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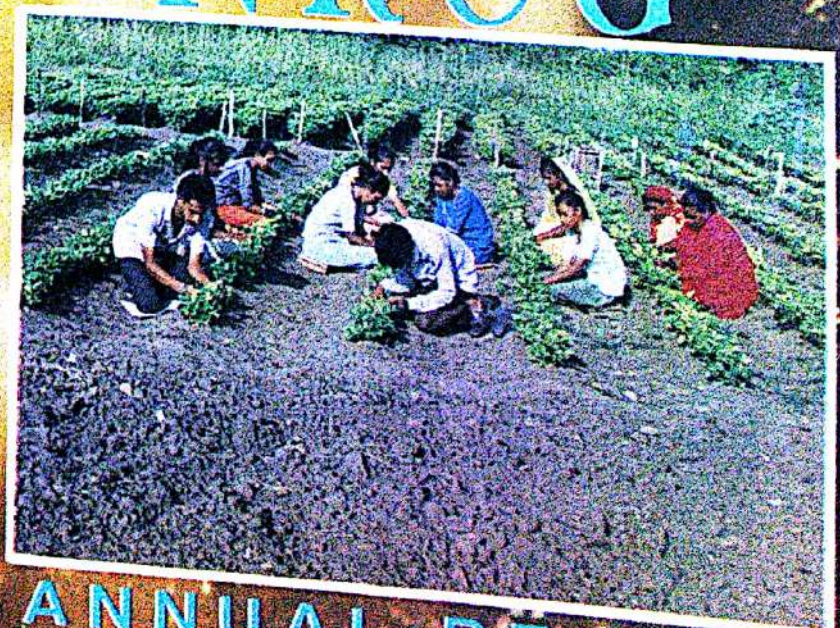

ANNUAL REPORT
1993-94

NRCG
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ICAR

National Research Centre for Groundnut
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PREFACE

It gives me great pleasure in bringing out the annual report of the National Research Centre for Groundnut, for the year 1993-94.

The year has seen some significant modifications in the management of research projects. The projects have been reoriented so as to fit into six major research programmes as per the recommendations of the Council and to encourage multidiciplinary researches.

The year has also seen a change in the coordinating system of groundnut research in India. A separate All India Coordinated Research Project on Groundnut (AICRPG) was created with its head quarters in the NRCG, Junagadh. The First Kharif Groundnut Research Workers Group Meeting was held at the NRCG during 21-24April, 1994 in which over one hundred groundnut research workers participated.

The developmental activities also received a special thrust during the year under report. About 35 hectares of land was additionally developed and brought under cultivation.

Work in the first phase of creating an irrigation grid for the NRCG experimental farm has been initiated and with this the crop management is expected to improve a lot with efficient utilization of the available water resources. A new biotechnology laboratory was established with the financial assistance of the World Bank and the NARP.

In the course of past fourteen years of its existence, the NRCG has been able to carve out a niche for itself by generating valuable information on groundnut research. As in the preceding years, this annual report for the period April 1993 to March 1994 represents another milestone, depicting NRCG's achievements in the areas of research, development and extension activities. I shall be grateful to receive suggestions, if any, that would help us to improve the quality and content of the future reports.

P. S. REDDY
DIRECTOR

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DIRECTOR'S STATEMENT

The National Research Centre for Groundnut was established by the Indian Council of Agricultural Research in 1979 to undertake basic, strategic and mission-oriented researches in groundnut.

The objectives of the Centre are as follows.

NRCG's Objectives

1. Collection, maintenance, evaluation, utilization and documentation of primary gene pool of groundnut.
2. Breeding varieties for high yield, quality, earliness, fresh seeddormancy, peg strength, tolerance to drought and cold and resistance to major insect pests and diseases.
3. Supply of segregating material in early generations for breeding varieties suitable for different agroecological situations.
4. Gene transfer from wild to cultivated species and rapid multiplication of hybrid material.
5. Studies on farming systems.
6. Studies on economically important diseases and insect pests and identification of stable sources of resistance among germplasm for further use in breeding programmes. Development of crop protection technologies with an emphasis on integrated control of diseases and pest complex.
7. Studies on groundnut composition and quality in relation to oil and protein.
8. Physiological studies onfundamental and applied aspects on productivity, energy harvest, mineral nutrition; abiotic stresses including moisture, temperature and salt stresses; seed dormancy and viability, pod development and post harvestpr oblems.
9. Studies on nitrogen fixation in relation to *Rhizobium*, host and environment.
10. Monitoring the programmes of multi-locational coordinated trials under AICRP on Groundnut through the Project Coordinating Unit.

Organizational Set-up

The research activities of the Centre are carried out by nine scientific sections- Genetic Resources, Plant Breeding, Genetics and Cytogenetics, Agronomy, Biochemistry, Plant Pathology, Entomology, Plant Physiology and Microbiology. All the nineteen research projects (see Annexure I) have been formulated to suit the Centre's mandate and appropriate strategies are followed for the successful implementation of these projects. In addition, two externally funded projects are also implemented at the NRCG. The supporting sections of the Centre are:

Library, Farm, Establishment and Audit and Accounts.

A brief account on the most significant achievements of the Centre during the year 1993-94 is presented below.

Research Accomplishments

1. Germplasm resources :

Twenty six species free from peanut stripe virus (PStV) were maintained.

The working collection of germplasm comprising 5518 accessions belonging to all the four habit forms was rejuvenated and characterized.

One thousand accessions were screened for the presence of seed borne nematodes.

A "Virginia Bunch Groundnut Germplasm Evaluation Catalogue" was published.

2. New sources of disease resistance :

Five genotypes, namely ICGV 86020, ICGV 86594, ICGV 87160, ICG 6284 and NCAc 343 were found to possess multiple disease resistance. Twelve other genotypes, viz. ICG nos. 2716, 7881, 6340, 7013, 4747, 7887, NCAc 927, NCAc 17149, NCAc 17133-RF, ICGV Nos. 87254, 86667 and ICGV 86707, possessing resistance to early leaf spot, late leaf spot and rust were identified.

3. Disease resistant cultures of NRCG :

The following disease resistant advanced breeding lines were developed by the NRCG :

Rust : PBDR 18, PBDR 32-6, PBDR 33a, PBDR 48, DRV 1, DRV 10, DRV 44; PBS 105
ELS : DRV 40, PBS 105
LLS : PBDR 18, PBDR 25, PBDR 48, DRV 19A, DRV 40, PBS 105

Alternaria blight : DRV 19A, PBS 105, IR 28

4. Insect pest resistant cultures :

The advanced breeding lines, IR 14, IR 34 PBS 105 and PBS 145 were found to possess resistance to thrips while the cultures, PBS 48, PBS 105, PBS 118 and IR 6 were resistant to jassid.

The released cultivar BG 2 and an advanced breeding line, PBS 105, were found to show moderate resistance to aphids.

5. Promising bold-seeded accessions :

Six bold seeded, high yielding virginia germplasm accessions (NRCGs 1005, 2746, 2863, 5505, 7276 and 8939) were identified. These accessions also possessed favourable confectionery qualities

The bold seeded accessions, NRCGs 839, 1840, 3040 and 7274 were found to be resistant to seed colonization

by *A. flavus*.

6. Utilization of wild Arachis *species :*

Fourteen species (10 of section *Arachis*, 3 of *Erectoides*, and 1 of *Triseminalae*) were analyzed for soluble seed proteins using polyacrylamide gel electrophoresis. The patterns differed significantly between sections.

The interspecific hybrids of crosses involving ten diploid wild *Arachis* species ICGs 11558, 11561, 4983, 8954, 8132, 8192, 8164, 8216, 8906 and *A. otavioi* as male parents and cv. SB XI as female parent, were produced.

7. In vitro studies :

Somatic embryogenesis upto 48% could be induced. Explants cultured on media containing 2/6 and 2/8 ppm of NAA/2,4-D produced 11.5 and 13.2 somatic embryos per explant, respectively. Germination in 32 % of the somatic embryos was obtained. Mature deembryonated cotyledons of cultivar SB XI were successfully used for micropropagation through production of multiple shoots.

8. Studies on mulching :

Wheat straw mulch increased pod yield by 18% over control by increasing the pod number per plant by 17.5% and pod weight by 28%. The combination of wheat straw and black polyethylene mulches was found to give 34% higher pod yield than the control. High levels of available Zn (0.892 ppm) and Fe (1.352 ppm) at harvest were recorded in wheat straw mulch.

9. Controlling collar rot :

Dressing the seed with Carbendazim 25 SD @ 3 g/kg seed reduced the incidence of collar rot by 50% which resulted in an increase in pod yield by 22.64% over the untreated control.

10. Integrated control of diseases and insect pests :

An integrated crop management practiceinvolving low cost components to control diseases, insect pests and weeds in groundnut has been developed.

11. Identification of biofungicides :

The leaf powders of plant species, *Eucalyptus, Terminalia catappa, Annona squamosa* and *karanj* were identified as potential biofungicides.

12. Studies on peanut stripe virus (PStV) :

The average seed transmission of PStV in groundnut was 17.73% when inoculated at vegetative stage while it was 5.11% when inoculated at flowering stage.

It was observed that significantly higher number of aphids were trapped by the yellow cylindrical trap than by square glue trap and yellow water traps.

13. New technique for oil estimation :

The specific gravity of isolated cotyledons (SPGR) was earlier shown to be inversely related with their oil content. The following two regression equations were developed for prediction of oil content in seed lots.

Oil' = 239.65 - (176.81 X SPGR)

Oil^ = 242.26 - (179.13 X SPGR)

14. Biochemical studies :

The contents of sucrose, reducing sugars and free amino acids, starch, total phenols and dihydroxy phenols were observed to show diurnal fluctuations in varying levels. Partitioning of assimilated carbon was more in sucrose than in starch during the photosynthesis by groundnut leaves.

15. Cold tolerant genotypes :

Four lines, NRCGs 9555 and 9528 and ICGs 3738 and 4617, were found to be tolerant to 18/12°C cycles and showed more than 75% seed germination.

16. Drought tolerant genotypes :

The genotypes, TAG 24, Girnar 1, J 11, RSHY 1, KRG 1, and Jyoti were found to germinate reasonably well under low moisture conditions.

17. Studies on nutrient requirements :

Application of micronutrients along with macronutrients produced 40% more pod yield than application of macronutrients alone. The critical sufficiency levels of Fe, Mn, Zn, Cu, B and Mo in soil were worked out.

18. Microbiological studies :

Inoculation of either *Bacillus polymyxa* or *B.circulans* along with 50 kg P_2O_5 of rock phosphate was found to significantly increase the phosphorus uptake, biomass production, nodulation and pod yield of groundnut plant.

B. Developmental Activities

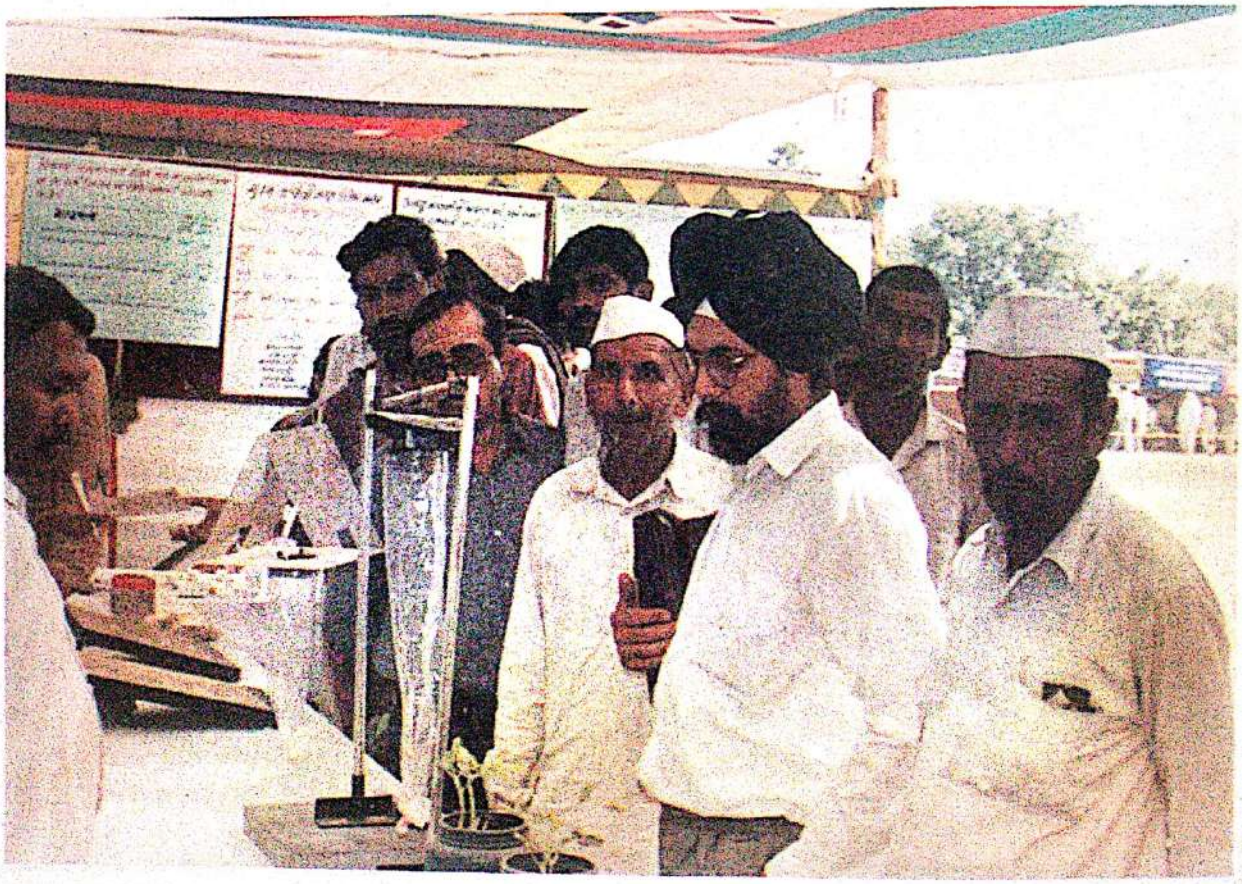
1. A separate biotechnology laboratory was established to undertake researches on rapid in vitro multiplication, transformation and disease resistance in groundnut. The project is funded by the World Bank and implemented through the National Agricultural Research Project, ICAR.

2. About 35 hectares land was additionally developed and brought under cultivation.

3. The work under the first phase of creating an irrigation grid system for the NRCG experimental plots has begun.

4. A rain-out shelter was installed with the technical cooperation of the ICRISAT for undertaking the simulated drought studies under the ACIAR (Australia) funded project.

5. The equipments procured by the centre during the year included a spectrophotometer, a sonicator, an electrophoresis system, a microcentrifuge, a cryostat, an automatic ELISA reader, an ultra low deep freezer, an osmometer,



Above : A view of the NRCG stall at the exhibition organized by the Junagadh Campus of the Gujarat Agric. University

Below : Farmers viewing at some of the exhibits displayed in the NRCG stall

a walk-in plant growth chamber, a binocular research microscope, an inverted tissue culture microscope, a lyophilizer, an ultra sensitive pH meter, two laminar air flow systems, a personal computer and a continuous seed blower.

C. Extension Activities

The Centre participated in three farmers fairs at Ajab and Moti Mohanpari villages, organized by the GROFED, Junagadh, on 12.4.93 and 18.3.94 and put up exhibition stalls on low cost production technologies generated at the Centre.

The NRCG technologies were also exhibited in the farmers fair organized at the Gujarat Agricultural University, Junagadh on the occasion of the inaugurations of its new Agricultural Engineering building complex.

