NRCG Perspective Plan

Vision 2025

NATIONAL RESEARCH CENTRE FOR GROUNDNUT
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
IVNAGAR ROAD, PO BOX 5, JUNAGADH 362001
GUJARAT, INDIA

TABLE OF CONTENTS

PREFACE

Agricultural research has been instrumental in raising productivity of foodstuffs of both plant and animal origin and thus providing food security to the ever-growing global population. The changes in Indian agriculture have so far been spectacular. Groundnut is one of the important oilseed crops of India and is likely to be so in the future. The groundnut crop, however, has all the potential of becoming an ancillary food crop as unlike most oilseeds, it can also be consumed directly. The average productivity of groundnut in India, however, is stagnating at 1000 kg/ha in the past decade and during the same period export of groundnut from India has also declined. These trends are a matter of concern and need to be addressed on a priority basis. In the WTO regime, the changes occurring in production and productivity of a crop commodity in one country significantly affect the export potential and price of the commodity in the other countries. Hence there is a need for not only an introspection about the course of research that has been tread so far but also to formulate a long-term research strategy keeping in view the research being conducted elsewhere in the world.

The Indian Council of Agricultural Research (ICAR) is the apex organization responsible for conducting and fostering agricultural research in India. The National Research Centre of Groundnut (NRCG) was established by the ICAR in 1979. Since inception, the NRCG has contributed significantly towards the enhancement of productivity of groundnut crop in India. The ICAR now intends to come out with a perspective plan 'Vision-2025' for the course of research that its constituent research units will follow in the coming decades. This exercise was initiated with the guidelines given by Dr. Mangla Rai, Director General, ICAR. Subsequently, the drafts prepared by various units of the Crops Division were reviewed at a series of meetings chaired by Dr. G. Kalloo, Deputy Director General (Crop Sciences), ICAR. The guidance provided by the DDG (CS) and the suggestions given by the Assistant Directors General associated with the Crops Division, have lead to a substantial improvement in the draft perspective plan of NRCG.

My colleagues at NRCG have provided their ideas and other inputs for building up this document. Thus this 'Vision-2025' document is a product of a rich interaction between the leadership of ICAR and my team at NRCG. I thank the leadership for the guidance and my colleagues for their painstaking efforts without which this document would not have taken its shape.

(M.S. Basu)
Director

EXPLANATIONS TO ABBREVIATIONS

AICORPO	All India Coordinated Project on Oilseeds
AICRPG	All India Coordinated Project on Groundnut
AVT	Advanced Varietal Trial
BARC	Bhabha Atomic Research Centre
BCR	Benefit Cost Ratio
CSIR	Council of Scientific and Industrial Research
DAS	Days After Sowing
DBT	Department of Biotechnology
DST	Department of Science and Technology
GAU	Gujarat Agricultural University
HPS	Hand Picked and Selected
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IMC	Institute Management Committee
IPR	Intellectual Property Right
IRC	Institute Research Committee
IVLP	Institute Village Linkage Programme
IVT	Initial Varietal Trial
JAU	Junagadh Agricultural University
KVK	Krishi Vigyan Kendra
NARS	National Agricultural Research System
NDDB	National Dairy Development Board
NRCG	National Research Centre for Groundnut
NSC	National Seeds Corporation
QRT	Quinquennial Review Team
RAC	Research Advisory Committee
RMP	Research Management Position
SAUs	State Agricultural Universities
WTO	World Trade Organization

EXECUTIVE SUMMARY

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of India and has all the potential of becoming an important ancillary food crop too. It is one the few crops that can be cultivated even on marginal lands under low input conditions. Unfortunately, however, the average productivity of groundnut in India is quite low (1000 kg/ha) which is quite low compared to that of the USA (3000kg/ha), China (2600kg/ha), Argentina (2100kg/ha) and Indonesia (1550 kg/ha).

A decade ago, India was one of the major exporters of groundnuts in the world but now it has lost that position to China. The USA and Argentina are the other competitors. Now the EU permits import of nearly aflatoxin free (<2 ppb) groundnut only as a result the current export is confined mainly to Indonesia and Malaysia as bird and cattle feed.

Considering the current scenario, the following five issues have been identified which need to addressed for enhancing productivity and sustainability of groundnut cultivation in India and recapturing the international export market.

1. Stagnation of overall groundnut productivity within a narrow range, instability of production and productivity, non-realization of existing yield potential/attainable yield in majority of the traditional groundnut areas and organic farming.
2. Development of groundnut for diversified value-added products for enhancing its consumption as an item of food in the country and for export.
3. Stabilizing groundnut farming in the non-traditional areas, especially, in the eastern and northeastern regions and introducing groundnut in coastal saline regions of the country.
4. Revamping of the breeder seed production system by strengthening the weak links in the existing system.
5. Initiate research work on groundnut marketing to create an ambiance of good marketing practices in the country to protect the interest of the farmers and also consumers.

