of the parental lines.

Groundnut-rhizobia

Evaluation of new strains of groundnut rhizobia

A field trial was taken up during *kharif* 2009 to evaluate the newly isolated *nod⁺nif* competitive strains of groundnut rhizobia. Eight strains *viz*., RH 16, RH 17, RH 29, SRR 7, RH 11, PAS 17-2, SRR 10 and RH 20 having additional traits like production of siderophore and IAA like substances, were tested along with standard culture NC 92. Compared to control (un-inoculated), the inoculation with the newly isolated strains of groundnut rhizobia and NC 92 enhanced the pod yield of cultivar Girnar 2. Among the newly isolated strains, RH 11 was adjudged the best. It gave an advantage of 9% in pod yield over the culture NC 92 (Table 4). Inoculation with rhizobia also improved the BNF parameters.

Table 4. Effect on inoculation of newly isolated rhizobia on the growth, yield and BNF parameters in groundnut, cultivar Girnar 2 (*kharif* 2009)

Treatment	PY (kg ha^{-1})	HY (kg ha^{-1})	Shelling turnover (%)	HSM (g)
Cont rol	1244	4100	63.8	40.2
NC92	1486	4550	65.6	41.1
RH16	1375	4483	65.5	41.9
RH17	1365	4533	66.6	42.8
RH29	1556	4200	66.0	40.8
SRR7	1497	4433	65.4	40.9
RH11	1617	4770	67.0	43.3
PAS17 -2	1590	4540	67.1	42.2
SRR10	1350	4400	64.7	40.7
RH20	1505	4760	66.5	42.7
CD (5%)	157	NS	1.24	NS

Liquid biofertilizer formulation

Studies on the shelf-life of liquid formulations

Different liquid formulations of *Pseudomonas fluorescens* biovar G BHU1 were prepared using additives in the Kings' medium B. These formulations were named as KB, K1, K2, K3, K4, K5 and K6. Two sets were stored - one at room temperature and the other at 4°C (in a refrigerator). Population of *Pseudomonas fluorescens* biovar G BHU1 was monitored at 30-day intervals. At 4°C, in two formulations, K3 and K4, a population (10^8 CFU ml^{-1}) was maintained up to 90 days of storage against the initial population (10^{10} CFU ml^{-1}).

Development of suppressive soils

Isolation and testing of DAPG-producing fluorescent pseudomonads for suppression of soil-borne fungal pathogens

The fluorescent pseudomonads are known to produce 2,4-diacetylphloroglucinol (2,4-DAPG) which is an antifungal compound and inhibits the soil-borne fungal pathogens. To develop suppressive soils which would naturally suppress the fungal pathogens, an attempt was made to isolate DAPG-producing fluorescent pseudomonads. From the rhizosphere of groundnut, seventy fluorescent pseudomonads were isolated and tested *in vitro* for inhibitory properties of soil-borne fungal pathogens like *A. niger*, *A. flavus* and *S. rolfsii*. Out of these, only seven isolates *viz*., DAPG 1, DAPG 2, DAPG 3, DAPG 4, DAPG 5, DAPG 6, and DAPG 7 showed antifungal activity against *A. niger* and *S. rolfsii* (Table 5; Fig. 1). The presence of genes responsible for production of DAPG in these isolates was also confirmed by PCR amplification of *phl*D genes by phl2aF and phl2aR primers and an amplicon size of 746 bp was obtained.

Table 5. Antifungal activity of some DAPG-producing fluorescent pseudomonads

Isolate	Inhibition zone (in mm) after 72 h of incubation at 28 ± 2°C (data mean of three replications)		
	A. niger	*A. flavus*	*S. rolfsii*
DAPG 1	26.0	12.0	17.0
DAPG 2	26.7	12.3	16.7
DAPG 3	25.3	12.0	14.3
DAPG 4	29.0	13.0	15.0
DAPG 5	30.7	13.7	15.7
DAPG 6	27.0	12.0	19.0
DAPG 7	20.3	00.0	14.7

Figure 1. Antifungal activities of DAPG-producing fluorescent pseudomonads as indicated by the zone of inhibition

Under artificially inoculated conditions, when the pathogen (*S. rolfsii*) was applied to pots, the seedling mortality was 90%. The mortality, however, reduced to 67% when the pathogen and DAPG-producing fluorescent pseudomonads were applied together. Thus, confirming the inhibitory effect on *S. rolfsii* observed in Petri plates.

Table 6. Effect of inoculation of DAPG-producing fluorescent pseudomonads on suppression of stem rot of groundnut caused by *S. rolfsii*

Treatment	No of plants	No of plants survived	Mortality (%)
Control	30	26	13.3
Pathogen (P)	30	3	90.0
P + DAPG 1	30	4	86.7
P + DAPG 2	30	6	80.0
P + DAPG 3	30	7	76.7
P + DAPG 4	30	8	73.3
P + DAPG 5	30	10	66.7
P + DAPG 6	30	8	73.3
P + DAPG 7	30	5	83.3

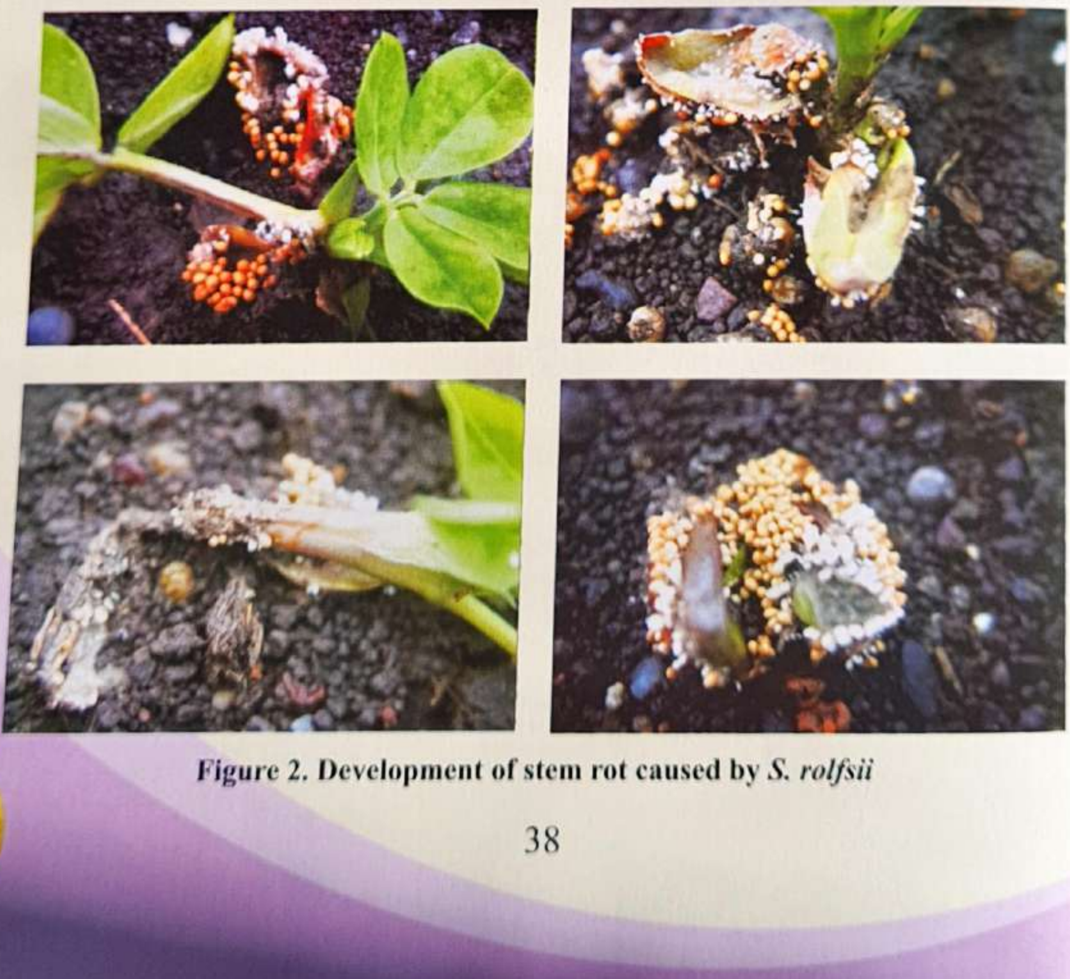


Figure 2. Development of stem rot caused by *S. rolfsii*

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

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Sub-Project 1: Mineral nutrient requirements and related disorders in groundnut

(A.L. Singh and R.S. Jat)

Nutrition of various seed-sizes of groundnuts

The nutrition of 43 groundnut genotypes varying in their sizes of pod and seed was studied for both macro (P and K) and micro (Zn and B) nutrients in a field experiment. The genotypes were fertilized with various combinations of $P_{50} + K_{100}$, $P_{50} + K_{100} + 2$ kg ha^{-1} Zn + 1 kg ha^{-1} B and without any of these. Depending upon the size of seed, a large variation in the response was observed. The genotypes with large seed required more P, Ca and K and had higher contents of P and Ca in their seeds and shell compared to the genotypes with small seeds. The effect of application of B and Zn improved the pod filling in all genotypes but it had a more pronounced effect on the large-seeded genotypes, as could be seen from the high contents of these nutrients in the seed and shell of large-seeded genotypes. Thus, supply of P, K, Zn and B increased the pod yield by mainly increasing the size of pods (both length and diameter) and improving the pod filling. Hence for maintaining proper pod and seed size for production of export quality produce of large-seeded genotypes, application of the above mentioned nutrients is essential.

Studies on the various levels and modes of application of Mo

The mode of application and doses of Mo were tested in micro-plot using four groundnut cultivars (GG 2, GG 7, ICGS 76 and GG 20). There was a significant and commensurate improvement in yield of all the four cultivars by application of Mo (sodium molybdate) up to 0.5 kg ha^{-1}. The response was, however, more pronounced in GG 7, ICGS 76 and GG 20 - the large-seeded cultivars. Hence for groundnut, it is recommended to apply sodium molybdate up to 0.5 kg ha^{-1}.

Seed-treatment with micronutrients

Various micronutrients (copper sulphate, manganese sulphate, iron sulphate, zinc sulphate, each at 5 kg ha^{-1} and sodium molybdate at 1 kg ha^{-1}) were evaluated for seed treatment in micro plot studies by using four popular cultivars GG 2, GG 7, ICGS 76 and GG 20. All the cultivars responded to the application of these micronutrients as seed treatment and as indicated by significant improvement in their yields. In general, there was maximum response to application of zinc followed by iron. All the cultivars showed a good response of Mo, Mn and Cu. In the cultivars ICGS 76 and GG 20 maximum improvement in yield was due to application of Zn while in cultivar GG 2 it was due to Fe and in GG 7 due to Mo.

Screening of core germplasm collection for fertilizer response and high nutrient density

To study the fertilizer response and kernel micronutrient content, 179 core germplasm lines were grown under unfertilized and fertilized conditions. The study revealed that:

- The genotypes, NRCG 11711, NRCG 11942, NRCG 11693, NRCG 1913, NRCG 6064, NRCG 12272, NRCG 10911, NRCG 10496, NRCG 3198, NRCG 11866 with more than 200 g pods m^{-2} were high-yielding and responsive to application of fertilizers.
- The genotypes, NRCG 11996, NRCG 168, NRCG 7306, NRCG 12329, NRCG 12881, RCG 12748, NRCG 12879, NRCG 11701, NRCG 11868 with less than 60 g pods m^{-2}, were low yielding and not responsive enough to fertilizer application Some of the genotypes identified for high kernel nutrient density are:
- High Fe (above 100 ppm): NRCG 12291, 12148, 11088, 12880, and 11236
- High Mn (above 40 ppm): NRCG 11126, 12291, 3533, 10820, and 12321
- High Zn (above 50 ppm): NRCG 11868, 3648, 12321, 1086, and 11925
- High Cu (above 14 ppm): NRCG 12746, 9966, 10820, 11088, and 11276
- High Ca content (above 1000 ppm): NRCG 11651, NRCG 5360, NRCG 12319, NRCG 12713, NRCG 12393, NRCG 7443, NRCG 12339, NRCG 6811, and NRCG 8956

Studies on response of groundnut cultivars to application of Zn and B

Under unfertilized condition or fertilized with Zn and B, 110 groundnut cultivars were grown to study the effect of application of Zn and B on the enrichment of these nutrients in kernels. The study revealed that:

- The cultivars CSMG 84-1, GG 20, GG 11, Chitra, ICGS 37, JSP 19, M 197, GG 16, TG 37A, and Girnar 2 with more than 200 g pods m^{2} were high yielding and Zn-responsive.

- The cultivars CSMG 84-1, GG 20, GG 11, GG 16, GG 13, M 335, ICGS 76, GG 12, GG 8, TG 37A, CSMG 9510, JSP 19 and Girnar 2 with more than 200 g pods m^{-2} were high yielding and B-responsive.

Screening of groundnut cultivars for high Zn content in seed

The seeds of 103 groundnut cultivars were analyzed for Zn and Fe contents. The Zn concentration in seed was in the range of 18-117 mg kg^{-1} with a mean value of 55 mg kg^{-1}. Similarly, the Fe concentration in seed was in the range of 30-198 mg kg^{-1} with a mean value of 85 mg kg^{-1}. Out of 103 cultivars, 15 cultivars each were identified to contain high Zn content and high Fe content.

Yield targeting in groundnut

In a calcareous clayey soil with 50 kg ha^{-1} available N, 17 kg ha^{-1} available P, and 230 kg ha^{-1} available K, besides 2.8, 45, 0.54 3.8 and 0.68 ppm available Fe, Mn , Zn, Cu and B, respectively, a field experiment for a targeted yield of 6 t ha^{-1} pod yield was conducted during *kharif* and also in summer. Based on soil analysis and nutrient requirement, 40 kg N ha^{-1} as urea, 50 kg P ha^{-1}as DAP, 100 kg ha^{-1} K as MOP, 1000 kg ha^{-1} Gypsum, 10 t ha^{-1} FYM, 30 kg ha^{-1} S as elemental S, 2 kg ha^{-1} Zn as zinc sulphate and 1 kg ha^{-1} B as Agricol were applied. The pod yield of 5 t ha^{-1} was easily achieved with three cultivars GG 20, GG 7, TG 37A and one genotype FEESG 10 in summer season and up to 4.5 t ha^{-1} in rainy season.

In summer, the pod yields of cultivars FeESG 8, GG 7, and FeESG 10 were 4458, 4969 and 4520 kg ha^{-1}, respectively in fertilized plots against 1969, 1847 and 2642 kg ha^{-1}, respectively in control. In *kharif*, the pod yield of cultivars GG 20, GG 7 and TG 37A were 3728, 4563 and 3198 kg ha^{-1}, respectively in fertilized plots against 2506, 3268 and 1772 kg ha^{-1}, respectively, in control. However, in the previous *kharif*, the pod yield of cultivars GG 20, GG 7 and TG 37A were 3033, 3048 and 2673 kg ha^{-1}, respectively, in fertilized plots against 1722, 2096 and 1547 kg ha^{-1}, respectively, in control plot.

Screening, maintenance and multiplication of nutrient-efficient and inefficient lines

A total of 194 core germplasm lines were multiplied during summer season and distributed to various places in NEH region. About 120 groundnut genotypes having tolerance to various abiotic stresses and efficient or in-efficient in nutrient utilization, were maintained in the field.

Sub-project 2: Management of soil acidity and related problems of groundnut

(A.L. Singh, N.P. Singh, M. Datta, Y. Ramakrishna and K.A. Pathak)

Screening of groundnut genotypes for tolerance of Al-toxicity

In sand culture

A pot study was conducted to screen groundnut genotypes for their tolerance of Al-toxicity (1000 µM of Al as $AlCl_3$). The symptoms of Al-toxicity were noticed on roots and subsequently on plants at 25-30 days after sowing causing reduction in growth and yields. Thirty-five groundnut genotypes were screened and on the basis of their relative performance, six genotypes NRCG-2239, 2906, 7109, 7138, 7105 and 7133 were identified to be relatively tolerant to Al-toxicity.

Field-screening in acid soils

A number of germplasm lines were screened in the acid soils of the NEH region, by growing under fertilized (Lime 500 kg ha^{-1}, FYM 10 t ha^{-1} and P_2O_5 50 kg ha^{-1}) and unfertilized conditions. There were considerable variations in the root and shoot length, biomass production and yield and yield related attributes.

At Tripura, at 35 DAE, the ranges of various attributes were: root length 10-22 cm, shoot length 13-40 cm, no. of secondary roots 10-43, number of nodules 6-110, nodule weight 0.04-0.234 g $plant^{-1}$, root wt 0.14-1.4 g $plant^{-1}$, and shoot weight 4.4-30 g $plant^{-1}$. However, these values were 11-29 cm, 16-78 cm, 19-56, 10-82, 0.04-0.34 g $plant^{-1}$, 0.29-1.9 g $plant^{-1}$, and 5.6-42 g $plant^{-1}$ at 65 DAE. Wide variations in the number of pods (2 to 8) and in pod weight (2.7-22.0 g $plant^{-1}$) were observed. With application of lime + FYM + phosphate, the pod/seed weight increased in most of the genotypes.

Experiment on organic farming

As lime and chemical fertilizers are not easily available in NEH region and their application adds to the cost of cultivation, various organic farming approaches were tested along with the traditional farmers' practice of Bun farming. It was noticed that Bun farming was closer to nature and more practical for poor farmers. The organic fertilizers always showed their superiority to inorganic fertilizers in the highly eroded soils and discarded lands with low organic matter. Application of FYM at 10 t ha^{-1} alone was the best in alleviating Al-toxicity in the highly eroded soils of NEH region. The promising organic sources identified were slurry of waste from piggery, vermi-compost, poultry manure and green leaves of *Gliricidia* and subabul. In Nagaland, Meghalaya and Tripura, there was an excellent response to growing of hedge rows of *Tefrosia microphylla, Crotalaria microphylla, Plemengia* and *Glirricidia* on the bunds and subsequently incorporating these as organic manure in groundnut and rice fields.

Nutrient management in bold-seeded groundnut

As water is not a limiting factor, generally the yield of groundnut is quite high in NEH region which has a lot of potential area for growing confectionery groundnut. Moreover, the temperatures prevailing during pod filling stage are congenial for proper pod filling. The soil acidity and Al-toxicity due to high rainfall, however, is a hurdle in realizing the yield potential. Field experiment were conducted to find out the ameliorative measures for soil acidity and Al-toxicity and to identify the key nutrients for large-seeded groundnuts. Various combinations of organic and inorganic nutrients were studied. The study revealed that in acid soils combined application of organic with inorganic sources was advantageous over the use of inorganic fertilizers alone (Table1 and 2). Several years of study revealed that P, Ca, K and B and many a time N also are the key nutrients in acid soils where deficiencies are induced. Hence application of P, Ca and B and organic fertilizers is essential. The study with various fertilizers, lime and FYM has shown that with proper management of nutrients, it was possible to realize a pod yield of about 2000 kg ha^{-1} (Table1 and 2).

Table 1. Yield and yield attributes of bold seeded groundnut under various regimes of nutrition in acid soils at Tripura

Treatment	Pod no. plant^{-1}	Pod wt (g plant^{-1})	Seed wt (g plant^{-1})	Plant wt (g plant^{-1})	100-seed wt (g)	Shelling turnover (%)	Productivity (kg ha^{-1}) Pod	Productivity (kg ha^{-1}) Haulm
T_1- Control	9	12.4	3.9	6.4	56.6	58.8	1290	2200
T_2- P_{50}	15	15.1	7.7	16.0	50.0	63.7	1350	2440
T_3- K_{100}	11	11.8	6.3	17.6	66.6	60.0	1290	2210
T_4-Lime (2.5t ha^{-1})	11	13.9	9.1	11.1	56.6	63.9	1520	3400
T_5-T_2 + T_4	14	24.6	16.2	21.2	63.3	66.7	1750	3400
T_6-T_2 + T_3+T_4	17	24.9	12.4	25.1	56.6	68.7	1780	3930
T_7- T_6 + 1kg ha^{-1}B	15	21.1	10.8	23.0	63.3	72.1	1730	3760
T_8-T_6 + 10 t FYM	15	19.6	13.6	20.2	66.6	71.2	2120	4030
SE (±)	1.80	1.97	0.99	1.85	2.9	1.25	44	60
CD (5%)	2.34	2.45	1.73	2.37	4.5	3.29	360	420

Table 2. Yield and yield attributes of bold seeded groundnut under various regimes of nutrition in acid soils at Kolasib and Mizoram

Treatment	Plant height (cm)		Branches (no.plant^{-1})		No of pods plant^{-1}		100 pod weight (g)		Pod to kernel ratio		100seed mass(g)		Yield (kg ha^{-1})	
	ICGS 76	TG 37	ICGS 76	TG 37	ICGS 76	TG 37	ICGS 76	TG 37	ICGS 76	TG 37	ICGS 76	TG 37	ICGS 76	TG 37
T1Control	19.3	20.5	4.0	3.5	13	14	148	127	78.3	74.4	59.6	45.6	570	760
T2P50	23.3	23.8	4.5	3.5	17	14	157	139	73.8	70.2	59.8	42.6	690	1190
T3K100	25.0	28.4	6.7	4.4	18	15	155	149	79.2	68.9	62.7	47.3	900	1810
T4Lime 2500	27.4	25.1	4.9	5.9	15	16	137	142	84.9	71.7	54.2	47.3	950	1620
T5T2 +T4	24.3	23.7	5.3	4.3	12	16	158	132	74.4	75.2	60.1	46.0	1410	1610
T6T2+ T3 + T4	24.1	28.2	5.7	5.0	20	16	159	130	79.1	78.0	64.2	45.8	1090	1570
T7T6 + 1kg/ha B	28.9	31.7	7.7	6.5	17	20	151	155	78.1	75.3	58.2	54.3	1550	2110
T8T6+10 t/ha FYM	26.8	27.8	5.0	4.0	18	17	150	138	77.9	75.6	60.5	46.3	1040	1950

Sub-project 3: Development of sustainable production technologies for north-eastern India

(A.L. Singh, J.B. Misra, N.P. Singh, Subrata Biswas, K.A. Pathak, Y Ramakrishna, R. Bhagawati, Magan Singh, P.H. Bhatt (ICAR Res. Complex for NEH Region)

Evaluation of recently released cultivars and nutrient-efficient lines

The evaluation of groundnut varieties for yield and tolerance of soil acidity and Al-toxicity is being done regularly in NEH region. So far more than 100 varieties have been tested and many of these have been recommended. About 40 genotypes comprising cultivars and nutrient efficient lines were evaluated for three years and the high yielding cultivars with tolerance of insect pests and foliar diseases were identified for their cultivation in this region:

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

The data in Table 3 shows that Among 14 groundnut varieties, grown at Tripura, the ranges of values for no. of pod plant^{-1} was 5 to 21, for pod weight 4.0 to 23.8 g plant^{-1} and for seed weight 3 to 18 g plant^{-1}. The variety, GG 13 with a pod yield of 2880 kg ha^{-1} and GG 11 with 2250 kg ha^{-1} were the best performers followed by Kaushal and GG 2. The highest 100-seed mass (57 g) was observed in varieties ICGS 76 and GG 13. A few early varieties like TG 37 A fit well in various cropping system.

Table 3. Productivity parameters of groundnut varieties in Tripura

Groundnut variety	Pods plant^{-1}	Pod wt (g plant^{-1})	Seed wt (g plant^{-1})	Haulm wt (g plant^{-1})	100-seed wt (g)	Yield (kg ha^{-1})	
						Pod	Haulm
ICGS 76	16	3.8	17.7	18.8	56.6	1080	1250
GG2	11	13.7	10.0	16.9	50.0	1850	1510
GG 13	11	14.8	10.1	28.2	56.6	2880	1710
TG 37A	19	22.8	15.7	14.4	40.0	1620	1410
FeESG 10	13	11.2	7.9	13.9	40.0	500	550
FeESG 8	5	4.0	3.0	12.4	53.3	430	460
K 134	11	8.9	6.8	13.3	50.0	80	1120
GG 6	20	15.7	12.3	23.8	36.6	1310	1500
SB XI	21	15.2	11.0	29.0	33.3	1330	1630
GG 11	12	21.2	14.6	37.0	53.3	2350	1160
Kaushal	14	19.2	13.9	26.7	43.3	1860	1860
GG 4	17	16.8	12.4	20.9	33.3	980	1210
GG 2	15	12.1	9.2	15.4	43.3	1410	940
GG 8	14	16	13.7	23.3	40.0	1430	1180
SE (±)	1.17	1.28	1.04	2.05	2.4	120	110
CD (5%)	1.81	1.89	1.70	2.39	5.1	360	350

Identification of suitable groundnut varieties for various intercropping systems

Among the three intercropping systems (rice + groundnut, maize + groundnut, and green gram + groundnut) with four groundnut varieties (ICGS 76, TKG 19A, JL 24 and ICGV 86590) evaluated in Manipur for three years, the highest total grain yield was obtained in maize + groundnut intercropping system and the varieties ICGV 86590 and TKG 19A were most suitable for intercropping.

In another experiment, three genotypes of groundnut (FeESG-8, FeESG-10 and GG 7) were intercropped with sesamum, mung, or rice in Tripura (Table 4). The experiment was conducted with recommended package of practices and doses of fertilizers (NPK applied at 40:60:50 kg ha^{-1} in combination with cowdung (5 t ha^{-1}). The results are presented in Table 4. As the soil was eroded, the crop yield was poor. The data, however, indicated that the pod yield of sole groundnut crop of genotypes GG 7 and FeESG-8 was 1220 and 1090 kg ha^{-1}. The highest pod yield of 1570 kg ha^{-1} was recorded by groundnut genotype FeESG-10 when intercropped with rice at 2:2, followed by 1080 kg ha^{-1} in FeESG-8 + rice, and 970 kg ha^{-1} in GG7 + mung at 1:1.

Table 4. Productivity of groundnut based intercropping systems in Tripura

Treatment	Groundnut						Eequivalent groundnut yield (kg ha^{-1})		
	No of pod $plant^{-1}$	Pod weight (g $plant^{-1}$)	Seed weight (g $plant^{-1}$)	Plant weight (g $plant^{-1}$)	Shelling turnover (%)	Pod yield (kg ha^{-1})	Rice	Sesamum	Mung
T1-Sesamum sole crop	-	-	-	-	-	-	-	550	-
T2-Mung sole crop	-	-	-	-	-	-	-	-	130
T3-Rice sole crop	-	-	-	-	-	-	-	470	-
T4-Groundnut (GG 7) sole crop)	13	38.	12.7	32.3	47.8	1220	-	-	-
T5 -Groundnut (FeESG 8 sole crop)	11	15.0	10.3	44.0	48.4	270	-	-	-
T6 -Groundnut (FeESG 10 sole crop)	10	9.7	6.0	33.3	44.8	410	-	-	-
T7 Groundnut (GG7)+Rice	20	24.8	13.7	45.0	42.1	330	460	-	-
T8 - Groundnut (FeESG 8) +Rice	18	21.3	14.5	44.2	40.7	660	420	-	-
T9 - Groundnut (FeESG 10) +Rice	15	14.2	9.0	38.5	38.2	1090	480	-	-
T10 Groundnut (GG 7) + Sesame	17	14.0	9.7	22.3	40.0	350	-	150	-
T11 - Groundnut (FeESG 8) + Sesame	21	25.76	17.8	25.7	54.1	740	-	210	-
T12 - Groundnut (FeESG 10) + Sesame	12	10.5	6.7	21.7	44.2	200	-	130	-
T13 - Groundnut (GG 7) + Mung	21	22.2	14.5	27.3	53.9	910	-	-	60
T14 - Groundnut (FeESG 8) + Sesame	18	23.0	16.7	25.8	53.0	520	-	-	30
T15 - Groundnut (FeESG 10) + Mung	19	21.7	13.2	30.3	45.5	80	-	-	30
CD (5%)	1.27	1.78	1.05	4.12	2.58	61			

Selling price of 1 kg produce: groundnut Rs 30, sesame Rs 35, mung Rs 40, and rice Rs 10.

Evaluation of confectionery groundnut genotypes in NEH region

In Mizorum, Tripura, Barapani and Nagaland, ten confectionery/large-seeded varieties, *viz.*, GG 20, HNG 10, ICGS 76, BAU 13, TPG 41, GG 7, Somnath, NRCGCS 148, 268 and 281 were evaluated under high management conditions of FYM (10 t ha^{-1}), PSM, PGPR and all the recommended fertilizers. On the basis of data of two years, NRCGCS 268, and 281, TPG 41, CSMG 84-1, and ICGS 76, were identified to be high yielding. The performance of these large-seeded groundnut, however, remains poor due to low fertility conditions (NPK (40:60:50) + 5 t ha^{-1} cowdung) at Tripura (Table 5) whereas the varieties BAU 13, HNG 10, GG 20, and NRCGCS 148, performed well. Hence the large seeded varieties should be grown only under high management conditions.

Table 5. Evaluation of confectionery and large-seeded groundnut in Tripura

Variety	No of pods $plant^{-1}$	Pod weight (g $plant^{-1}$)	Seed weight (g $plant^{-1}$)	Plant weight (g $plant^{-1}$)	100-seed weight (g)	Shelling turnover (%)
GG 20	34	49.4	30.8	71.2	73.3	54.9
HNG 10	45	52.7	32.4	58.7	53.3	61.1
ICGS 76	26	35.3	21.4	55.6	60.0	53.9
BAU 13	45	95.1	47.9	117.7	60.0	51.9
TPG 41	23	39.2	27.3	29.1	66.6	51.1
GG 7	6	3.7	1.7	10.3	43.3	50.0
Somnath	17	20.3	13.2	39.7	46.6	51.8
NRCG CS 148	26	47.9	22.7	100.7	53.3	50.0
NRCG CS 268	12	20.8	13.2	19.3	60.0	41.7
NRCG CS 281	15	31.6	17.1	36.1	70.0	47.6
SE (±)	3.53	6.01	4.05	9.49	4.2	2.21
CD (5%)	3.48	5.93	3.99	9.37	4.14	2.54

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

(R.S. JAT, H.N. MEENA, I.K. GIRDHAR*, K.K. PAL AND P.C. NAUTIYAL)

*Up to July 2009

Studies on soil test crop response correlation

For developing prescription equations for soil test crop response, a field experiment was conducted in the *kharif* 2009. For this, a fertility gradient was created for generating basic data on requirement of various nutrients (N, P, K, S, Ca, B kg t^{-1}) and the extent of contributions of nutrients from soil, fertilizers and FYM, and the efficiencies of soil and fertilizers in providing nutrient were calculated. The fertility gradient was created by dividing the experimental field into seven strips which were fertilized by different levels of nutrients while considering the innate levels of nutrients in soil as zero level of fertility. The farmers' practice was also followed for comparison (control). The one season data indicated significant improvement in PY and HI of cultivars TG 37A, GG 7 and GG 20 with the application of 60 kg N, 100 kg P_2O_5, 125 kg K_2O, 200 kg Ca, 50 kg S, 60 kg Mg, 5 kg Zn and 2 kg B per ha. There was significant improvement in the soil organic carbon, N, P, and K contents with the increasing levels of application of nutrients.

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

The experiment was taken up to revisit the recommendations for application of N, P and K fertilizers for *kharif* groundnut. A total of 27 combinations, comprising each nutrient at three different levels, were tested. The one season data revealed that the application of 25 kg N, 80 kg P_2O_5 and 60 kg K_2O per ha brought about significant improvement in PY and yield attributes. There was a positive response to application of potassium up to 60 kg ha^{-1} while the extent of response to applications of N and P were low at higher levels (37.5 kg N and 80 kg P_2O_5 ha^{-1}). There was a significant effect on the status of nutrients in the soil due to application of various levels of N, P, and K. The data on pod yield is given in Table 1.