GENETIC RESOURCES

A. Collection, maintenance, evaluation, documentation and distribution of genetic resources of cultivated groundnuts and related *Arachis* species

(N.R.Bhagat, K. Rajgopal, P. Sen, M.P.Ghewande, V.Nandagopal, A.L.Singh and S.K.Yadav)

1. Collection of germplasm:

Fifty-eight special-feature groundnut accessions, showing wide variability for the size, shape, beak, constriction and reticulation of pod, number of seeds per pod,. seed colour and seed size were assembled from the ICRISAT, Patancheru.

Dr.N.R.Bhagat participated in a crop specific groundnut germplasm collection expedition in Cameroon organized by the ICRISAT in collaboration with the Institute of Agronomic Research, Yaounde, Cameroon and the NRCG, Junagadh, from 20th July to 2nd September, 1993.

The fund for the joint collection mission was provided by the Asian Development Bank, Manila, Philippines. The main purpose was to collect traditional landrace populations belonging to four botanical types of cultivated groundnuts grown by the farmers in south Cameroon and to observe cultural practices in Cameroon.

The exploration team surveyed 91 villages, 16 markets and 20 farmers' fields of seven provinces in southern part and collected 93 seed/pod samples belonging to the three botanical forms (25 spanish (VUL), 51 valencia (FST) and 17 virginia) from 63 villages of 20 districts, as presented below.

rovince	District	Village	Spanish	Valencia	Virginia
Eastern	3	20	6	30	-
Coastal	4	11	2	6	8
Southern	2	11	4	9	1
Littoral	3	4	3	2	1
South west	3	11	10	2	-
West	2	3	-	-	6
North west	3	3	-	2	1

The farmers of Eastern, Central and Southern provinces grow mixed valencia forms with moderate to deeply reticulated, thick or thin shelled 2-4 seeded pods. The colour of the seed testa in these forms is either purple, rose or white. The farmers, after shelling the pods, separate purple and rose seeds and plant them separately, though their production potential is not known.

In coastal region at low altitude in the Littoral and the Southern provinces, mostly spanish and a few valencia cultivars are grown either in mixed or pure form. In high rainfall and high altitude zones in North west and Central provinces, apart from valencia and spanish cultivars, virginia bunch (HYB) cultivars are more popular and extensively cultivated as sole crop or mixed with maizeand other conventional crops. These virginia forms are 2-3 seeded with rose testa and mature in 90-100 days. In this region, ridge-and-furrow system is very popular as it has been found to result in high pod yield.

2. Maintenance and multiplication of germplasm :

Rejuvenation of two specific collections (126 valencia, 257 virginia) was done in polyhouse in the summer season to ensure freedom from PStV vectors. The crop was free from PStV and other foliar diseases and sizeable number of pods could be harvested.

In Kharif 1993, the entire working collection of 5518 accessions belonging to FST (612 accessions), VUL (2180), HYB (577), virginia runner (HYR) (1560), specific accessions (370) and bold-seeded virginias (219) was field-planted along with two controls of respective habit forms, in an augmented block design. Because of moisture stress, crop growth and pod yields were poor.

3. Characterization of germplasm accessions :

The FST and HYB collections, numbering 602 and 551 accessions respectively, were characterized for stem hairiness, stem pigmentation, leaf colour and peg colour at maturity by adopting ICRISAT-IBPGR descriptors. The results are presented below.

Descriptor		Number of accessions	
		FST	HYB
Stem hairiness	Sparse	362	514
	Abundant	240	37
Stem pigment	Absent	422	500
	Present	180	51
Peg colour	Absent	341	502
	Present	261	249
Leaf colour	Light green	179	54
	Green	416	348
	Dark green	7	149

Abundant hairiness was recorded in 240 FST accessions, whereas 514 HYB accessions showed sparse hairiness. Stem pigmentation at maturity was absent in majority of FST (422) and HYB (500) accessions. Peg colour was observed in nearly half of the accessions in both collections. The foliage colour was dark green in 149 HYB accessions.

Variation in pod beak,constriction, and reticulation recorded in 580 FST and 512 HYB accessions, displayed the following trend :

Trait	Pod Beak		Constriction		Reticulation	
	FST	HYB	FST	HYB	FST	HYB
Absent	130	54	118	76	97	16
Slight	312	309	256	340	323	158
Moderate	130	149	196	92	146	310
Prominent	8	-	10	4	14	28

Majority of the accessions thus had slight to moderate beak, constriction and reticulation of pods.

4. Evaluation of germplasm :

The Kharif crop was exposed to thrips at the initial stage of growth, followed by the end-season drought which resulted in poor pod bearing. Only 450 accessions gave moderate to good pod yield (range 81-200 g per 3 m row). Among these, four FST (NRCGs 827, 3812, 3659, 6978), four VUL (NRCGs 5506, 6845, 7665, 7821) and two HYR (NRCGs 5187 and 7285) had pod yield ranging from 161 - 200 g per 3 m row.

5. Report of PStV survey team :

The ICAR/Government of India survey team visited the summer-sown germplasm in April-1993, and found no symptoms (primary or secondary) of PStV.

6. Studies on bold seeded collection :

a. Yield evaluation of bold-seeded virginia collection :

Seventeen HYB and 10 HYR bold-seeded accessions identified as promising based on the results of the last two years, were further evaluated for pod yield and seven other related traits. The experiment was laid out in a completely randomized block design with four replications, along with three checks, M13, GG 11, and BAU 13.

The results are presented below:

Character	Mean	Range	VMSS	$CD_{0.05}$
Pod yield (g/plant)	4.0	1.4-7.4	10.2**	1.5
Shelling (%)	60.1	51.6-67.5	63.6**	5.9
Sound mature seed (%)	63.2	48.6-78.6	258.5**	12.8
100-seed mass (g)	51.8	37.6-62.3	145.7**	5.2
Pod length (mm)	30.6	24.0-36.0	32.1**	3.4
Pod width (mm)	14.0	12.2-19.5	8.9**	1.3
Seed length(mm)	15.5	13.0-18.0	6.2**	1.5
Seed width (mm)	8.0	7.1-8.6	0.7**	0.9

VMSS=varietal sum of squares; ** Significant at 1 % level

Varieties of both the collections showed significant differences for all the eight traits. There was significant variation for 100-seed mass (range 37.6 to 62.3 g). Three HYB (NRCGs 2863, 5505 and 8939) and three HYR (NRCGs 1005, 2746 and 7276) were promising for pod yield and related traits. These accessions also possessed favourable physical confectionery qualities.

b. Screening for resistance to *Aspergillus flavus* colonization :

Seeds of 14 HYB and 21 HYR accessions were artificially screened against *A.flavus* colonization. The accessions, NRCGs 839 (HYB) and 1840, 3040 and 7274 (HYR) were resistant to seed colonization. Two HYB (NRCGs 2863 and 5505) and two HYR (NRCGs 1005 and 2746) accessions possessing desirable agronomic traits and moderate resistance to *A.flavus* colonization were identified.

c. Screening for biochemical traits :

The seed oil content in 15 HYB and 25 HYR accessions ranged from 38.8 to 52.4% with a mean value of 45.7%. Similarly, protein and total sugar contents in seed ranged from 17.7 to 25.6% and 5.2 to 15.9%, respectively. The accessions recording low oil content (38-42%) were NRCGs 5505 (HYB), 994 and 5363 (HYR). The HYR accessions, NRCGs 734, 1005, 2746, 5343 and 8941 exhibited 24.3 to 25.6% seed protein content. Similarly, NRCGs 479 and 5505 (HYB) and 698 and 994 (HYR) recorded high sugar content (13 - 15.9%) in seeds.

7. Inter-institutional Collaboration :

Screening of 1000 accessions, drawn at random, was undertaken against the presence of seed-borne nematodes in collaboration with the Plant Quarantine Division, NBPGR, New Delhi, to identify resistant sources and to prevent further spread of an unidentified species of *Aphelenchoides* reported in Andhra Pradesh, to other groundnut growing regions in India. Out of these, 16 accessions were found to be infested with live specimens of *Ditylenchus* spp., 39 with *Aphelenchoides* spp., 43 with *Aphelenchus* spp., 19 with *Rhabditis* spp. and 2 with *Pratylenchus brachyurus*.

8. Documentation of evaluation data :

A database was created for the entire NRCG germplasm collection and the passport and evaluation data were documented for identifying the useful accessions and to facilitate their use in regional, national and international crop improvement programmes.

9. Publication of catalogue :

The "Virginia Bunch Groundnut Germplasm Evaluation Catalogue" published by the NRCG comprised data on 13 economically important characters on 653 accessions, averaged over four crop seasons, beside listing promising accessions with desirable traits. The catalogue was distributed to groundnut researchers and genebank managers throughout the ICAR, the IPGRI and the ICRISAT.

PLANT BREEDING

A. Breeding and genetic studies for improving yield and other qualitative and quantitative characters in groundnut

(A. Bandyopadhyay and Vijendra Singh)

1. Multiplication and selection:

Advanced breeding lines and segregating families were multiplied in polyhouses in Rabi-summer 1993.

In kharif 1993, 130 cultures from F_2 to F_6 generations from the crosses made for incorporating resistance to aflatoxigenic fungi (67 crosses), earliness in virginia(31) and spanish/valencia types (2) , dormancy in spanish (3) and high BNF (16) were grown. From these, 375 single plant selections were made on the basis of yield characteristics. In addition, 252 advanced breeding lines were multiplied. Ten HPS lines were identified for further yield trials. All the above materials were further advanced in Rabi-summer 1994.

2. Yield trials:

Three yield trials viz. one with 28 spanish/valencia cultures, another with 13 virginia bunch/virginia runner cultures and the third one with 21 virginia bunch/virginia runner cultures, were conducted in Kharif 1993. The season was affected by mid-season drought and as a result the yield levels were low. In the first and the second trials no test culture could significantly outyield the checks. In the third trial, three cultures were significantly superior to the checks but showed low shelling percentages.

3. Experiments :

a. Variation in oil content within and between plants of fixed genotypes :

This preliminary study, having a bearing on selection for oil content in segregating generations (as recommended by the quinquennial review team) was made by using the method of oil estimation developed by the Biochemistry section of the NRCG, though the method is destructive. Oil percentage of a single kernel from each of the ten plants from 10 cultivars and 5 plants from 2 cultivars was determined. Analysis of variance of the data showed that the within plant variation, even in fixed lines, could be as high or higher than the between-plants variation.

b. Effect of sample size on estimates of yield related characters of small-plot yield trials :

A random sample of fifteen individual plants was harvested from each plot of two yield trials ; one with spanish/valencia and the other with virginia bunch/virginia runner. The yield characteristics of each sampled plant and the whole plot were noted. A computer programme has been developed to select random sub-samples

of 5,7,9,11 and 13 plants from the 15 and such selections have been made. Further analyses of these data are being done.

4. New hybridizations:

As a test attempt three crosses viz. Kadiri 3 x NCAc 17090, Girnar 1 x GG 2 and Kadiri 3 x Chico were made in polyhouse. Ninety three pods of F_0 were harvested.

Crosses made in Kharif 1993 included five for introducing aflatoxin resistance into HPS types, three for earliness in virginia and two for earliness in spanish types, two for increasing shelling percentage in the cultivar Girnar 1 and one for incorporating fresh seed dormancy in spanish types.

B. Breeding for resistance to biotic and abiotic stresses in groundnut
(Vijendra Singh, M.P. Ghewande, V. Nandagopal, A.L. Singh and A. Bandyopadhyay)

1. Breeding for resistance to insect-pests :

Results of a field experiment conducted in Rabi-summer 1993 to screen groundnut genotypes against insect pests indicated that the released cultivar BG 2 supported minimum (14.0) aphid count per plant and an advanced culture, PBS 105, had 16.33 aphids per plant. The overall mean was 53.8 aphids per plant. The high yielding genotypes on the basis of yield per plant were Girnar 1 (11.16 g), IR 1 (8.93 g) and IR 34 (7.0 g).

2. Experiment on abiotic stresses:

An experiment was conducted in Summer 1993. Observations were recorded on plant height (cm), shoot dry matter (g/ plant) and sodium and potassium contents of shoots. The data were statistically analyzed. The cultivar Girnar 1 had maximum dry matter (2.19 g/ plant) against the grand mean of 1.39 g/plant, while the germplasm accession, NRCG 168 had the maximum plant height (13.90 cm).

Nineteen cultures including advanced breeding lines, selections made in the cultivar Girnar 1 along with checks were sown in Rabi-summer 1994 in a trial with three replications for assessing their iron absorption efficiency. Visual scores for iron chlorosis were recorded at two stages and further analysis is in progress.

3. Trials :

Three trials, comprising 20 disease resistant (DRV series) cultures in the first trial, 25 (PBDR series) in the second trial and 15 cultures in the third trial, were conducted in Kharif 1993. Spore suspension of ELS, LLS and rust pathogens was sprayed in all the trials to create artificial epiphytotic conditions. Sprinkler irrigation system was used to create high humidity. Data on morphological characters and disease scores were recorded and statistically analyzed. Trial-wise results are given below.

a. Trial 1

PBDR 6 : Moderately resistant to rust,

PBDR 13 : Moderately resistant to late leaf spot (LLS) and rust,

PBDR 15 : Moderately resistant to early eaf spot (ELS) and rust,

PBDR 18 : Resistant to LLS and rust, moderately resistant to *Alternaria* blight,

PBDR 20 : Moderately resistant to ELS and LLS,

PBDR 25 : Moderately resistant to ELS, resistant to LLS,

PBDR 25-1 : Moderately resistant to ELS and LLS,

PBDR 32-6, PBDR 33a : Resistant to rust, moderately resistant to *Alternaria* blight,

PBDR 48 : Moderately resistant to ELS, resistant to LLS and rust,

PBDR 49 : Moderately resistant to LLS and rust,

Among the advanced foliar disease resistant cultures, PBDR 25 had the maximum yield (5.78 g/ plant). Statistical analysis of data revealed that the cultures PBDR 25, PBDR 15, PBDR 25-1, PBDR 6, PBDR 20, PBDR 48 and PBDR 49 were on a par with check varieties Girnar 1, JL 24 and GG 2 for pod yield while the others had significantly lower yields than check varieties.

The cultures having significantly higher 100-pod weight than the grand mean (64.6 g) were PBDR 18 (85.1 g), PBDR 48 (79.1 g) and PBDR 15 (76.3 g). PBDR 25-1 and PBDR 33a had low 100-kernel weight (23 g and 24.5 g, respectively). Shelling per cent of PBDR 18 and PBDR 48 were on a par with checks. Shelling per cent of cultures PBDR 32-6, PBDR 15, PBDR 33a and PBDR 20 were at par with grand mean value (66.7%).

b. Trial 2

DRV 1, DRV 10 and DRV 44 : Resistant to rust,

DRV 19A : Resistant to *Alternaria* leaf blight and LLS,

DRV 40 : Resistant to ELS and LLS,

Among the resistant cultures, DRV 40 had significantly higher pod yield per plant (5.31 g) than the check variety Kadiri 3 (3.46 g). The pod yields in the cultures, DRV 19A, DRV 10, DRV 44 and DRV 1 were on a par with check varieties Kadiri 3 and ICGS 44 (4.93 g).

c. Trial 3

Girnar 1 : Resistant to thrips and jassids

PBS 48 : Resistant to jassids, moderately resistant to rust

PBS 105 : Resistant to ELS, LLS, rust, *Alternaria* blight, jassids and thrips

PBS 118 and IR 6 : Resistant to jassids

IR 14, IR 34 and PBS 145 : Resistant to thrips

IR 28 : Resistant to *Alternaria* blight

PBS 105, identified as having multiple disease and insect pest resistance,had significantly lower pod yield per plant (1.64 g) thanthe grand mean (2.58 g). The cultivar Girnar 1 had significantly higher pod yield (4.51 g/plant) than the grand mean + CD, 2.58 ± 0.76). Rest of the resistant/ tolerant cultures had yield/ plant at par with grand mean.