Dealing with these issues will require formulation of both short-term and long-term research strategies. Scientific research projects cutting across the boundaries of discipline have been formulated to address these issues and generate solutions. Inter-institutional linkages may be required in certain areas. This document envisions these

research projects and thus aims at providing interim and lasting solutions to most of the problems concerning sustainable production of groundnut.

For pursuing various research activities, properly trained manpower and funds will be critical. The scientific manpower already sanctioned should be adequate for the task envisaged. Unfortunately, however nearly half the scientific positions have been lying vacant over the decades at NRCG. This situation will have to be remedied on a priority basis. Moreover, the existing national and international linkages will have to be further strengthened. The skills of the available manpower can be further improved by exposure to appropriate training and exchange of ideas at various fora. The IPR issues connected with the development of cultivars and other technologies will have to be adequately addressed for safeguarding the interests of Indian farmers and scientists alike.

1 PREAMBLE

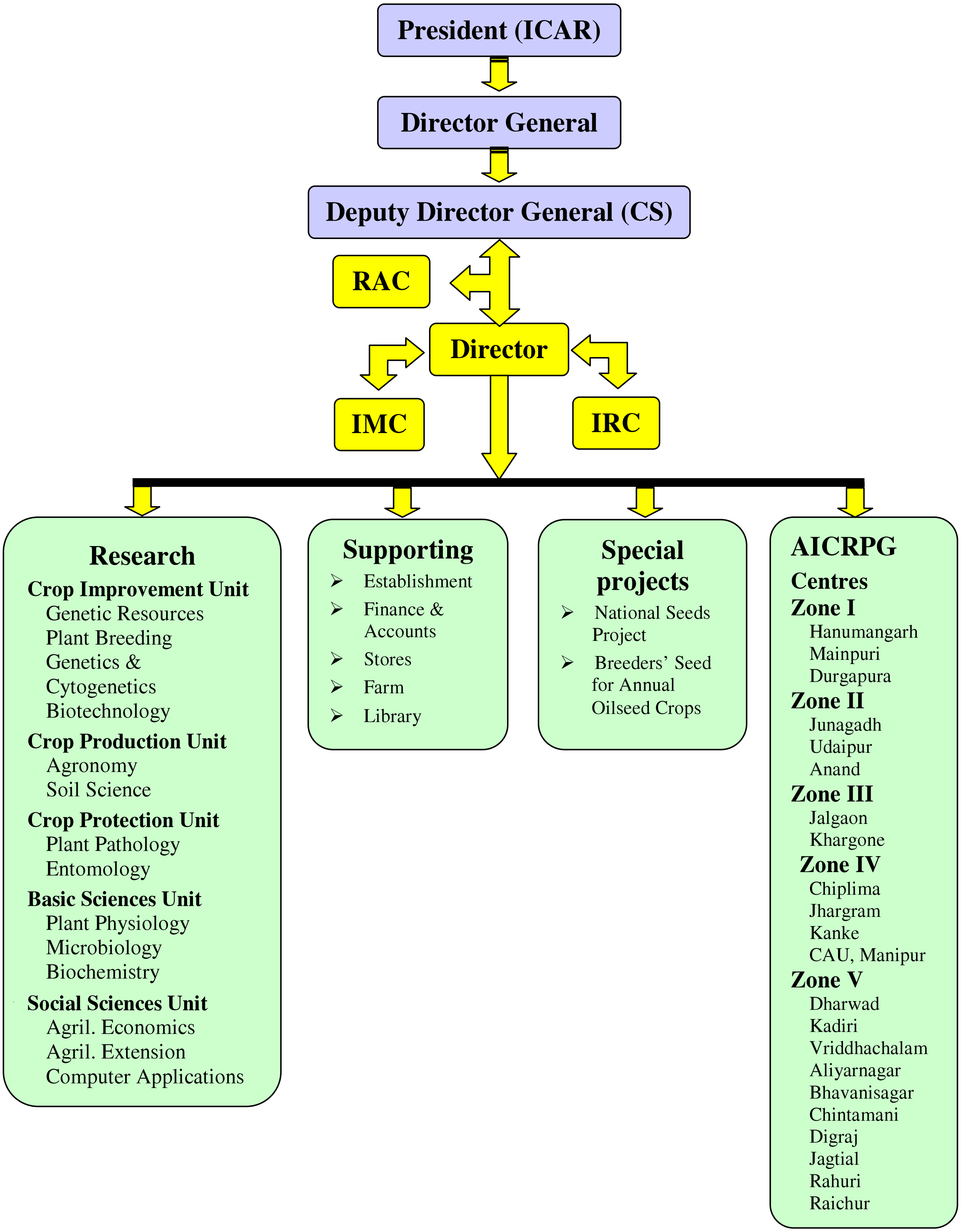
The vegetable oils form an essential ingredient of Indian cookery. No wonders, in India, oilseeds are the second largest commodity after cereals in acreage, production and value. However, since independence of India, the demand for the edible oils has been growing along with the growing population. Hence, Government of India considered it necessary to give a fillip to research for enhancing productivity of oilseeds. A task force was therefore constituted by the ICAR to workout in detail the plans for the establishment of Central Institute for Oilseeds Research in the country. After a great deal of deliberations a consensus was arrived at to establish a separate national research centre exclusively for groundnut– a crop, which then accounted for 43% of total area under oilseed crops and 60 percent of total production. Accordingly, it was decided in March 1979 to establish the National Research Centre for Groundnut for a period of 4 years (approved, in the interim VI plan), vide office order No. 7(33)/77-CCI dated 7th March, 1979 of Government of India, Ministry of Agriculture and Irrigation, Department of Agricultural Research and Education, Krishi Bhavan, New Delhi. The objective was to generate scientific knowledge about the crop, which could help close the gap between the yield realized and the realizable yields and help preserve the produce till its disposal or utilization. The selection of Junagadh for establishing the NRCG was most appropriate as the crop was already very popular among the farmers of Saurashtra region of Gujarat.