Table 1. Pod yield (kg ha^{-1}) of groundnut at various levels of nutrients

	Levels of N (kg ha^{-1})								
	12.5			25.0			37.5		
Levels of K_2O	Levels of P_2O_5			Levels of P_2O_5			Levels of P_2O_5		
	40	60	80	40	60	80	40	60	80
0	1100	1254	1267	1326	1329	1381	1227	1284	1229
30	1354	1189	1369	1337	1346	1465	1297	1280	1229
60	1369	1342	1363	1355	1344	1572	1432	1331	1441

CD (5%): 202

Permanent experiment on nutrient dynamics and sustainability under groundnut based cropping system

A long-term experiment with five popular groundnut based cropping systems *viz*, sole groundnut, two intercropping systems (with pearl millet and pigeon pea) and two sequential cropping systems- 'groundnut-wheat' and 'groundnut-wheat-green gram' was initiated during *kharif* 1998 under different regimes of combinations of inorganic sources and of organic and inorganic sources to study the nutrient dynamics and sustainability of the systems. The cropping systems significantly affected the groundnut PY and the total system productivity (TSP) in terms of groundnut equivalent yield. Groundnut with FYM+50% RDF, wheat with 50% RDF and green manuring with green gram in the groundnut-wheat-green gram cropping system recorded highest groundnut PY in the *kharif* season. The 'groundnut (FYM+50% RDF)-wheat (FYM+50% RDF)-green gram' cropping system recorded the significantly higher TSP (4063 kg ha^{-1}). The different nutrient management practices (organic and inorganic) did not bring any significant improvement in groundnut PY or TSP, however, the highest PY was recorded with the integrated use of organic and inorganic fertilizers (FYM+50% RDF). Application of different combinations of sources of nutrients and the cropping systems significantly influenced the haulm yield and HI. Both

Table 2. Pod yield of groundnut (*kharif* 2009) in various cropping systems and nutrient management practices

Treatment	Pod yield (kg ha^{-1}) Nutrient application in Groundnut RDF 100%	FYM+50% RDF	Mean
Sole groundnut	890	1333	1111
WHeat (100% RDF)	1003	1442	1222
Wheat (50% RDF)	921	1164	1042
Wheat (FYM+50% RDF)	905	1169	1037
Wheat (100% RDF) - Green gram	890	1218	1054
Wheat (50% RDF) - Green gram	895	1183	1039
Wheat (FYM+50% RDF) - Green gram	940	1216	1078
Pigeon pea (100% RDF)	467	662	564
Pigeon pea (50% RDF)	570	543	556
Pearl millet (100% RDF)	313	299	306
Pearl millet (50% RDF)	318	297	308
Main-plot: CD (5%) = 20			
Sub-plot:CD (5%) = 59			
Interactions: Main-plot at same sub-plot; CD-123, Sub-plot at same main-plot; CD - 118			

haulm yield and HI were highest with the combined application of FYM and inorganic fertilizers in the 'groundnut-wheat-green gram' cropping system. Highest yield of pearl millet and pigeon pea were recorded with 100% RDF each to groundnut, pearl millet and pigeon pea crops. Wheat recorded the highest grain yield in the 'groundnut-wheat-green gram' system followed by groundnut-wheat system. Among different management practices the highest wheat grain yield (3442 kg ha^{-1}) was found in 'groundnut (FYM+50% RDF)-wheat (FYM+50% RDF) and green gram as green manure'. The 'groundnut-wheat-green gram' cropping system also recorded the highest green gram grain yield (775 kg ha^{-1}). The soil fertility data showed that the maximum build up of organic carbon was in 'groundnut-wheat-green gram' among the cropping systems and in 'FYM + 50% RDF' among the nutrient management systems.

Studies on modes of application of citric acid for enhancing P-availability

The experiment was laid out in the summer season to assess the increase of availability of phosphorus in soil by applying citric acid (CA) and to study the suitability of various methods of application of CA for enhancing P-availability in soil. The treatments consisted of four levels of citric acid (control, 2, 4 and 6 kg ha^{-1}) and five modes of application (CA alone, CA with FYM 2t ha^{-1}, CA with FYM 1t ha^{-1}, CA with SSP 250 kg ha^{-1} and CA with SSP 125 kg ha^{-1}). The results indicated that differences in pod yield due to modes of application were not significant but the differences due to levels were. The highest PY (3053 kg ha^{-1}) was recorded with '2 kg CA + 2 t FYM ha^{-1}'. The response however, was not proportionate with increasing doses of CA. As a corollary the modes of application did not significantly differ in improving the net returns but with the increasing rate of application of CA there was a significant improvement in the net returns. The interaction between the levels and mode was also significant and application of CA, 2 kg ha^{-1} with 2 t FYM ha^{-1} gave the highest net returns (Rs. 47027 ha^{-1}). The soil organic carbon (SOC) and phosphorus contents

Table 3. Effect of citric acid and its mode of application on pod yield and soil P content

Treatment	Pod yield (kg ha^{-1})	P (kg ha^{-1})
CA alone	2428	6.2
FYM (2 t ha^{-1})	2819	10.9
FYM (1 t ha^{-1})	2334	8.4
SSP (250 kg ha^{-1})	2694	10.1
SSP (125 kg ha^{-1})	2528	9.9
CD (5%)	NS	2.4
Control	2330	7.9
Citric acid (2 kg ha^{-1})	2856	8.6
Citric acid (4 kg ha^{-1})	2661	9.7
Citric acid (6 kg ha^{-1})	2555	10.3
CD (5%)	246	NS

increased significantly due to mode of application as FYM or SSP when added to the soil. The highest SOC content (0.94%) was observed in the plots receiving 4 kg CA along with 2 t FYM ha^{-1}, whereas the highest phosphorus content (13.5 kg ha^{-1}) was observed in the plots receiving 6 kg CA along with 2 t FYM ha^{-1}.

Development of technologies for production of organic groundnut

The experiment was conducted in summer season with 14 organic treatments along with one treatment of RDF and one control. The results of one season revealed that application of organic sources did not differ significantly in their effect on PY, however, the application of 10 t FYM ha^{-1} coupled with biofertilizers (*Rhizobium* and PSB) and biopesticides (*Trichoderma* and castor cake) recorded the highest pod yield (3528 kg ha^{-1}) and also brought about improvement in yield attributes. The economics, calculated by considering the sale price of groundnut as Rs. 21 kg^{-1} pod, indicated that application of 'FYM + biofertilizers + biopesticides' fetched the highest net returns (Rs. 54815 ha^{-1}), followed by 'vermicompost + biofertilizers + biopesticides + sea weed' (Rs. 51123 ha^{-1}); 'FYM + biofertilizers + biopesticides + sea weed' (Rs. 48965 ha^{-1}); and 'sea weed' alone (Rs. 48600 ha^{-1}).

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

(I.K. GIRDHAR*, H.N. MEENA, R.S. JAT AND R. DEY)

*Up to July 2009

Use of saline water in groundnut based cropping system

Consolidated results of five years (2005 to 2009)

Ground water forms an important source of irrigation next to surface water in arid, semi-arid and coastal regions of the country. About 32.84 percent of total utilizable potential of the ground water in such regions are of poor quality. In Gujarat, particularly in Saurashtra region, farmers generally raise only one rain-fed crop of groundnut and keep fields fallow in the *rabi* (winter season) as they cannot use under-ground saline water for irrigation on the one hand and non-availability of canal water for irrigation on the other hand.

An experiment was started in the year 2002 and continued up to 2010 with the objective of exploring the possibility of using saline ground water for irrigation in different crop rotations (groundnut-groundnut, groundnut-wheat, groundnut-mustard and groundnut-bajra). After nine years of experimentation it could be concluded that instead of taking single crop of groundnut in coastal areas of Saurashtra region, farmers can take one more crop in *rabi* season for their economic benefit by using saline water of 2-3 dS m^{-1} salinity as supplementary irrigation for *kharif* groundnut, and in *rabi* season, 4-6 dS m^{-1} salinity of water can be used for irrigation of wheat, mustard and bajra crops for their optimum yield (about 1000 kg ha^{-1} of groundnut, 1500 kg ha^{-1} of mustard, 3500 kg ha^{-1} of wheat and 3300 kg ha^{-1} of bajra), whereas saline water was not suitable for irrigation of summer groundnut because of build up of high soil salinity due to use of saline water for irrigation. The buildup of salinity in root zone (ECiw = 4 dS m^{-1} to groundnut and ECiw = 6 dS m^{-1} to wheat, mustard and bajra) adversely affected absorption of water by plants even though the soil had enough water. This resulted in stunting of plants and further significant decrease in yield. Prolonged use of saline water for irrigation increased the soil pH from 7.8 in 2002 to 8.2 in 2009, which also possibly deteriorated the soil health and affected the yield. The oil content in groundnut kernels and mustard seeds also decreased significantly with increase in salinity of the water from 0.5 to 6 dS m^{-1}.

Bajra (2008-09)

After harvest of *kharif* groundnut in 2008, bajra crop was taken in rotation during November 2008 in the saline black clay soil using saline water of four different salinity levels (0.5, 2, 4 and 6 dS m^{-1}). It was observed that the seed yield decreased from 3845 to 2285 kg ha^{-1} with an increase in water salinity from 0.5 to 6 dS m^{-1} and soil salinity from 0.9 to 6.7 dS m^{-1}, respectively. The decrease in yield due to soil salinity of 4.9 dS m^{-1} and use of saline water for irrigation up to 4 dS m^{-1} salinity over the control was at par. The differences in other yield attributing characters such as seed yield, dry matter yield, thousand-seed mass, number of branches and ear length were also at par at the aforesaid levels of soil and water salinity. The yield and yield contributing characters were significantly adversely affected at high water (ECiw = 6 dS m^{-1}) and soil (ECiw = 6.7 dS m^{-1}) salinity, yet economical yield (3300 kg ha^{-1}) could be obtained. Thus, it was observed that due to use of saline water for irrigation of bajra crop there was a progressive build up of soil salinity in the root zone with passage of time from sowing to harvest of bajra crop.

Evaluation and screening of released varieties in saline environment

In *kharif*, a large number of germplasm accessions and released varieties of groundnut were screened in saline environment at hot spot area at JAU Research Station, Khapat (Porbandar). The released varieties comprised MA 16, T 64, ICGS 5, GG 20, AK 265 and CSMG 884 under Virginia bunch group; GG 13, Kadiri 71-1, GG 15, Chitra, S 230, Chandra, TMV 1, TMV 4, M 197 and TMV 3 under Virginia runner group and R 2001-3, Kisan, RG 141, ALR 3, JL 501, Tirupati 2, S 206, KRG 1, JL 286, and ALR 2 under Spanish bunch group. The initial soil and water ECe was 0.72 and 3.75 dS m^{-1} and at harvest it was 2.0 & 2.80 dS m^{-1}, respectively.

Among these three habit groups of groundnut, there were significant differences within the groups and the highest and lowest pod yields were recorded in MA 16 (2137 kg ha^{-1}) and CSMG 884 (1435 kg ha^{-1}) in Virginia bunch group, GG 13 (2581 kg ha^{-1}) and TMV 3 (1253 kg ha^{-1}) in Virginia runner group, and R 2001-3 (2318 kg ha^{-1}) and ALR 2 (963 kg ha^{-1}) in Spanish bunch group. Further, the varieties under Virginia group were more tolerant of salinity than the Spanish group. In saline environment, almost a similar trend was observed in the performance of other yield attributing factors.

One experiment that was conducted in 2008 was repeated in 2009, but with different varieties, namely GG 20 and GG 21 in Virginia bunch group, GG 11 and GAUG 10 in Virginia runner group and GG 2, GG 4, ICGS 44, GG 7, GG 5, TPG 41, TG 26, TG 37 A and TAG 24 in Spanish bunch group. Among the varieties of Virginia bunch and Virginia runner groups, there were no significant differences but significant differences within Spanish groups, there were no significant differences but significant differences within Spanish

Table 1. Effect of treatments of salinity on yield and yield contributing characters of Bajra grown in *rabi*-summer after *kharif* groundnut

ECiw (dS m^{-1})	ECe of soil (dS m^{-1})	Plant height (m)		Branches (no. $plant^{-1}$)	Length of ears (cm)	1000-seed weight (g)	Dry matter (q ha^{-1})	Seed yield (q ha^{-1})
		At 45 DAS	At harvest					
0.5	0.9	1.5	1.69	3.7	18.2	11.07	49.0	38.5
2	2.9	1.4	1.51	3.3	16.8	10.60	40.3	37.5
4	4.9	1.2	1.39	2.5	17.2	10.73	47.0	33.1
6	6.7	0.9	1.03	4.6	14.6	8.60	31.0	22.9
CD (5%)		0.1	0.2	NS	1.6	0.9	8.7	5.2

bunch groups were obseved and the highest and lowest pod yields were recorded in GG 2 (2020 kg ha^{-1}) and TAG 24 (736 kg ha^{-1}), respectively.

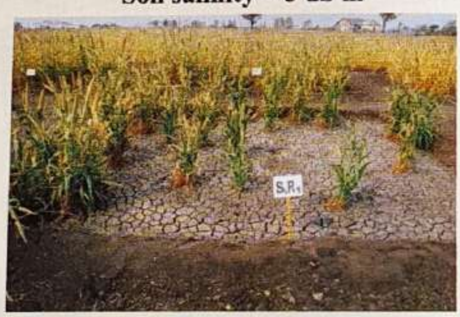
Table 2. Build-up of soil salinity due to use of saline water for irrigation in Bajra crop (2008-09) taken after *kharif* groundnut

ECiw	Soil Salinity (dS m^{-1})				
(dS m^{-1})	Initial	17-11-08	30-12-08	13-01-09	07-03-09
0.5	0.8	0.8	0.8	0.8	0.9
2	1.2	2.5	2.9	2.5	2.9
4	1.9	3.5	3.7	4.8	4.9
6	2.8	4.4	4.6	6.5	6.7
0.5	7.76	7.66	7.81	7.84	72
2	8.10	7.89	7.92	7.87	7.95
4	8.21	8.04	8.10	7.85	8.05
6	8.17	8.01	8.22	7.86	8.20

Water salinity = 2 dS m^{-1}
Soil salinity = 2.5 dS m^{-1}

Water salinity = 4 dS m^{-1}
Soil salinity = 5 dS m^{-1}

Water salinity = 0.5 dS m^{-1}
Soil salinity = 1.0 dS m^{-1}



Water salinity = 6 dS m^{-1}
Soil salinity = 7.5 dS m^{-1}

Figure 1. Effect of soil and water salinity on the performance of *rabi* bajra crop taken after *kharif* groundnut

Table 3. Effect of soil and water salinity on groundnut based cropping system

Kharif Groundnut (2002 and 2003)			Summer Groundnut (2002 and 2003)		Summer Wheat (2004 and 2005)		Summer Mustard (2006 and 2007)		Summer Bajra (2008 and 2009)	
ECiw ($dS\ m^{-1}$)	ECe ($dS\ m^{-1}$)	Pod yield ($kg\ ha^{-1}$)	ECe ($dS\ m^{-1}$)	Pod yield ($kg\ ha^{-1}$)	ECe ($dS\ m^{-1}$)	Grain yield ($kg\ ha^{-1}$)	ECe ($dS\ m^{-1}$)	Grain yield ($kg\ ha^{-1}$	ECe ($dS\ m^{-1}$)	Grain yield ($kg\ ha^{-1}$)
0.5	0.8	1309	1.6	1123	2.0	3923	1.5	1604	0.9	3845
2	1.7	1046	4.8	435	5.1	3771	2.9	1489	2.9	3752
4	3.3	787	7.9	25	7.3	3549	5.2	1255	4.9	3312
6	4.8	420	9.4	0	7.8	2548	7.6	985	6.7	2285
CD (5%)		190		121		892		405		518

PROJECT 08: MANAGEMENT OF GERMPLASM OF CULTIVATED GROUNDNUT (*A. hypogaea* L.) AND ITS WILD RELATIVES (A.L. RATHNAKUMAR, S.K. BERA, T.V. PRASAD*, VINOD KUMAR** AND V.V. SUMANTH KUMAR***)

* Up to June 2009
** Up to September 2009
*** Up to November 2009

Field maintenance of wild *Arachis* germplasm

Under genus *Arachis*, 81 accessions belonging to sections *Arachis* (28), *Caulorhizae* (1), *Erectoides* (6), *Heteranthae* (1), *Procumbentes* (8) and *Rhizomatosae* (37) were maintained in the field gene bank.

Acquisition, distribution and utilization of germplasm accessions

Seeds of 14 released varieties; 7 identified for release, and two wild accessions were acquired from 7 AICRP-G centres for inclusion in the germplasm collection.

For use in the crop improvement programme, 1656 germplasm accessions including wild relatives of groundnut were supplied to 36 indenters. These germplasm accessions were supplied to the scientists of DGR (333), State Agricultural Universities (1268), ICAR Institutes (30) and others (25) for identification of promising lines for WUE, tolerance of diseases and nematode, large seeded types and for use in crossing programmes.

At UAS, Bangalore, five promising accessions were identified for two WUE traits, ^{13}C and ^{18}O. The identities of these accessions along with the respective values for ^{13}C and ^{18} are: NRCG 11915- 17.4, 22.5; NRCG 12568- 17.9, 21.1; NRCG 12965-18.7, 21.1; NRCG 12274- 18.3, 23.3; and NRCG 12326-19.2, 21.1. Three of these accessions have been used as parents (NRCG 11915, NRCG 12326 and NRCG 12568) in hybridisation programme to develop mapping populations (RILs) and for further identification of markers of the above traits.

Multiplication and conservation of germplasm accessions

Voucher samples

In *kharif* 2009, for multiplication and depositing with NBPGR, New Delhi, 284 (HYB: 60; HYR: 40; VUL: 145; FST: 39) accessions were sown. Sufficient (>200 g) seeds, however, could be obtained only in 33 accessions and were deposited.

Mini-core collection

Out of 184 accessions of ICRISAT mini core collection, 75 (HYB: 06; HYR: 11; VUL: 30; FST: 28) accessions were multiplied in *kharif* 2009 of which 31 accessions have been deposited with NBPGR for long-term conservation.

DUS reference varieties

For enhancing sufficient quantity of seeds, 30 DUS reference varieties (HYB: 07; HYR: 08; VUL: 13; FST: 02) were multiplied in *kharif* 2009 season.

General accessions

A set of 197 accessions (HYB: 72; HYR: 29; VUL: 42; FST: 54) received from ICRISAT was multiplied in *kharif* season. Of these, 132 accessions in which sufficient quantity of seeds could be produced, were deposited with NBPGR.

Released varieties

A set of 158 released varieties (HYB: 39; HYR: 23; VUL: 92; FST: 04) was multiplied in *kharif* season for distribution and conservation.

Variability museum

A set of 45 morphologically unique accessions identified from among the working collections was multiplied for distribution and conservation. The number of accessions in each habit group was HYB: 15; HYR: 02; VUL: 10; and FST: 18.

High-oil collection

A set of 19 accessions (HYB: 06; HYR: 01; VUL: 03; FST: 09) having high oil (>50%) content was multiplied and conserved.

Sub-set of NRCG working collection

A total of 167 accessions (HYB: 37; HYR: 9; VUL: 72; FST: 49) of a subset of NRCG working collection were multiplied in *kharif*, out of which 86 accessions have been deposited with NBPGR for conservation.

Repatriated accessions

In *kharif* 2009, a set of 156 accessions repatriated from ICRISAT was multiplied; however, the quantity obtained by multiplication was not adequate for depositing with NGB (NBPGR, New Delhi). Hence, these accessions will be multiplied again in the ensuing *kharif*.

Morpho-physiological characterization of mini-core germplasm

Morphological characterisation in *kharif* 2009

Characterisation of subset of NRCG working collection

A set of 167 accessions (HYB: 37; HYR: 9; VUL: 72; FST: 49) of a subset of NRCG working collection was evaluated and characterised in *kharif* 2009 for 19 qualitative and 27 quantitative traits.

Two accessions, NRCG 10259 and NRCG 11157 exhibited earliness (105 d). The range observed for this trait was 105-138 days; shelling turnover was in the range of 44.7% (NRCG 12299) to 69.5% (NRCG 11700). Hundred-seed mass was as small as 16.0 g (NRCG 12698) to as high as 52.8 g (NRCG 5405). Pod yield ranged from 1.2 g $plant^{-1}$ (NRCG 10969) to 10.2 g $plant^{-1}$ (NRCG 12591). Number of pods ranged from 1 (NRCG 12299) to 17 (NRCG 11511).

The low yields observed in most of the germplasm accessions could be attributed to the incessant heavy rains (550 mm in July 2009) received during peak flowering to pod formation stages.

Characterisation of new accessions

A total of 42 new accessions (HYB: 21; HYR: 3; VUL: 5; FST: 3; UNK: 10) were evaluated and characterised in *kharif* 2009 for 19 qualitative and 27 quantitative traits. Of these, seeds of four accessions failed to germinate. Pod yield in these accessions was in the range of 2.2 g $plant^{-1}$ (NRCG 11984) to 15.0 g $plant^{-1}$ (NRCG 13317); Shelling turnover was in the range of 40.0% (NRCG 13487) to 76.6% (NRCG 13491). The range of hundred-seed mass was 22 g (NRCG 13313) to 52.8 g (NRCG 17148) and that of number of mature pods from 2 $plant^{-1}$ (NRCG 13500) to15 $plant^{-1}$ (NRCG 13308).

Characterisation of exotic collection

Forty exotic collections were evaluated and characterised in *kharif* 2009 for 19 qualitative and 27 quantitative traits. Among these accessions, the yield and number of pods were as low as 1.3 g $plant^{-1}$ with a single pod in EC416393. The accession EC4 14465 gave the highest yield of 9.0 g $plant^{-1}$ with 5 pods $plant^{-1}$. The hundred-seed mass was in the range of 26.4 g (EC416434) to 54.2 g (EC 416454) and the shelling turnover from 57.3 (EC 416509) to 69.2% (EC416428).

Characterisation of large-seeded accessions

For 15 pod and seed traits, 28 large-seeded Virginia accessions (HYB: 18; HYR: 10) were evaluated and characterised. The hundred-seed mass (HSM) was in the range of 38.0 g (NRCG 12499) to 70.8 g (NRCG 4917) and 20 accessions exhibited the value >60 g. The pod yield of these accessions was in the range of 1.9 g (NRCG 5195) to 19.8 g (NRCG 12806) $plant^{-1}$ while the shelling turnover of accessions having HSM value >60g, was in the range of 66 (NRCG 9045) to 68.3% (NRCG 4917).

Assessment of morphological diversity in Spanish bunch accessions of mini-core collection in summer 2009

In summer 2008 and 2009, for 19 qualitative and 27 quantitative traits, 67 Spanish bunch mini-core germplasm accessions were evaluated to identify diverse and promising ones for yield and related traits. Wide variability existed for all the qualitative and quantitative traits studied.

Diversity analysis performed through Ward's minimum variance method indicated the presence of appreciable diversity for important yield related traits. The principal component analysis indicated that the first three vectors cumulatively explained 73.2% of the observed variation.

The characters contributing to diversity in the 1st vector were days to flowering (first -0.24; fifty%- 0.29; and seventy five%- 0.25), days to maturity (0.58), hundred-pod mass (0.68) and hundred-seed mass (0.79), pod-length (0.81), pod-width (0.84), seed-length (0.81) and seed-width (0.46). In 2nd vector, days to flowering (first: 0.60; fifty%: 0.70; and seventy five%: 0.65) and days to maturity (0.28) contributed more towards the diversity. Thus, it is clear that the accessions studied exhibited more diversity in duration of flowering and maturity in addition to pod and seed traits (Table 1) compared to the other traits.

Table 1. Performance of germplasm accessions showing diversity for eight quantitative traits (values indicate mean of two seasons)

NRCG	DTG	DIF	DFF	NMP	PYP	SHE%	HSW	DTM
14329	15	35	39	13	12	58	40	117
14351	14	33	37	20	15	65	34	108
14407	15	29	34	17	11	69	41	118
14409	15	35	37	13	8	67	34	115
14422	14	34	39	11	7	70	40	115
14434	14	34	39	11	7	64	39	110
14437	14	35	39	15	10	70	41	117
14461	14	33	38	14	11	70	41	120
14465	14	35	39	13	8	65	39	117
14474	14	33	39	13	11	66	37	115
14482	14	34	41	15	12	57	36	117
14485	14	32	37	14	12	72	39	115

DTG=Days to germination; DIF=Days to initial flowering; DFF=Days to fifty percent flowering; NMP=Number of mature pods; PYP= pod yield plant^{-1} (g); shelling turnover (%); HSW=Hundred-seed weight (g); DTM=Days to maturity

Flowering behaviour of large-seeded accessions

Thirty large-seeded accessions belonging to Spanish bunch and Valencia groups were evaluated for their flowering behaviour. On the basis of number of flowers produced on weekly basis, the accessions were classified as low, medium and high flower producers in each category. In each category, there were wide variations for both number of flowers and the duration of flower production. Among low-flower-producers of *fastigiata* and *vulgaris* accessions, there was a single peak while in medium-flower-producers of *fastigiata* and *vulgaris* accessions, there were two peaks with large variations in number of flowers produced. In high-flower-producers, flowering was gradual with a single peak while in others it was erratic with multiple peaks. When the data on seed mass of these accessions grown at two locations (Ratnagiri and Junagadh) was compared, it was observed that among the accessions which produced low number of flowers, there was a greater filling of kernels as reflected by eventual mass of their seeds. The number of pods and yield plant^{-1}, however, appeared to be slightly lower at Ratnagiri than the corresponding values observed at Junagadh (Table 2). The temperature, which was more congenial for pod filling at Ratnagiri seemed to have played an important role.

Table 2. Period of maturity, pod yield and seed mass of accessions evaluated for behaviour of flowering at Junagadh and Ratnagiri

Accession	Junagadh			Ratnagiri			Gain in HSM
	DTM (days)	HSM (g)	PY (g plant^{-1})	DTM (days)	HSM (g)	PY (g plant^{-1})	(g)
3648	112	45.0	9.4	111	54.6	12.3	+10
10910	112	38.0	8.5	101	50.4	11.2	+12
11183	111	51.6	12.3	108	55.3	10.4	+3
11044	112	54.0	12.9	109	55.7	10.8	+2
12383	115	54.4	13.5	111	59.9	11.4	+5
CD (5%)	2.9	4.8	2.2	3.8	2.7	1.9	-

Evaluation of a sub-set of working collection, mini-core collection and released varities for ^{13}C

Carbon isotope discrimination (^{13}C) is widely recognized as a surrogate trait for WUE and accordingly as many genotypes as possible were analysed for this trait.

Sub-set of working collection: With a view to understand the genetic variations in WUE in a sub-set of working collection, leaf samples were collected in two replicates and analysed for ^{13}C using mass spectrometry at UAS, Bangalore. The observed range of values was quite narrow from 18.25 (NRCG 11924) to 21.97 (NRCG 12639) showing a very low variability (CV = 3.37%). The modal value was 20.61. Among the 49 FST germplasm accessions studied, only one accession recorded low value for ^{13}C (Table 3a). Low values for ^{13}C are desirable from the WUE point of view. Some of the promising accessions having low ^{13}C are as follows:

Table 3a. ^{13}C values of promising accessions in a subset of the working collection

Habit Group	Identity of a ccession	^{13}C	Days to maturity
FST	NRCG 11924	18.25	124
HYB	NRCG 404	18.69	132
	NRCG 8963	18.70	132
	NRCG 11865	18.72	126
	NRCG 12138	18.74	130
	NRCG 11942	18.92	130
HYR	NRCG 666	18.65	120
	NRCG 17	18.77	130
	NRCG 12393	18.85	130

Mini-core collection

The mini-core collection comprising 184 accessions was analysed to study the genetic variation in ^{13}C (in fact, only 183 accessions could be analysed). The range observed was 10.86 (NRCG 14442) to 23.49 (NRCG 14461). The co-efficient of variability was 10%. Six accessions (Table 3b), two of Virginia bunch and four of Virginia runner types, recorded low ^{13}C values. The modal value in this collection was 19.65.

Table 3b. Promising accessions for low ^{13}C in mini-core collection

Habit Group	Identity of accession	^{13}C	Days to maturity
HYB	NRCG 14390	18.65	134
	NRCG 14395	18.87	130
HYR	NRCG 14342	16.02	132
	NRCG 14352	18.61	132
	NRCG 14357	18.77	135
	NRCG 14442	10.86	139

Released varieties

The genetic variation for ^{13}C was analysed in 122 released varieties. The lowest ^{13}C value was observed in a semi-spreading cultivar T 64 (18.49) and the highest value was observed in a Spanish cultivar AK 12-24 (21.64). The modal class was 19.55 and the CV was very low (1%). Twelve varieties, two of Spanish bunch, seven of Virginia bunch and three Virginia runner types were found promising as these recorded low ^{13}C values (Table 3c).

Table 3c. Groundnut varieties with low ^{13}C values

Habit Group	Identity of accession	^{13}C	Days to maturity
VUL	ICGV 86590	18.86	110
	DRG 12	18.94	110
HYB	BG 2	18.61	124
	BG 3	18.56	123
	Kadiri 2	18.81	129
	Kadiri 3	18.80	123
	T 64	18.49	122
	TG 1	18.83	122
	TMV 10	18.51	120
HYR	DSG 1	18.59	124
	GAUG 10	16.60	123
	M 197	18.50	124

In all the three groups of genotypes i.e. sub set of working collection, mini-core collection and released varieties, genotypes with low ^{13}C were rare among the Spanish bunch types.

Screening of Spanish mini-core collection for fresh seed dormancy

Ten accessions out of 67, which exhibited fresh seed dormancy during summer 2008, were further evaluated in summer 2009 for confirmation. It was observed that all the ten genotypes which exhibited fresh seed dormancy of various periods in summer 2008 showed the same pattern of dormancy in summer 2009 also. The two accessions, NRCG 14350 and NRCG 14409, were found to possess a long period of fresh seed dormancy (>60 days) while the other two accessions, NRCG 14326 and NRCG 14336 possessed fresh seed dormancy for 40 days.

In addition, the fresh seed dormancy was assessed in thirty large-seeded accessions. All the accessions, except for NRCG 12731, lacked fresh seed dormancy. The accession NRCG 12731 exhibited dormancy for more than a month.

Nodulation efficiency in mini-core collection

Nodulation efficiency in 184 germplasm accessions and 11 released varieties which are used as checks, were analysed at 70 DAS in *kharif* 2009. On an average, 50 nodules plant^{-1} were observed.

The number of nodules plant^{-1} was as low as 3 (NRCG 14443) to as high as 315 (GAUG 10). More than 100 nodules plant^{-1} was observed in 6 accessions namely NRCGs

14432 (184), 14374 (100), 14373 (102), 14495 (126), 14437 (154), 14459 (123). Among the released varieties, GAUG 10 (313) and M 13 (282) recorded maximum number of nodules plant^{-1}.

Screening of mini-core collections for major pests and diseases at hot spots

During *kharif* and summer 2009, the sub set of germplasm collection of NRCG and mini-core collection of ICRISAT were screened for resistance to PBND and PSND at Kadiri and Raichur centres. In summer (at Raichur), incidence of PBND was high (56.3%) in susceptible variety, GG 11, while three ICRISAT mini-core accessions, ICGs 5245 (4.35), 14105 (4.55) and 11687 (6.52) recorded <10% incidence and four NRCG accessions, 9225, 11511, 13603 and 14710 recorded <15% incidence.

In *kharif*, five ICRISAT mini core accessions (ICG 4543, 1415, 5745, 13787, 2106) and four NRCG accessions (CS 083, 107, 203 and NRCG 11212) recorded <10% incidence against 80% incidence in the susceptible genotype, ICG 4911. The resistant variety, ICGS 44 recorded 8.3% incidence.

At Kadiri, the incidence of both PBND and PSND was low (<10%) in summer and hence, no valid conclusion could be drawn.

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

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

Genetic transformation

Confirmation of putative transgenics from *mtlD* gene construct

An attempt was made to transform groundnut cultivar GG 20 with *mtlD* gene. In all 636 de-embryonated cotyledons were co-cultured with *Agrobacterium* containing the gene construct *mtlD*. Multiple shoots could be induced only in 380 explants. From these explants 207 shoots were isolated and grown on medium with selection pressure of antibiotic kanamycin. Only 84 (40.6%) putative transgenics were identified of which only 16 were PCR positive with the expected fragment of length of 400 bp.

The nine transgenics identified earlier as positive by PCR based amplifications of the candidate gene as well as by the southern hybridisation for confirmation of integration, were confirmed further by RT-PCR for the expression of the *mtlD* gene sequence.