A field trial consisting of 25 advanced cultures, selected earlier for resistance to diseases and insect pests, was laid out in summer 1994 with three replications to select multiple resistant cultures with satisfactory yield performance. Screening against third instar of *Helicoverpa* was done in a choice test and the results are being analyzed.

4. Multiplication and selection:

The advanced and the segregating materials, bred for biotic and abiotic stresses, were multiplied in Rabi-summer 1993 and Kharif 1993. The segregating material multiplied included 64 F_2 to F_5 lines bred for resistance to biotic stresses and 24 to abiotic stresses. The advanced lines multiplied included 28 for resistance to insect pests and 128 for disease resistance. A number of selections made from Girnar 1 were also multiplied.

In addition to selections made in trials, twelve selections in segregating generations were made in Kharif 1993 for resistance to diseases and insect pests and tolerance to drought.

5. Screening advanced cultures against foliar diseases:

Forty five advanced cultures were screened in Kharif 1993 for foliar diseases in a uniform disease nursery trial. Results showed that PBDR 15 was resistant to ELS and LLS, PBDR 25-1 to ELS, and PBDR 32-6 and PBDR 33 to rust. Twenty five virginia bunch cultures were sown in field for screening against PStV, bud necrosis and *Alternaria* diseases in Rabi-summer 1994.

6. Hybridizations :

Three crosses viz., JL 24 x NCAc 17149, Girnar 1 x BG 2 and BG 2 x 5S were made in polyhouse in summer 1993 as a testattempt. Twenty three F_0 pods were harvested.

Ten cross combinations to combine various biotic and abiotic stresses were attempted in Kharif 1993. A total of 595 F_0 pods were harvested.

C. Breeder seed production of national varieties of groundnut (Vijendra Singh and A. Bandyopadhyay)

About 1 ha area was sown with the nucleus seed of Girnar 1 in Kharif 1993 and 4.2 quintals of seed was harvested.

As breeder seed production has been suspended, no target of breeder seed was taken in Rabi-summer 1994.

GENETICS AND CYTOGENETICS

A. Characterization and utilization of wild *Arachis* species for genetic improvement of groundnut

(P. Sen, T.G.K. Murthy and T.Radhakrishnan)

1. Collection and maintenance:

Twenty four species, 19 belonging to section *Arachis*, three to *Erectoides*, one to *Extranervosae* and one to *Ambinervosae*, were collected from t he ICRISAT and 22 were established. Twenty six species free from PStV were maintained in poly houses.

2. Electrophoretic patterns of seed proteins :

Fourteen species (10 of *Arachis*, 3 of *Erectoides*, and 1 of *Triseminalae*) were analyzed for soluble seed proteins using polyacrylamide gel electrophoresis. The patterns differed significantly between sections. Intrasectional variations were also present. However, annual and perennial species could be separated based on the banding patterns. *A. monticola* was closer to *A. khulmanii, A. duranensis, A.* sp. GK 30008 and *A. correntina* than to *A. stenosperma, A. helodes, A. cardenasii, A.* sp. GK 30011 and GK 35001. *A. pusilla* of section *Triseminalae* had a distinctly separate banding pattern compared to other species.

3. Seed oil and seed protein contents in advanced interspecific derivatives :

The analysis of 44 interspecific derivatives by the Biochemistry section for oil content revealed that four cultures of cross cv. GG 2 x *A. chacoense* had over 53 % oil (7-6-26 = 55.5%, 1-10-1 = 54%, 7-6 = 54%, 2-21b = 53%). Seed protein content ranged from 18.9% (7-6-26) to 27.2% (2-21b). Among them, 7-6-26, 7-6 and 2-21b were also high yielders as revealed by yield trials over three years. The culture 2-21b had thus high content of oil as well as proteins in seeds in addition to high yield potential and may be considered for further testing.

4. New interspecific hybridizations :

Crosses were attempted by using the cultivar SB XI as female parent and 22 *Arachis* species as male parents (18 of section *Arachis*, 1 of *Extranervosae*, 1 of *Rhizomatosae* and 2 of *Erectoides*). Over 10,000 hormone aided hand pollinations were made and over 600 F_1 pods harvested. The seeds were grown in Rabi-summer 1994 to isolate interspecific hybrids. The hybrids of crosses involving the species ICGs 11558, 11561, 4983, 8954, 8132, 8192, 8164, 8216, 8906 and *A. otavioi* as male parents were isolated.

5. Generation advancement and selections :

Early interspecific derivatives of nine different crosses were grown and foliar disease resistant selections were made in all the crosses, as mentioned below.

1. J 11 x *A.cardenasii* - 15 (BC1F4)
2. J 11 x *A.duranensis* - 29 (BC1F6)
3. J 11 x *A.chacoense* - 5 (F5)
4. J 11 x *A.stenosperma*- 2 (F4)
5. J 11 x *A. villosa* - 1 (F4)
6. J 11 x *A.*sp Manfredi5 1 (F4)
7. GG 2 x *A.chacoense* - 5 (F6)
8. Girnar 1 x (J 11 x *A.chacoense*) - 1 (BC1F4)
9. JL 24 x 2-16-1-120 (BC1F3)

6. Testing yield potential of advanced derivatives :

Twenty one advanced derivatives of crosses GG 2 x *A. chacoense*, M 13 x *A. villosa*, J 11 x *A. chacoense*, and J 11 x *A. duranensis* were grown in a replicated randomizedblock design to evaluate their yield potential.Two semispreading cultures, T1 (cv. GG 2 x *A. chacoense*) and CS 21 (M 13 x *A. villosa*) yielded significantly (38%) higher than Kadiri 3 and one bunch culture, 7-6 yielded 50% over the control JL 24.Three semispreading cultures yielded more than 20 % over Kadiri 3 and one bunch culture yielded 15% more than JL 24.

7. Genetical studies on the material generated :

a. Dwarfism : Tetragenic control of extreme dwarfism was observed in the F_2 generation of a reciprocal cross between 2-16-1,an advanced compact-spreading derivative of cross cv. GG 2 x *A. chacoense*, and JL 24 (bunch).

F_2 phenotypic ratios :

(JL 24 x 2-16-1 :1159 N : 63 dwarf; $X^2_{243:13}$ = 0.015; 2-16-1 xJL 24 : 1245 N : 68 dw; $X^2_{243:13}$ = 0.027).

b. Leaflet size : In the above cross, leaflet size was found to follow monogenic ratio in F2.

F_2 phenotypic ratio :

(JL 24 x 2-16-1 - 269 N : 94 small; X^2 3:1=0.15;
2-16-1 x JL 24 - 669 N : 175 S; X^2 3:1 = 0.48).

8. Cytological studies :

Meiotic chromosome associations were studied in 15 diploid *Arachis* species. Univalent formation was found to be 0.02 to 0.4 per pollen mother cell (PMC) in different species (Table 1). They were maximum in the species *A.* sp. Manfredi 5 which is of experimental origin.

B. Genetics and breeding for high peg strength in groundnut

(P. Sen and T.G.K. Murthy)

1. Generation advancement and selection

Forty three selections in F_7 and F were grown in the field in Rabi-summe 1993. Due to severe PStV symptoms the entire crop had to be destroyed Sixteen of these selections could be rescued by growing in polyhouse F_7 families of selected high yielding and/or high peg strength selections were grown in Kharif 1993. Forty seven selections with high peg strength (over 15 Newtons) were made in crosses GAUG 10 x PBDR 25, GAUG 10 x CGC 4018, GAUG 10 x NRGS 1, GAUG 10 x P 393523, C 364 x CGC 4018, C 364 x

Table 1. Metaphase I chromosome associations in some diploid *Arachis* species.

Species identity	Section	Bivalents per PMC	Univalents per PMC
A. paraguariensis	*Erectoides*	9.98	0.04
A. correntina	*Arachis*	9.92	0.16
A. villosulicarpa	*Extranervosae*	9.90	0.20
A. villosa	*Arachis*	9.92	0.16
A. sp. ICG 8164	*Arachis*	9.90	0.20
A. khulmanii	*Arachis*	9.92	0.16
A. sp. ICG 8200	*Arachis*	9.90	0.20
A. sp. ICG 8210	*Arachis*	9.88	0.24
A. sp. ICG 8216	*Arachis*	9.80	0.40
A. sp. ICG 8906	*Arachis*	9.98	0.04
A. sp. Manfredi#5	*Arachis*	9.70	0.60
A. sp. 338454	*Arachis*	9.88	0.24
A. otavioi	*Arachis*	9.90	0.20
A. chacoense	*Arachis*	9.96	0.08

PI 393523, C 364 x PBDR 25, GG 11 x PBDR 25, GG 11 x NRGS 1, Karad 4-11 x PI 393523, Karad 4-11 x CGC 4018, Karad 4-11 x PBDR 25, Karad 4-11 x NRGS 1, M 13 x PBDR 25, PBDR 25 x CGC 4018 (all in F_7), C 364 x NCAc 17090 and GAUG 10 x PI 393523 (both in F_9).

Half of the total seed of the 47 high peg strength selections (F_8 and F_{10}) were planted for further testing peg strength and other agronomic traits in Rabi-summer 1994. Twenty three selections were grown along with checks for assessing pod losses at harvest.

2. Yield evaluation :

Two medium peg strength cultures, codes 8 and 44 (of crosses GAUG 10 x PI 393523 and M 13 x PI 393523 respectively), were grown along with spreading control M 13, to study their yield potential during Kharif 1993. Code 44 yielded 8% more than the check.

C. Embryo rescue, micropropagation and haploid production ingroundnut (T.Radhakrishnan, T.G.K. Murthy and P. Sen)

1. Embryo rescue :

Immature ovules of crosses J 11 x *A. prostrata*, J 11 x *A.marginata*, J 11 x *A.* sp 11558 and J 11 x *A. paraguariensis* were cultured on Murashige Skoog's agar medium with 0.2 ppm naphthalene acetic acid (NAA) and 0.02 ppm benzylaminopurine (BAP). The plantlets thus produced were transferred to soil. The identity of the plants is yet to be verified.

2. Micropropagation :

Multiple shoots were induced in cultivars GG 2 and JL 24 by growing the whole seeds in MS medium supplemented with 50 ppm 2,4-D. Rooting could be done in the larger shoots while the smaller one could not be propagated further. Callii could be generated by culturing leaflet segments of 15 diploid species on MS medium with 18 different combinations of growth regulators, NAA and BAP. Organogenesis was observed in case of *A. villosulicarpa* and *A. correntina* only. Several plantlets could be regenerated in case of *A. villosulicarpa*.

3. Anther culture studies :

Anthers of *A.chacoense* and *A.* sp. GK 30008 were cultured on MS medium with 6% sucrose (normal = 3%) and callii could be generated. However, regeneration of the plantlets was not possible.

D. NARP project on biotechnological approaches for increasing and sustaining yield in major field crops;

sub project I : Crop improvement
Objective 6 : Groundnut disease resistance

(A. Bandyopadhyay, T.G.K. Murthy and T. Radhakrishnan)

1. Somatic embryogenesis :

Immature cotyledons of 5-8 mm length of variety Kadiri 3 were cultured on MS medium supplemented with 66 different combinations of NAA and 2,4-dichlorophenoxyaceticacid (2,4-D) to induce somatic embryogenesis. The embryogenesis varied from zero to 48% in different combinations. The response to somatic embryogenesis was high (13.5% to 48.3%) in eight media combinations (NAA/2,4-D = 0 ppm/2 ppm, 1/6, 1/8, 1/10, 1/12, 2/6, 2/8, and 2/14) (Table 2). Explants cultured on media containing 2ppm/6ppm and 2ppm/8ppm NAA/2,4-D produced 11.6 and 13.3 somatic embryos per explant, respectively (see cover). Maturation and repeated germination of the somatic embryos in media containing varying concentrations of casein hydrolysate resulted in germination of 32% of the embryos (Fig. 1).

2. Induction of multiple shoots :

Mature deembryonated cotyledons of cultivar SB XI were cultured on MS medium with concentrations of BAP ranging from 0 to 50 ppm at five ppm intervals and so multiple shoots were induced (Fig.2). Production of multiple shoots varied from 5 to 58% of the explants in different media. Highest frequencies were obtained with 10 ppm (50% response) and 15 ppm (58%, Table 3). Concentrations of BAP beyond 30 ppm led to fall in induction frequency. Based on their length, after 2 months of culture, the shoots were grouped in to categories 1, 2 and 3 (1 = >1 cm; 2 = 0.5 to 1 cm; 3 = <0.5 cm). Subsequent upon transfer to MS media with or without indole-3-butyric acid (IBA), shoots of category 1 produced roots whereas those in categories 2 and 3 could not produce roots. It indicates a relationship between shoot growth and root production.

Table 2. Response to in-vitro somatic embryogenesis in immature cotyledons of cultivar Kadiri 3 cultured in MS medium with varying combinations of NAA and 2,4-D.

2,4-D ⇨ (mg/l) NAA (mg/l)		0	2	4	6	8	10	12	14	16	18	20
0	%	8	30	7	2	0	0	17	0	0	0	2
	N	1.5	2.4	3.5	4.0	-	-	3.2	-	-	-	1.0
1	%	10	12	0	33	48	18	25	2	2	8	17
	N	1.7	1.7	-	2.6	4.8	4.2	5.3	7.0	4.0	1.5	2.4
2	%	15	2	11	38	28	17	21	13	2	2	0
	N	1.5	1.0	5.0	11.6	13.3	4.2	2.7	9.5	1.0	3.0	-
3	%	7	2	7	8	2	10	10	7	0	2	7
	N	3.0	4.0	8.5	5.0	1.0	3.7	6.3	1.5	-	4.0	6.5
4	%	17	10	7	0	0	2	2	2	2	2	12
	N	3.2	2.7	1.5	-	-	7.0	2.0	2.0	6.0	2.0	1.3
5	%	7	0	17	2	0	2	2	2	0	2	0
	N	2.5	-	3.2	10.0	-	1.0	2.0	1.0	-	1.0	-

% = per cent explants responding to somatic embryogenesis; N = mean number of somatic embryos per explant in responding explants.

Table 3. Multiple shoot formation in deembryonated cotyledons of five genotypes cultured on MS medium supplemented with varying concentrations of benzylaminopurine

Genotype	% explants producing multiple shoots									
	BAP concentrations (mg/l)									
	5	10	15	20	25	30	35	40	45	50
GG 2	48	40	54	60	+	+	+	+	+	+
SB XI	32	24	29	20	36	21	31	+	+	30
M 13	+	28	25	21	+	+	+	+	+	+
GAUG 10	19	32	60	27	21	+	+	+	+	+
Kadiri 3	+	+	+	+	+	17	33	32	32	+

+ indicates less than 15 % response

3. Wide hybridization for transferring resistance to PStV :

Seven interspecific crosses were attempted by using cv. J 11 as ovule parent and *Arachis* species ICGs 11558, 8132, 8210, 8216, 4983, *A. glabrata* and *A. marginata* as male parents. The the embryos dissected out from the fully grown ovules were cultured on MS medium with 0.5 ppm BAP. Two hybrids of crosses involving species ICGs 4983 and 8216 (both compatible with *A. hypogaea*) could be identified

Fig. 1 Different stages of germination of somatic embryos in groundnut

Fig. 2 *In vitro* production of multiple shoots from deembryonated cotyledons

AGRONOMY

A. Development of suitable agronomic practices in groundnut

(Devi Dayal)

1. Effect of mulching on nutrient availability, growth and yield of groundnut :

A field experiment was conducted in Rabi-summer 1993 with six mulches, namely (i)wheat straw @ 5 tonnes per hectare, (ii) white polyethylene (WP), (iii) black polyethylene (BP), (iv) WP + wheat straw, (v) BP + wheat straw and (vi) control (no mulch). Four durations of polyethylene mulch, viz. (i) up to germination (ii) upto flowering, (iii) upto pod development and (iv) upto maturity were maintained. The significant findings are summarized below.

a. Bulk density and nutrient availability in soil :

Bulk density (BD) (at 0-15 cm soil depth), recorded at 60 days after sowing (DAS) and at harvest indi cated that polyethylene mulch plot had the highest soil BD of 1.41 g/cm^3 while wheat straw had the lowest BD (1.351 g/cm^3). The BD in the plots where combination of wheat straw and polyethylene mulches were applied was similar to that of the control plot. The availability of macronutrients (N, P, K) and micronutrients (Fe, Cu, Mn, Zn) were assessed in soil (0-15 cm) at 30, 60, 90 and 120 (maturity) DAS. Among the nutrients studied, N was the most affected due to mulch treatment. Wheat straw mulch recorded the lowest available N (166 - 185 kg/ha) upto 60 DAS. However, N levels increased gradually and were maximum at 90 DAS and at maturity. The NO_3 fraction of available nitrogen was responsible for its less availability during early stages of crop growth. There were no differences in available P and K upto 60 DAS due to various mulches. However, at 90 DAS and at maturity, wheat straw mulch and the combination of wheat straw with polyethylene recorded higher availability of the P and K than the control and polyethylene mulch treatments.