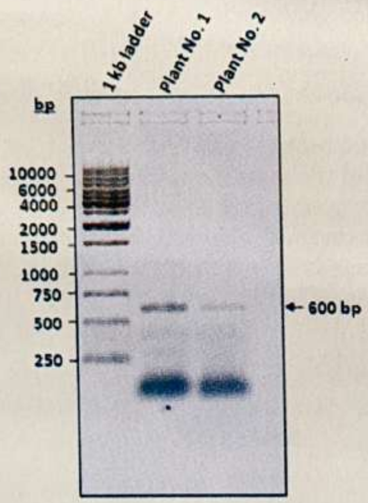


Figure 1. RT-PCR amplification of the *mtlD* gene showing the expected amplification of 600bp

Rapid multiplication of transgenics from *mtlD* gene construct

Vegetative multiplication of the T_0 plants was done to increase the plant population required for the characterisation. From 9 confirmed plants, about 40 plants were produced which were grown and the pods were harvested. About 100 pods each from the nine confirmed T_0 plants are now available for further studies.

Figure 2. Rapid multiplication of the transgenics under greenhouse conditions

Confirmation of putative transgenics from *defensin* gene constructs

Using de-embryonated cotyledons as explants, 1191 co-cultures were made. Only 869 explants regenerated. From the regenerated shoots, out of 112 shoots transferred for rooting under selection pressure only 33 shoots produced roots.

Though several putative transgenics, which passed the antibiotic selection were grown. All these plants, however, failed the PCR test for the presence of the transgene. A second lot of plants is now being PCR tested for confirmation.

Development of mapping populations and assessment of molecular diversity Fresh hybridisations for developing mapping populations

Three crosses were made for developing mapping populations for tolerance of stem rot. Probable hybrid pods were harvested for confirmation and isolation of true hybrids. The particulars of the crosses made are given in table 1. Three crosses were made for developing mapping populations for tolerance of foliar fungal diseases and another two crosses for tolerance of stem rot and confirmed F_1 hybrids were isolated. The particulars of these five crosses are given in table 2.

Table 1. Probable hybrid pods harvested

No.	Cross	No of pods harvested
1.	GG 20 x CS 75	91
2.	GG 20 x CS 83	91
3.	GG 20 x CS 19	71

Table 2. Number of confirmed hybrids isolated from the crosses

No.	Cross	Pods harvested	Confirmed hybrids
	Foliar fungal diseases		
1.	TG 37A x VG 9816	67	16
2.	JL 24 x VG 9816	71	30
3.	GAUG 10 x VG 9816	23	07
	Stem rot		
4.	GG 20 x CS 19	36	23
5.	GG 20 x JSP 39	57	29

Phenotyping of the mapping populations in sick plot

The mapping population of recombinant inbred lines from the cross TAG 24 x R 9227 was screened in a sick plot for stem rot. The extent of infection, among the 316 inbred lines, was in the range of 0 to 100%.

Figure 3. RILs being grown in sick plots

Genotyping of the parental lines and populations

The genotypes *viz.* TAG 24, R 9227, JL 24, ICGV 86590, GG 20, CS 83, CS 75 and CS 19 which were used for developing mapping populations were analysed for DNA polymorphisms. Out of 54 primers already screened, only 5 primers were polymorphic and several primers did not even produce amplicons.

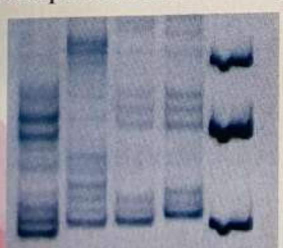


Figure 4. Electrophoregram of four cultivars showing polymorphic amplicons with PM 30

Fingerprinting of extant cultivars

The 26 extant cultivars selected for fingerprinting were tested with the available primers and then 18 primers were short listed for developing the fingerprints. A dendrogram (fig. 5) was developed to represent, the composite differentiation patterr of the cultivars using these primers. Of these primers, PM 15, 32, 35, 36, 45, 50 and 238 could individually distinguish the varieties VRI 4, LNG 2, ALR 3, VG 9251 and JL 220.

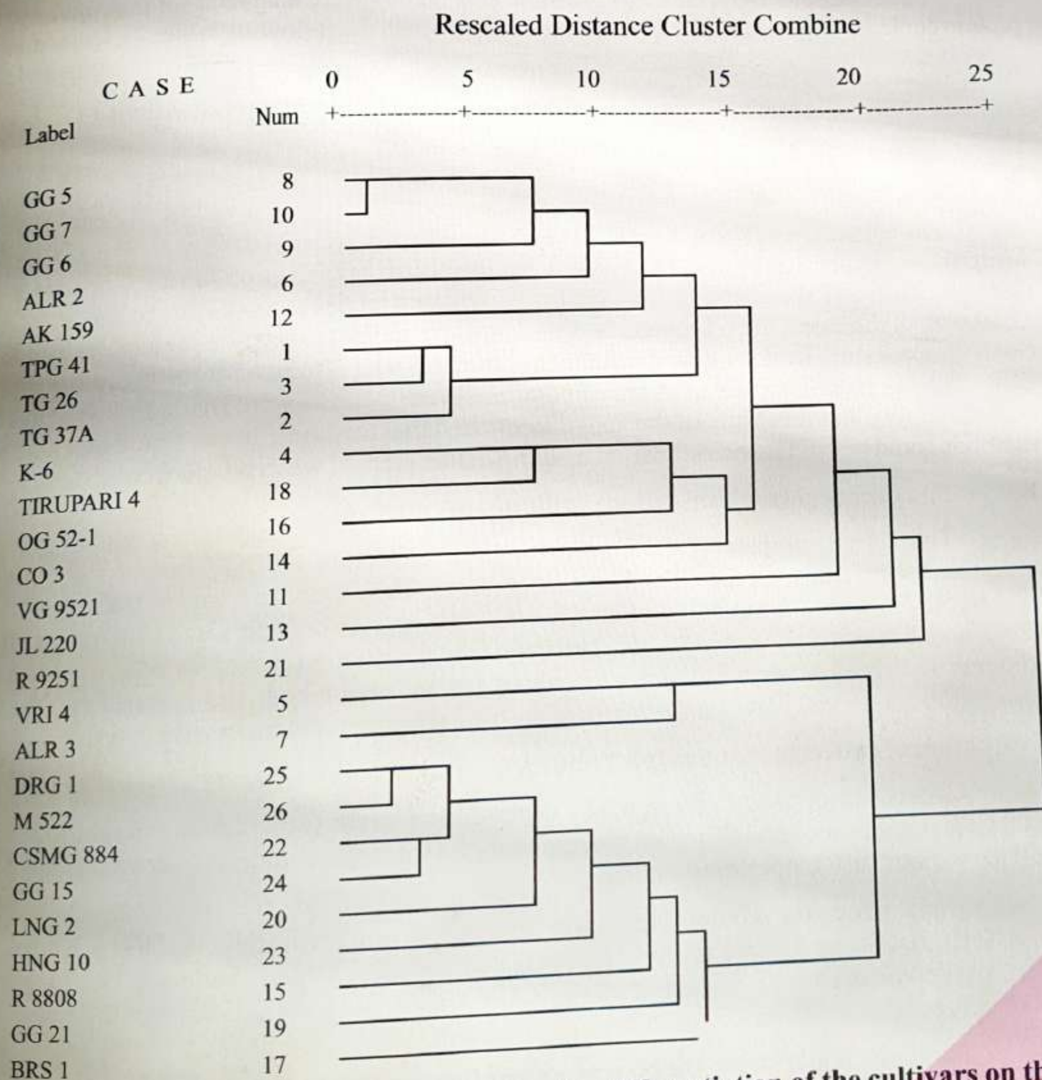


Figure 5. Composite dendrogram depicting the differentiation of the cultivars on the basis of DNA polymorphism elicited by using 18 SSR primers

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

(J.B. MISRA AND S.K. BISHI)

Assessment of quality in groundnut

Chemical composition of groundnut cultivars

Kernel samples of 64 cultivars grown in *kharif* 2009 were analyzed for their oil and protein contents. The values for range and mean are given in the following table:

Parameter	Oil (%)	Protein (%)
Minimum	41.3 (DRG 12)	17.8 (M197)
Maximum	50.2 (CSMG 84-1	30.7 (SG 84)
Mean	45.3	23.2

The cultivars TMV 2 and DRG 12 were identified as low oil (42% or less) cultivars while the cultivars SG 84 and TKG 19A were identified as high protein (28% or more) cultivars. Tirupati 2 was identified as a low oil (43.8%) and high protein (27.8%) cultivar.

In all the cases, the oil content was measured by solvent extraction method by using Soxhlet apparatus. Besides this, densitometric method was also used to estimate the oil content using *Arachilipometer*. A set of parallel oil estimations were made to check the reproducibility and reliability of the above mentioned two methods. It was found that both methods could be used for oil estimation though Soxhlet method was a bit more consistent.

Evaluation of core germplasm collection for quality attributes

The kernel samples of the core germplasm collection of DGR comprising 126 accessions were analyzed for oil and protein contents. The oil content was in the range of 39.2 to 50.7% with a mean value of 42.6% while the protein content was in the range of 12.4% to 34.7% with a mean of 20.8%. The frequency distribution curves for oil and protein contents indicated a normal distribution about the mean for both the parameters. The correlation coefficient between the values of the oil and protein contents was negative.

Evaluation of cultivars for quality attributes

Groundnut cultivars grown under water-deficit stress (50% CPE) and controlled (100 CPE) condition at pod filling stage were analysed for their oil and total nitrogen content and the varietal differences were studied.

Under stress, the protein content was high in cultivars B 95, HNG 10, GG16, Kadiri, GAUG10, JL 286 and low in cultivars CSMG 884, GG 20, DRG 17, Somnath, GG 14 and GG 11 whereas in case of Girnar 2, M 13, ICGV 86590, SG 99 and GG 4 the differences were very low.

Similarly, under stress, the oil content was low in cultivars DSG1, GAUG 10, ICGV 86590 and GG 4 whereas the differences were quite low in TG 37A and SG 99. Under water deficit stress, both oil and protein contents were high in DSG 1 and GAUG 10.

Value-added products of groundnut

Preparation and determination of nutritive values of some popular value-added products of groundnut

A number of new and already popular groundnut value added products were prepared and their nutritive values were worked out on the basis of nutrient composition of the ingredient foodstuffs. The standard values for the nutrients of each foodstuff (as published in the compilation 'Nutritive Value of Indian Foods' a publication of NIN, Hyderabad), were used for this purpose.

Table 1. Some value-added products of groundnut and their nutritive values

Product	Composition 100^{-1}g product					
	Energy (K cal)	Carbohydrate (g)	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)
1. Groundnut *kurkure*	751	48.1	23	51.9	2.7	3.9
2. Groundnut *chakri*	561	35.6	17.8	38.6	2.4	2.7
3. Groundnut *burfi*	661	75.9	18.8	31.3	1.8	2.2
4. Groundnut *halwa*	177	9.5	7.9	12	0.8	0.9
5. Salted groundnut	616	28.9	28.3	43	2.7	3.4
6. Spicy groundnut	587	30.3	24.1	41	2.5	3.4
7. Crispy masala groundnut	595	42.9	24.2	36.2	3	4.6
8. Groundnut *kachori*	534	16.8	2.2	36.8	35.5	2.6
9. Groundnut khajur pak	518	46.7	16.9	29.3	2.4	3.6
10. Groundnut sweet	523	64	11	25	1.3	1.63
11. Groundnut khaman	501	46.6	16.9	27.4	2.9	4.6
12. Groundnut flakes	638	35.1	25.8	43.7	2.7	4
13. Groundnut Salty papadi	606	40.1	15.7	42.5	2.2	2.2
14. Groundnut sweet *crispy para*	580	54.7	11.7	34.9	1.6	1.6
15. Groundnut *fafada*	514	38	19	31.6	2.4	2.9
16. Groundnut *khakhra*	486	49.8	19.2	23.3	2.7	2.9
17. Groundnut biscuits	630	70.1	12.9	33.1	1.8	1.7

Figure 1. Some groundnut preparations

Services rendered to other sections/AICRP-G centres

A total of 1235 groundnut kernel samples received from Plant Breeding, Agronomy, Plant Physiology, Soil Science, Microbiology, Entomology, and Cytogenetics sections of DGR and AICRP-G centres were analyzed for oil content and the results were furnished to the respective sections/centres. Another 285 samples received from Plant Physiology, Microbiology and GRS sections were analyzed for

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

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

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

Isolation of thermotolerant proteolytic bacteria

Using enrichment technique proteolytic bacterial cultures were isolated from soil samples collected from the fields of DGR, Junagadh. The enrichment was carried out at temperatures of 50°, 60°, 70°, 80° and 90°C. Proteolytic bacteria were isolated on Skimmed Milk Agar (SMA) plates following dilution and spread plating. At 50°C, seven isolates; at 60°C, six isolates; and at 70°C and 80°C, one isolate each were obtained.

Screening for salt-tolerance of proteolytic bacterial cultures

The thermotolerant proteolytic bacterial cultures were screened for salt tolerance at 5, 10, 15 and 20% concentrations of NaCl separately in Nutrient Agar (NA) and Skimmed Milk Agar (SMA) media. The Petri dishes were incubated at 50°C and 60°C. At 50°C in NA and SMA media, four out of seven isolates could grow at 10% NaCl. In case of P1, the zone of hydrolysis of casein was large (dia. 17 mm) in SMA medium (control, without salt) compared to that (dia. 14 mm) in medium containing 10% salt. No growth was observed in any of the isolates at 15% salt concentration.

At 60°C, none of the isolates could grow even at 10% NaCl concentration in NA or SMA medium. In NA medium, only three out of the six isolates could grow at 5% NaCl concentration.

Thus at both the temperatures, the size of the zone of hydrolysis decreased with increase in concentration of salt.

Slurry fermentation of de-oiled groundnut cake

Finally, on the basis of their tolerance of high temperatures, concentration of salt, and heavy metals (Ni, Co, Hg, Cd: 0.5 mM to 12.5 mM); seven bacterial cultures were selected for slurry fermentation of de-oiled groundnut cake for evaluating their protease production potential in slurry fermentation at 50°C. Enzymes were extracted from the culture media at 24, 48, 72 and 96 h of incubation at 50°C and then protease activity was determined in the extracts of various isolates by standard protease assay procedure. Two cultures were identified to be very efficient in producing high temperature and salinity tolerant alkaline protease. Isolate F1 produced 302.9 IU protease g^{-1} de-oiled groundnut cake after 48 h of incubation at 50°C in a slurry fermentation, whereas isolate SP8-14 produced 174.8 IU g^{-1} de-oiled groundnut cake under similar conditions (Table 1).

Table 1. Proteolytic activity of high temperature and salt tolerant isolates

Isolate	Protease activity (IU g^{-1} de-oiled groundnut cake)	
	At pH 8.6	At pH 9.0
P1	18.9	13.4
P4	19.7	0.0
P7	18.9	13.7
F1	302.9	25.0
F6	4.7	0.0
SP5-8	67.7	35.9
SP8-14	174.8	129.5
B. subtilis	11.5	5.9

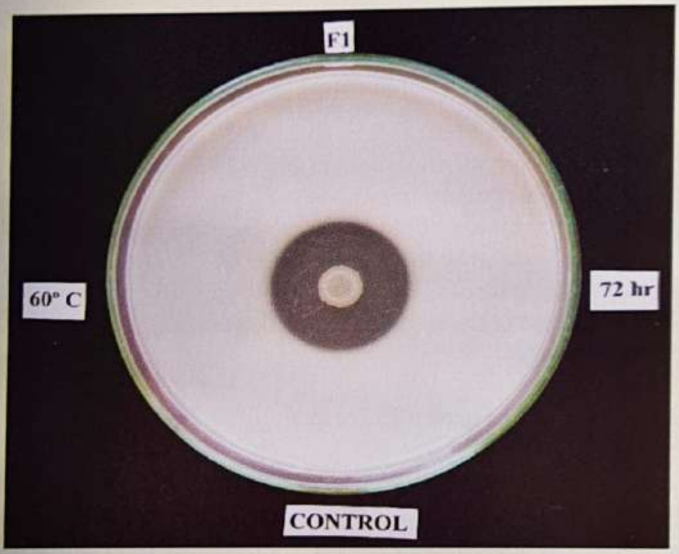


Figure 1. Zone of proteolysis of isolate F1 on Skimmed Milk Agar at 60°C

PROJECT 12: PREVENTION AND MANAGEMENT OF MYCOTOXIN CONTAMINATION IN GROUNDNUT

(VINOD KUMAR* and P. P. THIRUMALAISAMY**)

* Principal Investigator of the project up to September, 2009

** Included as an associate since August, 2009

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

Soil population of *Aspergillus flavus* was determined by serial dilution technique before sowing and also immediately after harvest of garlic, onion, and groundnut and also from fallow land.

Table 1. Soil population of *Aspergillus flavus* in the crop rotation experiment

Variety	Treatment	Population of *Aspergillus flavus* x 10^3 g^{-1} soil			
		Summer		*Kharif*	
		Before sowing	After harvest	Before sowing	After harvest
	Garlic	9.4	5.4	6.0	6.4
J 11	Onion	7.8	6.0	5.9	4.6
	Groundnut	7.4	7.1	12.7	6.3
	Fallow	9.7	6.2	15.0	5.6
	Garlic	8.3	7.1	5.6	6.1
GG2	Onion	8.7	6.7	5.6	5.0
	Groundnut	10.2	6.2	8.0	10.7
	Fallow	8.0	6.2	5.0	5.9

The estimated population of *A. flavus* before and after harvest of summer and *kharif* crops showed that population was always higher in groundnut plots when grown in rotation with groundnut than in rotation with onion or garlic or fallow land. During summer, the soil population of *A. flavus* decreased in crop rotation with garlic, onion, or in fallow land. Groundnut-groundnut crop rotation was more congenial for buildup of *A. flavus* population which increased up to 7.1 x 10^3 g^{-1} soil. In *kharif*, the fungal population decreased further when groundnut was grown after rotation with garlic or onion or fallow land than when groundnut was grown in rotation of groundnut itself (Table 1). Further, seed infection and colonization of *A. flavus* on groundnut kernels were determined by agar-plate technique. Both the infection and colonization were higher in seeds of *kharif* groundnut than those of summer groundnut. Seed infection and seed colonization were comparatively higher in *kharif* groundnut than summer groundnut. A maximum of 43.3% seed infection and 23.3% seed colonization were recorded in *kharif* groundnut whereas only 11.1% seed infection and

6.7% seed colonization was observed in summer groundnut. Thus all the infected seeds were not colonized by *A. flavus* (Table 2).

Table 2. Seed infection and seed colonization of *Aspergillus flavus* and aflatoxin content in groundnut

Variety	Treatment	*Aspergillus flavus* Summer Seed infection (%)	Summer Seed colonization (%)	Summer Aflatoxin (ppb)	*Kharif* Seed infection (%)	*Kharif* Seed colonization (%)	*Kharif* Aflatoxin (ppb)
J 11	Garlic	-	-	-	37.8	20.0	10.8
	Onion	-	-	-	42.2	22.2	10.9
	Groundnut	11.1	6.7	21·0	38.9	17.8	24.4
	Fallow	-	-	-	38.9	22.2	7.6
GG 2	Garlic	-	-	-	36.7	20.0	12.1
	Onion	-	-	-	35.6	17.8	10.6
	Groundnut	8.9	6.7	15.8	43.3	23.3	9.7
	Fallow	-	-	-	37.8	20.0	13.6

Aflatoxin content (AFB1 in ppb) was estimated by indirect competitive ELISA. The AFB1 content was in the range of 7.6 to 24.4 ppb. Compared to cv. J 11, in groundnut-groundnut rotation, the cv. GG 2, harboured a larger population of *A. flavus* (seed infection and colonisation).

Studies on the post-harvest handling of groundnut *vis-a-vis Aspergillus flavus* infection and aflatoxin contamination at various stages of delivery chain (producers-traders-processors)

Samples of groundnut, its by-products and value-added products were collected from various stages of processing in different industries. The moisture content, *A. flavus* infection and aflatoxin contamination in these samples were analysed. Maximum moisture content (11%) was recorded in the sample obtained after conditioning where water was sprinkled to prevent the breakage of kernels during shelling. The *A. flavus* infection in these samples was in the range of 15 to 65% (Fig. 1). The range of aflatoxin B1 content was 0.5 ppb to 27.3 ppb in randomly selected samples. However, in suspected samples it was as high as 85.2 ppb (Table 3). The conditioned pods showed more moisture content, *A. flavus* infection and aflatoxin contamination. Sprinkling of water (conditioning of pods) to reduce the breakage of kernels facilitated the further growth of infection of *A. flavus* and thereby increased aflatoxin contamination in the samples.

Table 3. Natural seed infection of *Aspergillus flavus* and aflatoxin content of groundnut samples obtained from processing industries

Sr. No.	Sample type (process)	Moisture content (%)	Seed infection (%) Total infection	Seed infection (%) *A. flavus* infection	Aflatoxin content (ppb) Randomly selected kernels	Aflatoxin content (ppb) Suspected kernels
1	Harvested pods	5	100	45	0.5	4.2
2	Stored pods	5	100	35	2.0	32.0
3	Conditioned pods	11	100	40	24.5	85.2
4	Decorticated pods	7	45	15	1.0	19.5
5	Stored kernels before sorting	6	55	40	0.9	13.1
6	Kernels after manual sorting	5	55	30	1.2	3.1
7	Discarded kernels after manual sorting	7	85	30	0.7	15.3
8	Kernels before vacuum packing	5	45	20	0.8	6.5
9	Roasted kernels	3	80	50	0.9	1.6
10	Packedkernels	3	90	55	0.7	0.9
11	Discarded roasted kernels	2	90	50	0.6	81.3
12	Kernelsfrom oil extraction mill	7	90	65	273	-
13	Ground nut oil cake (S-737)	6	-	-	7.8	-
14	Ground nut oil cake (S-737)	9	-	-	7.9	-
15	Ground nut oil cake (S-737)	6	-	-	6.6	-
16	Deoiled cake	8	-	-	5.8	-
17	Peanut butter	-	-	-	0.8	-

Figure 1. Natural infection of *Aspergillus flavus* in groundnut kernels obtained from industries

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

(G.D. SATISH KUMAR AND A.P. MISHRA)

Surveys were conducted in Kutch in Gujarat and Chittoor in Andhra Pradesh. Out of 10 *talukas* in Kutch, six *taluks viz.*, Kutch, Anjar, Abdasa-Nalia, Lakhpat, Rapar, and Nakhatrana were identified and from each *taluka* 2-3 villages were selected based on largest area of groundnut. Chittoor district, out of 66 *mandas* spread across three revenue divisions (Chittoor, Madanapalle, and Tirupati), data were collected from only four *mandals*. From each *mandal*, 3-4 villages were selected on the basis of largest groundnut area.

Major crops grown in Kutch are oilseeds, bajra, jowar, cotton, pulses, date palms and brinjal. Groundnut, castor, rapeseed and mustard are important among oilseeds crops. Paddy, groundnut and sugarcane are the major crops in Chittoor.

An inventory of the recommended package of practices was prepared and the farmers' responses on adoption of these practises were collected and analyzed. In summer season, in Kutch, 85% farmers were growing groundnut cv. GG 2, 11% were growing Western 44, and the remaining farmers were growing TATA Sumo and even J 11 (Table 1), whereas in Chittoor, 60% farmers were growing old varieties TMV 2 and/or JL 24 and 40% were growing the improved varieties *viz.*, Narayani, TPG 41 and ICGV 91114. In *kharif*, in Kutch, 60% farmers were growing GG 2, 11% GG 20, 6% each GG 7 and Western 44, and 5 GG 5. A few farmers also grew TATA Sumo and J 11.

During summer, 53% farmers in Kutch and 60% in Chittoor purchased seed from informal sources *viz.*, neighbouring farmers, seed traders, private seed agencies and oil millers. In Kutch, 26% farmers used their own seed and 21% purchased from formal sources (public seed agencies), whereas in Chittor only 10% farmers used their own seed while 30% purchased from the formal sources. All the farmers in Kutch and 90% farmers in Chittoor followed the practice of treating seeds with fungicides (Carbendazim/Dithane M 45/Thiram), whereas only a small fraction (18% in Kutch and 20% in Chittoor) adopted seed treatment with *Rhizobium* cultures. In Kutch, 86% farmers and 80% in Chittoor completed sowing in time but did not care to maintain the optimum spacing. The recommended seed rate was followed by only 30% farmers and conversely 70% used higher than the recommended seed rate. The seed rate used by farmers was in the range of 150-300 kg ha^{-1} with spacing in the range of 20x5 cm to 75x5 cm.

In Kutch, sowing was done with tractor drawn seed drill by 36% of farmers and farmers with small and marginal land holdings (64%) do manual sowing behind the plough, whereas in Chittoor all the farmers followed manual sowing behind the plough. In Kutch and Chittoor, 23% and 28% of the farmers, respectively applied organic manures. In Kutch, 17% farmers and in Chittoor, 12% farmers applied fertilizers on the basis of soil test values. A vast majority of farmers of both the districts applied higher than recommended doses of fertilizers, while only 17% farmers in Kutch and 20% in Chittoor applied the recommended

Table 1. Extent of adoption of improved practices by the groundnut farmers

Practice	Summer		Kharif
	Kutch (n=70)	Chittoor (n=50)	Kutch (n=80)
Optimum tillage	65 (92.9)	48 (96.0)	71 (88.8)
Suitable variety	67 (95.7)	20 (40.0)	72 (90.0)
Source of seed			
i. Own	18 (25.7)	5 (10.0)	34 (42.5)
ii. Formal	15 (21.4)	15 (30.0)	13 (16.3)
iii. Informal	37 (52.9)	30 (60.0)	40 (50.0)
Seed treatment with fungicides	70 (100)	45 (90.0)	78 (97.5)
Bio-fertilizers	09 (18.6)	08 (12.0)	09 (11.3)
Timely sowing	60 (85.7)	40 (80.0)	69 (86.3)
Optimum seed rate	20 (28.6)	15 (30.0)	32 (40.0)
Optimum spacing	30 (42.7)	10 (20.0)	59 (73.8)
Sowing behind the plough	45 (64.3)	50 (100.0)	33 (41.3)
Sowing with tractor drawn seed drill	25 (35.7)	0	47 (58.8)
Application of organic manures	14 (22.7)	14 (28.0)	28 (35.0)
Soil test based fertilizer application	12 (17.1)	6 (12.0)	8 (10.0)
Fertilizer application			
i. Optimum	12 (17.1)	10 (20.0)	14 (17.5)
ii. Low	4 (05.7)	15 (30.0)	10 (12.5)
iii. High	54 (77.1)	25 (50.0)	25 (50.0)
Weed management (chemical)	20 (28.6)	07 (14.0)	12 (15.0)
Application of gypsum	18 (25.7)	8 (16.0)	15 (18.8)
Micro nutrient management	18 (25.7)	7 (14.0)	16 (20.0)
Management of insect pests			
i. Optimum	25 (35.7)	16 (32.0)	22 (27.5)
ii. Low	12 (17.1)	14 (27.3)	10 (12.5)
iii. High	33 (47.1)	20 (40.0)	48 (60.0)
Management of diseases			
i. Optimum	22 (31.4)	5 (10.0)	26 (32.5)
ii. Low	8 (11.4)	16 (32.0)	14 (17.5)
iii. High	40 (57.1)	29 (58.0)	40 (50.0)
Timely harvesting	60 (85.7)	38 (76.0)	65 (81.3)
Optimum drying	68 (97.1)	48 (96.0)	55 (68.8)
Storage in optimum conditions	25 (35.7)	5 (10.0)	20 (25.0)

Figures in parenthesis indicate per cent value doses of fertilizers. Farmers perceived that the higher the rate of application of fertilizers the higher the yields. In both the districts, farmers generally practised manual weeding and only 28% in Kutch and 14% in Chittoor applied chemical weedicides. In Kutch, 26% farmers and 16% in Chittoor applied gypsum and almost an equal number of farmers adopted suitable micro nutrient management practices by spraying commercially available micronutrient mixtures (Groth, Mahaphal and Mazik).

In *kharif*, 50% farmers purchased seed from informal sources, 40% used own seed and only 16% purchased from the formal sources. A vast majority of farmers (97.5%) adopted seed treatment with fungicides (Bavistin/Thiram/Mancozeb/Vitavax) but only 11% adopted seed treatment with *Rhizobium* culture. Sowing is completed in time by 86% farmers. The tractor drawn seed drill is used by 59% farmers and optimum spacing was followed by 73% farmers. The seed rate of 125-200 kg ha^{-1} with spacing in the range of 45x15 cm to 75x30 cm was followed by most farmers. Organic manures were used by 35% farmers whereas only 10% farmers applied fertilizers on the basis of soil test values. Almost 50% farmers applied higher than the recommended doses of fertilizers, as they perceived that the higher the rate of application the higher the yields. The farmers generally (85%) practised manual weeding and only 15% farmers used chemical weedicides. Only a small number of farmers applied gypsum (19%) and micronutrients (20%).

Plant protection

Though most of the farmers believed that the insect pests and diseases were not a major problem for summer groundnut yet they resorted to spray of insecticides and fungicides. Farmers reported the fairly noticeable incidence of sucking pests *viz.*, aphids and jassids and negligible incidence of whitefly. Farmers used Acephate, Imidaclorprid, Monocrotophos and Quinolphos for spray. As the farmers considered insect pests and diseases as the major problems for *kharif* groundnut, they applied higher than the recommended doses of insecticides and fungicides. Farmers reported the incidence of sucking pests such as aphids, jassids and diseases such as stem rot, collar rot and leaf spots. The stem rot was the major problem encountered by the farmers.

Harvest and post-harvest management

Most of the farmers (86% in Kutch and 76% in Chittoor) harvested their crop at 'right maturity stage'. The harvesting was done mostly by tractor in Kutch, whereas the same was done manually in Chittoor. Farmers generally followed sun-drying their produce in open fields. The threshing was done with the help of mechanical threshers in Kutch whereas it was done manually in Chittoor. All the farmers practised collection of the left over pods from the fields after harvesting the crop and most farmers mixed these left over pods with the main lot. Majority of the farmers were not aware of aflatoxin contamination and hence did not adopt any management practice for preventing aflatoxin contamination. In Kutch the farmers stored the produce for 2-4 months in the form of pods untill they could realize better market prices whereas in Chittoor most of the farmers (73%) sold their produce immediately to traders approaching their fields.

In Kutch, the farmers did adopt most of the critical practices but applied higher than the recommended seed rate, and also doses of fertilizers, insecticides and fungicides for cultivation of groundnut in summer, whereas in Chittoor the most critical component i.e. improved varieties was not adopted by majority of the farmers.

In both the districts, however, the extent of adoption was lower for practices such as use of bio-fertilizers, optimum seed rate, soil test based fertilizer application, gypsum application, micronutrient application and chemical weed management.

To assess the impact of improved technologies, the farmers could be grouped into two groups on the basis of their adoption scores: adopters (score > 10) and non-adopters (score = or < 10).

The results showed that there were significant differences between adopters and non-adopters in respect of livelihood assets such as human assets, natural/physical assets, financial and social assets. In case of human assets, however, there were no differences in the farmers' education and dependency ratio (Tables 2 and 3). Significant differences were also there between adopters and non-adopters in respect of formal institutional contacts and livelihood outcomes (Table 4). The differences in livelihood assets *viz.*, age, household (hh) size, number of effective workers, farm size, irrigated area and possession of livestock indicated that the adoption of improved technologies was influenced by these factors.

Table 2. Quantitative values of human and physical/natural assets of adopters and non-adopters

Livelihood assets	Quantitative value			Overall mean
	Adopters (n=38)	Non-adopters (n=82)	*Z* value	
Human assets				
Age (in years)	40.6	47.2	3.44**	42.7
Farmers' education (score)	7.5	6.8	0.87	7.3
Children education (score)	24.8	13.1	6.64**	16.8
Household size (score)	5.7	4.7	3.43**	5.0
Number of effective workers (score)	2.5	2.0	2.31*	2.2
Dependency ratio	2.5	2.4	0.30	2.5
Physical/natural assets				
Material possession	24.3	17.6	8.50**	19.7
Farm size (ha)	3.8	1.9	5.71**	2.5
Irrigated area (ha)	2.3	0.9	6.18**	1.4
Live stock (score)	0.9	0.6	5.16**	0.7

* indicates significance at $P < 0.05$; ** indicates significance at $P < 0.01$

It can also be construed that the major impact of adoption of improved technologies was realization of high pod yields of groundnut (3185 kg ha^{-1}), which resulted in increased income from agriculture (Rs. 1,88,078 hh^{-1}) compared to low pod yields (2112 kg ha^{-1}) and low income (Rs. 60,041 hh^{-1}) of non-adopters (Table 4). The step-wise regression analysis indicated that various attributes like household size, material possession, institutional contact for advice and adoption of improved technologies significantly influenced the pod yield. The adjusted R^2 was 0.929 (Table 5) indicating that these variables accounted for almost 93% variation in pod yield.