The avilability of micro nutrients, especially Fe and Zn was significantly affected by mulch treatments. The differences between mulches were greater at 90 DAS and at maturity than at maturity than at early stages. High levels of available Zn (0.892) and Fe (1.352 ppm) at harvest were recorded in wheat straw mulch. The polyethylene mulch and control treatments recorded similar values for these nutrients.

b. Growth and yield of groundnut :

Maximum (79%) germination was recorded in wheat straw and in combination of wheat straw and polyethylene mulch treatments. The flowering began 40.6, 38.2 to 38.7 and 38.3 DAS in wheat straw, polyethylene and control treatments, respectively. The corresponding days for 50% flowering were 50.8, 45.3 to 46.3 and 44.8 DAS. Groundnut plant under wheat straw mulch showed N deficiency in early growth stage due to immobilization of N in the soil. However, after 60 DAS, the plant recovered from this deficiency and had maximum chlorophyll content at 90 DAS (1.079 mg/g fresh leaf) and at harvest (1.223 mg/g).

Wheat straw mulch increased pod yield by 18% over the control by increasing the pod number per plant by 17.5% and pod weight by 28%. The combination of wheat straw and black polyethylene mulch gave the highest pod yield (28.28 Q/ha) which was 34% higher than the control. Duration of polyethylene mulch significantly affected the pod number, pod weight and pod yield. High pod yield (26.1 Q/ha) was realized in plots where polyethylene mulch was kept upto pod development. However, retention of polyethylene mulch upto maturity of the crop caused significant reduction in pod yield

2. Fertility management in groundnut based cropping system :

In a field experiment, four Rabi crops, viz. gram, sunflower, wheat and mustard were grown after Kharif groundnut and evaluated under different fertility treatments. Soil analysis indicated that plots sown with Kharif groundnut had lesser available Zn, Fe and Cu than fallow plots (no groundnut). However, such differences were not present in case of N, P and K.

Dry matter production recorded at two phenological stages (30 and 60 DAS) showed significant variation due to cropping system (Table 1). Irrespective of crops, fallow plot gave significantly more dry matter per plant than the plot sown with Kharif groundnut crop.

Grain yields differed significantly due to cropping system and fertility level (Table 2). In general fallow plot recorded higher grain yield than Kharif sown groundnut plot. The maximum increase was realized in wheat (41.6%). However, grain yield of sunflower did not differ at all due to cropping system treatment. All crops except gram responded to fertilizer treatment and gave higher grain yield than the control.

Table 1. Dry matter at different growth stages of Rabi crops as affected by cropping system.

Rabi crop	Dry matter (g/plant)			
	30 DAS		60 DAS	
	After Kharif groundnut	After fallow	After Kharif groundnut	After fallow
Wheat	0.188	0.225	2.53	2.89
Mustard	0.682	0.871	20.66	23.88
Gram	0.224	0.299	2.35	3.12
Sunflower			21.99	22.88

Table 2. Yield (Q/ha) of Rabi crops as influenced by cropping system and fertility levels.

Rabi crop	Wheat		Mustard		Gram		Sunflower	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	straw
Cropping system								
Kharif groundnut	17.94	20.98	12.79	34.23	12.02	18.59	7.15	25.05
Kharif fallow	25.41	28.87	13.52	36.99	15.00	24.15	7.55	25.91
Fertilizer dose								
No fertilizer	17.49	20.36	12.25	33.59	13.96	20.68	5.45	21.95
1/2o frecom. dose	21.84	25.68	13.30	34.12	13.78	21.40	7.82	25.35
Recom. dose	23.27	25.90	13.49	35.96	13.26	21.04	8.15	26.40
$1^1/_2$ of reco.dose	24.16	27.77	13.59	38.76	13.04	22.34	7.98	28.23

B. Factors affecting yield in groundnut through variation in plant population
(Devi Dayal and V. Ravindra)

1. Effect of plant geometry on growth and yield of groundnut :

Effect of two planting patterns (normal and paired row) along with three plant densities, namely 1.1, 2.2 and 4.4 lakh per hectare and four spatial ratios (1:1, 1:2, 1:4 and 1:9) was studied on growth and yield of spanish variety GG 2.

Dry matter production recorded at four stages of crop growth (30, 60, 90 DAS and at maturity) indicated that as the spatial ratio was more than 1:1, the dry matter production decreased considerably (Table 3). The paired row planting recorded higher dry matter production than normal planting at 60 DAS, 90 DAS and at maturity (Table 4). As the plant densitydecreased the dry matter production increased by 2.6 to 17.5% at 60 DAS, 17.3 to 34.0 % at 90 DAS and 12.2 to 15.7 at maturity in 1.1 lakh per hectare plant density over the other two densities, while at 30 DAS the increase was less. The pod number and pod weight per plant also showed similar trends (Table 4). Higher spatial ratio (1:9) recorded the lowest pod number (8.22 per plant) and pod weight (5.03 g), whereas 1:1 ratio recorded the highest pod number (9.18 per plant) and pod weight(7.5 g). The pod/peg ratio was highest in 1:1 ratio (0.47) and lowest (0.38) in 1:9 ratio (Table 3).

Table 3. Influence of spatial ratio on some agronomic traits in groundnut

Spatial ratio	Dry matter production (g/plant)				Pod number/ plant	Pod weight (g/plant)	Pod/peg ratio
	30 DAS	60 DAS	90 DAS	At maturity			
1:1	2.39	8.88	15.46	18.90	9.18	7.50	0.470
1:2	2.37	8.22	14.23	17.48	8.67	6.44	0.401
1:4	2.16	7.81	14.63	17.43	8.27	5.33	0.388
1:9	2:10	7.23	14.07	17.27	8.22	5.03	0.380

2. Effect of seed maturity on germination, growth and yield of groundnut.

Based on the colour of inner surface of pod shell (white to dark brown) seed of spreading cultivar M 13 were grouped into six categories. These are (i)immature shriveled, (ii)immature smooth, (iii)semi-mature, (iv) mature, (v)semi-overmature and (vi)overmature. These groups varied significantly for seed weight and shelling percentage. Immature shriveled type recorded the lowest 100-seed weight (52 g) and shelling percentage (67.3) while overmature and semi-over mature typerecorded the highest (90 g and 77.3% respectively). Subsequently, the germination of the seeds of these groups was tested in field. More than 70% germination was ecorded in semi-mature, mature and semi-overmature groups. The minimumgermination (60.1%) was recorded in immature shriveled seeds. High pod

yield was recorded in case of mature seed (1321 kg/ha) and semi-overmature seed (1284 kg/ha) while low yield was recorded by immature (982 - 1046 kg/ha) and overmature (1073 kg/ha) groups (Table 5).

Table 4. Effect of plant density and planting system on agronomic traits in groundnut

	Dry matter production (g/plant)				Pod number / plant	Pod weight (g/plant)	Pod / peg ratio
	30 DAS	60 DAS	90 DAS	At maturity			
Plant density (lakhs/ha)							
1.1	2.67	8.62	16.80	19.71	9.22	7.96	0.395
2.2	2.06	8.40	14.32	17.56	8.34	6.46	0.368
4.4	2.11	7.33	12.53	17.03	8.13	5.40	0.361
Planting system							
Paired row	2.25	8.14	15.29	18.65	8.77	6.43	0.385
Normal	2.30	7.43	14.80	17.88	8.36	5.52	0.385

Table 5. Effect of seed maturity on seed germination and some yield traits in groundnut.

Seed group	100-seed weight(g)	Shelling (%)	Germination (%)	Pod yield (kg/ha)
Immature shriveled	52	67.3	60.1	982
Immature smooth	63	72.9	68.2	1046
Semi-mature	73	75.1	72.4	1115
Mature	81	76.5	72.5	1321
Semi-overmature	86	77.3	72.1	1284
Overmature	90	75.1	68.0	1073

PLANT PATHOLOGY

A. Studies on economically important fungal and virus diseases of groundnut
(M.P. Ghewande)

1. Identification of sources of resistance to major diseases :

One hundred thirty four genotypes along with a susceptible check, GG 2, were evaluated against major fungal foliar diseases (*Alternaria* blight, ELS, LLS and rust) in a uniform disease nursery trial during Kharif 1993. Out of these, six cultures, namely ICGV 86020, ICGV 86594, ICGV 87160 (FDRS 10), ICG 6284, NCAc 343 and DRV 1 were found to possess multiple disease resistance, scoring 1-4 grade on 1-9 scale. In addition to these, 14 other genotypes, viz. ICG nos. 2716 (EC 76446-292), 7881 (PI 215646), 6340 (PI 350680), 7013 (NCAc 17133-RF), 4747 (PI 259747), 7887 (PI 390595), NCAc 927, NCAc 17149, DRV 10, DRV 25, DRV 29, ICGV 87254, ICGV 86667 and ICGV 86707 were resistant to ELS, LLS and rust. On the whole 53 genotypes showed resistance to rust.

Another set, comprising 62 genotypes developed by the Plant Breeding section, was evaluated along with susceptible checks, Kadiri 3 and GG 2 against major foliar diseases under natural and artificially created epiphytotic conditions. Following lines were found resistant to various diseases.

1. Alternaria blight: PBS 105, DRV 19A
2. ELS : DRV 40, PBS 105
3. LLS : PBDRs 15,18,25 & 48; DRVs 19A & 40, PBS 105
4. Rust : PBDRs 18, 48, 32-6, 33A; DRVs 1, 10 & 44; PBS 105

2. Management of seed and seedling diseases using seed dressing fungicides :

Four fungicides, namely carbendazim 50 WP, carbendazim 25 SD, mancozeb and thiram @ 2 g, 3 g and 4 g/kg seed each were evaluated for their efficacy as seed dressers against collar rot, aflaroot, stem rot and root rot diseases in a replicated field trial in Kharif 1993. Carbendazim 25 SD @ 3 g/kg

seed reduced the incidence of collar rot by 50% which resulted in an increase in yield by 22.64% over untreated control. The next best was Carbendazim 50 WP @ 3 g/kg seed. Almost similar trend was observed in case of other diseases also.

3. Integrated management of major diseases :

The individual components previously identified under integrated disease management (IDM), integrated insect-pest management and integrated weed management programmes of the Plant Pathology, Entomology and Agronomy sections respectively, were further integrated under the programme IPM in groundnut during Kharif 1993. The integration of the following components reduced the intensity of ELS by 33.3% and of LLS by 62.5%. It also reduced the population of jassids and thrips considerably.

a. Pre-interculturing at 35 days after emergence (DAE)
b. One hand weeding at 30 DAE
c. Spray of insecticidal mixtures (2% neem oil + 0.02% phosphomidon + 0.04% endosulfan) at 40, 55 and 70 DAS
d. Use of pheromone traps for leaf miner, *Spodoptera* and *Heliothis*
e. Spray of fungicidal mixture (Carbendazim 0.05% + Mancozeb 0.2%) at 55 DAS
f. Spray of neem leaf extract (2%) at 40 DAS
g. Spray of culture filtrate of *Penicillium islandicum* (50%) at 70 DAS and use of trap/barrier crops(soybean, red gram with border crops of bajra and castor).

3. Management of seed - borne pathogens using plant - products :

Leaf powders of ten plant species were tested for their efficacy as seed dressing fungicides. The cultivar GG 2 was used for this purpose. Dry and we. (seed-soaking for 1 h) seed treatments were given with leaf powders @ 1% each along with controls (i.untreated, ii. treated with 0.05% carbendazim and iii. 0.3% thiram). Seed inoculation with *A. flavus* and *A. niger* was done in each case separately. After incubating at laboratory condition for one week, observations on seed infection and colonization were recorded.

The seed infection and colonization by *A. flavus* was significantly more in the dry seed treatment with 1% leaf powder of *Eucalyptus* spp. and *Terminalia catappa* than in the untreated control. Dry seed treatment with 1 % leaf powder of *Pongamia pinnata* was found to be more efficacious than other treatments in controlling the seed infection and colonization by *A. niger.*

Soaking of seeds for 1 h in leaf powder suspensions of *P. pinnata* gave maximum contol (30%) of seed infection by *A. flavus.* The next best treatment was *Eucalyptus* for inhibiting seed infection and colonization. Seed soaking treatment with 1% leaf powder suspension of *Annona squamosa* and *Azadirachta indica* gave maximum control of seed infection (53.5 - 58.1%) and seed

colonization (72.2 - 77.7%) by *A. niger.*

Eucalyptus spp. leaf powder, either as dry or wet seed dresser could inhibit seed infection and colonization by *A. flavus* and *A. niger*. *Terminalia catappa* leaf powder as dry seed dresser was effective against both the fungi. *P. pinnata*, in general was also found to be good for controlling seed infection and colonization by these fungi. Thus, leaf powders of *Eucalyptus* spp., *Terminalia catappa* and *P. pinnata* appear to hold potential as seed dressing biofungicides.

5. Seed transmission of PStV:

The results of a poly house experiment done during summer 1993 revealed that the average seed transmission of PStV in groundnut was 17.73% when inoculated at vegetative stage while it was 5.11% when inoculated at flowering stage.

B. Studies on seed pathological aspects with special reference to seed health and aflatoxin contamination of groundnut

(M.P. Ghewande)

Five bold seeded genotypes, ICGV 86564, ICGV 88398, ICGV 88428, CSMG 9101 and RG 244, along with susceptible check M 13 and the resistant check J 11, were evaluated against A. flavus seed infection and colonization under arfiticially inoculated conditions. The seed infection ranged from 13.3% to 70% while the seed colonization varied from 6.7% to 66.7%. Among the bold seeded lines, RG 244 was found to be moderately resistant to A. flavus seed colonization. There was a significant correlation between seed infection and seed colonization (r = 0.942).

ENTOMOLOGY

A. Studies on major insect pests of economic importance in groundnut (V. Nandagopal)

1. Integrated insect - pest management :

An experiment was conducted in Kharif 1993 by combining the components of the integrated pest management (IPM) isolated by the Plant Pathology, Entomology and the Agronomy teams of the NRCG. The feasible components isolated were combined in 12 treatments. Each experimental plot consisted of the cultivar Girnar 1 grown in 9 rows of 5 m each with an inter-row spacing of 45 cm. The results indicated that the jassids were significantly less in number in the plots where trap crops (soy bean as the middle row, caster as the border row and bajra surrounding the groundnut crop) were grown and the plots were given with three sprays of insecticides mixture (2% crude neem oil + 0.02% phosphomidon + 0.04% endosulfan). The number of jassids in the post spray observations at 45th and 60th days after germination were 7.7 and 10 per 5 sweeps respectively, as compared to 58.3 and 26 in the pre-spray observations (Table 1). Almost similar results were obtained in case of thrips also.