Table 3. Quantitative values of financial and social assets of adopters and non-adopters

Livelihood assets	Quantitative value			Overall mean
	Adopters (n=38)	Non-adopters (n=82)	*Z* value	
Financial assets (Rs. hh^{-1})				
Income from agriculture	188078	60041	9.02**	100586
Income from livestock	13650	6579	6.34**	8818
Other income	12830	976	2.89**	4017
Total income	119246	43708	8.80**	113421
Credit availed	13737	2061	5.12**	5758
Social assets				
Membership in org.	0.9	0.2	13.80**	0.5
Extension participation	0.9	0.3	7.99**	0.5

** indicates significance at $P < 0.01$.

Table 4. Quantitative values for formal institutional contacts and livelihood outcomes of adopters and non-adopters

Variable	Quantitative value			Overall mean
	Adopters (n=38)	Non-adopters (n=82)	*Z* value	
Institutional contacts				
Inputs	0.8	0.4	5.10**	0.6
Advisory	0.9	0.3	9.94**	0.5
Livelihood outcomes				
Pod yield (kg ha^{-1})	3185	2112	21.09**	2452
Haulm yield (kg ha^{-1})	3975	3265	18.24**	3490

** indicates significance at $P < 0.01$.

Technology assessment and refinement

In four villages of Junagadh district, 22 on-farm trials (OFTs) were conducted during summer and 16 during *kharif* for assessment and refinement of technologies.

Improved varieties of groundnut

In order to create awareness for motivating the farmers to adopt the improved varieties, the potential of variety TG 37A was demonstrated to the farmers' in their own fields during summer to facilitate comparison with the prevailing variety GG 2. The results of the OFTs indicated that TG 37A was superior in yield (2421 kg ha^{-1}) compared with GG 2 (1833 kg ha^{-1}). With TG 37 A, there was an advantage in pod yield by 24.3% and haulm yield by 16% compared to GG 2. Consequently, the gross monetary returns (GMR) also increased by 24% and the net returns (NR) by 43%. The benefit cost ratio was 2.3 with TG 37 A compared to 1.8 with GG 2.

During *kharif*, the potential of improved varieties *viz.*, TG 37A and Girnar 2 was demonstrated in the farmers' fields to facilitate comparison with the popular variety GG 20. The results indicated that with TG 37A the pod yield was 1625 kg ha^{-1} while with GG 20 it was 1407 kg ha^{-1}. Thus by using TG 37 A, there was an advantage in pod yield by 15% and in haulm yield by 16% compared to GG 20 and consequently the GMR with TG 37 A was higher by 15.6% and the NR 28% over the popular variety GG 20. The benefit cost ratio was 2.6 with TG 37A compared to 2.2 with GG 20.

Table 5. Step-wise regression of independent variables on pod yield

Variables	*b*-value	SE of *b*	*t*-value
Constant	1602.264	62.242	25.743**
Household size	-20.283	9.126	-2.280*
Material possession	10.397	3.845	2.704**
Institutional contact (advisory)	81.293	28.309	2.872**
Adoption	80.813	40.32	20.045**
Adjusted 2 = 0.929; = 313.201**; SE of estimate 130.247			

*Indicates significance at P<0.05; **indicates significance at P<0.01

Balanced use of fertilizers

The package of balanced use of fertilizers (NPK) recommended by DGR was assessed in farmers' fields along with the farmers' practice of nutrient management through only DAP and Urea. The results of summer trials indicated that application of recommended of doses NPK through AS, SSP, and MOP, and also application of PGPR increased the pod yield of groundnut by 13% and haulm yield by 12% over farmers' practice. This also recorded 9% higher GMR and 11% higher NR over farmers' practice, whereas in *kharif*

Table 6. The performance and profitability of improved variety TG 37 A and popular variety GG 20

Economic indicators	Summer			*Kharif*		
	FP	IP	Increase over FP (%)	FP	IP	Increase over FP (%)
Pod yield (kg ha^{-1})	1833	2421	32.1	1407	1625	15.5
Haulm yield (kg ha^{-1})	2815	3012	07.0	2450	2850	16.3
CoC (Rs. ha^{-1})	24650	24650	-	18250	18250	-
GMR (Rs. ha^{-1})	43395	57389	32.2	40778	47137	15.6
NR (Rs. ha^{-1})	18749	32739	74.6	22528	28887	28.2
Additional NR (Rs. ha^{-1})	-	13990	-	-	6359	-
BCR	1.8	2.3	-	2.2	2.6	-

the pod and haulm yields increased by 7% each compared to farmers' practice. The CoC increased by 12%, GMR and NR increased by 15% and 7% respectively notwithstanding the decrease in BCR from 2.3 with farmers' practice to 2.2 with the improved practice. As the increase in net returns by the application of the recommended doses through their supply by AS, SSP, and MOP was not very encouraging, there appears to be a need for recommending alternative cheaper combinations of sources of these nutrients like urea, DAP, and MOP alongwith sources of sulphur and calcium.

Table 7. The performance and profitability of balanced use of fertilizers

Economic indicators	Summer			*Kharif*		
	FP	IP	Increase Over FP (%)	FP	IP	Increase Over FP (%)
Pod yield (kg ha^{-1})	1817	2100	15.6	1275	1475	15.7
Haulm yield (kg ha^{-1})	2605	2975	14.2	2800	3050	8.9
CoC (Rs. ha^{-1})	25340	27511	8.6	17500	19637	12.2
GMR (Rs. ha^{-1})	44645	49350	10.5	38112	43712	14.7
NR (Rs. ha^{-1})	19345	21839	12.9	22525	24075	6.9
Added NR (Rs. ha^{-1})	-	2494	-	-	1550	-
BCR	1.8	1. 8	1.7	2.3	2.2	-

Monitoring, evaluation and implementation of Frontline Demonstrations (FLDs) in groundnut

Planning of season wise FLDs

The technical programme for conducting FLDs was planned during the AICRP-G meetings or workshop for *rabi*-summer and *kharif* seasons. Accordingly, 642 FLDs were conducted in several states *viz.*, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and North eastern states during 2009-2010. In *rabi*-summer, 278 FLDs were conducted at 18 centres and in *kharif*, 364 at 20 centres. The FLDs were conducted on different aspects of improved technology such as Improved Variety, Integrated Nutrient Management (INM), Integrated Pest Management (IPM), Integrated Disease Management (IDM), Integrated Weed Management IWM), Plant Growth Promoting Rhizobacteria (PGPR) and groundnut based intercropping systems.

Evaluation and Reporting

The results of FLDs on improved varieties, averaged over all the centres, indicated that the pod and haulm yields increased by 33.3% and 25.5% respectively over local varieties. The GMR and NR increased by 37% and 60% respectively and the BCR increased from 2.43 to 2.84 compared to local varieties. The results of FLD on whole package indicated that the pod and haulm yields increased by 30.5% and 28.5% respectively over farmers' practice. The cost of cultivation increased by 9%, and the GMR and NR increased by 19% and 33%, respectively. The BCR increased from 2.43 to 2.67 with whole package compared to farmers' practice.

The FLDs on INM indicated that the pod yield of 2369 kg ha^{-1} could be realized with INM, which was 9% higher compared to farmers' method of nutrient management (2170 kg ha^{-1}). Due to INM, the cost of cultivation increased from Rs.17,067 ha^{-1} to Rs.18,070 ha^{-1}, whereas the GMR, NR and BCR increased from Rs. 47,731 ha^{-1} to Rs.52,109 ha^{-1}, Rs.30,667 ha^{-1} to Rs.34,039 ha^{-1}, and 2.8 to 2.9 respectively.

The FLDs on IPM indicated that compared to farmers' method of pest management, with IPM the pod yield and GMR increased by 9% each, and NR by 10%. The FLDs on IDM indicated that the pod yield with IDM was 2230 kg ha^{-1}, which was 17% higher compared to farmers' method of disease management (1900 kg ha^{-1}). The haulm yield also increased from 2395 kg ha^{-1} with farmers practice to 2610 kg ha^{-1} with IDM. The cost of cultivation increased from Rs. 17,990 ha^{-1} to Rs. 19,955 ha^{-1} with IDM, whereas the GMR, NR and ECR increased from Rs. 40,558 ha^{-1} to Rs. 49,038 ha^{-1}, Rs. 22.568 ha^{-1} to Rs. 29,083 ha^{-1} and 2.3 to 2.5 respectively.

The FLDs on IWM indicated that the pod yield, GMR and NR increased by 12% each as compared to farmers' method of weed management. Whereas the FLDs on PGPR indicated that the application of PGPR recorded an average pod yield of 2909 kg ha^{-1}, which was 13% higher than farmers' practice (2574 kg ha^{-1}). The haulm yield increased to 3236 kg ha^{-1} with PGPR, which was 10% higher than farmers' practice (3023 kg ha^{-1}). The economic analysis indicated that the cost of cultivation increased only slightly (2.7%) from Rs. 18,961 ha^{-1} to Rs. 19,491 ha^{-1}, the GMR and NR increased by 13% and 19% respectively with PGPR.

Training programmes organized at DGR

Model Training Course for officers of agricultural departments

A Model Training Course (MTC) on Farmer Participatory Research for Increasing Groundnut Production was organized for the extension functionaries of Andhra Pradesh, Chhattisgarh, Gujarat, Orissa, Maharashtra, Punjab and Tamil Nadu. The course covered the following topics and activities :

- Farmer participatory research approaches such as PRA
- Rapid Rural Appraisal (RRA) and Participatory learning and action (PLA)
- Present varietal development scenario of groundnut
- Improved groundnut production and protection technologies
- Farmer participatory evaluation of groundnut varieties: DGR experiences
- Farmer participatory evaluation of groundnut varieties: JAU experiences
- Use of Information and Communication Technologies (ICT) in Agricultural Extension Hands-on-experience of conducting FPR and developing ICT tools, and
- Field visits to DGR and JAU experimental fields, farmers' fields in and around Junagadh

The trainees were evaluated for their knowledge on 23 items covering all the aspects of the training course by administering a specifically designed test on the first day of the course and again on the last day of the course. The scores of 0 or 1 was assigned to each item for incorrect and correct response, respectively. The marks obtained by each trainee out of 23, were converted in to percent marks. The average per cent marks of trainees before and after the training were 47 and 83, respectively, there by indicating a substantial gain in knowledge due to training. There was improvement in the minimum score from 34.8% to 56.5% and in the maximum score from 69.6% to 82.6%.

Farmers training programmmes

- A three-day Farmers Training programmme on Groundnut Production Technology sponsored by ICRISAT was organized from 24.08.2009 to 26.08.2009. The farmers from four districts of Tamil Nadu attended the training programme.
- Farmers training programme on Low Cost Technologies for Improving Groundnut Production was organized first from 09.09.2009 to 13.09.2009 and then again from 17.03.2010 to 22.03.2010. The farmers from five districts of Orissa attended the training. The training was sponsored by the ISOPOM.

Farmers visits to DGR, Junagadh

Six groups each comprising farmers, students, or officers visited this directorate. Over 350 visitors from various states *viz.*, Gujarat, Rajasthan and Andhra Pradesh visited this directorate. The State Departments of Agriculture and State Agricultural Universities sponsored these visits. The visitors were shown round various field experiments, museum, and library and laboratories equipped with state-of-the-art equipments. The visitors were shown the audio-visuals about DGR and its activities. Interaction of visiting farmers, students, officers with the scientists of DGR was also organized.

PROJECT 14: BREEDING FOR LARGE-SEEDED AND CONFECTIONERY GROUNDNUT

(CHUNI LAL, RADHAKRISHNAN, T., A.L. RATHNAKUMAR, M.C. DAGLA*, VINOD KUMAR** AND S.K. BISHI*)

* January 2010 onwards
** Up to September 2009

Hybridization

During *kharif* 2009, ten crosses were attempted to incorporate the large seed size coupled with high yield. Advanced breeding lines from DGR, ICRISAT and BARC were used in the hybridization programme. A total of 1686 buds were pollinated and 480 probable hybrid pods were harvested and thus the success rate was 28% (Table 1).

Table 1. Crossing programme in *kharif* 2009

Sr. No.	Cross	Number of buds pollinated	Number of F1 pods harvested	Success rate (%)
1	ICGV 00440 x Girnar 2	198	78	39
2	PBS 29069 x ICGV 00440	277	63	23
3	PBS 29077 x ICGV 97079	207	59	29
4	PBS 29077 x ICGV 00440	144	45	31
5	PBS 29078 x ICGV 97079	202	63	31
6	PBS 29078 x ICGV 00440	181	47	26
7	PBS 29079A x ICGV 00440	98	20	20
8	PBS 29079B x ICGV 97079	109	26	24
9	TG 40 x ICGV 99101	138	37	27
10	TG 40 x ICGV 00440	132	42	32
	Total	**1686**	**480**	**28**

Raising of F_1s and identification of true hybrids

Ten crosses generated in *kharif* 2008 were raised along with parents and the true hybrids were identified on the basis of vigour of the plants and dominant male-characters. Pods of the identified plants were harvested separately for further advancement. Two doubtful crosses were rejected; from the remaining eight crosses, 28 confirmed hybrid single plants were identified.

Selection and generation advancement

In F_2 generation, 12 crosses were sown and true F_2s (segregating) were identified. In this generation also six crosses, which did not show segregation, were rejected. The remaining crosses were cross-wise bulk-harvested for advancing to next generation. Ten crosses in F_3 were sown and their progenies were harvested in bulk, after rejecting one cross with inferior attributes. Eleven crosses in F_4 were advanced without selection. Of these seven with inferior attributes were rejected. Similarly, 14 crosses were advanced from F_5 to F_6 generation. Phenotypic selections were made from the stabilized material in F_6 generations. In F_7 generation, seven new advanced breeding lines were developed from three cross combinations. Similarly, three advanced breeding lines were developed in F_8 generation from other three cross combinations (Table 2).

Table 2. Selections made in different filial generations (*kharif* 2009)

Generation	Crosses		
	Sown	Rejected	Selected
F2	10	2	8
F3	12	6	6
F4	10	1	9
F5	11	7	4
F6	17	3	14
F7 and F8	10 new advanced breeding lines selected		

Maintenance and multiplication of advanced breeding lines

To obtain sufficient seeds for different station trials, seeds of 29 advanced breeding lines were multiplied. Seeds of another set of 90 advanced breeding lines (14 Spanish and 76 Virginia types) were maintained.

Station trials

In *kharif* 2009, two yield evaluation trials were conducted. In both the trials, observations on pod and kernel yields, and related traits were recorded. The growth and yield of the lines were poor because of the prolonged dry spell coinciding with the reproductive phase of the crop.

Preliminary yield evaluation trial of advanced breeding lines

Twenty-five groundnut genotypes comprising twenty-one advanced breeding lines developed for large-seed types and four check varieties (TPG 41, GG 20, M 13 and Somnath) were evaluated in *kharif* 2009 in a replicated complete block design with three replications (plot size: 5 rows each of 5 m; row-to-row distance: 60 cm; and plant-to-plant spacing within a row: 10 cm).

The differences due to genotypes were highly significant for all the traits studied as was indicated by the analysis of variance. GG 20 was found to be the best check variety for all the traits and none of the genotypes surpassed this variety with respect to pod and kernel yields, SMK and shelling turnover (ST). However, a few advanced breeding lines were significantly superior to GG 20 for HSM (PBS 19022, PBS 29148 and PBS 29154) and HSMK (PBS 19022 and PBS 19023) (Table 3).

Table 3. Performance of promising advanced breeding lines in preliminary yield evaluation trial for large-seed size

Sr. No	Genotype	PY (kg ha^{-1})	KY (kg ha^{-1})	HSM (g)	HSMK (g)	SMK (%)	ST (%)
	Test entry						
1	PBS 19022	1593	1139	52*	63*	40	71
2	PBS 19023	1769	1186	48	63*	35	67
3	PBS 29148	1614	867	53*	59	26	54
4	PBS 29154	1243	830	51*	61	33	67
	Check						
1	TPG 41	1190	818	39	51	30	69
2	GG 20	1895	1375	45	57	50	72
3	M 13	1220	763	38	50	23	63
4	BAU 13	1020	587	42	54	33	58
	Mean	1347	833	42	53	30	61
	Range	798-1993	430-1375	37-53	44-63	18-50	52-72
	CV (%)	14	16	6	8	27	4
	CD (5%)	221	153	3	5	9	3

Advanced yield evaluation trial for large-seed

Single year

Twenty-four groundnut genotypes comprising twenty-one advanced breeding lines developed for large-seed types and four check varieties (TPG 41, GG 20, M 13 and Somnath) were evaluated for their performance in *kharif* 2009 in a replicated complete block design with three replications (plot size: 5 rows each of 5 m; row-to-row distance: 60 cm; and plant-to-plant spacing within a row: 10 cm).

Highly significant differences due to genotypes were found for all the traits studied as indicated by analysis of variance for these traits. GG 20 was found to be the best check for all the traits studied. None of the genotypes surpassed this best check variety with respect to the pod and kernel yields, SMK and shelling turnover. A few advanced breeding lines, however, performed significantly superior to the best check variety for HSM (PBS 29125 and PBS 29127) and HSMK (PBS 29117, PBS 29124, PBS 29125, PBS 29127 and PBS

29144, ICGV 00456 and ICGV 97079 (Table 4). This trial will be repeated for one more season.

Table 4. Performance of promising advanced breeding lines in yield evaluation trial for large-seed (*kharif* 2009)

Sr. No	Genotype	PY (kg ha^{-1})	KY (kg ha^{-1})	HSM (g)	HSMK (g)	SMK (%)	ST (%)
	Test entry						
1	PBS 29116	957	630	45	59*	40	66
2	PBS 29124	1584	1041	47	61*	41	66
3	PBS 29125	967	617	50*	62*	31	64
4	PBS 29127	1302	887	55*	68*	41	68
5	PBS 29144	1483	873	48	59*	30	59
6	ICGV 00456	1264	842	47	64*	42	67
7	ICGV 97079	1739	1181	50*	60*	46	68
	Check						
1	TPG 41	980	684	40	50	32	70
2	GG 20	1603	1159	46	54	46	72
3	M 13	985	643	44	52	33	65
4	BAU 13	745	450	39	52	27	60
	Mean	1097	696	44	55	36	63
	Range	415-1739	222-1181	38-55	47-68	27-46	53-72
	CV (%)	21	21	7	5	28	2
	CD (5%)	272	173	4	3	12	2

Advanced yield evaluation trial for large-seed

Two years

In *kharif* 2008 and 2009 seasons, 18 advanced breeding lines developed for large-seed were evaluated along with four check varieties (TPG 41, GG 20, M 13 and BAU 13). Analysis of variance revealed that differences due to genotypes were highly significant for all the traits studied. The G X E interactions were also significant.

The variation due to years was significant only for SMK and ST. On the basis of genotypic means, ICGV 97079 was significantly superior to best check for both pod and kernel yields. Similarly for HKW six advanced breeding lines (PBS 29124, PBS 29125, PBS 29127, ICGV 00451, ICGV 00456, ICGV 97079) and for HSMK, four advanced breeding lines (PBS 29124, PBS 29125, PBS 29127 and ICGV 00456); and for SMK only one line (PBS 29124), were found significantly superior to the respective best check variety (Table 5).

Table 5. Pooled analysis of 18 large-seeded advanced breeding lines (*kharif* 2008 and *kharif* 2009)

Sr. No	Genotype	PY (kg ha^{-1})	KY (kg ha^{-1})	HSM (g)	HSMK (g)	SMK (%)	ST (%)
	Test entry						
1	PBS 29093	850	525	47	55	40	62
2	PBS 290 96	928	582	46	54	38	63
3	PBS 29097	733	439	39	46	34	60
4	PBS 29116	1336	880	45	56	42	66
5	PBS 29117	852	534	42	53	36	63
6	PBS 29122	603	343	43	51	45	56
7	PBS 29123	1207	791	44	55	43	66
8	PBS 29124	1315	887	50*	61*	60*	68
9	PBS 29125	1111	711	50*	62*	35	64
10	PBS 29127	1235	850	53*	63*	52	69
11	PBS 29129	1020	630	41	48	37	62
12	ICGV 00451	1256	806	48*	58	40	64
13	ICGV 00456	1455	1003	53*	66*	59	69
14	ICGV 97079	1761*	1201*	49*	57	46	68
	Check						
1	TPG 41	940	636	39	46	34	67
2	GG 20	1408	1026	45	52	53	73
3	M 13	1187	794	45	53	39	67
4	BAU 13	1054	669	46	57	44	63
	CD (5%)	217	146	2	3	7	1

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

(S.K. BERA, P.C. NAUTIYAL, A.L. SINGH, RADHAKRISHNAN, T., CHUNI LAL AND P.P. THIRUMALAISAMY)

Characterization of wild *Arachis* accessions for the traits related to drought tolerance

The specific leaf area (SLA) of genotypes is being widely used as tool for selection for drought tolerance in crops on the basis of its being negatively associated with drought tolerance. The SPAD Chlorophyll Meter Reading (SCMR) has been found to be negatively associated with SLA. Both SLA and SCMR were recorded at two stages of crop growth (first on 20th March and then on 20th April 2009) in 88 wild *Arachis* accessions (Table 1).

The SCMR was in the range of 12.37 to 45.77 with a CV of 8.66% in March while it was in the range of 23.9 to 44.83 with a CV of 9.88% in April. The differences between the mean values for March (32.68) and April (33.77) were negligible (Table 1). As most of the wild accessions are perennial in nature, this variation in values indicated the environmental influence on this trait.

The SLA was in the range of 64.69 to 471.00 with a CV of 30.65% in March and 107.01 to 346.25 with a CV value of 16.84% in April (Table 1). Both the values for individual genotypes and the means of the population varied widely from March to April. The mean values are shown in Table 1. This indicated a significant influence of environment on this trait.

The change in the values of the individual genotypes (Fig. 1) and also the population mean from March (182.24) to April (143.66) revealed that SLA is much more influenced by environment than SCMR. As indicated by the values of most of individual genotypes and also the population means for March and April, the SLA was relatively quite low in April. Thus SLA is likely to be influenced more with change in environment than SCMR. Thus it would be more advantageous to use SCMR for selection than SLA in groundnut breeding.

Table 1. Variance of SCMR and SLA of 88 wild *Arachis* accessions

	SCMR		SLA ($cm^2 g^{-1}$)	
	20th March	20th April	20th March	20th April
Minimum	12.37	23.9	64.69	107.01
Maximum	45.77	44.83	471.00	346.25
Mean	32.68	33.77	182.24	143.66
CD(5%)	4.81	5.67	93.63	41.11
CV%	8.66	9.88	30.65	16.84

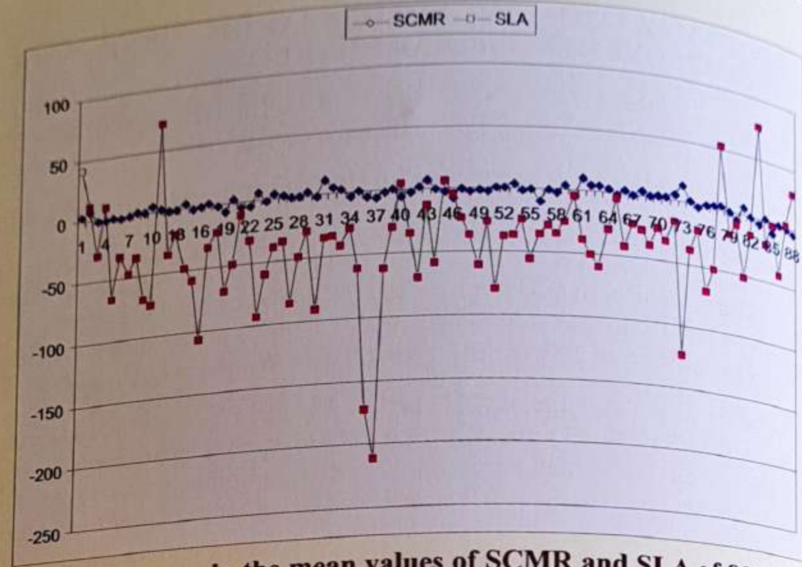


Figure 1. Change in the mean values of SCMR and SLA of 88 wild accessions at one month interval (each point depicts the magnitude of difference in the mean values recorded in March and April 2009)

For a given trait, the availability of stable genotypes with wider adaptability across the environments is the primary requirement of a breeding programme. For this purpose, SLA and SCMR of wild *Arachis* accessions were determined in *kharif* 2006 and 2007 and also in summer 2008 and 2009. The data was subjected to stability analysis over the four environments by standard statistical model. The accessions NRCG nos' 8188, 11793, 11810, 11815, 11823, 11831, 11836, 12036 and 12038 were identified to be more stable genotypes for their low mean SLA values, close to one b_i values, and small S^2d_i values. Similarly, accessions NRCG nos'. 8189, 8903, 11816, 11823, 11826, 11829, 11839, 12033, 12036 were identified to be stable genotypes for SCMR for their values slightly higher than mean, close to one b_i values and small S^2d_i values. Among these accessions NRCG nos' 11823 and 12036 were found to be stable for both SLA and SCMR a more desirable attribute for its use as a parent in breeding programme.

In vitro screening of wild *Arachis* accessions for tolerance of salinity

The calli generated from leaves of 28 wild *Arachis* accessions were screened *in vitro* for tolerance of salinity by incorporating NaCl in the growth media. The calli were subcultured in MS medium with 250 mM NaCl and allowed to grow for one month. The sodium and potassium ratio and chlorophyll (A+B) content have been reported as selection criteria for tolerance of salinity. In tolerant genotypes, the chlorophyll content increases under salinity stress. The chlorophyll content was higher in 250 mM NaCl-salinity than that in control (without NaCl) in all the accessions except 186 and 197 (Fig. 3) with maximum difference in the accession 189, followed by 179 thereby indicating that these two genotypes were least affected by salinity. This can be ascertained by analyzing sodium and potassium uptake ratio of calli concerned.

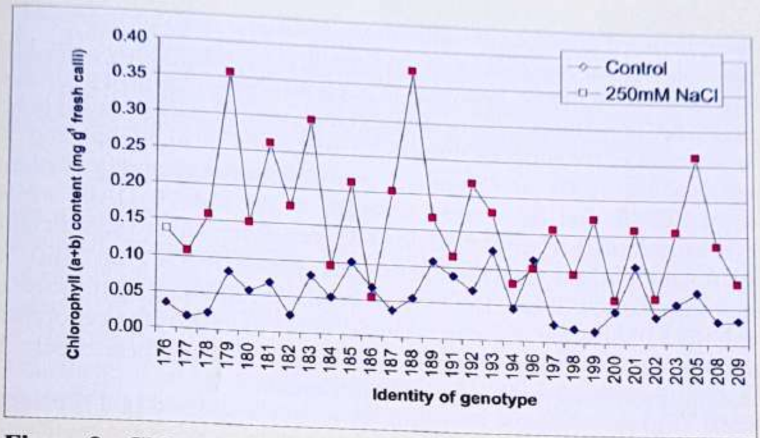


Figure 2. Chlorophyll content (mg g^{-1}) in the calli of 28 wild *Arachis* accessions growing under control and salt stress condition (250 mM NaCl)

Hybridization

Fresh hybridization was done in field conditions in *kharif* season to develop interspecific hybrids *vis-à-vis* introgression of desirable genes in cultivated groundnut. Cultivar J 11 was used as female parent in all the crosses, while accessions of various wild species namely *A. duranensis, A. appresipilla, A. regoni, A. diogoi, A. helodes, A. pusilla, A. corentina, A. kemf-mercadoi and A. kretschmeri* were used as male parents. For each cross, about 500 flowers were pollinated and the probable cross-pods were harvested. The highest number of probable cross pods (594) was harvested in the cross between J 11 and derivative of *A. pusilla* and the lowest number was harvested in the cross between GG 20 and derivative of *A. pusilla*. The probable cross pods will be sown in the field during ensuing rainy season for identification of true hybrids and their subsequent use in back crossing.

Evaluation of breeding lines

Initial evaluation trial

Advanced interspecific derivatives were evaluated in summer season for yield and yield related traits. Fifty-four genotypes were sown along with three checks in augmented design having three blocks. Each genotype was sown in two lines of three metre following standard crop management practices. Thirty-four genotypes gave pod yield higher than check, TAG 24 (128.7g $10pl^{-1}$). NRCGCS nos' 409, 385 and 411 gave hundred-kernel mass higher than 60 g and were identified as promising HPS genotypes.

Advanced evaluation trial

Promising interspecific derivatives were evaluated for yield and yield related traits during summer season. Twenty-four genotypes along with three checks were sown in RBD with 3 replications. Each genotype was sown in five lines of three metre bed by following recommended practices of cultivation. Statistical analysis indicated that none of the genotypes out-yielded the checks in pod yield (129.3 g ± 33.7). The pod yields of NRCGCS nos' 285 and 363 were, however, at par with checks. For pod yield and its related traits, 12 Spanish breeding lines were evaluated along with check (TAG 24) in rainy season. Genotypes were sown in five lines of three metre bed with line to line spacing of 45 cm and plant to plant spacing of 10 cm. Standard crop management practices were followed. Observation on SCMR and SLA were recorded at 45 and 70 DAE, while the other observations were recorded at harvest. None of the genotype differed significantly with best check (50.0g $10plant^{-1}$) in pod yield though the genotypes, NRCGCS nos' 360, 361, 366 and 401 were at par with the best check. Both the harvest index and shelling turnover of genotype CS 360 were higher than those of the best check, while in case of the genotypes NRCGCS nos' 401 and 361, only shelling turnover was higher than the best check. These three genotypes could be promising and need further evaluation.

Three Virginia advanced breeding lines were evaluated in a separate trial along with check (GG 20) for pod yield and its related traits during rainy season. Genotypes were sown in five lines of three metre bed with 60 cm spacing between lines and 10 cm spacing between plants. Standard crop management practices were adopted to raise the crop. Observation on SCMR and SLA were recorded at 45 and 70 DAE, while other observations were recorded at harvest. The pod yield of none of the genotypes was significantly different than that of the best check (4.9 g pl^{-1}). The pod yield of two genotypes, NRCGCS 385 and 376 was, however, numerically higher than that of the best check. Both the shelling turnover and harvest index of the genotype CS 385 were at par with the best check. The harvest index (28%) of NRCGCS 376 was, however, higher than that of the best check, but shelling turnover was lower. Thus, out of these two genotypes NRCGCS 385 was found to be promising.

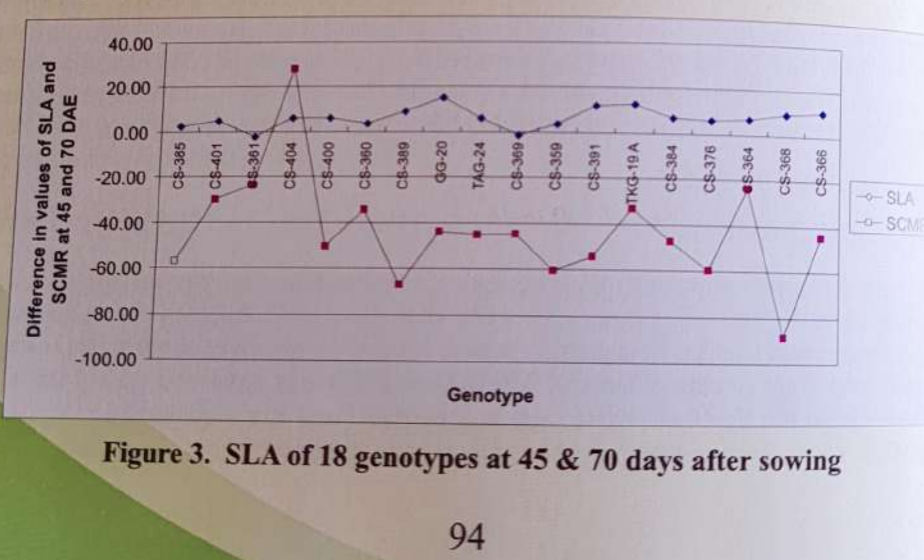


Figure 3. SLA of 18 genotypes at 45 & 70 days after sowing

The values of SLA of both Virginia and Spanish genotypes were higher at 45 then at 70 DAE except in NRCGCS 404 (Fig. 4) thus indicating that SLA in groundnut, in general, decreases with increase of the age of the crop. A similar trend was observed in wild *Arachis* species over environments i.e. 45 and 70 DAE. In the present study, the SCMR showed a trend opposite to that of SLA. i.e. the SCMR values of most of the genotypes were higher at 70 DAE than the values at 45 DAE with the exception of NRCGCS 361, 369 (Fig. 5) showing negligible differences only. Genotypes NRCGCS nos' 361, 385 and 401 were identified to be low-SLA and high-SCMR genotypes and may be used as donor parents in breeding programmes aimed at improving drought tolerance in groundnut.