Table 1. Jassid population in the experimental plots where IPM was followed.

Treatment	Mean Number of jassids per 5 sweeps per plot					
	First spray		Second spray		Third spray	
	Pre-	Post-	Pre-	Post	Pre-	Post
T1	28.0	21.0	58.3	7.7	26.0	10.0
T2	37.9	40.7	67.7	29.0	34.0	26.7
T3	34.0	64.3	81.7	72.7	66.7	59.0
T4	43.0	38.0	43.3	26.3	30.7	21.7
T5	38.0	37.0	63.3	30.0	23.0	28.0
T6	38.3	39.7	52.3	14.0	21.7	10.7
T7	32.7	39.7	70.7	29.7	33.3	36.7
T8	28.3	27.3	52.7	16.3	29.3	11.0
T9	41.3	31.3	51.7	22.7	32.7	14.0
T10	29.3	55.7	65.7	52.0	41.0	21.3
T11	34.0	38.3	73.7	22.0	25.3	15.7
T12	43.7	72.0	97.7	87.0	55.3	48.7
$CD_{0.05}$	5.75*	11.32**	14.19**	8.89**	12.17**	

2. Monitoring of flux of aphid population :

To monitor the most common aphid species occurring around Junagadh, *Aphis craccivora* Koch and *Hysteronuera satarriea*, three types of traps, viz., (i) yellow cylindrical trap (YCT), (ii) sticky glue trap (SGT) and (iii) yellow water trap (YWT), were used in five replications. The aphids trapped in the glue were counted.

The data collected between April 1993 to March 1994 indicated that the YCT trapped significantly higher number of aphids (32 per week) than SGT (1.8) and YWT (0.32) (Fig.1).

3. Monitoring of leaf miner moths by pheromone lures :

The square glue trap designed by the NRCG was used to monitor leaf miner in groundnut experimental plots. No moths could be trapped between April 1993 and August 1993. However, the moth population started appearing from September 1993 (Table 2), and in January 1994 the population reached a peak (90 males per week per trap).

4. Testing the potential of leaf miner pheromone lure :

For testing the potential of

Table 2. Number of leaf miner moths trapped by the square glue trap in 1993-94

Month	Number of moths trapped per week	
	Range	Mean
April-Aug., 93	-	-
Sept. 93	0 - 137	49.25
Oct. 93	9 - 37	25.25
Nov. 93	1 - 7	4.10
Dec. 93	2 - 24	13.75
Jan. 94	54 - 167	90.63
Feb. 94	11 - 53	22.13
Mar. 94	0 - 18	5.00

leaf miner lures, the males attracted to the all-weather trap having leaf miner lures were collected in test tubes during the day time (between 8 am and 10 am). The males collected were also verified for their normality in activity, wing compactness, etc. and then paired with laboratory-reared virgin females in the ratio of 1:1, 1:2, 1:4, 2:2, 2:4, 2:5 and 3:6 on a healthy, caged groundnut plant for mating and oviposition. After 10 days the foliar damage due to neonate larvae was evident, indicating that the pheromone trapped males were potent.

5. Seasonal fluctuation of insect- pests of groundnut:

For collecting data on seasonal variations in the insect population of groundnut, a miniplot of eight 5 m rows was sown on the 5th day of every month in 1993. The damage due to occurrence of jassids, thrips and leaf miner was recorded at weekly intervals. The jassid population was considerably high till November. Almost similar observation was made on density of thrips. The damage by leaf miner in the October-sown crop started by December 1993.

6.Compatibility of pesticides with neem products :

A field trial was conducted to test the compatibility of neem products with the synthetic pesticides, endosulfan, phosphomidon, carbendazim and mancozeb. Aqueous solutions of 2% crude neem oil, 2% neem seed extract and 2% neem leaf extract were mixed with 0.04% endosulfan, 0.02% phosphomidon, 0.05%

Treatment	Mean number of oviposition by leaf miner
1 male + 1 female	3.83
1 male + 2 females	10.00
1 male + 4 females	15.33
2 males + 2 females	37.16
2 males + 4 females	36.67
2 males + 5 females	76.00
3 males + 6 females	56.67

carbendazim and 0.025% mancozeb in different proportions and sprayed on single rows of groundnut at vegetative, flowering and maturity phases. From the very next day of spray the scorching and yellowing symptoms caused by reaction of the mixture on the foliage were recorded at three intervals. At harvest, the pod yield per plant was recorded.

All the treatments involving the crude neem oil caused mild scorching on the terminal foliage which subsequently recovered after 10 days. Therefore care should be taken while using the crude neem oil in an insecticide mixture.

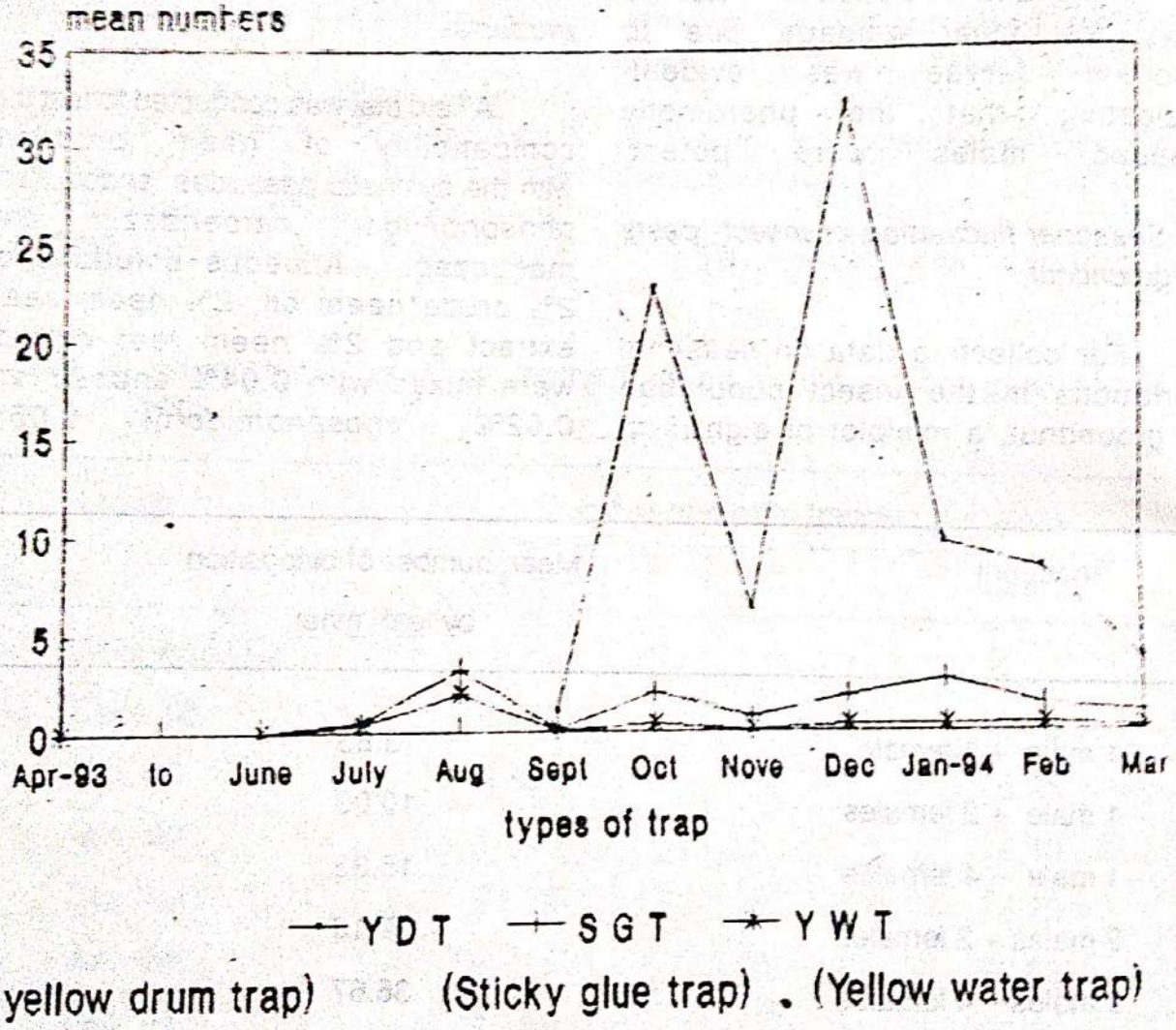


Fig. 1 Aphid density at NRCG in 1993 - 94

BIOCHEMISTRY

A. Biochemical aspects of groundnut quality and composition

(J.B. Misra and S.K. Yadav)

1. Evaluation of predictability of oil content of groundnut kernels on the basis of their specific gravity :

The specific gravity of isolated cotyledons (SPGR) was earlier shown to be inversely related with their oil content (Oil(S)). Experiments were undertaken to test the feasibility of utilizing this relationship as an index for predicting oil content of groundnut genotypes. Seeds of 23 genotypes with oil content ranging from 41.1% to 54.6 % were used for the purpose. Five of these genotypes were characterized by their shrivelled testa. Pools of complementary cotyledons were used for estimation of SPGR and Oil(S) of each genotype. Highly significant correlations between SPGR and Oil(S) were obtained both with ($r = -0.882$, $n = 24$) and without ($r = -0.964$, $n = 18$) taking into calculation the values pertaining to genotypes with shrivelled testa. Thus the exclusion of values of SPGR and Oil(S) of genotypes with shrivelled testa enhanced the predictability from 78 to 93%. Predictability of this relationship was also evaluated for comparing sub-samples of genotypes. For this SPGR and Oil(S) of pools of complementary cotyledons of six sub-samples each of seven genotypes were determined. The correlations were found to be significant only for four genotypes. However, when correlation was estimated between representative values (average of six determinations) of SPGR and Oil (S) of seven genotypes, it was found to be highly significant ($r = -0.984$) with a predictability of 97% (Table 1).

It was concluded that for estimating the oil content of a large number of genotypes, the representative values (average of several determinations) of SPGR of isolated groundnut cotyledons can be used provided that the samples do not exhibit visible shrivelling of testa and have reasonably a constant (4.6% ± 1%) moisture content. Any of the following two regression equations can be used for predicting oil content (%) with equal degree (97%) of predictability:-

$$Oil^{\wedge} = 239.65 - (176.81 \times SPGR)$$
$$Oil^{\wedge} = 242.26 - (179.13 \times SPGR)$$

2. Enzymes of sucrose metabolism in developing seed and in vitro *callus:*

Activities of sucrose phosphate synthase (SPS) and sucrose synthase (SS) were determined in the leaf, in vivo and in vitro, developing and germinating seeds and callus tissues.

Table 1. Correlation coefficients (r) and predictability (r^2 x 100) for relationship between various sets of Oil(S) and SPGR

Particulars of set		n	r	r^2 X 100
Across genotypes (complementary cotyledons of a single sub-sample of each genotype)		24 [s]	-0.882**	78
		18	-0.964**	93
Within a genotype (complementary cotyledons of six sub-samples of each genotype)				
	GG 2	6	-0.813*	66
	Girnar 1	6	-0.842*	71
	JL 24	6	-0.902*	81
	Jyoti	6	NS	
	NCAc17500	6	-0.812*	66
	TMV 2	6	NS	
	TMV 10	6	NS	
Across genotypes (taking average values of six sub-samples)		7	-0.984**	97

[s] includes genotypes with shrivelled testa
* and ** significant at 5 and 1% levels, respectively

The callii were cultured on three different sources of carbon *viz.*, fructose (callus F), glucose (callus G) and sucrose (callus S). The composition of sugars of the three callii and developing cotyledons was determined by HPLC. In the developing cotyledons, all the three sugars viz., fructose, glucose and sucrose were present. Sucrose was, however present in the highest quantities and was 4.2 and 10.4 times that of fructose and glucose, respectively. Sucrose was present in all the three callii while glucose and fructose could not be detected in callus-F and callus-G. The level of sucrose was, however, highest in the developing cotyledons and were 5.3, 10.6 and 4.4 times that of callus-F, callus-G and callus - S, respectively.

Both SPS and SS were presen in detectable quantities in the developing cotyledons, but only SS could be detected in the three callii in the developing cotyledons the SS

was about 22 times that of SPS. On a fresh unit weight basis SS in the developing cotyledons was, however, 11 times that of both callus-F and callus-G and 15 times that of callus-S.

The developing natural sinks are characterized by having either a very low level of SPS compared to that of SS or lack of it. Hence, the absence of SPS (or its presence in negligible quantities in relation to SS) in callii was not considered unusual inasmuch as callii are analogous to sink (Table 2). Since SPS was not found in detectable quantities in the callii grown on a medium having glucose or fructose as a carbon source and yet there was sucrose present in the callus, it was concluded that the callus growing on a fructose or glucose medium invoked easy reversibility of the SS for *in vivo* synthesis of sucrose.

3. Fatty acid composition of advanced breeding lines :

Fatty acid composition of oil of 25 genotypes was analyzed. The ranges of major fatty acids were: palmitic acid 8.7-14.6%, stearic acid 1.5-3.2%, oleic acid 43.9-67.3%, and linoleic acid 18.7-38.4% (Table 3). Negative correlation was observed between the contents of palmitic acid and oleic acid and those of oleic acid and linoleic acid. On the other hand, the contents of palmitic acid and linoleic acid were positively correlated (Table 4). As a result, the stability index (SI) of oil

Table 2. Sugars and enzymes of sucrose metabolism in callus and natural tissues of groundnut

Tissue	Sugars mg g-1 FW			Enzymes nkat g-1 FW	
	Fructose	Glucose	Sucrose	SPS	SS
Callus F	0.55	nd	1.29	nd	3.90
Callus G	nd	0.45	0.65	nd	3.95
Callus S	nd	nd	1.56	nd	2.90
Developing kernel	1.63	0.66	6.88	1.95	42.20

(oleic/linoleic) and nutritive value index (NVI) of oil [linoleic / (palmitic + stearic)] were negatively correlated. The range of NVI (1.65-2.80) was narrower than that of SI (1.14-3.60). The highest NVI was found in cultivar Kadiri 3 while the breeding line 5S and NFP 101 were the secon and third in the stated order. Th highest SI was found in HO 2 while HO 31 and HO 39 A 3 we second and third, respectively.

Table 3: Composition of major fatty acids, stability parameter and nutritive value of oil of advanced breeding lines

Genotype	Palmitic acid (P) %	Stearic acid (S) %	Oleic acid (O) %	Linoleic acid (L) %	Stability index (O:L)	Nutritive value index [L:(P+S)]
HPS 17	14.58	2.26	46.04	33.68	1.37	2.00
HPS 20	12.64	1.86	44.87	37.25	1.20	2.57
HO 24	9.78	1.68	56.89	27.25	2.09	2.38
HO 35	12.32	1.95	52.19	29.73	1.76	2.08
HO 4A	9.88	2.26	58.87	24.98	2.36	2.06
HO 17	10.06	2.21	52.63	30.67	1.72	2.50
HO 23	8.69	2.45	67.29	18.71	3.60	1.70
HO 24 Red	9.45	1.79	61.82	23.87	2.59	2.12
HO 25 A	10.14	2.05	57.94	26.07	2.22	2.14
HO 30	12.41	1.59	51.66	30.80	1.68	2.20
HO 31	10.15	3.07	61.86	21.80	2.84	1.65
HO 33	11.22	1.56	55.08	28.81	1.91	2.25
HO 39 A-1	12.37	1.87	47.09	35.28	1.33	2.48
HO 39 A-2	12.29	1.75	46.84	35.53	1.32	2.53
HO 39 A-3	10.36	1.77	61.42	22.88	2.68	1.89
PBS 193	11.03	2.19	57.35	24.70	2.32	1.87
NFP 101	12.24	1.86	45.21	36.99	1.22	2.62
5 S	12.08	1.51	45.07	37.88	1.19	2.79
NFP 140	13.16	1.69	46.18	35.40	1.30	2.38
RB 90	13.00	1.60	45.84	35.67	1.29	2.44
RB 46	12.26	2.54	45.03	36.14	1.25	2.44
PBS 8	13.57	2.37	45.66	34.40	1.33	2.17
PBS 15	13.86	3.16	44.76	34.36	1.30	2.02
TG 19 A	10.77	1.51	53.33	30.49	1.75	2.48
Kadiri 3	12.17	1.54	43.91	38.43	1.14	2.80
Mean	11.62	2.00	51.79	30.87	1.79	2.26
SE_m	0.30	0.09	1.40	1.15	0.13	0.06

Table 4. Functional relationships between various pairs of traits of advanced breeding lines of groundnut

Pair of traits	Relationship	Correlation coefficient
Protein and oil	Inverse	-0.403'
Palmitic acid and oleic acid	Inverse	-0.874"
Palmitic acid and linoleic acid	Direct	0.796"
Palmitic acid and SI	Inverse	-0.825"
Stearic acid and NVI	Inverse	-0.607"
Oleic acid and linoleic acid	Inverse	-0.985"
Oleic acid and SI	Direct	0.980"
Oleic and NVI	Inverse	-0.707"
Linoleic acid and SI	Inverse	-0.977"
Linoleic acid and NVI	Direct	0.811"
SI and NVI	Inverse	-0.766"
All others	Not significant	

' and " significant at 0.01 and 0.05 levels, respectively.