Advancement of segregating progenies

In rainy season, 27 segregating progenies were sown in five lines of five metre bed for further selection. These progenies (F_6 to F_8) were derivatives of five wild *Arachis* accessions. Out of 27 progenies, 14 did not segregate further and were selected for evaluation under IVT. The pod yield, shelling turnover and hundred kernel mass of six progenies *viz*., JADU-164, JADU-108, JADU-119, JADU-120, JADU-60/A, JADU-138 were higher than those of GG 20 (semi spreading type) and the values of these attributes of the rest of eight genotypes were higher than those of TAG 24 (bunch type). The single plant selections from the segregating progenies were used for generation advancement.

Screening for tolerance of PBND

In *rabi* season at Raichur, 28 promising genotypes were screened for tolerance of PBND. The disease incidence was recorded at 40 and 60 DAS and also at harvest. Maximum disease incidence (56.25%) was recorded in GG 11. In NRCGCS nos' 107 and 171, less than 10% disease incidence was recorded at all the three stages. Thus these two genotypes were identified to be highly resistant to PBND while with a disease incidence of 10-20%, the genotypes NRCGCS nos' 50, 83, 103, 108, 164, 166, 205 and 221 were found to be moderately resistant.

Screening of genotypes for tolerance of *Alternaria* leaf blight

There was severe natural incidence of *Alternaria* blight in summer season in Junagadh and the surrounding areas. In DGR-farm, the disease incidence was in the range of 0% (in a few genotypes) to 80% in the genotype ICR 41. Interestingly, the multiple disease resistant interspecific advanced lines (NRCGCS nos' 19, 27, 70, 74, 77, 83, 85, 86, 124, 176,180, 186, 195, 196, 222, 240, 242, 244, 247, 249, 280, 285, 296, 298, 349, 396, 363), developed earlier at DGR were found to be free from the disease under field conditions and thus these lines possess resistance to *Alternaria* blight also.

Identification of multiple disease resistant genotypes

Interspecific groundnut derivatives were tested initially at Junagadh and then at Raichur for reaction to various diseases. For rust, early leaf spot, late leaf spot, PBND, stem rot and *Alternaria* leaf blight diseases, the reactions of all the 25 genotypes were in the range of tolerance to resistance. Eight genotypes, NRCGCS nos' 21, 77, 83, 85, 86, 124, 180 and 222,were identified to possess multiple disease resistance in fields for rust, early leaf spot, late leaf spot, PBND, stem rot and *Alternaria* leaf blight at two locations (Junagadh and Raichur) over years (2005-2009). The proposals for registration of these genotypes have been submitted to NBPGR, New Delhi for registration. Some of these multiple disease resistant genotypes are being used as donor parents in breeding programmes for incorporating resistance to biotic stresses.

Novel groundnut germplasm developed and registered

A 'crinkle-leaf white-testa' mutant was developed from the cross of 'crinkle-leaf rose-testa' mutant and 'normal-leaf white-testa' mutant while another 'crinkle-leaf red-testa' mutant was developed from the cross of 'crinkle-leaf rose-testa' mutant and 'normal-leaf red-testa' mutant. The trait of crinkle-leaf is dominant over normal-leaf while the trait of white or red colour of testa is dominant over rose colour.

Both the newly developed mutants were novel in the sense that the traits of 'crinkle-leaf' and white or red colour of testa segregate independently and are under monogenic control in the newly developed genotypes. Registration numbers INGR 09127 and INGR 09128 of these novel genetic stocks with 'crinkle-leaf white-testa' and 'crinkle-leaf red-testa', respectively was obtained with NBPGR, New Delhi.

Molecular analysis of salt tolerant wild accessions

Identification of sequences of cDNA fragments prepared from the transcriptomes of tissues having differential expressions is being used to discover the functional candidate genes. On the basis of chlorophyll contents and Na/K uptake ratio in leaf induced callus grown *in vitro* under salt stress (Table 2) (Fig. 7), two accessions of *A. glabrata viz.*, NRCG 11832 and NRCG 11817 (Fig. 6) were identified to be salt tolerant. These two genotypes are being now used to understand the mechanism of salt tolerance.

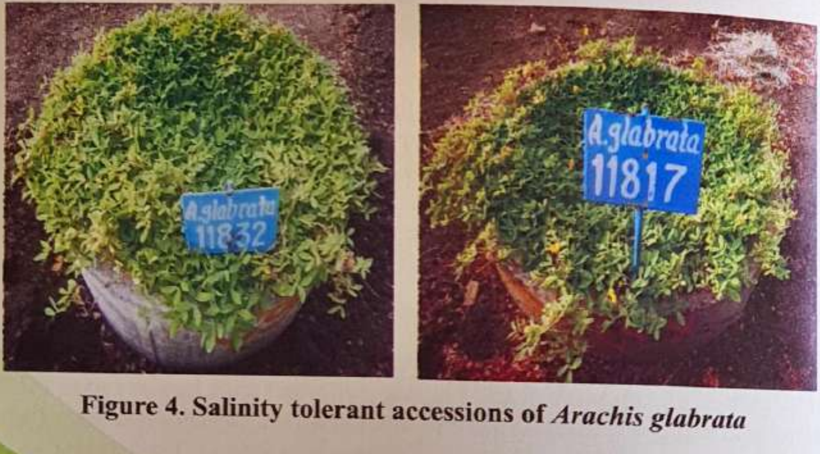


Figure 4. Salinity tolerant accessions of *Arachis glabrata*

Table 2. **Chlorophyll content of calli of three *Arachis* accessions growing separately in media having 0 and 250 mM NaCl**

Identity of *Arachis* accession	Chlrophyll A (mg g^{-1})		Chlorophyll B (mg g^{-1})		Chlorphyll A+B (mg g^{-1})		Carotenoids (mg g^{-1})	
	0 mM	250 mM	0 mM	250 mM	0 mM	250 mM	0 mM	250 mM
NRCG 8932#	0.340	0.136	0.076	0.017	0.416	0.153	0.139	0.049
NRCG 11832*	0.185	0.202	0.036	0.047	0.221	0.249	0.04	0.063
NRCG 11817*	0.077	0.093	0.012	0.024	0.089	0.117	0.016	0.048

#susceptible genotype; *tolerant genotype

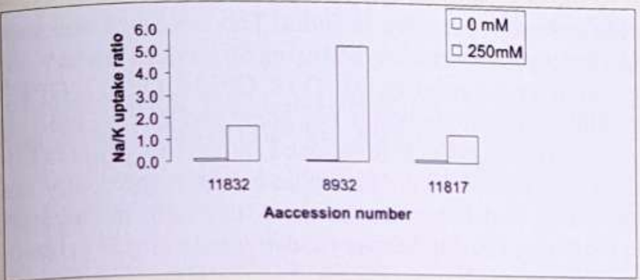


Figure 5. Na/K uptake ratio in the calli of one susceptible (NRCG 8932) and two salt tolerant (NRCG 11832 and 11817) *Arachis* Accessions

The transcriptomes isolated from the calli of salt tolerant genotypes (NRCG 11832 and 11817) were subjected to Differential Display Reverse Transcriptase (DDRT) analysis. More than 400 bands could be separated in agarose gel. The differentially expressed transcripts were collectively named as Groundnut Transcripts Responsive to Salt Stress (GTRSS). Five GTRSS bands, which were either induced or suppressed due to salt stress, were eluted from gel to understand the molecular mechanism of salt stress in groundnut at transcriptome level. The size of these five GTRSS amplicons was in the range of 400 bp to 900 bp. GTRSS-1 was an induced transcript, while GTRS-2 to 5 were suppressed transcripts. Four GTRSS (1, 2, 3 and 5) products out of five were sequenced. GTRSS-1 showed 94 matches in Gene bank with average of 90% sequence similarity. Out of 94 matches, the following four matches were found to be associated with abiotic stresses.

1) PvL006 *Phaseolus vulgaris* leaves under intermediate drought stress *Phaseolus vulgaris* cDNA clone 006 similar to Putative senescence associated protein (high identity), mRNA sequence- 91% similarity.
2) Water deficit stressed gmrtDrNS01 *Glycine max* cDNA 3', mRNA sequence- 91% similarity.

3) Potato abiotic stress cDNA library *Solanum tuberosum* cDNA clone POACM 35 5' end, mRNA sequence- 90% similarity.
4) Gc02 AAFCECORC cold stressed *Glycine clandestine* SSH *Glycine clandestina* cDNA clone Gc02 03a05, mRNA sequence- 93% similarity

As for GTRSS-5, it showed similarity with normalized cDNA library from cotyledons and young leaves of peanut *Arachis hypogaea*. GTRS-2 and GTRS 3 did not match with any of the identified gene sequences in the genomic database.

Identification of molecular marker linked with resistance of stem rot in groundnut

Among biotic factors limiting the production of groundnut in India, stem rot caused by *Sclerotium rolfsii* is considered to be of paramount importance as it is a soil-borne disease and is now of wide spread occurrence in India. The DNAs of one susceptible and three resistant groundnut genotypes were analyzed using 56 random primers out of which 55 were polymorphic. Among these, six primers D 9, D 17, OPI 14, OPI 17, OPT 3 and OPT 8 could amplify a larger number of unique bands per allele and can be used to design genotype specific primers. Out of the six primers mentioned above, four primers D 9, D 17, OPT 3 and OPT 8 generated 29, 17, 19 and 18 polymorphic bands, respectively with more than 95% polymorphism indicating that these four primers may help in fingerprinting of the four genotypes used in the study. The dendrogram constructed using 56 primers discriminated the four genotypes into two major clusters (Fig. 8).

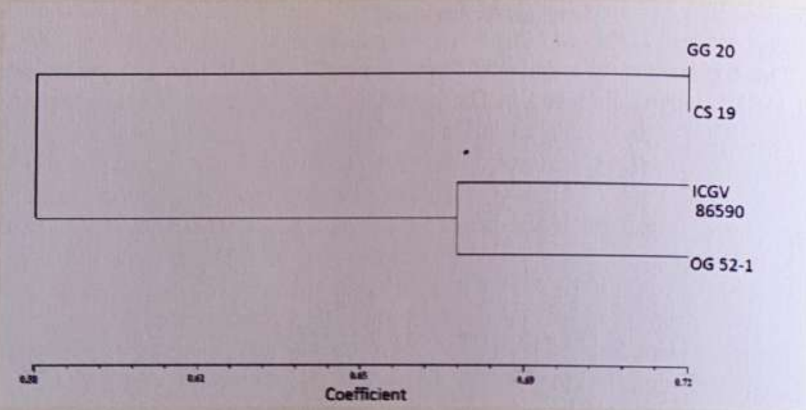


Figure 6. Cluster analysis of four groundnut genotypes (one susceptible and three resistant to stem rot) grouped on the basis of 56 RAPD primers

The analysis indicated that the cluster-I comprising GG 20 and CS 19 showed 72% similarity and the cluster-II, the major cluster, comprised two minor clusters. One minor cluster of ICGV 86590 the other minor of OG 52-1 having 67% similarities. Eleven F1 plants of GG 20 and CS 19 were subjected to RAPD analysis using16 selective primers to find heritable polymorphic bands which could be linked to stem rot resistance in groundnut. In 11 F_1 progenies, 16 selected primers reproduced as many as 22 fragments of varying sizes (100 bp to 1200 bp). These fragments are to be further amplified in F_2 progenies and validated with field resistance for identification of marker(s) linked to stem rot.

PROJECT 16: ECONOMICS OF GROUNDNUT CULTIVATION IN MAJOR GROUNDNUT GROWING AREAS

(G. GOVINDRAJ)

This project was under suspended animation for the period of this report as the PI of the project was on study leave.

PROJECT 17: BREEDING FOR IMPROVED FODDER QUALITY TRAITS IN GROUNDNUT

(A.L. RATHNAKUMAR, CHUNI LAL AND R.S. JAT)

Effecting crosses to develop six populations (P_1, P_2, F_1, F_2, B_1, B_2) for generation mean analysis

On the basis of earlier studies, two genotypes TG 37A and ALR 2 giving high pod yield and superior fodder quality were identified as parents for hybridisation. Two crosses (both direct and reciprocal) were made in *kharif* 2008 and one cross, ALR 2 x TG 37A, was

Table 1. Center-wise mean values of nitrogen content (%) in fodder of 15 groundnut genotypes and check varieties grown at four locations

Genotype	Location and rank									
	Vriddhachalam	Rank	Dharwad	Rank	Jalgaon	Rank	Junagadh	Rank	Mean	Rank
AG 2243	2.18	1	3.16	1	2.88	1	3.92	1	3.04	1
UG 10	2.08	2	2.44	6	2.59	7	2.87	9	2.49	6
CTMG 3	1.99	4	2.53	4	2.72	4	3.22	5	2.62	4
TG 60	1.95	5	2.76	3	2.79	2	3.25	4	2.66	3
AG 2244	1.79	7	2.32	11	2.53	10	2.60	14	2.31	12
TVG 0004	1.75	8	2.76	2	2.64	6	3.90	2	2.77	2
Dh 108	1.68	10	2.39	8	2.40	14	3.09	8	2.39	9
TCGS -APNL -888	1.62	11	2.23	13	2.64	5	2.85	10	2.34	11
J 71	1.57	12	2.20	14	2.53	9	3.17	7	2.37	10
TCGS -APNL -913	1.55	13	2.04	15	2.46	12	2.53	15	2.14	15
VG 0420	1.44	14	2.33	9	2.37	15	2.83	11	2.24	13
AG 2245	1.32	15	2.28	12	2.57	8	2.65	13	2.21	14
TAG 24 (NC)	2.01	3	2.46	5	2.44	13	3.18	6	2.51	5
TG 26 (ZC)	1.68	9	2.32	10	2.48	11	3.31	3	2.45	7
Dh 86 (ZC)	1.80	6	2.42	7	2.75	3	2.74	12	2.40	8
R 8808 (ZC)	-	-	2.30	-	2.44	-	2.71	-	2.48	-
CD (5%)	0.39		0.31		0.33		0.48		0.28	

develop the next six generations. Back-crosses and a fresh cross were effected in *kharif* 2008. All the six generations were raised in a randomised block design with three replications. The plants were harvested separately, generation and replication-wise, for analysis of fodder quality and to work out the inheritance of these traits. The samples have been sent to ILRI and ICRISAT for analysis.

Multi location evaluation of fodder quality in *rabi*-summer entries of AICRP-G

Fifteen IVT-I *rabi*-summer entries along with check varieties (national and zonal) evaluated during 2008-09 at four main AICRP-G centers, *viz*., Vriddhachalam (Tamil Nadu), Dharwad (Karnataka), Jalgaon (Maharashtra) and Junagadh (Gujarat) were harvested separately and analyzed for fodder quality. The center-wise mean values of nitrogen content in the fodder of the 15 genotypes are given in Table 1.

At all the four locations, the nitrogen content was highest in the fodder of the genotype AG 2243 with a mean value of 3.04%. This indicated not only the superiority but also the stability of this genotype for its fodder nitrogen content. Hence, this can be used as a donor parent for improving nitrogen content in the groundnut fodder. This other two genotypes with high fodder nitrogen content were TVG 0004 (2.77%) and TG 60 (2.66%).

The heritability estimates of the seven fodder traits (Table 2) indicated a very high value for nitrogen content (0.82). The trait of neutral fibre was found to be non-heritable as indicated by its estimated value of zero. The values for the other traits were moderate (Table 2).

Table 2. Heritability (in broad sense) values for fodder quality traits across 4 locations

Trait	Value
Nitrogen content	0.82
Neutral detergent fibre	0.00
Acid detergent fibre	0.36
Acid detergent lignin	0.31
Metabolizable Energy	0.26
IVOMD	0.24

The Additive Main Effect and Interact ve Multiplicative (AMMI) analysis was carried out with data on four locations and 15 genotypes to identify the best location and genotype through a biplot (Fig. 1). The location-2 (Dharwad) was the most congenial location and four genotypes *viz*., TG 60, AG 2244, UG 10, and CTMG 3 were found to be the stable. This experiment will be repeated for one more year.

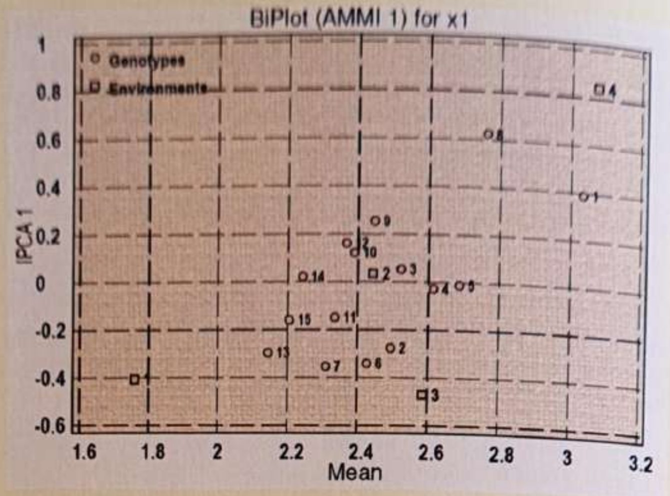


Figure 1. Biplot of genotypes and locations for nitrogen content

Removal and addition of nutrients by different wild species of groundnut in wasteland conditions

Seven wild species, though mostly rhizomatous and non-nodulating, were identified earlier for their potential of annually producing more than 2.0 tons of green biomass ha^{-1} in wastelands. Hence, an experiment was conducted to estimate the addition and removal of major nutrients (N, P, K) to and from the soil, respectively. The results are presented in Table 3.

Table 3. Addition of nitrogen and removal of phosphorus in soil by promising wild species, four years after field establishment

Species	Addition of nitrogen (kg ha^{-1} $year^{-1}$)			Total available phosphorus (kg ha^{-1} $year^{-1}$)	
	5^{th} year	6^{th} year	7^{th} year	6^{th} year	7^{th} year
A. appressipila	123.7	113.8	151	11.0	12.0
A. rigonii	111.2	105.5	176	22.0	17.0
A. marginata	110.2	114.9	171	11.0	3.0
A. prostrata	105.9	101.3	141	9.2	5.0
A. glabrata	103.1	106.9	179	8.6	14.0
A. hagenbeckii	117.0	98.2	147	6.6	10.0
A. pintoi	116.6	109.3	127	7.1	20.0
Control	75.0	72.0	69.0	21.0	21.0
CD (5%)	4.5	4.3	7.9	4.4	5.2

The nitrogen content of soil was determined in December before plantation of wild species and again after five, six and seven years. It was observed that, all the species studied enriched the soil nitrogen content. The maximum addition was brought about by *A. glabrata* (179 kg ha^{-1}) followed by *A. rigonii* (176 kg ha^{-1}) and *A. marginata* (171 kg ha^{-1}). The maximum removal of phosphorus was done by *A. marginata* followed by *A. prostrata and A. rigonii* (Table 3). Conversely, two species *viz*, *A. glabrata* and *A. hagenbeckii* brought about a substantial addition of phosphorous to the soil. The species, *A. pintoi*, however, did not affect the soil phosphorous content. The substantial removal of K could be noticed only in the 7^{th} year (data not shown).

With the establishment of wild species, interestingly, there was a slight change in soil pH from 7.8 to 8.1.

The study indicated that certain wild species of groundnut can efficiently remove P and K from and add nitrogen to the black calcareous wasteland soils and thus can play an important role in developing wastelands into a pasture land.

ALL INDIA COORDINATED RESEARCH PROJECT ON GROUNDNUT

The All India Coordinated Research Project on Groundnut (AICRPG) is a plan scheme approved for the periods of five years coinciding with Five-Year Plans of Govt. of India. The scheme came into being since the beginning of VIIIth Five Year Plant in 1992. The research under this scheme is pursued at 22 approved centres of which 21 are assigned to SAUs and one to CAU. Out of 22 centres, five function as main centres and 17 as supporting centres (fig. 1). The DGR is vested with the responsibility of providing scientific coordination of research activities and also regulating the flow and utilization funds. A few voluntary centres also contribute to the research activities of AICRP-G. The funding of this scheme is borne by the ICAR to extent of 75% while the SAUs associated with scheme bear to the extent of 25%. The Imphal centre under CAU, Manipur, however, is fully funded by the ICAR. The highlights of the achievements of AICRPG in the year 2009-10 are described here. During the year 2009-10, there was 100% utilization of the allocated funds (Rs 315 lakhs).

Each year, though the field experiments planned for rabi-summer are laid out much before the 31st March the analysed results become available only during June or July of the next financial year. Accordingly, the results of the rabi-summer experiments conducted in 2008-09 are included in the report of year 2009-10. The salient features of achievements of AICRP-G are described below.

Figure 1. Centres of AICRP-G

CROP IMPROVEMENT

Maintenance and evaluation of groundnut germplasm

In *rabi*-summer (2008-09), 40 accessions of wild *Arachis* spp. and 2605 germplasm accessions and advanced breeding lines belonging to four habit groups were maintained at six centres *viz.* Anand, Chinthamani, Shirgaon (Ratnagiri), Rahuri, Kadiri and Vridhachalam. For yield and related traits, 280 accessions were evaluated at two centres *viz.*, Rahuri, 230 accessions and Shirgaon, 50 accessions. Among these 50 accessions were found promising for yield, two for earliness, three for drought tolerance and seven for large seeds.

About 100 germplasm accessions were screened at Raichur, a hotspot centre for PBND. Two germplasm accessions ICG-14015 and ICG-52457 suffered less than 5% incidence while one accession ICG-11687 and two inter specific hybrid derivatives CS-171 and CS-107 suffered less than 10% incidence of PBND. In comparison the susceptible genotype CS 161 suffered 50% incidence.

In *kharif* 2009, 57 wild accessions, 92 interspecific hybrid-derivatives and 4088 groundnut germplasm/advanced breeding lines belonging to four different habit groups were maintained at ten centres located in Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Rajasthan and Tamil Nadu.

Hybridisation and selection

In *rabi*-summer (2008-09), 163 crosses were attempted at ten AICRP-G centres for developing high-yielding groundnut cultivars possessing earliness, fresh seed dormancy, and tolerance of major biotic stresses.

In *rabi*-summer (2008-09), among various varieties used by the breeders, TG 37A was most extensively used as a donor for high yield, earliness and compact fruiting. For incorporating tolerance of foliar fungal diseases like ELS, LLS and rust, the variety GPBD 4 was used as a donor. For tolerance of PBND, two varieties GPBD 4 and VG 9816 were used extensively as donors.

In *kharif* 2009, two hundred single crosses and eight double-crosses were made using different cultivars, advanced breeding lines, germplasm accessions. The segregating generations of objective specific inter-varietal and intra-varietal crosses made at 16 AICRP-G centers earlier, were advanced to next filial generations.

Progenies of 955 crosses were advanced to their respective next filial generation during *kharif* 2009 and 8,400 selections were made at 15 AICRP-G centres. The selections comprised large number (4389) of single plants and 4111 line/progeny bulks. Of the total crosses, which were advanced to different filial generations, 48% were in early generations (F_2-F_4) and the rest (52%) in the advanced generations (F_5 and onwards). A majority of single plant selections made during the last season were in early generations (69%) and the rest (31%) in advanced generations. The same was true in case of progeny bulks also, where the early generation selections (62%) constituted more than the selections made (38%) in the advanced generation selections.

Interspecific hybridisation

At Vriddhachalam, nine inter-specific crosses were made in the *rabi*-summer season 2008-09 using four agronomically superior genotypes (TAG 24, ICGV 91279, VRI Gn 6, and ICGV 92029) and nine different amphidiploids of wild *Arachis* species were raised. From these crosses 221 true F_1s were isolated.

Progenies of eight interspecific crosses beween the agronomically superior varieties and various amphidiploids of wild species were evaluated in F_3 generation in *kharif* 2009 and 371 selections were made. Maximum selections (107) were made in the cross, ICGV 92029 x (*A. stenosperma* x *A. cardenasii*), followed by (80) the cross, VRI (Gn)- 6 x (*A. duranensis* x *A. khulmanis*).

In *kharif* 2009, in F_5 generation 164 selections; in F_6 generation11 selections, and in F_8 generation13 selections were made from the interspecific crosses produced earlier at this centre.

Selections from DGR breeding material

Sharing of segregating and advanced breeding material developed at DGR with the breeders at AICRP-G centres to enable them make location specific selections lead to identification of several promising genotypes in various filial generations. The genotypes were selected for earliness, fresh seed dormancy, large seed size, resistance to insect pests and resistance to major soil borne, foliar fungal and viral diseases.

In *rabi*-summer, selections made for large-seeds from different crosses in advanced generations had the progenies with seed size (hundred seed mass, HSM) in the range of 37.1 g (PBS 24030 X TG 37 A) to 102.4 g (PBS 24030 X TG 37 A). Progenies of two other crosses, GG 20 X ICGV 87280 (101.8 g) and ICGV 86564 X ICGV 91114 (101.3 g) also recorded >100g HSM.

In *kharif* 2009, segregating and advanced generation breeding materials belonging to as many as 23 crosses were supplied to 5 AICRP-G centres for location specific selections and further advancement. Out of these crosses, 478 promising location specific selections were made for further advancement.

Breeding materials supplied by ICRISAT and selections made

Several populations of crosses made at ICRISAT for specific traits were supplied to 12 AICRP-G centres (Akola, Tirupati, Dharwad, Chinthamani, Mohanpur, Manipur, Durgapura, Mainpuri, Ranchi and Hanumangarh).

Varieties released and promising genotypes in pipeline during *rabi*-summer 2008-09

Two varieties VRI Gn 6 (VG 9816) and TMV Gn 13, both developed at Vridhachalam centre, were released for Tamil Nadu for *kharif* and *rabi*-irrigated conditions. A few other genotypes are likely to be released soon while several others are at different stages of yield evaluation at various AICRP-G centres.

Varietal Evaluations

Initial Varietal Trial (IVT Stage-I)

In *rabi*-summer 2008-09 season 23 new Spanish bunch entries were evaluated. In *kharif* 2009, seventeen new entries of Spanish bunch and eleven entries of Virginia type were evaluated in all the test locations across the four zones.

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

In 2008-09 *rabi*-summer season, 12 entries were tested for two years in all the four zones. Two entries, VG 0420 (pods: 2823 kg ha^{-1} and kernels: 1771 kg ha^{-1}) and TG 60 (pods: 2363 kg ha^{-1} and kernels: 1653 kg ha^{-1}) gave with significantly higher pod (2119 kg ha^{-1}) and kernel (1423 kg ha^{-1}) yields over the check variety R 8808. Thus, both VG 0420 and TG 60 were promoted to AVT in zone IIIb.

In *kharif* 2009, seven Spanish bunch and six Virginia entries were tested for two years in all the five and four zones, respectively. Among Spanish bunch entries, none and among Virginia, the genotype, RG 510 in zone I and JSSP 35 in zone were promoted to AVT.

Advanced Varietal Trial (AVT)

In *rabi*-summer 2008-09, this trial was conducted only in one zone *viz*., IIIb. There were only two entries, ICGV 00350 and AK 303. Over three years, the entry ICGV 00350 with 2988 kg ha^{-1} and 1944 kg ha^{-1} of pod and kernel yields, respectively, exhibited yield superiority over the best check of the zone, TAG 24 which gave 2296 kg ha^{-1} and 1578 kg ha^{-1} of pod and kernel yields, respectively. This entry also showed tolerance of foliar fungal diseases and thrips and hence was proposed for identification in zone IIIa. The other qualifying entry was not found meritorious enough to be proposed for identification.

In *kharif* 2009, the Virginia bunch genotype, HNG 123, which exhibited an increase in pod and kernel yields of 24.7 and 25.1% over M 13 (NC); 42.2 and 44.0% over Kaushal (NC); 22.2 and 24.4% over CSMG 84-1 (ZC) and 18.6 and 15.3%, over HNG 10 (ZC) respectively, was proposed for identification in Zone I (Rajasthan, Uttar Pradesh, and Punjab).

Under Spanish bunch group, two genotypes ICGV 00350 and J 70 were proposed for identification in Zone II (Gujarat, Southern Rajasthan). The pod and kernel yields of ICGV 00350 were respectively 32 and 29% higher than those of JL 24 (NC); while the corresponding values for higher yields given by J 70 were 27.8 and 29.5%, respectively.

Likewise, the pod and kernel yields of ICGV 00350 were respectively 13.1 and 12.1% higher over TG 37A (ZC). The pod and kernel yields of other qualifying entry, J 70 were respectively 9.5% and 12.6% higher than those of TG 37 A. Compared to GG 2, the entry, ICGV 00350 recorded 20.5 and 20.2% higher pod and kernel yields while those of J 70 were respectively 21.5 and 20.6% higher. The yield advantage of ICGV 00350 over GG 7 (ZC) was 16.1 and 12.6% for pod and kernel, respectively and that of J 70 was 12.4 and 13.0%, respectively.

Breeder seed production

For the year 2008-09, a total indent of 22897.20 q breeder seed of 58 groundnut varieties was received from DAC. The varieties TMV 2 (11843 q.) and JL 24 (5567.90 q) together comprised more than 50% of the total indent.

Depending on the availability of nucleus/breeder seed stage-I, a combined target of production 9065.10 q was assigned to 19 groundnut breeder seed production centres/ /agencies.

However, during *kharif* 2008, only 2552.45 q breeder seed could be produced. Therefore, to overcome the shortfall, compensatory breeder seed production programme was launched in *rabi*-summer 2008-09 and an additional 4992.00 q of breeder seeds was produced. Thus, during 2008-09, a total of 7544.45 q breeder seed was produced and there was a shortfall of 1520.65 q.

CROP PRODUCTION

Survey of agronomic management practices in the farmer's field

The survey conducted in *rabi*-summer 2008-09 revealed that in most states, the farmers continued to grow old or some local cultivars, however, in the state of Gujarat, most of the farmers cultivated relatively recent varieties. Application of herbicides, micronutrients and bio-fertilizers was not being generally practiced but the awareness of the need for application of gypsum was slowly growing among the farmers in most states.

The survey conducted in *kharif* 2009, revealed that depending on location 65 to 75% farmers did not adopt all the components of the recommended package of practices (optimum seed rate/plant population; application of balanced NPK fertilizers, gypsum and critical micronutrients like Fe, Zn, Mo and B; treatment of seeds with bio-fertilizers/fungicides; application of herbicides for weed control, and use of high-yielding and disease resistant/tolerant cultivars.

Some centres reported that the cultivation of the groundnut is becoming less remunerative due to enhanced cost of cultivation and low returns. High-value and competitive crops like Bt-Cotton and maize are replacing groundnut in the traditional *kharif* groundnut areas especially in the states of Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh.

Most of the farmers were not aware of integrated weed management practices comprising application of pre-emergence herbicides (Pendimethalin, Alachlor, or Fluchloralin) and post emergence herbicides (Quizalofop ethyl 5 EC or Imazethapyr 10 WC) and inter-culture operations.

Use of straight fertilizers like urea, single super phosphate, muriate of potash and to some extent di-ammonium phosphate was hardly practiced by the farmers due mainly to their non-availability. Most of the farmers used complex fertilizers (17:17:17 or 19:19:19). The farmers generally did not follow the practice of integrated nutrient management (INM) comprising applications of organic manures/compost and the recommended doses of fertilizers. Use of low-seed rate and wide spacing in groundnut cultivation was quite common across the country. Non-availability of quality seeds of high yielding/improved cultivars in sufficient quantities at the time of sowing was another major constraint in almost all the states. High cost of seed and erratic rainfall either with dry spells at critical stages or incessant rainfall at flowering stages smothered the groundnut crop.

Effect of bio-fertilizers on productivity of groundnut in rice fallows during *rabi*-summer 2008-09

At Chinthamani, application of bio-fertilizers (*Rhizobium* NRCG 9, IGR-6 and TNAU 14) as seed treatment and application of RDF, improved the pod yield over the application of RDF alone. Seed treatment with NRCG 9 and application of RDF produced higher net returns (Rs. 30,316 ha^{-1} with a higher B:C ratio of 2.63) as compared to application of RDF alone (net returns Rs. 27,269 ha^{-1} and B:C ratio 2.44) and control (net returns Rs. 3,297 ha^{-1} and B:C ratio 1.20).

Effect of rice cultivars differing in their duration of maturity on the productivity of groundnut in rice groundnut sequence cropping system in *rabi*-summer 2008-09

Cultivation of short duration (90-100 days) rice cultivars followed by criss-cross sowing of groundnut in the rice-groundnut cropping system was found to be most rewarding at Jhargram.

Integrated nutrient management in rice-groundnut cropping system during *rabi*-summer 2008-09

In rice-groundnut cropping system, over two years, the application of the recommended doses of nitrogen and phosphorus to rice and recommended doses of nitrogen and phosphorus + *Rhizobium II* (IGR 6) to groundnut gave the highest yield and economic returns from groundnut at Jhargram and Vyara.

Management of micronutrient nutrition during rabi-summer 2008-09

Significant improvement in yield and economic returns were obtained with the application of one or more micronutrients at the following locations:

- Aliyarnagar: Soil application of borax @ 17.6 kg ha^{-1} (2 kg B ha^{-1}), 50% as basal and 50% at 30 DAS
- Jhargram: Soil application of $ZnSO_4$ @ 20 kg ha^{-1} along with RDF
- Vriddhachalam: Soil application of $ZnSO_4$ @ 30 kg ha^{-1} + boron 2 kg ha^{-1} (seed treatment) along with RDF increased the pod yield
- Junagadh: Soil application of borax @ 6 kg ha^{-1} or seed treatment with MoO_4 @ 1.0 kg ha^{-1}

In *kharif* 2009, soil application of zinc and boron at Chintamani; boron at Hanumangarh; iron and zinc at Ludhiana, and zinc at Ratnagiri enhanced the pod yield. Further, the soil application of micronutrients was found superior to seed dressing at most of the centres.

Application of organic manure, biofertilizers and biopesticides during rabi-summer 2008-09

Application of poultry manure + biofertilizers + biopesticides at Rahuri, Vriddhachalam and Aliyarnagar; FYM + RDF (25:75:25) at Dharwad and Kadiri; and FYM + biopesticides (neem cake @ 500 kg ha^{-1} + *Trichoderma* seed treatment @ 5 g kg^{-1} + Neem Seed Kernel Extract 2%) at Junagadh were found effective in increasing groundnut yields.

Evaluation of post emergence herbicides during rabi-summer 2008-09

Use of fluchloralin 0.9 kg a.i. ha^{-1} + one hand weeding at 45 DAS at Aliyarnagar; and pendimethalin 1.0 kg a.i. ha^{-1} + one hand weeding at 30-35 DAS at Rahuri, Jhargram and Kadiri) were found effective in controlling the weeds. Use of pendimethalin 1.0 kg a.i. ha^{-1} + quizalofop ethyl 50 g a.i. ha^{-1} at Jagtial, Ratnagiri and Junagadh; and pendimethalin 1.0 kg a.i. ha^{-1} + imazethapyr 50 g a.i. ha^{-1} at Vriddhachalam were found to be the best herbicide treatments.

Intercropping of groundnut with sugarcane during *rabi*-summer 2008-09

At Rahuri, intercropping of sugarcane (Co 94012) with groundnut (TPG 41) at 1:2 row ratio gave the highest gross monetary returns (Rs. 1,11,964 ha^{-1}), net monetary returns (Rs. 57,903 ha^{-1}) and B:C ratio (2.07) in the entire cropping cycle.

Evaluation of groundnut cultivars for late sown conditions during *kharif* 2009

Delayed sowing by 7 to 21 days than normal sowing i.e. immediately after the monsoon rains in *kharif* season, resulted in 5.8 to 73.2% reduction in pod yield of groundnut. The yields of most of the AVT entries reduced with every week of delay in sowing.

Under the late sown conditions, the performance of cv. Chinthamani 1 in Karnataka (Chinthamani), GG5 in Gujarat (Junagadh), Kadiri Harithandhra in Andhra Pradesh (Kadiri) and VRI 7 in Tamil Nadu (Vriddhachalam) was, however, better over the other entries.

Evaluation of post-emergence herbicides in groundnut during *kharif* 2009

Pre-emergence application of pendimethalin 30 EC @ 0.75 to 1.0 kg a.i. ha^{-1} + one hand weeding at 40 to 45 days after sowing was very effective in controlling the weeds in groundnut in *kharif* season. Post-emergence application of either quizalofop ethyl 5 EC @ 50 g a.i. ha^{-1} at 20 days after sowing or imazethapyr @ 50 to 75 g a.i. ha^{-1} at 20 days after sowing reduced the weed density and enhanced the efficacy of weed control in groundnut.

Development of packages for organic groundnut in *kharif* 2009

Application of FYM pretreated with microbe @ 7.5 t ha^{-1} + seed treatment with bio-fertilizers and bio-pesticides, and foliar spray of either *Pseudomonas* @ 1% at 40 to 45 days after sowing or of Neem Seed Kernel Extract (NSKE) @ 5% at 42 to 45 days after sowing or foliar spray of 'panchagavya' @ 3% at 40 to 45 days after sowing was found beneficial in organic groundnut production.

Optimization of requirements of potassium and calcium fertilizers for groundnut in *kharif* 2009

Application of higher doses of potassium and calcium fertilizers was found to increase pod yield of groundnut in sandy and sandy loam soils. Higher doses of potassium and calcium fertilizers, however, did not enhance pod yield of groundnut in medium black soils. Split application of none of these fertilizers was beneficial over the basal application of the entire quantity.

Management of sulphur and calcium nutrition in groundnut through gypsum application in *kharif* 2009

In sandy soils and sandy loam soils, application of gypsum @ 400 to 600 kg ha^{-1} increased the pod yield of groundnut. However, groundnut did not respond to application of gypsum in medium black soils. Basal application of entire quantity of gypsum was found to be better than split application.

CROP PROTECTION

Disease situation

In *rabi*-summer 2008-09, at Aliyarnagar, foliar diseases like late leaf spot (LLS) and rust were severe while at Dharwad the incidence of these diseases was moderate. At other centres these diseases were not severe. Incidences of soil borne diseases were low at Dharwad, Junagadh, Kadiri, Raichur and Vriddhachalam. Incidence of PBND was high at Raichur (up to 50% at harvest). At Junagadh, appearance of new diseases like pepper leaf spot and *Alternaria* leaf blight were noticed in certain farmers' fields.

In *kharif* 2009, at Aliyarnagar, LLS and rust appeared in a severe form while stem rot incidence was moderate. During survey, low incidence/intensity of collar rot, ELS and PBND were observed in farmers' fields.

At Dharwad, LLS and rust were severe while stem rot was moderate. All the 13 fields surveyed had the infection of stem rot, LLS and rust. At Hanumangarh, collar rot was very high and moderate incidence of root rot and PBND were noticed. ELS appeared in severe form as compared to LLS. At farmers' field in Hanumangarh, collar rot was very high but the intensity of ELS and PBND were very low and stem rot and LLS were in moderate form.

At Jalgaon, intensity of ELS and rust were very low. The incidence of collar rot, stem rot, rust and PBND were very low in farmers' fields though LLS appeared in moderate to severe form. Very low incidence of collar rot, stem rot, LLS and rust were noticed at Junagadh both at research farm and the farmers' fields. However, *Alternaria* leaf spot was observed in most of the fields surveyed.

At Kadiri, ELS, stem rot, dry root rot and PSND appeared in moderate form at research station as well as at farmers' fields.

Management of viral diseases of groundnut through eco-friendly approaches in *rabi*-summer 2008-09

Since, the incidence of the two viral diseases, PBND and PSND even in the susceptible variety was below 20%, no-meaningful conclusion could be drawn on the bio-efficacy of the treatments. At Jalgaon, however, spray of 10% aqueous leaf extract of *neem* or *datura* was found to be equally effective as only 3.33% disease incidence was recorded with each. The seed-treatment with imidacloprid (5ml kg^{-1} seeds) was the next best treatment and found to be effective up to 50 DAS.

At Kadiri, seed treatment with imidacloprid (5ml kg^{-1} seeds) gave the lowest incidences of PSND (6.6%) and PBND (2.6%) as compared with other treatments.

Studies of compatibility of *Trichoderma viride* with various fungicides used for seed-treatment in groundnut in *rabi*-summer 2008-09

Seven fungicides which are commonly used for seed treatment *viz*., mancozeb, captan, propiconazole, hexaconazole, vitavax, carbendazim and tebuconazole (raxil 2% DS) were tested *in vitro* to study the compatibility of *T. viride* with these fungicides. The results indicated that *T. viride* was highly compatible with mancozeb (as the biological control agent showed 100% growth in all concentrations of mancozeb) followed by captan. However, three fungicides *viz*., propiconazole, hexaconazole and carbendazim completely inhibited the growth of *T.viride*. The biocontrol agent *T. viride* was found to be sensitive to tebuconazole and higher concentrations (>500 ppm). Therefore, it was concluded that mancozeb and *T. viride* can safely be combined for seed treatment. Captan may also be used up to 1000 ppm as at this concentration it does not exert any inhibitory effect on the growth of *T. Viride*.

Management of dry root rot (*Rhizoctonia bataticola*) during *rabi*-summer 2008-09

At Kadiri, seed treatment with *Trichoderma* @ 4 g kg^{-1} of seed + soil application of *Trichoderma* @ 2.5 kg ha^{-1} recorded lowest dry root rot incidence of 5.5% as compared to 15.1% of control. In addition, this combination of treatments also gave a high pod yield (2335 kg ha^{-1}) and the highest cost benefit ratio of 1:3.3. At Vridhchalam also, the same treatment performed the best.

At Raichur, seed treatment with mancozeb @ 4 g kg^{-1} seed recorded the least disease incidence (2.32%) and the highest pod yield (2412 kg ha^{-1}), followed by seed treatment with *P. fluorescens* + soil application of *P. fluorescens* (disease incidence: 2.83 % and pod yield: 2316 kg ha^{-1}).

Among various treatments tried at Vriddhachalam and Kadiri, seed treatment with *Trichoderma* (4 g kg^{-1} seed) + soil application of *Trichoderma* (2.5 kg h^{-1}) gave significantly higher initial and final plant stands and the lowest incidence of dry root rot. At Vridhachalam the yield of control was 1268 kg ha^{-1} and that of treatment was 1596 kg ha^{-1}. At Kadiri, the yield in control was 1928 kg ha^{-1} and in treatment 2606 kg ha^{-1}; and the B:C ratio was 1:2.3 in control and 1:3.3 in treatment.

Evaluation new fungicides for controlling soil borne diseases by seed treatment in *kharif* 2009

At Dharwad, propiconazole significantly lowered the incidence of stem rot and was followed by captan. Although the differences in yield were not significant, the highest yield was obtained in hexaconazole @ 2ml kg^{-1} seed. At Hanumangarh, tebuconazole 2DS @1.5g kg^{-1} seed, significantly reduced collar rot and propiconazole was the next best.
At Jalgaon, hexaconazole @ 2ml kg^{-1} seed or tebuconazole 2DS @1.5g kg^{-1} seed were effective in reducing collar rot and stem rot and the highest pod yield was also obtained in these treatments. Similarly, tebuconazole 2DS @1.5g kg^{-1} seed was found highly effective in reducing collar rot and stem rot at Junagadh.

At Vriddhachalam, tebuconazole 2DS @1.5g kg^{-1} seed was highly effective in reducing stem rot and root rot and the highest pod yield and BCR were obtained in this treatment. At Raichur also, tebuconazole 2DS @ 2.0g kg^{-1} seed was effective in reducing stem rot and the highest pod yield was also obtained in this treatment.

At Dharwad, the data of two years revealed that there was a significant reduction in stem rot with hexaconazole + captan while propiconazole and tebuconazole were relatively less effective. At Hanumangarh, tebuconazole 2DS @1.5g kg^{-1} was found superior in reducing collar rot and the highest BCR was also obtained in this treatment. Tebuconazole was found superior in reducing collar rot and stem rot at Junagadh with the highest CBR. At Raichur too, with the highest CBR, tebuconazole was found the best in reducing stem rot. Based on these data, it was concluded that out of ten treatments, seed treatment with tebuconazole 2DS @1.5g kg^{-1} seed was highly effective in reducing collar rot and stem rot.

Integrated management of major diseases of groundnut during *kharif* 2009

At Dharwad, LLS and stem rot reduced significantly with application of *Trichoderma* as seed and soil treatments along with spray of hexaconazole. While, the minimum ELS and the highest pod yield were recorded in seed treatment with *T. harzianum* @10 g kg^{-1} + soil application of *T. harzianum* @ 4.0 kg ha^{-1} + soil application of castor cake @ 250 kg ha^{-1} + two foliar sprays of hexaconazole @1.0 ml l^{-1}.

At Jalgaon, seed treatment with *Trichoderma* 10g kg^{-1} and soil application (4 kg ha^{-1}) along with neem cake 250 kg ha^{-1}, followed by two sprays of hexaconazole 1ml l^{-1} (T5) significantly reduced the incidence of collar rot, stem rot, *tikka* and rust with a corresponding increase in pod yield.

At Junagadh, the lowest incidence of collar rot and stem rot were observed in pots the seed treatment with and spray of tebuconazole. This was followed by seed treatment with *Trichoderma* @ 10 g kg^{-1} + soil application of *Trichoderma* @ 4 kg ha^{-1} + castor cake @ 200 kg ha^{-1} + two sprays of hexaconazole @ 1 ml l^{-1}. However, the highest pod and fodder yields were obtained with seed treatment with *Trichoderma* @ 10 g kg^{-1} and its soil application @ 4 kg ha^{-1} with castor cake @ 200kg ha^{-1} + two sprays of hexaconazole @ 1 ml l^{-1}.

At Kadiri, significant reduction of collar rot was recorded with seed treatment with tebuconazole (1.5g kg^{-1}) + two foliar sprays of tebuconazole (1ml l^{-1}) while dry root rot was reduced in mancozeb + two sprays of hexaconazole. The lowest incidence of stem rot was recorded by seed treatment with *Trichoderma viride* (10 g kg^{-1}) + soil application of *Trichoderma viride* (4.0 kg ha^{-1}) + neem cake (250 kg ha^{-1}) + two sprays of hexaconazole (1 ml l^{-1}). At Raichur, seed treatment with mancozeb (2 g kg^{-1}) + two sprays of hexaconazole (1 ml l^{-1}) was effective in controlling stem rot, late leaf spot and rust.

Insect pests

Insect pest situation during *rabi*-summer 2008-09

- At Dharwad, high infestations of *Spodoptera* (30-40%) and moderate levels of leaf miner (25-30%) were observed at different growth stages.
- At Junagadh, infestation of jassids was observed during the 3rd week of February to 4th week of March. Maximum jassid population (1.70 jassids 3 $leaves^{-1}$ $plant^{-1}$) was recorded at 4th week of February and 1st week of March. Activity of this pest was observed only at early stages of crop growth and thereafter it disappeared.
- At Jagtial, damages due to thrips (45%), jassids (75%) and *Spodoptera* (35%) were high during vegetative stage.
- At Kadiri, the incidence of damage by thrips was high in early stages of the crop in the villages of Talupula, Gandlapenta, Mudigubba and Nallamada mandals. Leafminer incidence was very high in Mudigubba, Talupula, Gorantla and Nallamada mandals.
- At Raichur, high activity of leafminer was noticed during pod formation stage irrespective of the places surveyed.

- In *kharif* 2009, generally at all the centres sucking pests such as thrips, aphids and jassids were observed to attack the crop during early vegetative stage followed by defoliators. However, in Vriddhachalam there was no incidence of s icking pests.
- Heavy incidence of *Spodoptera* was observed in most of the centres except Vriddhachalam, where the crop was exclusively ravaged by leafminer.
- Predators such as Coccinellid beetles, green lacewing bugs and ground beetles and parasitoids such as *Apantales* spp., *Xanthopimpala* spp. and *Compoletis chloridae* were also recorded. At Dharwad epizootics *Nomuraea rileyi* was observed on *Spodoptera litura*.

Integrated management of defoliators during *rabi*-summer 2008-09

At Vriddhachalam, the IPM module consisting of seed treatment with T. viride (4 g kg^{-1} seed), trap crop castor (200 g ha^{-1} randomly sown), pheromone traps for Spodoptera and leaf miner (12 traps ha^{-1} for each) bird perches (50 ha^{-1}), two NSKE 5% spray, need based chemical spray (Quinalphos, 2ml l^{-1}) significantly lowered the incidences of S. litura (5.37.8 %) and leaf miner (4.46.2 %) compared to control (16.029.8% and 8.19.0% incidence of S. ltiura and leaf miner, respectively). This treatment also recorded higher yield and favourable CBR.

Biological control of *S. litura* with *Nomuraea rileyi* during *rabi*-summer 2008-09

At Vriddhachalam, application of *N. rileyi* @ 2g l^{-1} with neem seed kernel extract (5%) gave better control of *Spodoptera litura* than those with other treatments. This treatment also recorded higher yield and CBR than those of control.

Monitoring insecticide residues in groundnut during *rabi*-summer 2008-09

A new experiment was initiated to study the insecticide residues, if any. Samples have been drawn from five centres located in the major groundnut growing states. The analysis is in progress.

Evaluation of new molecules for the control of *Spodoptera* and leaf miner during *kharif* 2009

This experiment was conducted in Dharwad, Jagtial, Tirupati, Latur and J ılgaon against *Spodoptera* and Raichur and Vriddhachalam against leafminer. Insecticides such as thiodicarb, spinosad and emmamectin benzoate were found to afford better control of the defoliators.

Testing of new pesticides against sucking pests during *kharif* 2009

This experiment was done in Junagadh and Jagtial against the sucking pests such as thrips, aphids and jassids. Among the different insecticides, thiomethoxam was found to afford better control over sucking pests.

Front Line Demonstrations (FLDs)

For *rabi*-summer 2008-09, in all 380 FLDs were allotted to 18 centres in groundnut growing states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and the north eastern states. Reports from only sixteen centres were received at the time of preparation of the report in respect of 340 FLDs. The component technologies considered for FLDs were: improved variety, whole package, integrated nutrient management (INM), integrated pest management (IPM), integrated disease management (IDM), integrated weed management (IWM) and application of plant growth promoting rhizobacteria (PGPR).

The FLDs on improved variety were conducted at 13 centres located in eight states. A total of 162 FLDs were conducted with 16 improved varieties of groundnut: GG 6, TG 26, ICGV 91114, Dh 46, JL 286, JL 501, TG 37A, TAG 24, TPG 41, K 1319, Kadiri 6, CSMG 20, ICGV 93468, Konkan Gaurav, Konkan Tapora, and Narayani. The results (values averaged over all the centres), indicated that compared to local varieties, the pod and haulm yields increased by 33.3% and 25.5%, respectively with the improved varieties; the GMR and NR increased by 37% and 60%, respectively, and the BCR increased from 2.43 to 2.84.

The FLDs on whole package were conducted at seven centres. The results of 85 FLDs indicated that compared to the prevailing farmers' practices, the pod and haulm yields increased by 30.5% and 28.5%, respectively. Although the cost of cultivation increased by 9%, the GMR and NR increased by 19% and 33%, respectively and the BCR increased from 2.43 to 2.67 with whole package.

On INM, five FLDs were conducted at Vriddhachalam. The pod yield (2369 kg ha^{-1}) with INM was 9% higher compared to farmers' method of nutrient management (2170 kg ha^{-1}). Although, in INM the cost of cultivation increased only by about Rs. 1000/- (from Rs.17067 ha^{-1} to Rs. 18070 ha^{-1}), the GMR increased from Rs. 47731 ha^{-1} to Rs.52109 ha^{-1}, the NR from Rs.30667 ha^{-1} to Rs. 34039 ha^{-1} and BCR from 2.80 to 2.88, respectively.

On IPM, only one FLD was conducted at Vriddhachalam. Compared to farmers' method of pest management, with IPM, both pod yield and GMR increased by 9% while the NR increased by 10%

The results of five FLDs conducted on IDM at Aliyarnagar indicated that the pod yield obtained with IDM (2230 kg ha^{-1}) was 17% higher than that obtained with farmers' method of disease management (1900 kg ha^{-1}). The haulm yield increased from 2395 kg ha^{-1} with farmers' practice, to 2610 kg ha^{-1} with IDM. Whereas compared to farmers' practice, the cost of cultivation with IDM increased from Rs. 17,990 ha^{-1} to Rs. 19,955 ha^{-1}, yet there were considerable gains as the GMR increased from Rs. 40558 ha^{-1} to Rs. 49038 ha^{-1}, NR increased from Rs. 22568 ha^{-1} to Rs. 29083 ha^{-1} and the BCR from 2.26 to 2.46.

The results of two FLDs conducted on IWM at Vriddhachalam, indicated that compared to farmers' method of weed management, in IWM the NR increased by 21% although the pod yield and GMR increased by only 12%

On PGPR, FLDs were conducted only at Jhargram centre. The results of 18 FLDs indicated that application of PGPR significantly enhanced pod yield (2909 kg ha^{-1}), which was 13% higher than that obtained with farmers' practice (2574 kg ha^{-1}). The haulm yield also increased (3236 kg ha^{-1}) by about 8% compared to farmers' practice (3023 kg ha^{-1}).

The economic analysis indicated that with the application of PGPR although the increase in the cost of cultivation was only slight (Rs. 18961 ha^{-1} to Rs. 19491 ha^{-1}), the increase in GMR (13%) and NR (19%) were highly encouraging.

For *kharif* 2009, FLDs were allotted to 20 centres in major groundnut growing states *viz.,* Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, West Bengal and north-eastern states. Results were received from 17 centres at the time of preparation of this report. A total of 472 FLDs were allotted, whereas results were received for 334 FLDs. The FLDs were allotted on Improved Variety (IV), Integrated Nutrient Management (INM), Integrated Pest Management (IPM), Integrated Weed Management (IWM), Intercropping System (ICS), Integrated Disease Management (IDM) and Whole Package (WP).

With different improved varieties, 192 FLDs were conducted at 13 centres. The data indicated an average pod and haulm yields of 1855 kg ha^{-1} and 3074 kg ha^{-1}, respectively with improved varieties as compared to 1461 kg ha^{-1} and 2746 kg ha^{-1} with local varieties. Compared to local varieties, the pod and haulm yields of improved varieties were higher by 27% and 14%, respectively. The gross returns (GR) increased by 31% at Rs.54517 ha^{-1} and net returns (NR) increased by 77% at Rs. 32744 ha^{-1} with improved varieties as compared to local varieties.

The 21 FLDs on INM were conducted at three centres. The INM included recommended doses of NPK, micronutrients gypsum and were compared with the farmers' method of nutrient management. On an average, the pod and haulm yields of 2383 kg ha^{-1} and 3125 kg ha^{-1} respectively were realized with INM as compared to 2024 kg ha^{-1} and 2317 kg ha^{-1} with farmers' practice. Thus with INM, pod and haulm yields increased by 20% and 37%, respectively; the GR increased by 20% at Rs. 72292 ha^{-1}, and NR increased by 24% at Rs. 47213 ha^{-1}.

A total of 27 FLDs on IPM were conducted at six centres. The IPM included soil application and seed treatment with biological control agents such as *Trichoderma*, seed treatment with chemical fungicides, planting of pheromone traps, application of plant based cakes and need-based spray of chemicals. The IPM was compared with farmers' method of insect pest management. On an average, 1751 kg ha^{-1} and 2740 kg ha^{-1} pod and haulm yields respectively, were obtained with IPM as compared to 1494 kg ha^{-1} and 2310 kg ha^{-1}, respectively with farmers' practice. While the pod and haulm yields increased by 19% each, the GR increased by 16% at Rs. 55022 ha^{-1} and NR increased by 22% at Rs. 30624 ha^{-1}.

A total of 11 FLDs were conducted on IWM at two centres. The IWM included application of pre-emergence herbicides, inter-cultivation and hand weeding and was compared with farmers' method of weed management (manual weeding). On an average, pod and haulm yields of 1160 kg ha^{-1} and 1760 kg ha^{-1} respectively were obtained with IWM as compared to 945 kg ha^{-1} and 1492 kg ha^{-1}, respectively, with farmers' practice. The pod and haulm yields increased by 23% and 18%, respectively, the GR increased by 21% at Rs. 23216 ha^{-1} and NR increased by 81% at Rs. 8711 ha^{-1}.

A total of 33 FLDs were conducted on ICS at four centres. The ICS comprised groundnut + pigeon pea (3:1/7:1) and groundnut + Bt cotton (3:1), which were compared with farmers' practice of sole groundnut. With ICS, the average groundnut equivalent yield of 2441 kg ha^{-1} was obtained as compared to 1427 kg ha^{-1} with farmers' practice. The GR increased by 18% at Rs. 41761 ha^{-1} and NR increased by 28% at Rs. 26462 ha^{-1}.

A total of 13 FLDs were conducted on IDM at two centres. The IDM included management of leaf spots and rust by spraying Difenaconazole (0.1%) and Tebuconazole (0.15%) at 30-35 DAS and 45-50 DAS and it was compared with farmer's method of disease management. The demonstrations showed an average pod yield of 1461 kg ha^{-1} with IDM as compared to 1250 kg ha^{-1} with farmers' practice. The GR increased by 17% at Rs. 42344 ha^{-1} and NR increased by 11% at Rs. 20931 ha^{-1}.

A total of 37 FLDs were conducted on WP at five centres. The WP included balanced use of fertilizers and micronutrients and need based plant protection as compared to farmers' method of crop management. The demonstrations showed an average pod yield of 2164 kg ha^{-1} with WP as compared to 1879 kg ha^{-1} with farmers' practice. The GR increased by 18% at Rs. 49013 ha^{-1} and NR increased by 28% at Rs. 26462 ha^{-1}.

Externally Funded Projects

1. ALL INDIA NETWORK PROJECT ON SOIL BIODIVERSITY - BIOFERTILIZERS

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

Funding agency: ICAR
Duration: 01.04.2007-31.12.2012
Fund: Rs. 23.00 lakh

Objectives:

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

Achievements:

Groundnut rhizobia

To evaluate the diversity of groundnut rhizobia in Gujarat, plant samples were collected from different predominantly groundnut growing talukas of seven districts- six in Saurashtra and Kutch. Out of 127 isolates obtained, purified and characterized, 73 were found to have both *nif* and *nod* genes. Studies for confirming the nodulation and nitrogen fixation functions in sterile soils in pots are in progress.

Identification of mixed biofertilizers suitable for groundnut

Seven sets of consortia of compatible strains of three groups of microbes *viz.*, PGPR (*Pseudomonas* sp. C185; *Pseudomonas* sp. ACC3), PSM (*Pseudomonas* sp. ACC10 and *Bacillus megaterium*), and rhizobia (TAL1000 and NRCG22) were evaluated for their influence of growth and yield of groundnut in *kharif* 2009. Groundnt variety Girnar 2 was used in the experiment. The consortia comprised i) both the strains (2 microbes) of PGPR, PSM, or rhizobia; ii) combinations of both the strains of any two groups (4 microbes); and iii) combinations of both the strains of all the three groups (6 microbes). The results indicated the seed treatment with different consortia improved plant growth and nodulation. The highest pod yield (1750 kg ha^{-1}) was obtained with the consortium 'TAL 1000 and NRCG22', which was followed by combined application of PSM and rhizobia (1600 kg ha^{-1}). The pod yield of un-inoculated control was of 1450 kg ha^{-1}. With the application of consortium of rhizobia alone or in combination with PSM (*Pseudomonas* sp. ACC10 and *Bacillus megaterium*), besides pod yield, there was improvement in shelling turnover, nodule number and nodule dry weight, halum yield, nitrogen contents of kernel and plants.

Evaluation of different delivery systems for application of microbial consortium

In *kharif* 2009, seven different delivery systems for application of the consortium of beneficial bacteria (PGPR: *Pseudomonas* sp. C185; *Pseudomonas* sp. ACC3; PSM: *Pseudomonas* sp. C185 + *B. megaterium;* and groundnut rhizobia: TAL 1000 and NRCG 22) were tested in a field trial. The delivery systems included application of consortium along with irrigation water, as seed treatment, and through carriers like soil, talcum powder, kaoline, charcoal, and FYM. The application of bacterial consortium in furrows with carriers like charcoal or FYM, or along with irrigation water resulted in significant enhancement of pod yield. Among the carriers used, the maximum pod yield of 1740 kg ha^{-1} was obtained with charcoal, followed FYM (1680 kg ha^{-1}) and the yield of control (un-inoculated) was 1470 kg ha^{-1}.

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

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

Funding agency: ICAR
Duration: 01.04.2007-31.03.2012
Fund: Rs. 38.10 lakhs

Objectives:

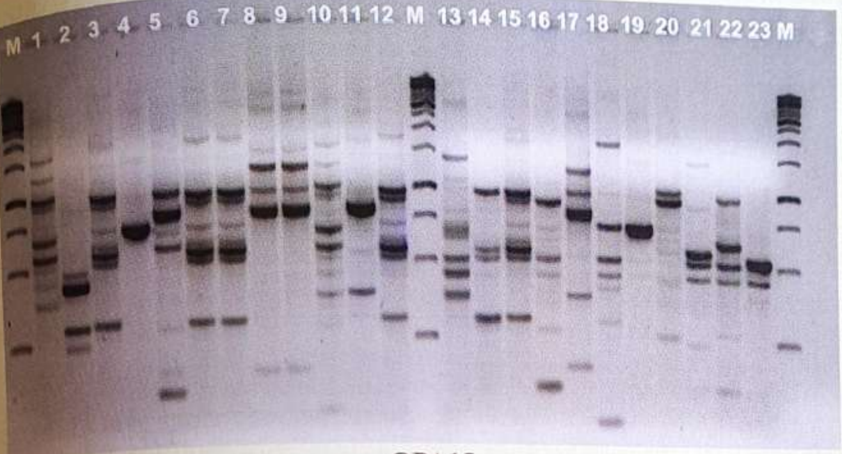
- Survey, isolation and characterisation of important bacteria from salt affected areas and salterns of Kutch eco-region of Gujarat
- Identification of potent salt tolerant strains of bacteria suitable for groundnut cultivation in salt affected areas of Kutch eco-region
- To study the diversity of representative 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:

Explorations conducted so far revealed the presence of multiple plant growth-promoting fluorescent pseudomonads in the rhizospheres of groundnut grown in high salinity conditions in Kutch eco-region of Gujarat. Many of these plant growth-promoting strains can tolerate salinity as high as 10% of NaCl. On the basis of complete 16S rDNA sequencing of the archaea at least five predominant genera *viz*. *Halorubrum*, *Haloarcula*, *Halobacterium*, *Haloterrigena* and *Halogeomatricum* were identified to occurr in the salt pans. RAPD profiles of 23 different archaebacterial isolates belonging to family halobacteriaceae were developed using Operon primer kit A (OPA1 to OPA20), for revealing polymorphism, DNA fingerprinting and diversity (Fig. 1). None of the primers used could produce a unique band for a particular isolate across 20 primers.

The RFLP profile of 23 archaebacterial isolates generated by digestion with *HhaI* yielded a unique 150 bp archaebacteria specific band in all the isolates. The phylogenetic relationship among the archaebacteria was also determined on the basis of complete 16S rDNA sequences and the 16 isolates could be grouped in to 5 major clusters and 10 sub-clusters (Fig. 2).