B. Biochemical basis of resistance to biotic and abiotic stresses in groundnut

(J. B. Misra, M. P. Ghewande, A.L. Singh, V. Nandagopal and S.K. Yadav)

1. Diurnal variations in carbohydrates, amino acids and phenolic contents:

The leaves of spanish groundnut variety JL 24 were sampled at 75 DAE at 4 h intervals over a 24h day-night cycle to study the diurnal variations in alcohol soluble metabolites. The sunrise and sunset were at 6.17 and 19.18 h, respectively. The contents of sucrose, reducing sugars, and free amino acids showed clear diurnal trends with a coefficient of variation of 31.0, 26.3, and 39.2%, respectively. The variations in starch, total phenols and o-dihydroxy phenols were comparatively narrow with a cv. of 14.3, 10.5 and 11.5%, respectively. The levels of the constituents (mg g-1 FW) analyzed are given in Table 5.

An increase in the pool sizes of sucrose and amino acids was observed during the sunshine hours. A smaller coefficient of variation as well as a smaller pool sizes of starch as compared to those of sucrose indicated that there was a greater partitioning of assimilated carbon in sucrose than in starch during the photosynthesis by groundnut leaves.

Table 5. Diurnal variations in carbohydrates, amino acids and phenols of groundnut leaves

Time of day (h)	Constituent mg g^{-1} FW						
	Sucrose	Reducing sugar	Starch	Free amino acid	Proline	Total phenols	o-dihydroxy phenols
0600	6.8	4.4	3.2	1.8	0.012	21.0	3.7
1000	13.6	7.6	3.0	4.6	0.026	18.8	3.3
1400	12.7	7.0	3.4	3.2	0.024	14.9	2.6
1800	13.4	6.9	4.1	2.5	0.023	19.9	3.5
2200	7.1	4.0	2.8	1.6	0.023	18.6	3.4
0200	8.6	5.0	3.0	3.1	0.028	20.4	3.5
Mean	10.4	5.8	3.3	2.8	0.022	18.9	3.3
cv%	31.0	26.3	14.3	39.2	24.600	10.5	11.5

2. Effect of mid-day stress on the chemical constituents of leaves:

Leaves of genotypes Girnar 1 (drought tolerant) and JL 24 (drought susceptible) were sampled from both moisture-stressed and unstressed plants at 1400 h when leaves showed inward folding due to mid-day stress. In case of unstressed crop, the levels of reducing sugars, ketose, sucrose and total sugars in the leaves of JL 24 were twice that present in Girnar 1, but the contents of free amino acids and proline were similar. In the stressed-crop the levels of reducing sugars, ketose, sucrose, total sugars and proline were similar in both the genotypes. Under stress condition, the levels of free amino acids in the leaves of Girnar 1 were, however, almost double that of in JL 24. In case of Girnar 1, the differences in the levels of sugars and amino acids in stressed and unstressed crops were negligible but in case of JL 24, there was a marked reduction in their levels in the stressed-crop. Under stress, leaves of both the genotypes, accumulated proline, and there was 10- and 12-fold increase in the proline content in JL 24 and Girnar 1, respectively.

3. Biochemical basis of resistance to biotic stresses :

Experiments were laid out for studying the functional relationship between the alcohol soluble metabolites of leaves of genotypes and i) occurrence of leaf spots, and ii) extent of damage by insect feeding. The experiments were, however, to be abandoned after the first sampling because of heavy infestation of thrips. The assay procedures for polyphenol oxidase, inhibitors of trypsin and chymotrypsin were standardized. These parameters will be included in the future studies.

PLANT PHYSIOLOGY

A. Studies on abiotic stresses in groundnut

(Y.C.Joshi, V.Ravindra and P.C.Nautiyal)

1. Screening for cold tolerance:

Seed samples of 100 germplasm lines were germinated in an incubator by maintaining temperature cycles of 18°C/12°C for 8 and 16 h respectively. Four lines, NRCG 955, NRCG 9528, ICG 3738 and ICG 4617, were found to be tolerant and showed more than 75% germination.

2. Screening for drought tolerance at germination phase :

Post-rainy produce of 30 spanish cultivars was screened for their germinability under water stress by using polyethylene glycol solutions of -3.0 bars (T_2),-7.5 bars (T_3), and -10 bars (T_4). Six days after incubation observations on germination were recorded and seedling vigour index (SVI) was calculated. The genotypes which exhibited greater germination percentage than the average in T_3 were considered as moderately tolerant and those having germination percentage greater than average plus CD in T_4 were considered as tolerant to low moisture availability.

The germination percentages of groundnut cultivars were 71-100 in T_1, 72-98 in T_2, 46-98 in T_3, and 20-92 in T_4 (Table 1). Results indicated that on an average there was no effect of T_2 (-3.0 bars) on germination of seeds but it adversely affected the root and hypocotyl length and lowered the SVI. However in T_3 and T_4, the lowering of SVI was due to confounding of germinability and root-hypocotyl length. Large genotypic differences were obtained for the germination and SVI in T_4. The genotypes, TAG 24, Girnar 1, J 11, RSHY 1, KRG 1, and Jyoti were able to germinate reasonablly well under low moisture conditions.

It is evident that the low moisture level more adversely affects the rate of growth of root and hypocotyl than the germinability *per se*. Higher levels of moisture stress however, affect both germinablity and growth of root and hypocotyl. The genotypic variations in germinability and SVI of groundnut seed gives scope for their improvement. It can be concluded that the cultivars, TAG 24, J 11, Girnar 1, RSHY 1, KRG 1, and Jyoti may be used in the areas where drought occurs at the germination stage of the crop.

3. Photosynthetic efficiency of groundnut :

The photosynthetic rates (P_N) of 30 released spanish varieties

Table 1. Genotypic variation in germination and seedling vigour of spanish groundnut in response to simulated moisture stress conditions

SN.	Varieties	Germination (%)				SVI			
		T1	T2	T3	T4	T1	T2	T3	T4
1	J 11	99	95	94	80	1156	396	310	125
2	TG 17	97	94	96	63	840	276	320	70
3	RSHY 1	98	83	97	76	1029	373	373	125
4	TG 3	97	92	94	70	746	352	263	59
5	DH 3-30	98	98	96	37	885	259	390	55
6	CO 1	95	94	93	58	1104	455	493	87
7	S 206	82	94	96	56	830	499	520	82
8	Spanish imp.	95	95	81	57	1418	1140	459	43
9	Pollachi 2	95	98	82	52	1260	728	396	122
10	Girnar 1	98	82	92	88	667	451	588	171
11	VRI 2	70	94	96	62	810	305	481	66
12	TAG 24	100	96	98	92	833	706	414	209
13	Jawan	93	92	81	52	885	477	229	17
14	TMV 7	98	96	67	72	1158	834	216	93
15	Akola sel.	96	96	46	20	1295	589	84	28
16	AK 12-24	98	95	62	70	1118	822	320	75
17	JL 24	98	93	92	50	905	532	613	36
18	GAUG 1	96	98	96	65	902	586	530	121
19	KRG 1	83	96	94	77	1029	590	331	137
20	ICGS 11	84	82	93	27	938	227	400	29
21	Jyoti	98	92	92	72	1078	553	502	119
22	TMV 2	97	98	95	38	976	459	365	14
23	ICGS 44	98	98	94	37	1486	474	314	17
24	DH 8	83	96	46	20	987	499	128	04
25	VRI 3	95	84	80	28	895	544	495	05
26	Kisan	96	93	94	55	545	903	452	28
27	GG 2	71	72	79	45	552	180	510	56
28	MH 1	98	93	82	58	1153	665	491	57
29	ICG 45	95	81	94	65	1290	616	327	54
30	SG 84	69	94	79	48	755	826	272	40
	SEm ±	8.38				140.50			
	CD(0.05)	16.42				275.37			

T1 = control; T2 = -3.0 bars; T3 = -7.5 bars; T4 = -10.0 bars

were measured using portable photosynthesis system at vegetative, flowering and pod-fill phases in a field study under rainfed and protective irrigation conditions during Kharif 1993. Severe drought occurred from flowering to early pod filling phase which affected P_N and pod yield considerably. The rainfall which occurred at mid pod-filling phase helped recovery of P_N and pod yield. The rainfed crop was left in the field upto 150 days without any further agronomic management practices and the yield obtained subsequently was comparable to that of the crop which received protective irrigations. The varietal differences for photosynthesis were distinct from flowering onwards. In all the varieties photosynthetic rate reached a peak at pod filling phase when the reproductive sink load was fully set. The varieties exhibited differential photosynthetic rates at more or less the same conductance level. The varieties with higher reproductive sink capacity exhibited higher photosynthetic rates, indicating its influence on photosynthesis. The varieties with ssp. *hypogaea* pedigree had superior photosy nthesis than those of ssp. *fastigiata* (Table 2). The data also revealed that, besides the reproductive sink size *per se*, the partitioning of the photosynthates from the sources is equally important in regulating the photosynthesis.

B. Selection for water use efficiency (WUE)and partitioning (p) in Groundnut (Y.C.Joshi and P.C.Nautiyal)

The experiment on WUE in groundnut with 50 genotypes in T1 (Adequately irrgated condition) and T3 (Rainfed treatment) and 20 genotypes in T 2 (Simulated drought under ROS) was conducted during Kharif 1993. Sampling for growth analysis, and calculating specific leaf area (SLA) and the carbon isotope discrimination ($^{12}C/^{13}C$) was done at 40, 75 DAS and maturity. Powdered leaf samples were sent to Australia for analysis of carbon isotope discrimination. Significant genotypic differences were noticed for SLA, crop growth rate (CGR), p, and vegetative and pod dry matter.

C. Physiology and biochemistry of seed viability and dormancy in Groundnut (P.C. Nautiyal, V. Ravindra and J. B. Misra)

1. Studies on seed viability:

An experiment was conducted to assess the effect of drying and storage methods on seed viability, field emergence and pod yield (Table 3). After 12 months of storage the maximum field emergence (30 plants/m^2) and pod yield (62.64 g/m^2) were recorded in the check (crop grown from previous Kharif seeds) followed by the pods dried by the Directorate of Oilseeds Research (DOR) method

Table 2. Photosynthesis (P_N) and pod yield in some groundnut 0varieties

Variety	Pn during Peggging phase		Recovery in Pn	Pod yield (g/plant)		
	P	RF	RF	P(120D)	RF(120D)	RF(147D)
ICGS 11	7.92	12.68	11.83	4.84	1.82	4.07
ICGS44	12.59	13.92	13.37	6.48	1.86	3.91
GG 2	9.81	13.16	11.77	4.79	0.54	3.60
Kadiri 3	10.46	16.95	12.50	3.65	2.07	2.11
VRI 3	13.77	14.29	17.82	4.53	0.46	3.04
TG 22	12.04	20.00	12.05	3.82	0.55	2.18
TAG 24	10.68	12.57	11.48	4.64	1.79	2.66
SG 84	12.09	15.74	16.53	2.10	2.01	5.44
JL 24	8.27	20.52	11.88	5.01	0.99	3.97
CO 2	10.36	23.73	14.47	4.09	0.67	3.19
Girnar 1	11.89	17.69	12.93	4.81	2.97	6.01
DH 8	10.60	11.72	12.20	2.32	0.72	2.88

P_N= μ m^2 s^{-1}, P=Protected irrigation, RF= Rainfed

and stored with $CaCl_2$ (22 plants/m^2 and 50.41 g/m^2, respectively).

b.Chemical composition of viable and nonviable seeds during germination:

This experiment was conducted to compare the patterns of changes in the chemical composition of Kharif and Rabi-summer produce of cv. GG 2 during seed germination. The seeds were germinated in water soaked paper towels at 30°C and sampled at 0, 2, 4, 6, 8 and 10 days of soaking (DOS). The samples were analysed for sucrose, reducing sugars, total phenols, o-dihydroxy phenol, protein and starch. The initial free amino acids were higher in the viable seeds while sucrose, total phenols, protein and starch contents were higher in the nonviable seeds. At 4 DOS, sucrose, o-dyhydroxy phenol, protein and starch contents were comparable in the two type of seeds. But reducing sugars and free amino acids were higher in the viable seeds while total phenols were higher in the nonviable seeds. At 8 DOS sucrose, protein and starch were comparable in viable and non viable seeds while reducing sugars, free amino acids, total phenols and o-dihydroxy phenol contents were higher in the nonviable seeds. In the viable seeds the contents of sucrose, total phenols, o-dihydroxy phenol and protein remained as such while the contents of reducing

Table 3. Effect of drying and storage methods on field emergence and pod yield of groundnut

Treatment	Pod yield (g/m^2)	Crop stand ($plants/m^2$)
T 1 W	20.97	12
T 1 WS	27.50	14
T 1 DOR	23.33	13
T 2 W	24.30	11
T 2 WS	43.33	18
T 2 DOR	50.41	22
T 3 W	14.44	12
T 3 WS	39.86	18
T 3 DOR	34.86	21
Check	62.64	30

W=Windrow, WS= Windrow shading , DOR= Directorate of oilseeds research method , T1 =Stored in polyethylene lined gunny bag,
T 2= T 1 + $CaCl_2$ (10 g/Kg), T 3= T 1 + Silica gel (10 g/Kg)

sugars and free amino acids increased and starch content decreased during germination. In the nonviable seeds, while total phenols and protein remained unchanged there was a decrease in sucrose and starch but an increase in reducing sugars, free amino acids, o-dihydroxy phenols as compared to the initial levels.

There was little difference in the initial levels of chemical constituents and their pattern of variation after soaking in viable and nonviable seeds. Therefore, the reasons for better germinability of *Kharif* produce are yet to be understood.

c. Studies on seed dormancy:

(i) Effect of accelerated ageing in dormant and nondormant groundnut:

The experiment was conducted to compare the patterns of changes in germination, membrane integrity, seedling vigour and chemical composition due to the accelerated ageing of seeds of cv.ICGS 11 (dormant) and cv.GG 2 (nondormant). The aging was accelerated by exposing the seeds to 95 per cent humidity at 40°C. The seeds were sampled at 0, 2, 4, 6, 8, 10 and 12 days of treatment (DOT) and analysed for sucrose, reducing sugars, total phenols, o-dihydroxy phenol, protein and starch contents.