OPA10



OPA15

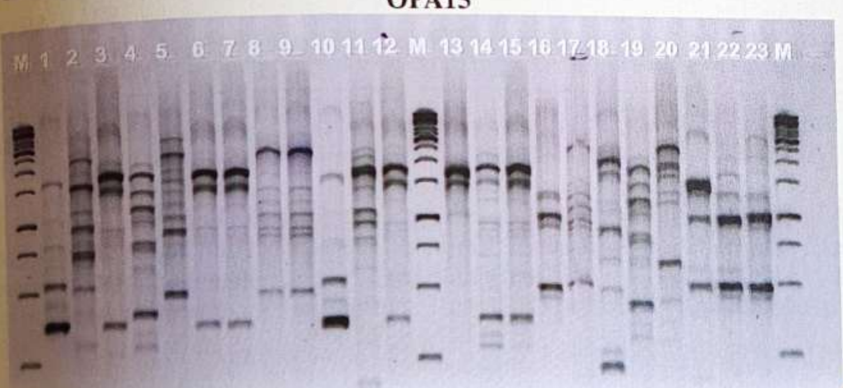


Figure 1. RAPD profiles of 23 archaeabacterial isolates generated using Operon Kit A (OPA10 and OPA15). Lanes: 1-23: H3; H18; 2A3M; ACIA; H5; IA4M; 1A4; 5A9; 5A3;H10; H1; 1A5B; H7; IAZ; 1A4B; 3A1; H2; H4; H22; 5A2; H9; 2ANA; 2A3B; 3A1A; M= 100 bp marker

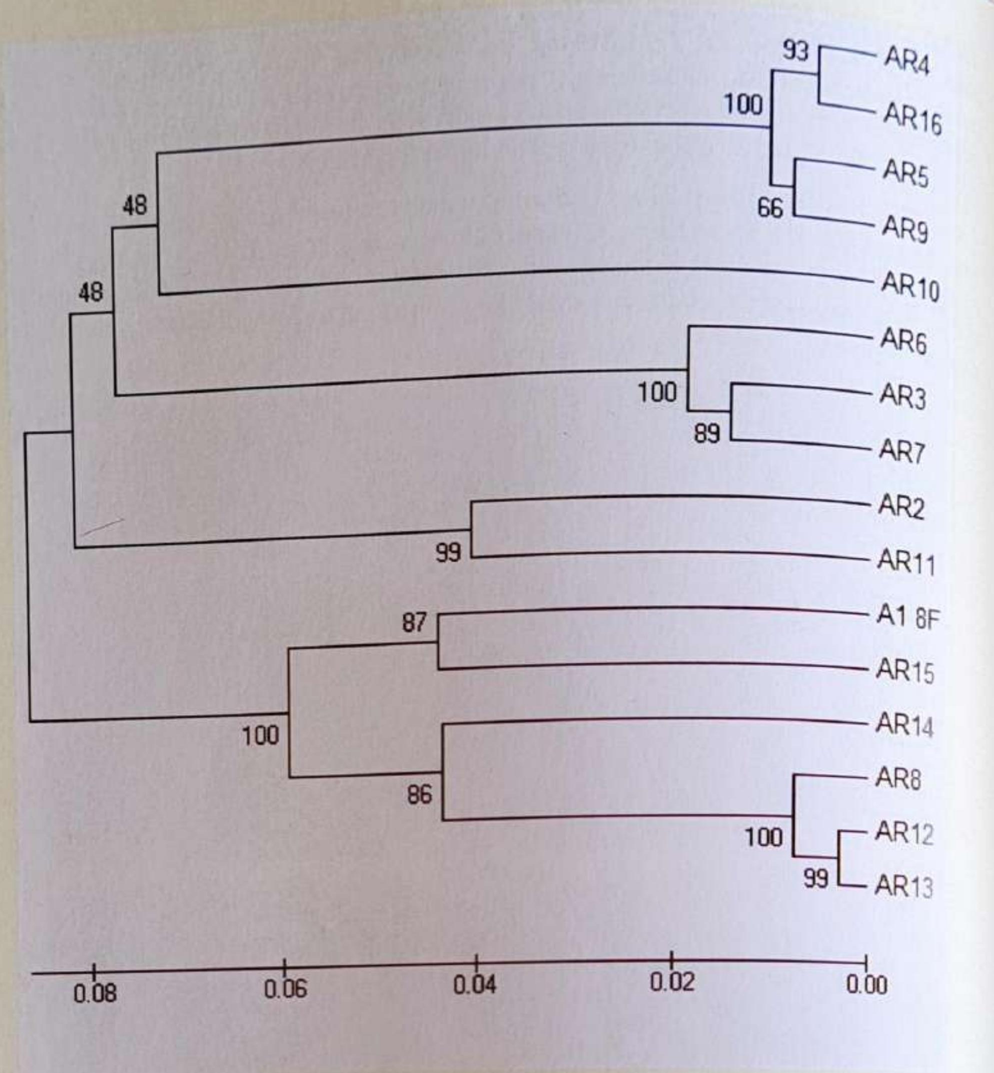


Figure 2. Cluster analysis of 16 archaebacterial isolates showing their phylogenetic relationship (generated on the basis of complete 16S rDNA sequences analysed by UPGMA)

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

(PI: K.K. PAL)

Funding agency: NAIP
Duration: 09.01.2009-31.03.2012
Fund: Rs. 63.89 lakhs

Objectives:

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

Achievements:

To study the diversity of extreme halophilic bacilli of the hypersaline environment, 13 samples of saline water, crystallized crust of salts, sludge etc. were collected from various locations of the little and greater Rann of Kachchh. From these samples 46 different morphotypes of bacilli could be isolated (Fig. 1). The diversity of the bacilli was studied by their ARDRA and RAPD profiles. Sequencing of 16S rDNA of 38 isolates representing different clusters was completed for identification and phylogenetics.

Among the 46 isolates, 13 could tolerate salinity (of NaCl) up to 10%, 15 up to 20%, another 15 up to 23.5%, one up to 30%. Surprisingly, two isolates (SB47 and SB49) could tolerate salinity even up to saturated NaCl concentrations. On the basis of phylogenetic analysis using ARDRA, developed by double digestion of PCR amplified 16S rDNA with *Alu*I and *Msp*I, 46 bacilli could be grouped into 16 clusters indicating the extent of diversity present in salterns (Fig. 2 and Fig. 3). The identification of 38 isolates by their full-length 16S rDNA sequence revealed that all these belonged to phylum-*Fermicutes*, order-*Bacillales* and family- *Bacillaceae*. Blast analysis revealed that five of the isolates belonged to genus *Oceanobacillus* while the rest of these could be of genus *Bacillus*. Out of the 38 isolates, eight isolates were having =97% similarity. Thus 30 of these could be of novel genus and/or species.

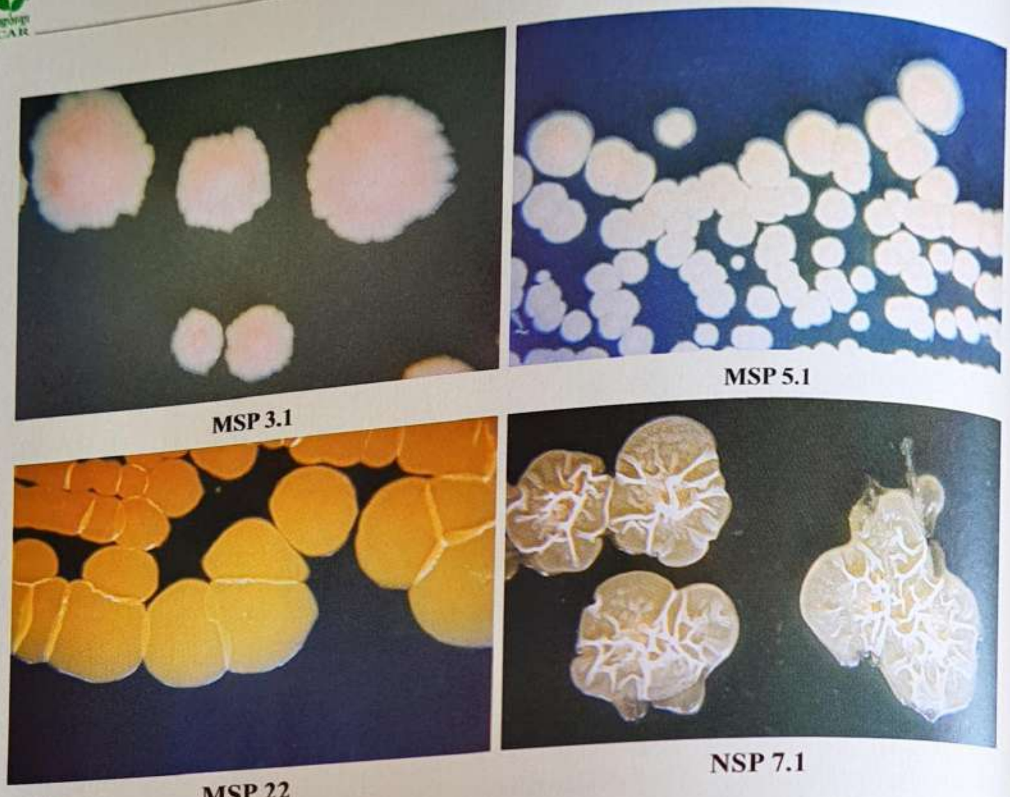


Figure 1. Colony characteristics of some bacilli obtained from natural and man-made salt pans

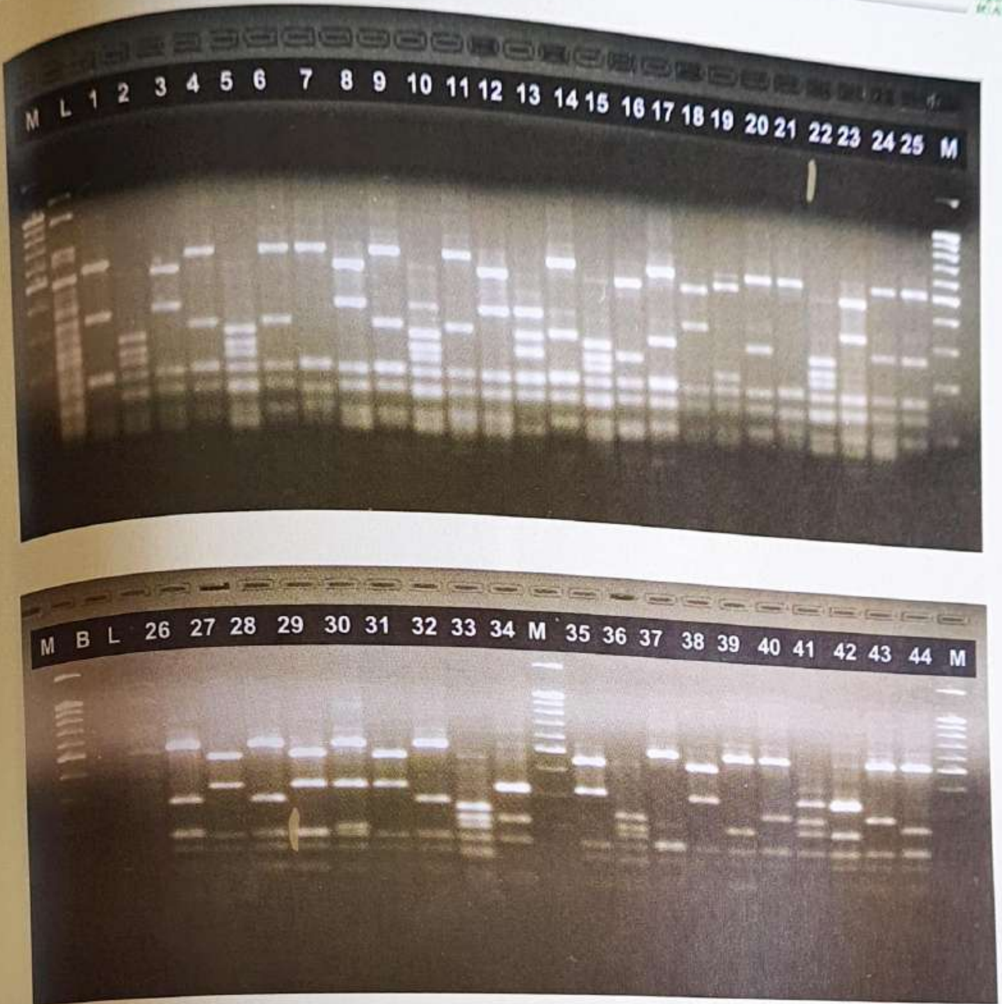


Figure 2. RFLP patterns of 46 bacilli developed by double digestion of PCR amplified 16S rDNA with *Alu*I and *Msp*I. Lanes: M=100 bp ladder; L= Lambda DNA; 1-25: NSP 2.2, MSP 5.2, MSP 5.4, MSP 2, MSP 10.1, NSP 7.4, NSP 4, MSP 16, NSP 9.1, MSP 8.1, NSP 7.6, NSP 7.2, NSP 2.1, MSP 20.1, MSP 10.3, MSP 10.2, MSP 10.4, MSP 18.2, NSP 10, NSP 7.3, MSP 4, MSP 5.3, SB 47, MSP 15.2, MSP 6; 26-44: NSP 9.3, MSP 9.3, NSP 7.1, NSP 7.5, MSP 18.3, MSP 9.2, MSP 15.1, MSP 3.2, MSP 3.1, M, NSP 6, MSP 5.5, NSP 9.2, MSP 5.7, MSP 5.1, MSP 22.2, NSP 3, MSP 18.1, SB 49, MSP 13

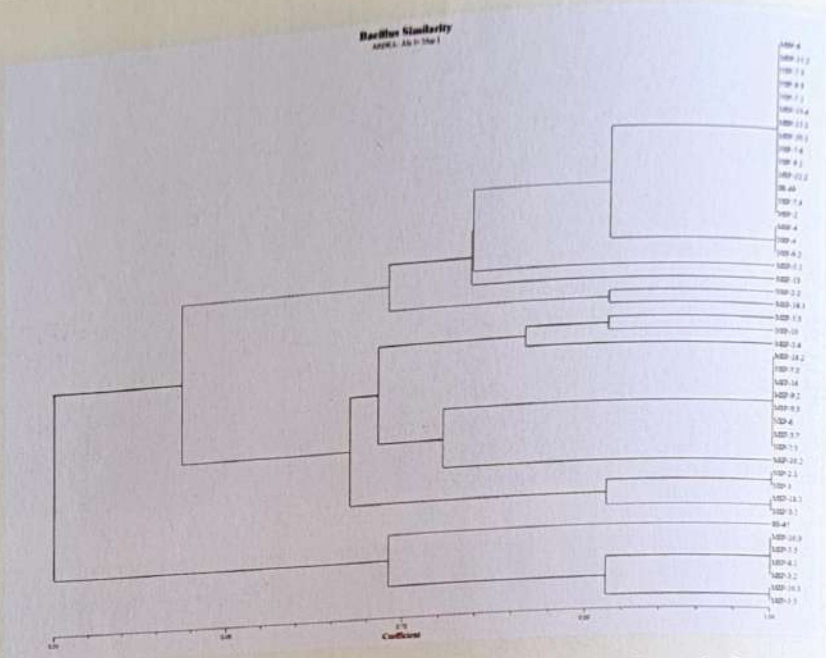


Figure 3. Cluster analysis of 38 bacilli (isolated from salterns) showing phylogenetic diversity among different bacilli isolates (developed by UPGMA analysis of 16S rDNA RFLP)

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

(PI: K.K. PAL)

Funding agency: NAIP
Duration: 04.05.2009-31.03.2012
Fund: Rs. 73.141 lakhs

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:

For isolating fungi tolerant of desiccation, high temperature and salinity, 32 samples of saline soil and sediments were collected from man-made and natural salt pans from Kachchh of Gujarat and Jaisalmer and Pokhran of Rajasthan. From these samples, 19 different fungal isolates could be obtained. All the isolates were characterized for colony morphology, pigmentation, sporulation, and the levels of tolerance of NaCl. Most of the

Isolates belonged to the genus *Aspergillus*. Seventeen out these, could grow at 23.5% NaCl concentration. One fungal isolate BF5, could grow even at saturated NaCl concentration. Six fungal isolates MSPF 1, MSPF 2, MSPF 3, MSPF 4, MSPF 5, and NSPF 1 could grow not only at 23.5% NaCl but also at 50°C (Fig. 1). By improvising the composition of growth nmedium, isolate BF 5 could be successfully cultured *in vitro* at saturated NaCl conditions.

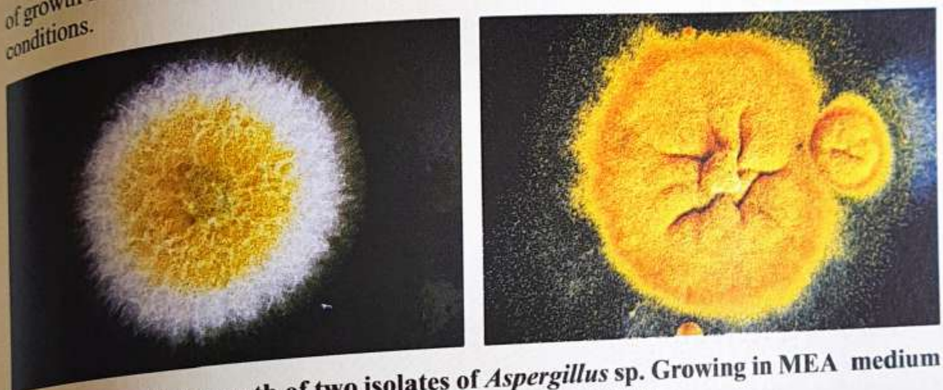


Figure 1. Mycelial growth of two isolates of *Aspergillus* sp. Growing in MEA medium containing 23.5% NaCl. A: MSPF1, and B: NSPF1

5. ICAR NETWORK PROJECT ON TRANSGENIC CROP

(PI: RADHAKRISHNAN, T.; Co-PI: ABHAY KUMAR)

Funding Agency: ICAR

Objectives:

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

Transformation work has been initiated with three gene constructs and good number of shoots has been regenerated. These shoots are now being selected in the antibiotic containing selection medium.

Achievements:

- For incorporating tolerance of abiotic stresses, especially drought and salinity two gene constructs *ZAT*12 TF and AtDREB1a were separately used for developing transgenic groundnut mediated through *Agrobacterium*. With *ZAT*12 TF gene, 1386 plants could be regenerated after co cultivation. The putative transformants are being selected in the antibiotic (kanamycin) medium. With the gene construct AtDREB1a, 1077 plants could be regenerated after co cultivation and are now being selected under antibiotic pressure (kanamycin).

- For developing groundnut having transgenic resistance to defoliating insect especially *Spodoptera litura*, the gene construct *cry1Fa1* was used. From the co-cultrues, 7974 plants are now in selection medium.

6. DEVELOPMENT OF TRANSGENIC RESISTANCE TO BUD AND STEM NECROSIS VIRUSES IN GROUNDNUT (a collaborative research project with IARI, New Delhi)

(PI: RADHAKRISHNAN, T.; Co-PI: P.P. THIRUMALAISAMI)

Funding agency: DBT

Objectives

- To develop transgenic plants of groundnut with nucleocapsid protein genes derived from PBNV and PSNV
- To characterize the putative transformants for integration, expression, and inheritance of the introduced gene(s)
- To carry out evaluation of the transgenic plants for resistance to PBNV and PSNV under glasshouse conditions

Achievements:

- Two gene constructs received from IARI were used for producing transgenics in the popular cultivars Kadiri 6 and Kadiri 136. Using the immature leaves and de embryonated cotyledons as explants several co-cultures were made, plants regenerated, selected under antibiotic pressure. The putative transformants are being subjected to confirmation by gene specific PCR. For PSNV construct, 12 events were confirmed for the transgene integration and expression. For PBNV construct, 16 events were confirmed for the transgene integration and expression. Confirmation of about 2000 plants which passed the antibiotic selection is yet to be completed.

- Dual gene construct (GBNV-N + TSV-CP gene) in *E.coli* and *Agrobacterium* were developed to confer resistance against both stem necrosis and bud necrosis. Production of polyclonal antibodies against coat protein of TSV and development of marker free dual gene construct are under progress.
- From the co-cultures using the dual construct, 143 plants are ready for testing for the integration of the transgene.

7. GENE BASED GENETIC MAPS AND MOLECULAR MARKERS FOR BIOTIC STRESS TOLERANCE

(PI: RADHAKRISHNAN, T., Co-PI: A.L. RATHANAKUMAR AND CHUNI LAL)

Funding Agency: National Fund (Collaborative programme with ICRISAT, Patancheru and UAS, Dharwad)

Objectives:

- Generation of microsatellite-enriched libraries and identification of ~500 microsatellite or simple sequence repeat (SSRs) loci
- Generation of groundnut unigene-derived SNP markers and development of cost effective CAPS assay
- Construction of integrated genetic maps with SSR, SNP and DArT markers
- Phenotyping of mapping populations at 3 locations (ICRISAT, NRCG, UAS) over 3 years

Achievements:

- QTLs associated with resistance to foliar diseases (rust and late leaf spot) and tolerance of drought (SCMR and SLA) were identified
- TAG 24 × ICGV 86031 map, was saturated with 191 polymorphic markers and comprehensive QTL analysis for drought related traits (T, TE, SLA, SCMR) and agronomic traits (pod weight, seed weight and haulm weight) was completed.
- On the basis of extended genetic map, a comprehensive QTL analysis was conducted for LLS and rust and the phenotyping data was updated based on TAG 24 x GPBD 4 population.
- Phenotyping was done for LLS, rust, *Sclerotium* and agronomic traits for JL 24 x ICGV 86590

8. IDENTIFICATION OF STEM ROT RESISTANT GENOTYPES IN GROUNDNUT (*A. hypogaea* L.) THROUGH MUTATION BREEDING

(PI: A.L. RATHNAKUMAR; CO-PI(s): CHUNI LAL AND VINOD KUMAR)

Funding Agency: Board of Research on Nuclear Sciences, Department of Atomic Energy, BARC, Mumbai

Objectives:

- To induce additional source of variability for yield and related traits through mutation
- To evaluate the usefulness of induced mutations in creating additional source of variabilty for ressistance/tolerance to stem rot
- To identify potential mutants having high yield with desired level of resistance/tolerance to stem rot

The project envisaged inducing additional sources of variability for yield and related traits through mutation; evaluating the usefulness of induced mutations in creating additional source of variability for resistance/tolerance to stem rot; and to identifying potential mutants possessing high yield with adequate resistance/tolerance to stem rot.

To screen the mutant population, an area of 1.0 acre was selected in isolation of other crop fields for development of a sick plot for stem rot. The initial population of *S. rolfsii* in the plot was negligible which due to inoculation of mass multiplied fungus, during the subsequent period of eight months increased to $37x10^3$ CFU^{-1}g soil.

From the infected groundnut plants, 59 isolates of *S. rolfsii* were obtained. Soil samples were collected from the rhizosphere of hot spot areas of Gujarat and Maharashtra state. These isolates were characterized for morphological and pathogenic variations. TheVirulence of the isolates was studied *in vitro* and on pot grown plants in a glasshouse. It could be seen that the virulent isolates thus identified could even overgrow the most efficient strains of *Trichoderma viride* and *T. harzianum*- the biological control agents of stem rot.

To develop broad-spectrum resistance in the cultivar, it is imperative to screen the genotypes/cultivars against large no. of isolates of the pathogen or the mixed inoculums. To fulfil this objective, compatibility of various combinations of isolates in pairs (400 permutation and combination) was tested in Petri dishes and the compatible consortia of isolates were worked out.

The effect of various crop residues on growth parameters of *S. rolfsii* was also studied. It was observed that the half-boiled sorghum grains supported the maximum growth of the fungus in two-three weeks. In susceptible cultivar, when grown in sick plots during summer 2009, suffered 56.3% incidence of stem rot.

Seeds of two high yielding but stem rot susceptible varieties; GG 20 (Virginia bunch; suitable for *kharif* cultivation in Gujarat) and TAG 24 (Spanish bunch; suitable for summer cultivation all over India) were irradiated with γ rays (200 Gy). The irradiated seeds of TAG 24 were grown in summer 2009 in a normal field. From 4000 M_1 p'ants, only 2800 single plants survived which were later harvested. From this population, 58,400 M_2 plants were raised in the sick plot in *kharif* 2009. Although the incidence of stem rot was as high as 67.2% in this season, 265 promising lines identified to be promising as these suffered less than 20% stem rot infection. These M_3 families are being grown in sick plot for further confirmation of resistance.

In cultivar, GG 20, among the plants grown from the irradiated seeds, the seedling mortality was as high as 46.7%. A total of 780 M_1 plants were harvested separately and preserved for further sowing as M_2 in the sick plot. Although visible morphological mutants could not be observed in this population, a large number of mutants for pod shape and size were observed.

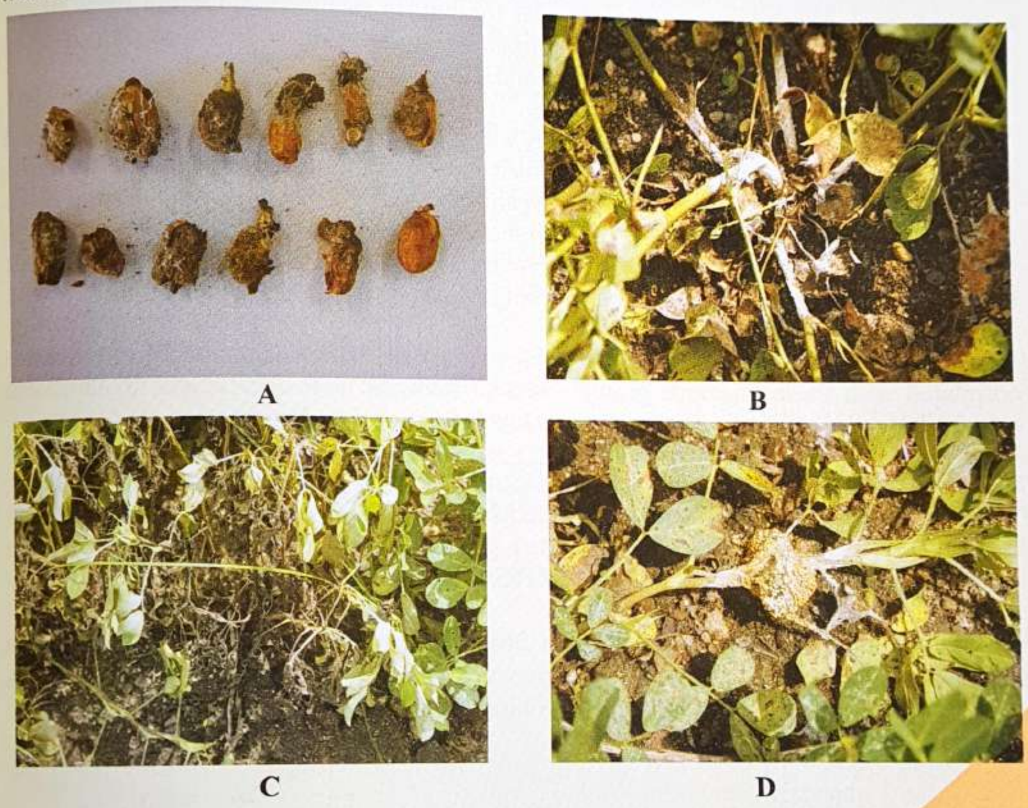


Figure 1: A. Seed, and B. stem infected by *S. rolfsii*; C. wilting and drying of branches, and D. Formation of sclerotia on infected branches

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

(PI: P.C. NAUTIYAL, Co-PI: RADHAKRISHNAN T., A.L. RATHNAKUMAR., CHUNILAL, MANJUNATHA, T.)

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

Achievements:

A group of 33 lines, grown in one rainy and two summer seasons, was characterized for the morphological, physiological and molecular characteristics. The relationships between morphological, physiological and molecular traits were established. On the basis of the results obtained, the mini-core group comprising 92 lines will be grown in rainy season (2010) for characterization of physiological and molecular traits.

Among 33 lines, wide genetic variability was observed in morphological, physiological and molecular traits related to drought tolerance. Various traits also showed their association with each other. For example, in TMV2NLM and Chico, TMV2NLM is characterized by its low SLA and Chico with its high SLA. On the basis of SLA values, these lines could be identified as most tolerant and susceptible ones, respectively. However, a common SSR molecular marker was also found only in these two lines.

Root traits were studied in 92 lines (mini-core group). The data on the root traits were correlated with those of above ground parts to find out their association, if any, with morphological, physiological and molecular levels for drought tolerance.

Work on heat-shock proteins and their association with drought tolerance was initiated. The core group of germplasm accessions and some additional lines are being screened at UAS, Bangalore, for tolerance of stress due to high temperature. The tolerant and susceptible lines thus identified will be studied further at DGR, Junagadh.

Encouraging results were obtained in SSR-markers studied in 33 lines. Hence the remaining 59 lines of the mini-core group (92 lines) will be studied for the DNA polymorphism and its association with physiological and morphological traits for tolerance of drought.

10. FARMER-PARTICIPATORY GROUNDNUT IMPROVEMENT IN RAIN-FED CROPPING SYSTEMS

(PI: P.C. NAUTIYA; Co- PI: RADHAKRISHNAN T.)

Funding Agency: Ministry of Agriculture, GOI under ISOPOM, 2006-2009)

Achievements:

With 12 new varieties/advanced breeding lines developed for high water-use efficiency and one local cultivar, on-farm farmers participatory selection trials were conducted.at five locations in Junagadh, Jamnagar and Rajkot districts of Gujarat. The locations could further be categorized into low- and moderate-rainfall on the basis of the average annual rainfall in the past 10 years. After two years, farmers' opinion on the suitability of new varieties was collected. The opinions differed in low and moderate rainfall areas. In low rainfall areas farmers' preferred ICR 3, a variety possessing drought tolerant traits, followed by JAL 42 having higher productivity. While in moderate rainfall areas farmers' preferred JAL 42 followed by ICR 3. In addition, farmers in low rainfall areas selected two more varieties i.e. JUG 16 having traits for cultivation as an intercrop with cotton, and ICGV 87846 having higher biomass productivity. The data generated at research station trial vindicated the farmers' preferences.. For example, ICR 3 having low specific leaf area *vis-à-vis* high drought tolerance showed stability in number of flowers plant^{-1}, shelling turnover and pod yield. The variety JAL 42, which acquired high leaf area index during early crop growth stages showed high biomass productivity. But JAL 42 could perform better in terms of shelling turnover and harvest index only under favourable conditions. In conclusion, groundnut productivity could be enhanced by promoting drought tolerant varieties for low water availability areas and varieties capable of acquiring early leaf area cover and high productivity for moderate water availability areas.

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

(PI: S.K. BERA, CO-PI: PROF. NEERA BHALLA SARIN, SCHOOL OF LIFE SCIENCES, JNU, NEW DELHI)

Funding agency: DBT
Fund: 31.99 lakhs

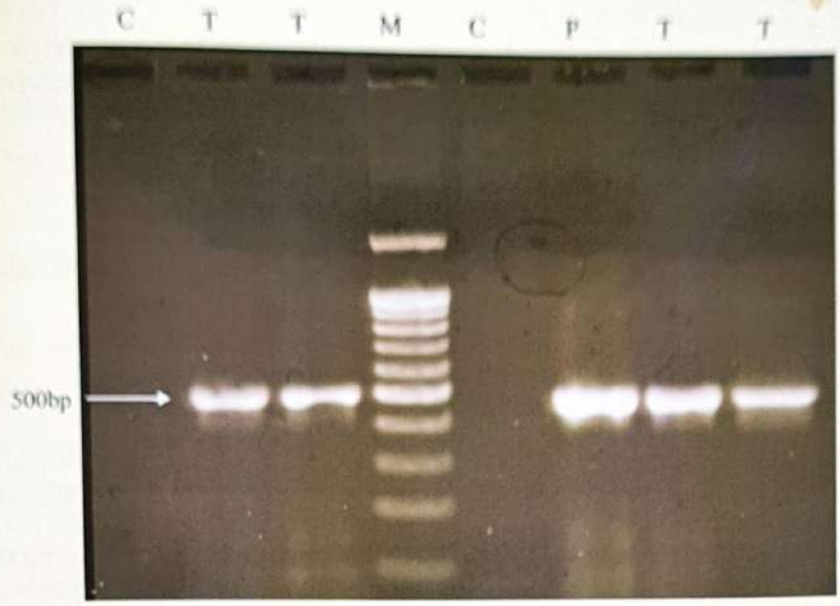
Objective:

Enhancing salt tolerance of two salt sensitive groundnut (*Arachis hypogaea* L.) cultivars (GG 2 and TAG 24) by over expressing *PR10* gene, isolated from salt tolerant cell lines of *Arachis hypogaea L.* Var. JL-24.

Achievements:

This gene *AhSIPR10* was cloned in a binary vector pCAMBIA 1302 and the gene construct driven by the constitutive *CaMV* 35S promoter and having *hptII* gene (hygromycin resistance) as the plant selection marker was mobilized in *Agrobacterium tumefaciens* which was used to transform explants of cultivar TAG 24. Shoots regenerated from de-embryonated cotyledons were selected in 3 cycles of hygromycin at 5, 10 and 15 mg/l. Total 671 explants of TAG 24 infected with *Agrobacterium* were cultured and sub-cultured for regeneration. Out of these 89 putative transgenic shoots were sub-cultured for rooting. Total 17 plants were hardened and then transferred to glass house (Fig. 1). DNA was extracted from putative transgenic were analysis by using PR 10 gene specific primers on a PCR. DNA isolated from eight out of 17 plants, showed amplicons with PR 10 gene specific primers indicating presence of this gene (Fig. 2A &2B). These putative transgenics will be confirmed further by RT-PCR and Southern blot.