The seeds of cv.ICGS 11 contained

higher initial reducing sugars and total phenols but lower initial starch content than GG 2. As a consequence of accelerated ageing for 12 days sucrose content in cv.ICGS 11 decreased while that of cv.GG 2 remained unchanged. The reducing sugars decreased in the cv.ICGS 11 while that of cv. GG 2 increased. The starch content of cv.ICGS 11 remained stable but that of cv.GG 2 decreased. There was a decrease in total phenol content in cv.ICGS 11 but in cv.GG 2 it remained stable. The protein in the seeds of the two cultivars remained unchanged while o-dihydroxy phenol showed similar decreasing trends.

The decrease in starch content of seeds of nondormant cultivar could be related to the loss of seed viability due to accelerated ageing. The results of germination percentage vindicated our earlier (1992-93) findings that the dormant seeds are more tolerant to accelerated aging than the nondormant ones.

(ii) Role of seed parts in dormancy:

To understand the role of seed parts like testa and cotyledons in the dormancy of groundnut seed, studies were conducted with six groundnut genotypes belonging to different botanical groups (Table 4). The apical and basal seeds were tested for germination, with (T1) or without testa (T2), single cotyledon without testa(T3), and half seed with embryonic axis without testa (T4). Another set consisting of the same treatments was treated with 0.5% ethrel and kept for germination at 30°C in an incubator for five days. In most of the genotypes the basal seed showed lesser germination than the apical seed even after ethrel treatment. The higher germination of ICGS 11 and ICGS 44 in T 3 followed by T 4 and T2, indicates reduction of the load of dormancy factor (s) due to removal of the seed coat, cotyledon and cotyledon's distal part. However removal of seed parts did not show any marked increase in germination of TG 22 while in Kaushal, M 13, and BG 3 germination did not enhance at all. This indicates that varietal differences for dormancy factor(s) exist in the location and concentration in various seed parts.

D. Inorganic nutrient requirements and their disorders in groundnut (A.L.Singh and Y.C.Joshi)

1. Yield evaluation of Fe-efficient genotypes:

The seven high yielding Fe-efficient genotypes tested during 1992, were again tested for their yield and yield attributing characters in Rabi-summer 1993, and six of them were evaluated during Kharif 1993 along with national and zonal checks (JL24, GG2, and SB Xi). The pod and haulm yields, shelling percentage and 100 seed weights of these genotypes are given in Table 5. It was observed that during dry season almost all the Fe-efficient

Table 4. Seed dormancy behaviour in groundnut

Variety	Treatment	Normal		With ethrel	
		Apical	Basal	Apical	Basal
ICGS 11	1	9	5	91	87
(SB)	2	84	78	84	82
	3	97	95	97	95
	4	92	92	95	97
ICGS 44	1	5	4	80	80
(SB)	2	85	71	87	80
	3	92	78	92	83
	4	89	72	92	78
TG 22	1	7	0	23	50
(SB)	2	7	3	43	23
	3	10	7	47	17
	4	17	13	47	17
Kaushal	1	58	40	73	60
(VR)	2	50	48	83	87
	3	28	23	73	85
	4	38	32	58	62
M 13	1	12	19	75	53
(VR)	2	15	15	58	62
	3	8	18	75	52
	4	7	7	60	47
BG 3	1	30	27	78	83
(VR)	2	20	17	72	87
	3	8	7	57	60
	4	8	8	62	52

Treatments1-4, as mentioned in the text

genotypes out yielded GG 2 while during wet season the weather was erratic and the genotypes 7085-1, 6919 and 7599 gave higher pod yields than GG 2, and the rest were at par with the checks. The shelling per cent of six of these genotypes varied between 64% and 70% while that of NRCG 7599 varied from 58% to 62%. The 100 seed weight of these genotypes was low during wet season due to erratic weather conditions during the cropping period. The genotypes 6919 and 7085 were early maturing (85-90 days in Kharif and 95-100 days in Rabi-summer).

Based on the results it was concluded that the genotypes, NRCGs 7085-1, 7085-3 and 6919 (Spanish) and NRCG 7599 (Valencia) can be tested under the AICRPG in multilocations.

2. Effect of macro- and micronutrients on yield and pod filling :

A field experiment was conducted to find out the effect of macro and micronutrients and the yield losses caused by their deficiencies in groundnut in calcareous soil. It was observed that the application of N, P, K, Ca, Mg, and S increased pod yield by 39% over control. Application of micronutrients along with macronutrients could further increase the pod yield by 40%. The yield losses caused by absence of Fe, Mn, Zn, Cu, B, and Mo were 16.3, 10.6, 13.3, 11.9, 14.5 and 13.8 per cent, respectively. The shelling percentage and the 100 seed weight also increased with the application of micro- and macronutrients.

3. Screening groundnut genotypes for tolerance to iron chlorosis:

One hundred and twenty two (72 during Rabi-summer and 50 during Kharif) selected groundnut genotypes, comprising 40 released varieties, 22 advanced breeding lines belonging to Cytogenetics and Plant Breeding sections and 60 germplasm accessions were screened for their tolerance to iron chlorosis by growing them in two replicates of 2 rows of 5 m length each. The visual chlorotic rating (VCR) based on the performance of top five leaves were given and the genotypes were classified into tolerant, moderately tolerant and highly susceptible to iron chlorosis (Table 6).

4. Detailed studies on the iron-efficient genotypes :

Three Fe-efficient(GG 2, PKVG 8, and TG 17) and three Fe-inefficient (NRCGs 162 and 7472 and NcAc 17090) genotypes, grown in the field were tested for total and active iron content, chlorophyll, total nutrient uptake and their concentration, and activities of peroxidase, ascorbic acid oxidase and nitrate reductase. A comparative histogram of these parameters is shown in Figure 1. It was noticed that the Fe-efficient genotypes contained 2-3 times more active iron content and higher uptake of other nutrients than the inefficient ones. The peroxidase

Table 5. Pod yield and related traits of some Fe efficient groundnut genotypes.

Genotypes (NRCG No.)	Pod yield (Kg/ha)		Haulm yield (Kg/ha)		Shelling (%)		100 seed wt (g)	
Seasons	RS	K	RS	K	RS	K	RS	K
7085-1	2772	1013	3655	1287	65	67	35.0	25.0
7085-3	2815	636	3741	1133	66	70	32.0	23.3
6919	2339	717	3216	1293	68	70	36.0	30.2
3498	1583	663	3625	1373	64	67	35.6	28.6
1308	2333	547	3834	1720	65	66	38.6	36.4
7607	3667	-	4530	-	70	-	36.0	-
7599	3185	699	4567	1573	58	62	44.0	37.3
GG 2	2520	640	3100	1267	65	70	40.3	27.6
SB XI	-	1011	-	1640	-	73	-	27.5
JL 24	-	733	-	1787	-	69	-	38.1
LSD (0.05)	151	78	175	134	1.5	2	2.8	2.2

RS = Rabi-summer; K = Kharif

Table 6. Groundnut genotypes showing tolerance to iron chlorosis.

Tolerant	Moderately tolerant	Susceptible
1. Varieties: GG 2, MA 10, JL 24, TG 17,CSMG 84-1, VRI 2, ICGV 86522, TGA 24, SG 84	Jawan, ICGV 86008 M 37, M 13 TG 1, Somnath	VRI 3, ICGS 65, ICGV 87276
2. Advanced breeding lines: PKVG 8, Akola Sel. I1, PBDR 41, PBS 70, 89, 91, 189,	CGC 3, PBS 13, 145, 90, PBDR 39,	AK NRCG 1, I2 PBDR 13, 36, 2-21
3. Germplasm accessions: NRCGs 5389, 4255 6450, 5513, 7267, 7027, 7417	NRCGs 4015, 7110, 4659	NRCGs 7472, 162

and nitrate reductase ((NR) activities, active iron ((Fe^{++})) and chlorophyll contents of Fe-efficient and Fe-inefficient groundnut genotypes were determined at different stages of crop growth. Peroxidase activity in the leaf, stem and root tissues of Fe-efficient groundnut genotypes were 1.5-3.0, 1.5-2.0, and 2.0-4.0 folds over the respective tissues of the Fe-inefficient genotypes. The nitrate reductase activity in young expanded leaves of Fe-efficient types was 1.2-2.5 folds to that in the inefficient ones. The peroxidase activity ($\triangle$O D g^{-1} s^{-1}) in leaves, stems and roots of Fe-efficient genotypes was higher than that of the Fe-inefficient ones. The NR activity in young expanded leaves was nearly 8 µ mol NO_2 g^{-1} fr wt h^{-1} or more in Fe-efficient while it was below 4 for Fe-inefficient genotypes. Interestingly, both the peroxidase and nitrate reductase activities increased with the application of iron.

5. Critical levels of micronutrients in soil and plant :

The soil and plant samples from the field experiment conducted in microplots during 1992 by applying different doses of micronutrients to find out the sufficiency and deficiency levels of Fe, Mn, Zn, Cu B and Mo in both plant and soils were analysed. Based on the soil analysis the critical sufficiency levels of Fe, Mn, Zn, Cu, B and Mo in soil were found to be 2-5, 4-6, 0.5-0.8, 0.2-0.5, 0.2-0.5 and 0.04-0.05 ppm, respectively. The concentrations above 200, 50, 20, 5 and 1 ppm of Mn, Zn, Cu, B and Mo were toxic to groundnut plant. The concentration of Fe, Mn, Zn, B and Mo below 40, 25, 20, 5, 15and 0.5 ppm, in leaves showed clear deficiency symptoms. Healthy plants showed mean concentrations of 300, 150, 50,15 40, 0.3 ppm of Fe, Mn, Zn, Cu, B and Mo respectively.

In a sand culture experiment during Kharif 1993, it was noticed that the toxicity levels of the micronutrients Cu and B caused stunted growth and interveinal to complete chlorosis leading to iron deficiency. Toxicity of Mo resulted in complete chlorosis.

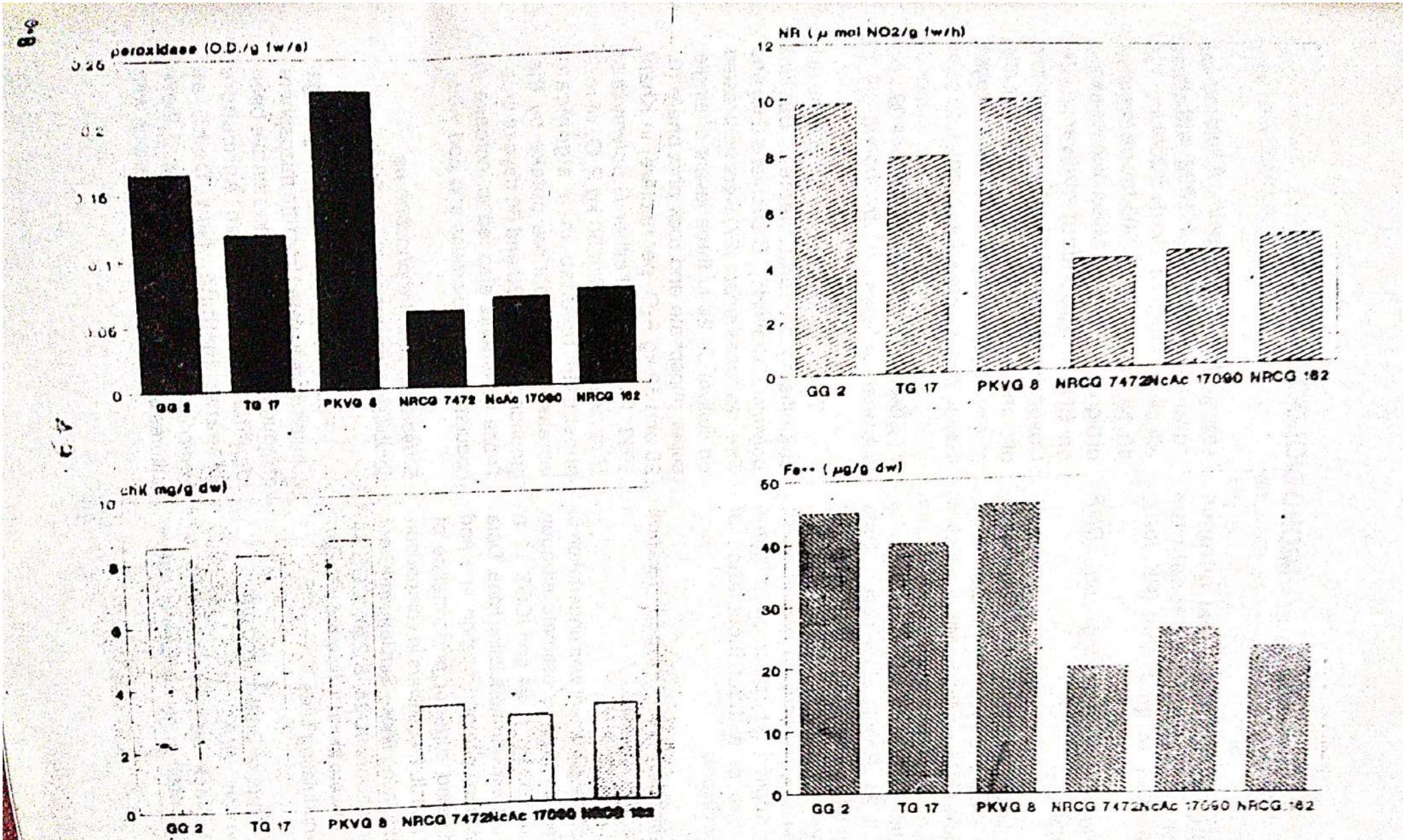


Fig. 1. Histogram showing the chlorophyll and active iron content and their relative peroxidase and NR activities in some groundnut genotypes.

MICROBIOLOGY

A. Studies on Biological nitrogen fixation and phosphorus solubilization in groundnut (P.K. Joshi)

1. Effect of mulching on BNF efficiency :

A field experiment was conducted to see the effect of polyethylene mulch (white and black) and inoculation with a effective culture of *Bradyrhizobium*, IGR 40, on nodulation and nitrogen fixation in the cultivar JL 24. Results of the observations made at different stages of crop indicated increase in nodulation, plant biomass, nitrogenase activity and pod yield at harvest in plots applied with black polyethylene mulch with or without inoculation of *Bradyrhizobium*.

2. Estimation of nitrogen fixation in groundnut cultivars :

A pilot experiment was undertaken in Rabi-summer 1994 to estimate nitrogen fixation in cultivars JL 24 and ICGS 11 in comparison with non-nodulating lines. Data on nodulation, nitrogen fixation and pod yield indicated superior performance of ICGS 11 and JL 24 cultivars in comparison to non-nodulating lines. Similarly in Kharif 1993, the cultivars JL 24, S 230, ICGS 44 and TMV 10 were found to fix more nitrogen than non-nodulating lines.

3. Effect of rate of Bradyrhizobium *inoculation on BNF :*

The black calcareous soils of Junagadh contain large number of native strains of *Bradyrhizobium*. A field trial was conducted in Kharif 1993 with three effective strains of *Bradyrhizobium*, IGR 40, NC 92 and TAL 1000 to see the effect of higher rate of inoculation of these strains on BNF in groundnut cultivar JL 24. Observations made at different intervals of plant growth indicated that higher rate of inoculation did not improve the nitrogen fixation by the groundnut plant.

4. Effect of phosphorus solubilising bacterial cultures on groundnut:

Three efficient phosphorus solubilising bacteria, namely *Bacillus polymyxa* (strain H5), *B. circulans* (H8) and *Pseudomonas striata* (27) were field tested on cultivar JL 24 at three levels of single super phosphate and rock phosphate (0, 25 and 50 kg P_2O_5 per hectare) in Kharif 1993. Inoculation of either *B. polymyxa* or *B. circulans* along with 50 kg P_2O_5 of rock phosphate resulted in a significant increase in phosphorus uptake by the groundnut plant at 30 and 60 days of crop. These treatments also led to increase in nodulation, plant biomass and pod yield.