Figure 1: Regenerated and putative transgenic shoots of groundnut variety TAG 24



A

M-marker, C-control, P-plasmid, Tputative transgenic

B

C-control, P-plasmid, M-marker,T-Putative transgenic, NT-non transformed

Figure 2 (A-B). PCR amplification of T0 shoots of TAG 24 with PR10 gene specific primers

12. EVALUATION OF AGRICOL® AND CHEMIEBOR® FOR THEIR SUITABILITY AS A SOURCE OF BORON IN GROUNDNUT CULTIVATION IN INDIA

(PI: A.L. SINGH, Co-PI: J.B. MISRA AND R.S. JAT)

Objective:

To determine the optimum dose and mode of application of Agricol® and Chemiebor® as boron fertilizers for groundnut crop

Achievements:

Field evaluation trials were conducted at Junagadh, Mainpuri, Aliyarnagar, Hanumangarh and Mizorum, in 2009 to find out effectiveness and feasibility of applying Agricol and Chemiebor and also some sources of B in groundnut. The results indicated that there was a pronounced effect of application of B on flowering, yield and yield related attributes. All the sources of boron used increased the pod yield by increasing the number and size (weight) of both pod and seed.

Among various, the soil application of equal amounts of B as borax, Agricol, and Solubor were at par in their effect Similarly the foliar application of various B sources showed similar responses. Soil application of 2.0 kg B ha^{-1} as Agricol, Chemiebor, Solubor, Borosol, and Maxibor increased pod yield by 24-27, 19-32, 13-24, 5-29, and 4-18%, respectively over control as against 19-26% by borax and 12-22% by boric acid in *rabi*-summer season. In *kharif*, however, the corresponding increase in pod yield due to these B sources were 18-27, 29-35, 19-36, 17-25, and 15-30%, respectively. The foliar application of 1.0 kg B ha^{-1} as Borosol, Chemiebor, Solubor and Librel, however, has rather similar response as the increase in pod yield was by 5-31, 11-20, 15-24 and 15-19%, respectively and haulm yield by 7-18, 13-22, 8-14 and 5-16%, respectively. The foliar applications may, however, be avoided during hot and dry weather to avoid scorching of groundnut leaves.

Thus basal application of 2.0 kg B ha^{-1} brings about significant improvement in number of pods formed and also the pod filling and thus not only the size and weight of pods increases but there is significant improvement in yield too. Among various sources of B tried Borax, Agricol, and Solubor showed rather a similar response and hence, depending on availability any one of these can be used, however, Agricol is the cheapest among these.

PUBLICATIONS

Research articles

Datta, M., Singh, N. P. and Singh, A. L. (2010). A variability in response of groundnut (*Arachis hypogaea* L.) to phosphate application in acid soils of Tripura. *Indian J. Soil Science* (in press).

Dey, R., Pal, K. K. and Tilak, K. V. B. R. (2010). Influence of soil and plant type on diversity of rhizobacteria. *Proceedings of National Academy of Sciences* (communicated).

Govindraj, G., Kumar, G. D. S. and Basu, M. S. (2009). Benefits of improved groundnut technologies to resource-poor farmers: A participatory approach. *Agricultural Economics Research Review* 22: 355-360.

Kumar, G. D. S. and Popat, M. N. (2010). Factors influencing the adoption of aflatoxin management practises in groundnut (*Arachis hypogaea* L.). *International Journal of Pest Management* 56(2): 165-71.

Kumar, N., Vijay Ananda, K.G., Sudheer, P. D. V. N., Sarkar, T., Reddy M.P., Radhakrishnan, T., Kaul, T., Reddy, M. K., Sopori, S. K. (2010). Stable genetic transformation of *Jatropha curcas* via *Agrobacterium tumefaciens*-mediated gene transfer using leaf explants. *Industrial Crops and Products* 32(1): 41-47.

Meena, H. N. and Shivay, Y. S. (2010). Productivity of short-duration summer forage crops and their effect on succeeding aromatic rice in conjunction with gypsum-enriched urea. *Indian Journal of Agronomy* 55(1): 11-15.

Nautiyal, P. C., Ravindra, V., Joshi, Y. C., Zala, P. V., Sodavadiya, P., and Tomar R. S. (2010). Increasing groundnut productivity in semi-arid tropics by utilizing genetic variability in agronomical desirable traits. *Field Crop Research* (communicated).

Nautiyal, P.C. (2009). Seed and seedling vigour traits in groundnut (*Arachis hypogaea* L.). *Seed Science and Technology* 37: 721-735.

Nautiyal, P.C. and Mariko Shono, (2010). Analysis of the role of mitochondrial and endoplasmic reticulum localized small heat shock proteins in tomato. *Biologia Plantarum* (in press).

Nautiyal, P.C., Misra, J. B. and Zala, P.V. (2010). Influence of seed maturity stages on germinability and seedling vigour in groundnut. *SAT Journal* (in press).

Singh, A. L. (2010). Physiological basis for realizing yield potentials in groundnut. In: *Advances in Plant Physiology*, (Ed.) A. Hemantranjan, Vol. 12 Scientific Publishers (India), Jodhpur, India.

Singh, A. L., Hariprasanna, K., Chaudhari, V., Gor, H. K. and Chikani, B. M. (2009). Identification of groundnut (*Arachis hypogaea* L.) cultivars tolerant of salinity. *Journal of Plant Nutrition* (in press).

Singh, A.L., Jat, R.S., Chaudhari, V., Baria, H., Sharma, S. (2010). Toxicities and tolerance of mineral elements Boron, Cobalt, Molybdenum and Nickel in crop plants. In: *Special Issues on Plant Nutrition and Abiotic Stress Tolerance* (Ed: Naser A. Anjum) Plant Stress.

Singh, A.L., Jat, R.S., Chaudhari, V., Zala, A., Bariya, H.,. Misra, J. B., Singh, A. B., Kumar, S., Maniyan, K., Masih, M. R., Pathak, K. A. and Vijaykumar, S. (2009). Inevitability of boron fertilization for realizing high yields of peanut in India. *Plant and Soil* (communicated).

Papers presented at symposia/seminars/conferences/other fora

Dey, R., Pal, K. K. and Misra, J. B. (2009). Prospects of cultivating edible mushrooms on groundnut shell and haulm. International Conference on Food Technology, August 28-30, 2009, Indian Institute of Crop Processing Technology (IICPT), Thanjavur, pp. 1-2.

Dey, R., Pal, K. K., Misra, J. B. and Bishi, S. K. (2009). De-oiled groundnut cake: a potential substrate for microbial production of amylase. International Conference on Food Technology, August 28-30, 2009, Indian Institute of Crop Processing Technology (IICPT), Thanjavur, pp. 2-3.

Jat, R. S., Meena, H. N., Girdhar, I. K., Pal, K. K. and Misra, J. B. (2009). Long term effects of nutrient management and cropping systems on soil organic carbon stock in groundnut based cropping systems. The Proceeding of the International Plant Nutrition Colloquium *XVI*.Paper 1369.

Kumar, G. D. S. (2009). Farmer participatory evaluation of groundnut (*Arachis hypogaea* L.) varieties: An on-farm experience in residual soil moisture situation of Orissa. Page 298-305 in Proceedings of the 43rd Conference of SASAE on Partnerships in Agricultural Development, 12-15 May, 2009, Potchefstroom, South Africa, South African Society for Agricultural Extension.

Kumar, G. D. S. (2009). Improving the livelihood security of tribal farmers through participatory approaches. Page 46 In: National seminar on sustainable development of tribal areas through integrated and eco-friendly approaches, 11-13 December 2009, KVK, Vaghai, Gujarat. Navsari Agricultural University.

Kumar, G. D. S. and Jain, V. K. (2009). Assessment of impact of improved groundnut (*Arachis hypogaea* L.) production technologies using sustainable livelihood approach. In: Compendium of National Seminar on enhancing efficiency of extension for sustainable agriculture and livestock production, 29-30 December, 2009, Page 46, IVRI, Izatnagar, Uttar Pradesh, India.

Prasad, T. V., Gedia, M. V., Savaliya, S. D., Barad, A. H. and Thirumalaisamy, P. P. (2010). Evaluation of new insecticides for management of sucking pests of groundnut. In: The national conference on plant protection in agriculture through eco-friendly techniques and traditional farming practices, 18-20 February, 2010, Durgapura, Jaipur.

Rathnakumar, A. L., Nautiyal, P. C., Raval, L. and Lalwani, H. B. (2009). Evaluation of groundnut mini-core accessions for water use efficiency and productivity. Souvenir and Abstracts Book: National Symposium on Recent Global Developments in the Management of Plant Genetic Resources. P.132. NBPGR, New Delhi, India, 17-18 December, 2009.

Singh, A. L., Jat, R. S. and Misra, J. B. (2009). Boron fertilization is a must to enhance peanut production in India. In: The proceeding of the International Plant Nutrition Colloquium XVI. Paper 1140.

Manual/Books

Kumar, G. D. S. and Jain, V. K. (2009). Course Material. Farmer participatory research for increasing groundnut production. Directorate of Groundnut Research. Junagadh, Gujarat. pp. 128.

Kumar, G. D. S. and Jain, V.K. (2009). Training Manual on Improved groundnut production technology. Directorate of Groundnut Research, Junagadh, Gujarat. pp. 47.

Tilak, K. V. B. R., Pal, K. K. and Dey, R. (2010). Microbes for Sustainable Agriculture, I.K. International Publishing House, Pvt. Ltd., New Delhi, India, pp. 1-200.

Meetings/Trainings Attended

Dr. G.D. Satish Kumar

- 43rd Annual Conference of South African Society for Agricultural Extension (SASAE) on Partnerships in Agricultural Development 12-15 May 2009, Potchefstroom, South Africa.
- Training on "Enhancing skills in ICT based DSS for market and agri-business orientation and sustaining rural livelihoods", 9-18 November 2009, MANAGE, Hyderabad, India.
- National Seminar on "Enhancing efficiency of extension for sustainable agriculture and livestock production" at Indian Veterinary Research Institute (IVRI), Izatnagar (UP), 29-30 December 2009, The Indian Society of Extension Education and IVRI.
- National Seminar on "Sustainable Development of Tribal Areas through Integrated and Eco-friendly Approaches at KVK, Waghai, 11-13 December 2009, Navsari Agricultural University and KVK, Waghai.
- Annual *rabi*-summer groundnut researchers group meeting, 15-16 October 2009, Junagadh Agricultural University, Junagadh, Gujarat.
- Annual *kharif* groundnut researchers group meeting, 22-24 April 2009, ANGRAU, Hyderabad.

Dr. P.P. Thirumalaisamy

- Indo-US sponsored International Congress-cum-Workshop on Intellectual Property Right (IPR), 5-7 October 2009, Amity University Campus, Noida.
- Training programme on Recent Advances in Biological Control of Plant Diseases, 1-21 December, 2009 NBAII, Hebbal, Bangalore.
- National Conference on "Plant protection in agriculture through eco-friendly techniques and traditional farming practices, 18-20 February 2010, Durgapura, Jaipur.
- Annual *rabi*-summer groundnut researchers group meeting, 15-16 October 2009, Junagadh Agricultural University, Junagadh, Gujarat.

Dr. R.S. Jat

- Annual *rabi*-summer groundnut researchers group meeting, 15-16 October 2009, Junagadh Agricultural University, Junagadh, Gujarat.

Dr. Radhakrishnan, T.

- 54th CSC meeting on variety release and notification, 27 July 2009, Krishi Bhavan, New Delhi,
- Annual *kharif* groundnut researchers group meeting, 22-24 April 2009, ANGRAU, Hyderabad.
- Annual Rabi-Summer workshop, 5-6 November 2009, Junagadh Agricultural University, Junagadh, Gujarat.
- Annual review meeting of the NFBSRA I "Gene Based Genetic Maps and Molecular Markers for Biotic Stress Tolerance", 1 May 2009, DGR, Junagadh, Gujarat.
- ICAR-ICRISAT Collaborative projects review meeting, 10 March, 2010, NASC complex, New Delhi.
- Meeting of Directors and Project Coordinators of Crop Science Division, 19-20 January 2010, Krishi Bhavan, New Delhi.
- QRT meeting, 22-23 July 2009, ARS, MPKV, Jalgaon, Maharashtra.
- QRT meeting, 7-8 November 2009, ARS, MPKV, Jalgaon, Maharashtra.
- QRT meeting, 27-28 April 2009, RRS, TNAU, Vridhachalam, Tamil Nadu.
- QRT meeting to review the AICRP-G programme, 9-11 October 2009, UAS, Dharwad, Karnataka.

- Review and Planning Committee Meeting of the Project on Evaluation of Groundnut Germplasm for Morphological, Physiological and Molecular Characters/traits Associated with Drought Tolerance for Enhancing Productivity in Rain-dependent System, 23 February, 2010.
- Review and planning meeting of ISOPOM supported projects, 2-3 June 2009, ICRISAT, Patancheru, Hyderabad.
- Training programme on *Law In Science*, 1-6 February 2010, ASCI, Hyderabad.

Dr. K. K. Pal

- Sensitization meeting organized by NAIP on "Bioprospecting of genes and allele mining for abiotic stress tolerance", 3-7 May 2009, NASC Complex, New Delhi.
- Technical programme planning meeting of AINP-Biofertilizer network project, 25-26 July 2009, CRIDA, Hyderabad.
- CIC meeting of NAIP subproject "Diversity analysis of *Bacillus* and other predominant genera in extreme environment and their utilization in Agriculture", 7 August 2009, Division of Microbiology, IARI, New Delhi.
- Annual review meeting of AMAAS project, 26 August 2009, NASC Complex, New Delhi.
- NAIP meeting, 29-30 September 2009 in connection with the matters related to purchase procedures and other administrative issues as per World Bank norms, CAZRI, Jodhpur.
- CIC/CAC meeting of NAIP subproject "Allele mining and bioprospecting of genes for abiotic stress tolerance", 20-22 October 2009, NASC complex, New Delhi.
- Half-yearly review meeting of AMAAS project, 17 November 2009, CPCRI, Kasargod.
- Meeting organized by SDAU, Dantiwada to discuss mass multiplication of biofertilizers and biocontrol agents proposed to be supplied to Kutch areas under Rashtriya Krishi Vikas Yojana, 3 January 2010, SDAU, Dantiwada, Gujarat.
- Annual review meeting of NAIP subproject "Diversity analysis of *Bacillus* and other predominant genera in extreme environment and their utilization in Agriculture", 5-6 March 2010, NASC Complex, New Delhi.
- Annual Kharif groundnut workshop 22-24 April 2009, ANGRAU, Hyderabad.

Human resource as on 31.03.2010

	Name	Designation
1.	Dr. J. B. Misra	Director
2.	Dr. P. C. Nautiyal	Principal Scientist (Plant Physiology)
3.	Dr. A. L. Singh	Principal Scientist (Plant Physiology)
4.	Dr. Radhakrishnan T.	Principal Scientist (Plant Breeding)
5.	Dr. A. P. Mishra	Senior Scientist (Agril. Statistics), joined on 01.08.2009
6.	Dr. A. L. Rathnakumar	Senior Scientist (Plant Breeding)
7.	Dr. Chuni Lal	Senior Scientist (Plant Breeding)
8.	Dr. S. K. Bera	Senior Scientist (Genetics and Cytogenetics)
9.	Dr. K. K. Pal	Senior Scientist (Microbiology)
10.	Dr. Rinku Dey	Senior Scientist (Microbiology)
11.	Dr. G. D. Satish Kumar	Senior Scientist (Agril. Extension)
12.	Sh. G. Govindraj	Scientist (Agril. Economics)
13.	Dr. Ram Swaroop Jat	Scientist (Agronomy)
14.	Dr. Har Narayan Meena	Scientist (Agronomy)
15.	Sh. Manjunatha T.	Scientist (Plant Biotechnology)
16.	Sh. M. C. Dagla	Scientist (Plant Breeding), joined on 19.06.2009
17.	Sh. Abhay Kumar	Scientist (Plant Biotechnology), joined on 19.06.2009
18.	Sh. Sujit Kumar Bishi	Scientist (Plant Biochemistry), joined on 20.06.2009
19.	Dr. Thirumalaisamy P. P.	Scientist (Plant Pathology), joined on 29.08.2009
20.	Sh. C. P. Singh	Technical Officer, T (7-8)
21.	Ms. S. M. Chauhan	Technical Officer, T (7-8)
22.	Dr. D. L. Parmar	Technical Officer, T (7-8)
23.	Sh. D. M. Bhatt	Technical Officer, T (7-8)
24.	Sh. V. G. Koradia	Technical Officer, T (7-8)
25.	Sh. P. K. Bhalodia	Technical Officer, T (7-8)
26.	Sh. N. R. Ghetia	Technical Officer, T (7-8)
27.	Sh. P. V. Zala	Technical Officer, T (7-8)
28.	Sh. H. B. Lalwani	Technical Officer, T6
29.	Sh. V. K. Sojitra	Technical Officer, T6
30.	Sh. H. M. Hingrajia	Technical Officer, T6
31.	Dr. R. S. Tomar	Technical Officer, T6
32.	Sh. Ranvir Singh	Technical Officer, T6

	Name	Designation
33.	Dr. S. D. Savalia	Technical Officer, T6
34.	Smt. Veena Girdhar	Technical Officer, T6
35.	Sh. H. K. Gor	Technical Officer, T6
36.	Dr. J. R. Dobaria	Technical Officer, T6
37.	Dr. M. V. Gedia	Technical Officer, T6
38.	Sh. P. R. Naik	Technical Officer, T6
39.	Mrs.V. S. Chaudhary	Technical Officer, T6
40.	Sh. Virendra Singh	Technical Officer, T6
41.	Sh. B. M. Chikani	Technical Officer, T6
42.	Sh. D. R. Bhatt	Technical Officer, T5
43.	Sh. R. D. Padavi	Technical Officer, T5
44.	Sh. Suraj Pal Singh	Technical Officer, T5
45.	Sh. V. K. Jain	Technical Officer, T5
46.	Sh. H. V. Patel	Technical Officer, T5
47.	Sh. Prabhu Dayal	Technical Officer, T5
48.	Sh. C. B. Patel	Technical Assistant, T4
49.	Sh. J. G. Kalaria	Technical Assistant, T4
50.	Sh. K. H. Koradia	Technical Assistant, T4
51.	Sh. A. M. Vakharia	Technical Assistant, T4
52.	Sh. G. J. Solanki	Technical Assistant, T3
53.	Sh. P. B. Garchar	Technical Assistant, T3
54.	Sh. Sugad Singh	Technical Assistant, T3
55.	Sh. N. M. Safi	Technical Assistant, T3
56.	Sh. B. M. Solanki	Technical Assistant, T2
57.	Sh. G. G. Bhalani	Technical Assistant, T2
58.	Sh. Pitabas Dash	Technical Assistant, T2
59.	Sh. R. N. Mallik	Administrative Officer, joined on 23.09.2009
60.	Sh. J. B. Bhatt	Assistant Administrative Officer
61.	Sh. M. B. Kher	Security Supervisor
62.	Ms. Rosamma Joseph	Senior Stenographer and PA to Director
63.	Ms. S. Venugopalan	Assistant
64.	Ms. M. N. Vaghasia	Assistant
65.	Sh. L. V. Tilwani	Stenographer

	Name	Designation
66.	Sh. Y. S. Karia	Stenographer
67.	Sh. R. D. Nagwadia	UDC
68.	Sh. C. G. Makwana	UDC
69.	Sh. H. S. Mistry	LDC
70.	Sh. P. N. Solanki	LDC
71.	Sh. M. H. Kava	LDC
72.	Sh. N. M. Pandya	SSS
73.	Sh. D. M. Sachania	SSS
74.	Sh. R. B. Chawda	SSS
75.	Sh. B. K. Baria	SSS
76.	Sh. C. N. Jethwa	SSS
77.	Sh. R. V. Purohit	SSS
78.	Sh. M. B. Sheikh	SSS
79.	Sh. K. T. Kapadia	SSS
80.	Sh. J . G. Agrawat	SSS
81.	Sh. V. N. Kodiatar	SSS
82.	Sh. R. P. Sondarwa	SSS
83.	Sh. G. S. Mori	SSS
84.	Sh. V. M. Chawda	SSS
85.	Ms. D. S. Sarvaiya	SSS
86.	Sh. N. G. Vadher	SSS
87.	Sh. A. D. Makwana	SSS
88.	Sh. P. M. Solanki	SSS
89.	Sh. B. J. Dabhi	SSS
90.	Sh. C. G. Moradia	SSS

Sanctioned strength, employees on position and their category-wise distribution as on 31.03.2010

Category	Sanctioned	In position	General	SC	ST	OBC
Scientific	39 + 1 RMP	19	09	02	02	06
Technical	40	39	25	05	05	04
Administrative	15	13	07	02	00	04
Supporting	19	19	04	05	03	07
Total	**114**	**90**	**45**	**14**	**10**	**21**

Discipline and grade wise sanctioned scientific positions

Discipline	S	Sr. S	PS	Total
Agril. Economics	1	-	-	1
Agril. Entomology	2	1	-	3
Agri. Extension	1	-	-	1
Agril. Statistics	-	1	-	1
Agronomy	1	1	1	3
Biochemistry (PS)	1	1	-	2
Biotechnology (PS)	2	1	-	3
Genetics and Cytogenetics	1	1	-	2
Microbiology	1	1	-	2
Plant Breeding	6	2	1	9
Plant Pathology	2	2	1	5
Plant Physiology	2	1		3
Soil Science (Pedology)	1	1	-	2
Agril. Engineering	1	-	-	1
Nematology	1	-	-	1
Total	**22**	**14**	**3**	**39**

PS=Principal Scientist; Sr. S=Senior Scientist; S=Scientist

Transfer

Sr. No.	Incumbent	Transferred from	Transferred to	With effect from
1.	Dr. V. V. Sumanth Kumar, Scientist	DGR, Junagadh	DCR, Nagpur	23.11.2009
2.	Dr. Vinod Kumar, Scientist (SS)	DGR, Junagadh	Directorate of Litchi, Muzaffarpur	30.09.2009
3.	Dr. T. V. Prasad, Scientist (SS)	DGR, Junagadh	NBPGR, New Delhi	16.06.2009

Resignation

Dr. P. Kannan, Scientist, Soil Science resigned from ARS w.e.f. 12.01.2010

Superannuation

Dr. I. K.Girdhar, Principal Scientist, w.e.f. 31.07.2009

Financial upgradation

Shri V. M. Chawada, SSS, w.e.f. 06.06.2009
Shri G. S. Mori, SSS, w.e.f. 22.12.2009.
Smt. D. S. Sarvaiya, SSS, w.e.f. 27.03.2010.

Promotions

Shri Virendra Singh T-5 to T-6 w.e.f. 01.07.2009
Shri Prabhu Dayal, T-4 to T-5 w.e.f. 01.07.02009

Clearance of probation

Dr. R. S. Jat, Scientist, w.e.f. 08.01.2009
Dr. H. N. Meena, Scientist, w.e.f. 07.01.2010
Shri P. N. Solanki, LDC, w.e.f. 29.10.2009

Important Meetings

Research Advisory Committee (RAC)

The 11[th] meeting of Research Advisory Committee was held on 14-15 April 2009. Dr. C. Kempanna, former DDG (CS), ICAR, chaired the meeting. Among the members Dr. S. N. Nigam, Principal Scientist, ICRISAT and Dr. M. Rangaswamy, former Director, School of Genetics, TNAU attended the meeting. Presentations on ongoing research projects were made by the PI's and the Co-PI's. The Chairman and members also visited the laboratories. While concluding the meeting the Chairman expressed that although overall performance of the scientists in the last three years was up to the mark yet a lot more was required to be done in other areas. The Chairman expressed his concern on the several scientific positions lying vacant for years together and hoped that ICAR would soon fill up the vacant scientific positions so that all the relevant areas of research are adequately addressed.

RAC meeting in progress

Institute Research Committee (IRC)

The 53[rd] and 54[th] meetings of Institute Research Committee were held on 25-27 May 2009 and 2-10 February 2010, respectively. Both the meetings were chaired by the Director, DGR. During the meetings, a project-wise progress of research work was reviewed and the technical programme for ensuing seasons were finalized. The PIs of different projects presented the highlights of their respective projects and then proposed future plans of work. The plans of work proposed by the scientists were discussed thoroughly in the meeting and subsequently the plans were approved keeping in view the priorities and available resources.

Quinquennial Review Team (QRT)

The QRT for the NRCG for the period 2002-2006, to review the progress and performance of the research work at the NRCG and also the All India Coordinated Research Project on Groundnut, was constituted by the ICAR vide order no F12-1/2007-IAIII dtd 9th October 2007 and amended on 29 August 2008. The team consisted of the following members:

1.	Dr. J. H. Kulkarni	Chairman
2.	Dr. M. V. C. Gowda	Member
3.	Dr. N. Shankaran	Member
4.	Dr. M. Sudarshan Reddy	Member
5.	Dr. Subbrathnam	Member
6.	Dr. Ashok Mishra	Member
7.	Dr. Radhakrishnan T.	Member-Secretary

The first sitting of the review team was held at NRCG on 19th and 20th of September 2008 to review the progress of the ongoing programmes and activities of the NRCG. Later, the team visited RRS, TNAU, Vridhachalam from 26th to 28th April 2009 to review the progress of this AICRP-G centre. The next meeting was held at the Oilseed Research Station of MPKV at Jalgaon on 4th and 5th of August 2009. In the fourth meeting of the team was held at UAS, Dharwad on 9th and 10th of October 2009 and the progress of the AICRP Centres *viz.* JAU, Junagadh; RRS, Kadiri and Tirupati, ANGRAU; UAS, Dharwad; and RAU, Raichur were reviewed. The review of progress of Kadiri centre, however, could not be completed in this meeting. In the final sitting at NRCG, Junagadh from 5th to 8th of November 2009, the functioning of AICRP-G workshop was reviewed. During this meeting, besides completing the review of AICRP-G centre at Kadiri, the progress of work of ARS, Durgapura; Hanumangarh; GRS, Mainpuri; CRS, Aliyarnagar; ARS, Bhavanisagar; RARS, Jagtial; ARS, Chintamani; ACU, Imphal; MPKV, Rahuri; and MPUA&T, Udaipur were reviewed.

GENERAL INFORMATION

Institute Management Committee

Chairman

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

Members

1. Dr. R.A. Sherasiya, Director of Agriculture (Gujarat), Krishi Bhavan, Sector 10-A, Gandhinagar
2. Shri S. Kosalaraman, IAS, Commissioner of Agriculture, Chepauk, Chennai 600 005
3. Dr. A.H. Memon, Principal and Dean, College of Agriculture Engg. & Tech., JAU, Junagadh-362 001, Gujarat
3. Shri Madhubhai K. Mankad, Progressive Farmer, Krishi Vigyan Kendra, Gundala Road, At. Sadau, Tal. Mundra (Kutch) 370 421
4. Shri Haridasbhai Bikhabhai Zala, Progressive Farmer, Post at: Vadhavi, Dist. Junagadh
5. Om Prakash Nagar, Finance & Accounts Officer, Central Arid Zone Research Institute (CAZRI), Light Industrial Area, Jodhpur 342 003
6. Dr. V. S. Bhatia, Principal Scientist, National Research Centre for Soybean, Khandwa Road, Indore 452 001
7. Dr. D. Kumar, Principal Scientist & Project Coordinator (Arid Legumes), Central Arid zone Research Institute, Jodhpur 342 003
8. Dr. C. Chattopadhyay, Head, Division of Crop Protection, Indian Institute of Pulses Research, Kanpur 208 024
9. Dr. D.B. Kuchchadia, Director of Research, Junagadh Agril.University, Junagadh
10. Dr. T. Radhakrishnan, Principal Scientist, DGR, Junagadh

Member Secretary

Administrative Officer, DGR, Junagadh

Research Advisory Committee

Chairman

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

Members

1. Dr. S.N. Nigam, Principal Scientist (groundnut), ICRISAT, Patancheru P.O., Hyderabad-502 324

2. Dr. V. Muralidharan, Professor (Oilseeds), Department of Oilseeds, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641 003
3. Dr. G. S. Jadhav, Ex-Director Instruction, MAU, Parbani, 'Prasad', 243, N-3, CIDCO, Aurangabad-431 003, Maharashtra
4. Prof. R. L. Savaliya, Director of Ext. Education, Junagadh Agricultural University, Junagadh 362 001, Gujarat
5. Dr. G. V. Subbaratnam, Retd. Professor of Entomology, Agri. Biotech Foundation, A. P. Netherlands Biotechnology Programme, ATIC Building, ARI Campus, ANGRAU, Rajendranagar, Hyderabad- 500 030
6. Director, DGR, Junagadh-362 001
7. Dr. V.D. Patil, Assistant Director General (O & P), Indian Council of Agricultural Research (ICAR), Krishi Bhavan, New Delhi 110 114
8. Shri Madhubhai K. Mankad, Progressive Farmer, Krishi Vigyan Kendra, Gundala Road, At. Sadau, Tal. Mundra (Kutch) 370 421
9. Shri Haridasbhai Bikhabhai Zala, Progressive Farmer, Post at: Vadhavi, Dist. Junagadh

Member Secretary

Dr. P.C. Nautiyal, Principal Scientist, DGR, Junagadh-362 001

Institute Research Committee

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

Quinquennial Review Team (QRT)

Chairman

Prof. J. H. Kulkarni, Ex- Vice Chancellor, University of Agricultural Sciences, Dharwad, Dharwad 580 005

Members

1. Dr. Subbrathnam, Ex-Professor of Entomology, Agri Biotech Foundation, A.P. Netherlands Biotechnology Programme, ATIC Building, ARI Campus, N G Ranga Agricultural University, Rajendranagar, Hyderabad-500 030
2. Prof. N. Shankaran, Ex-Professor of Agronomy, TNAU, Coimbatore, 52/101, Gopal Layout, Ponnayarajapuram, Coimbatore-641 001

3. Dr. Ashok Mishra, Ex-Principal, College of Agriculture, JAU, Junagadh; Jain Research & Development, Jain Irrigation Systems Ltd, Agripark, Jain Hills, PO Box 72, Shirsoli Road, Jalgaon-425 001
4. Dr. M. Sudarshan Reddy, Dean of Agriculture, N G Ranga Agricultural University, Rajendranagar, Hyderabad-500 030
5. Prof. M. V. C. Gowda, Professor of Genetics and Plant Breeding, UAS, Dharwad-580 005

Member Secretary

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

Institute Joint Staff Council

Chairman- Director, DGR

Members: Staff side

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

Members: Office side

1. Dr. P. C. Nautiyal, Principal Scientist
2. Dr. Chuni Lal, Senior Scientist
3. Dr. R. Dey, Senior Scientist
4. Shri C. P. Singh, Technical Officer (T-7/8)
5. Administrative Officer
6. Finance & Accounts Officer

FINANCE AND ACCOUNTS

EXPENDITURE STATEMENT FOR THE YEAR 2009-10

Rupees in lakhs

DGR-Main Unit

Sr. No.	Budget Head	Non-Plan			Plan		
		BE	RE	Expenditure	BE	RE	Expenditure
1	Estt. charges	350.00	437.05	448.55	3.00	3.00	0.00
2	OTA	0.10	0.00	0.00	0.00	0.00	0.00
3	Wages	32.00	32.40	35.60	0.00	0.00	0.00
4	TA	4.50	4.16	3.91	12.00	12.00	12.29
5	HRD	0.00	0.00	0.00	0.00	0.00	0.00
6	Other charges including equipment/vehicles	50.00	71.44	78.21	190.00	190.00	194.11
7	Works	18.00	0.00	0.00	45.00	45.00	44.99
	Total	**454.6**	**545.05**	**566.27**	**250.00**	**250.00**	**251.39**

AICRP-G

Rupees in lakhs

Sr. No.	Budget Head	Allocation	Expenditure
1	Pay and Allowances	244.00	249.37
2	TA	6.90	6.90
3	Recurring Contingency	64.10	48.45
4	HRD	0.00	0.00
5	Need Based Research	0.00	10.49
	Total	**315.00**	**315.21**

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

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EPABX	: 0285-2672461/2673041
Administrative officer	: 0285-2672843
Guest house	: 0285-2673629

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