5. Isolation of other phosphorus solubilising microbes :

Four phosphorus solubilising fungal cultures were isolated from the rhizosphere of groundnut. All the four isolates ave been identified by the Indian Agriculture Research Institute, New Delhi, as *Penicillium oxalicum*. Efficiency of these cultures is being tested in comparison with

other available P solubilising microbes under field conditions.

6. Screening rhizobial strains for emperature tolerance :

There are wide diurnal variations in temperature in Rabi-summer season. This affects the nitrogen fixation adversely. Hence there is a need to screen effective cultures of *Bradyrhizobium* for their tolerance to temperature extremities. Results of the laboratory testing of effective rhizobial cultures revealed tolerance of the culture 32 HI at 15°C as well as 40°C and tolerance of the cultures NC 92 and IGR 40 to high (40°C) temperature. These cultures can be effectively utilized in Rabi-summer and drought prone areas for higher productivity of groundnut.

7. Maintenance of rhizobial germplasm :

Several effective strains of *Bradyrhizobium* developed at the NRCG and the other places are being maintained for further use in research and development. These were supplied to indenters free of cost for popularization among farmers.

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	Seed Review Meeting, New Delhi, 28 July 1993.
	UNDP Meeting, New Delhi, 16 Sept.,1993.
	ICAR Directors' Conference, New Delhi, 5-6 October, 1993.
	Joint ICAR-ICRISAT Regional Training Workshop on Plant Genetic Resources, NBPGR, New Delhi, 13-16 October 1993.
	Group Discussion on IPM Strategies in Oilseeds, Punjab Agric.Univ., Ludhiana, 23-24 December, 1993.
Dr. P. S. Reddy, Dr. M.P. Ghewande Shri Y.C. Joshi, Dr. J.B. Misra Dr.P.K. Joshi, Dr. P. Sen	National Seminar on Oilseeds Research and Development in India : Status and Strategies and XIII Annual Rabi Oilseeds Research Workers' Group Meeting, Directorate of Oilseeds Research, and the Central Research Institure for Dryland Agriculture, Hyderabad, 2-8 August 1993.
Dr. M.P. Ghewande	VI Zonal (WZ) Meeting of the Indian Phytopathological Society, Nutan Mahavidyalaya, Sailu, Parbhani, 28-29 October 1993.

	Zonal Research and Extension Advisory Committee Meeting, Gujarat Agric. Univ., Junagadh, 16-17 March 1994
Dr. N.R. Bhagat	AICRP on Post-Harvest Technology, Gujarat Agric. Univ., Junagadh 26 May 1993.
Dr. N.R. Bhagat, Dr. J.B. Misra, Dr.P.K.Joshi, Sh. K. Rajgopal	XLII Annual Kharif Oilseeds Research Workers Group Meeting, Gujarat Agri. Univ., Junagadh, 20-23 April 1993
Dr. P.C. Nautiyal,	National Seminar on Newer Challenges in Agriculture and Industry" The Role of Physiologist and Biochemist. UAS Bangalore, 11-13 January 1993.
Dr.S.K.Yadav	Seminar on Recent trends in Chromatography organized by LC Users Forum, Spinco Biotech. Pvt. Ltd., Baroda, 12 July 1993

FOREIGN VISIT

Dr. N.R.Bhagat,	Senior Scientist (GRS) : To Cameroon from July 20 to September 2, 1993.

INSTITUTE MEETINGS / SEMINARS

MEETINGS

20 May 1993	Institute Management Committee
20-21 September 1993	Selection Committee
30 September 1993	Five Yearly Assessment Committee
1 October 1993	Departmental Promotion Committee
5 November 1993	Departmental Promotion Committee
5 January 1994	Selection Committee

SEMINARS

Dr. J. B. Misra	Bioenergetic Considerations in and Prospects of CO_2 Enrichment Technique for Increasing Productivity of Groundnut, 26.7.93.
Dr. N.R. Bhagat	Groundnut Genetic Resources in India,talk delivered at the Institute of Agronomic Research, Yaounde,Cameroon, 3.8.93.
Dr. T.G.K. Murthy	Somatic Embryogenesis and Its Applications in Groundnut Improvement, 3.9.93.
Dr. V. Nandagopal	Discussion on IPM With Special Reference to Groundnut, 28.9.93.
Dr. P.C. Nautiyal	Why Seeds Remain Dormant ? Groundnut- a Case Study, 20.10.93.
Shri T. Radhakrishnan	Direct Gene Transfer : the Physical Approach, 2.12.93.
Dr. N.R. Bhagat	Groundnut Germplasm Collection in Cameroon, 15.1.94.
Shri K. Rajgopal	Germplasm Conservation : Conventional and Recent Approaches, 29.1.94.
Smt. N. Geetha	Biological Control of Insect pests : Prospects and Problems, 20.2.94.
Dr. M.S. Basu	Water Use Efficiency Research in India and Australia, 28.3.94.

DISTINGUISHED VISITORS TO THE NRCG

15.04.1993	Dr. K.Janakiraman, Director of Research, and Dr.S.K.Waghmare, Director Extension, Gujarat, Agric. Univ., Ahmedabad.
22.04.1993	Delegates of the XLII Annual Khairi Oilseeds Research Workers Group Meeting, held at the GAU, Junagadh.
26.04.1993	Dr. S.Nagarajan, Deputy Director General (Crop Science) and Dr. D.P.Singh, Asstt. Director General (OP),ICAR, New Delhi.
18.10.1993	Dr. G.C. Wright, Principal Agronomist, Queensland Dept. of Primary Industries, Kingaroy, Australia, and Dr. R.C.N. Rao, Senior Plant Physiologist, ICRISAT. Patancheru.
21.10.1993	Ms. Beker G Eliazek, Israel, Dr. S.S. Bhadauria, NDDB, Anand and Mr. N.N. Dholakia, Managing Director, JUREUN, Junagadh.
10.02.1994	Dr. L.B. Aghera, Chairman, and Mr.P.H. Vora, Jt. Director, GSLDC, Gandhinagar.
11.02.1994	Dr. G. Singh, DDG (Engg.), ICAR, New Delhi along with Dr. B.D. Shukla, PC and Dr. Nawab Ali, PD, SPU Centre, CIAE, Bhopal.

Above : Experimental summer groundnut in the foreground with the backdrop of NRCG building

Below : Students of Kendriya Vidyalaya, Junagadh learning about the genetic variabilitv in groundnut

NRCG STAFF (AS ON 31.3.1994)

Director	Dr. P.S. Reddy

Scientific Staff

Dr. M.P. Ghewande	Senior Scientist
Dr. N.R. Bhagat	—do—
Shri Y.C. Joshi	Scientist (SG)
Dr. M.S. Basu	Senior Scientist
Dr. J.B. Misra	—do—
Dr. A. Bandyopadhyay	—do—
Dr. P. Paria	—do—
Dr. P.K. Joshi	—do—
Shri Devi Dayal	Scientist (Senior Scale)
Dr. P.C. Nautiyal	—do—
Dr. A.L. Singh	—do—
Dr. T.G.K. Murthy	—do—
Dr. V. Ravindra	—do—
Shri T. Radhakrishnan	Scientist
Dr. V. Nandagopal	—do—
Shri K. Rajgopal	—do—
Dr. S. Desai	Scientist (on study leave)
Dr. Vijendra Singh	Scientist
Dr. S.K. Yadav	—do—
Dr. Ajay	—do—
Dr. R.K. Mathur	—do—
Dr. P.K. Ghosh	—do—
Shri K. Chandran	—do—

Technical Staff

Dr. R.S. Tomar	Farm Superintendent (T-6)
Shri V.K. Sojitra	Farm Manager (T-5)
Shri C.P. Singh	—do—
Shri H.M. Hingrajia	—do—
Kum. S.M. Chauhan	Technical Officer (T-5)
Shri V.G. Koradia	—do—
Shri D.M. Bhatt	—do—
Shri D.L. Parmar	Senior Technical Assistant (T-4)

Shri Prem Narayan	Senior Technical Assistant (T-4)
Shri P.R. Naik	Technical Assistant (T-4)
Shri N.R. Ghetia	—do—
Shri P.K. Bhalodia	—do—
Shri P.V. Zala	—do—
Shri B.M. Chikani	—do—
Smt. V.S. Chaudhari	—do—
Shri Virendra Singh	Technical Assistant (T-II-3)
Shri M.A. Khan	—do—
Shri R.S. Mathur	—do—
Shri M.V. Gedia	—do—
Shri H.K. Gor	—do—
Shri Ranvir Singh	—do—
Shri B.N. Dongre	—do—
Shri J.R. Dobaria	—do—
Shri S.D. Savalia	—do—
Shri D.R. Bhatt	—do—
Kum. P.U. Pandit	—do—
Kum. T.T. Samarthia	Field-cum-Lab. Asstt. (T-2)
Shri A.D. Makwana	—do—
Shri G.J. Solanki	—do—
Shri Sugad Singh	—do—
Shri H.V. Patel	—do—
Shri Prabhu Dayal	—do—
Shri R.D. Padvi	—do—
Shri C.B. Patel	Artist-cum-Photographer
Shri A.M. Vakharia	Electrician
Shri P.B. Garchar	Tractor Driver (T-2)
Shri J.G. Kalaria	Driver (T-2)
Shri K.H. Koradia	

Administrative Staff

Shri Devendra Kumar	Finance & Accounts Officer
Shri J. Ramani	Assistant
Shri J.B. Bhatt	—do—
Shri R.T. Thakar	—do—
Smt. Rosamma Joseph	Stenographer
Kum. K.A. Vasani	Senior Clerk
Smt. Shanta Venugopalan	—do—
Shri Y.S. Karia	Jr. Stenographer
Shri L.V. Tilwani	—do—

Smt. M.N. Vaghasia	Hindi Typist
Shri A.D. Parmar	Junior Clerk
Shri C.G. Makwana	—do—
Shri H.S. Mistry	—do—

Auxiliary

Shri R.K. Singh	Security Supervisor
Shri G. Mookherjea	Hindi Translator (under suspension)
Shri G.G. Bhalani	Driver
Shri N.M. Safi	—do—
Shri B.M. Solanki	Tractor Driver

Supporting Staff

Shri N.M. Pandya	Field Assistant (SSG III)
Shri D.M. Sachania	—do—
Shri R.B. Chawda	Chowkidar (SSG II)
Shri R.V. Purohit	Chowkidar (SSG I)
Shri M.B. Sheikh	Chowkidar (SSG II)
Shri J.G. Agrawat	—do—
Shri G.D. Moradia	Chowkidar (SSG I)
Shri V.N. Kodiatar	—do—
Shri R.P. Sondarwa	—do—
Shri A.D. Makwana	—do—
Shri D.K. Odedara	—do—
Shri R.D. Nagwadia	Messenger (SSG II)
Shri V.M. Chavada	Messenger (SSG I)
Kum. D.C. Sachania	—do—
Shri N.G. Vadher	—do—
Shri P.N. Solanki	DMO (SSG I)
Shri K.T. Kapadia	Bullockman (SSG I)
Shri G.S. Mori	Lab. Cleaner (SSG I)
Shri P.M. Solanki	Auto Cleaner (SSG I)
Shri C.N. Jethwa	Safaiwala (SSG II)
Shri B.K. Bariya	—do—

NEW APPOINTMENT

Dr. P. K. Ghosh	Scientist (Agronomy) 30.3.1994
Dr. R. K. Mathur	Scientist (Plant Breeding) 30.3.1994

Dr. Ajay	Scientist (Plant Physiology)	30.3.1994
Kum. T. T. Samarthia	T.A. (T-II-3)	24.3.1994
Shri D. K. Odedara	Chowkidar	10.12.1993
Shri N. G. Vadher	Messenger	28.12.1993

TRANSFER

Dr. P. Paria	Sr.Scientist	-from CRIJAF, Barrackpore	8.2.1994
Shri Devendra Kumar	F.A.O	- from ICAR, New Delhi	2.3.1994
Dr. P. Sen	Sr.Scientist	- to CRRI, Cuttack	16.2.1994
Shri C. P. Singh	Farm Manager	- to RRS (NRCG), Cuttack (T-4)	19.2.1994

RESIGNATION

Shri R. K. Jaroli	Tech. Asstt. T-II-3	22.01.94

PROMOTION

Kum. S. M. Chauhan	Tech. Officer. T-5	1.1.1993
Shri V.G. Koradia	——do——	1.7.1993
Shri A. D. Makwana	Field-cum-Lab. Asstt.(T-2)	1.7.1993
Shri G. J. Solanki	——do——	1.7.1993
Shri H.V. Patel	——do——	1.7.1993
Shri D.M. Bhatt	Tech. Officer T-5	1.1.1994
Shri B. M. Chikani	Tech. Asstt. T-4	1.1.1994
Shri P. V. Zala	——do——	1.1.1994
Shri R.K. Jaroli	——do——	1.1.1994
Smt. V. S. Chaudhari	——do——	1.1.1994
Shri Sugad Singh	Field-cum-Lab. Asstt.(T-2)	1.1.1994
Kum. K. A. Vasani	Sr. Clerk	5.10.1993
Smt. S. Venugopalan	Sr. Clerk	5.10.1993
Shri R. T. Thakkar	Assistant	28.12.1993
Shri N. M. Pandya	Field Asstt. SSG IV	5.11.1993
Shri D. M. Sachania	——do——	5.11.1993
Shri M. B. Sheikh	Chowkidar (SSG II)	4.10.1993
Shri J. G. Agrawat	——do——	4.10.1993

ANNEXURE I

RESEARCH PROGRAMMES / PROJECTS IMPLEMENTED AT NRCG

Programme 1 : Management of genetic resources of groundnuts

Project 1.1 : Collection, maintenance, evaluation, documentation and distribution of genetic resources of cultivated groundnuts and related *Arachis* species

Programme 2 : Genetic improvement of groundnut

Project 2.1 : Breeding and genetic studies for improving yield and quality in groundnut

Project 2.2 : Breeding for resistance to biotic and abiotic stresses in groundnut

Project 2.3 : Genetics of and breeding for high peg strength in groundnut

Project 2.4 : Characterization and Utilization of wild Arachis species for groundnut improvement

Project 2.5 : Embryo rescue, micropropagation and haploid production in groundnut

Programme 3 : Agronomic management of groundnut

Project 3.1 : Development of suitable agronomic practices in groundnut

Project 3.2 : Factors affecting yield in groundnut through variation in plant population

Programme 4 : Integrated pest management in groundnut

Project 4.1 : Studies on economically important fungal and virus diseases of groundnut

Project 4.2 : Studies on major insect pests of economic importance in groundnut

Project 4.3 : Investigations on weed management in groundnut

Programme 5 : Seed technology research of groundnut

Project 5.1 : Physiology and biochemistry of seed viability and dormancy in groundnut

Project 5.2 : Studies on seed pathological aspects with special reference to seed health and aflatoxin in groundnut

Project 5.3 : Role of economically important storage pests on viability of groundnut

Programme 6 : Basic studies on physiological, microbiological and biochemical aspects of groundnut

Project 6.1 : Studies on abiotic stresses in groundnut

Project 6.2 : Studies on inorganic nutrient disorders in groundnut

Project 6.3 : Studies on nitrogen fixation and phosphorus solubilization in groundnut

Project 6.4 : Biochemical basis of resistance to biotic and abiotic stresses in groundnut

Project 6.5 : Biochemical analysis of groundnut quality and composition

Externally funded projects :

1. NARP : Biotechnology approaches for increasing and sustaining yield in major field crops; sub project 1 : crop improvement; Objective 6 : Groundnut disease resistance.

2. ACIAR : Studies on water use efficiency in groundnut

3. ICAR : Breeder seed production for annual oilseed crops; National Seed Project