Thus the NRCG came into being on the 1st October, 1979 at Junagadh with the generosity of Gujarat Agricultural University which leased out a land of about 18 ha along with a building situated in it, on the main Junagadh-Veraval highway.

Looking to its infrastructure requirements, the NRCG, in 1986 acquired another 100 ha land from the GAU on the Junagadh-Ivnagar road, about 4 km away from its original location to establish its own infrastructure. The construction of a new laboratory-cum-office building was completed in the third quarter of 1991 and within a few years of its inauguration, the centre was transformed into a modern laboratory and a well-equipped farm.

Being located in a corner of the country was in itself a constraint in the past hampering efficient interaction among the scientists of NRCG and AICRPG. Now with the advent of the Internet and generous travelling grants given by the ICAR, this problem is no more a bottleneck in communication and convening meetings of scientists anywhere in India. The Deputy Director General (Crop Sciences) at the ICAR headquarters provides guidance and patronage to NRCG in resolving various scientific and administrative issues. The Assistant Director General (Oilseed and Pulses) in the Crop Sciences Division looks after the interests of NRCG at the ICAR headquarters and also serves as a vital link between the director NRCG and DDG (CS).

The current organizational set up of NRCG in the ICAR set up is depicted below.



1.1 MISSION

The mission of the NRCG is to "conduct research to develop improved technologies for enhancing groundnut productivity in India from the current 1000kg/ha for kharif (rain-fed) and 1500 kg/ha for rabi-summer (irrigated) to the levels of 1200kg/ha in Kharif and 2000kg/ha in rabi-summer, respectively, by the year 2010 and subsequently to 1500kg/ha and 3000kg/ha, respectively, by the year 2025."

To develop remunerative, globally competitive and sustainable crop production and protection technologies for groundnut based cropping systems in different agro-ecological regions of India through a blend of basic and strategic multidisciplinary research.

1.2 VISION

The demand of edible oils in the country has been increasing over years due to changing food habits, enhanced purchasing capacity and growing population. Thus, the urgency of increasing domestic production of edible oils in general and groundnut in particular is times more than that of increasing food grain production. On the one hand, the genetic yield potential of groundnut yet remains to be fully exploited; on the other hand, considerable scope exists for enhancing tolerance of various biotic and abiotic stresses by employing either conventional breeding techniques or biotechnological tools. For expansion of area under groundnut, additional/new niches for groundnut in the eastern and the north-eastern regions can be developed by introducing groundnut to fit in the existing cropping systems. As groundnut is by and large cultivated under rain-fed conditions, improvement in yield can be brought about by enhancing drought tolerance as well as by adopting improved water management practices. Contamination of kernels by aflatoxins, which lowers the quality of the produce and many a time renders it unfit for export, can be minimized through exercising certain precautions while are harvesting and post-harvest handling of the produce.

Thus, the vision statement for groundnut is “Enhancing efficiency of groundnut based production system through appropriate cropping system and value- addition and diversification of products so that the groundnut production system as a whole becomes sustainable, remunerative and globally competitive”.

2 MANDATE

At its inception the centre was given the following mandate:

- To develop appropriated production technology for different growing situations and systems
- To conduct basic and strategic research for increased production and quality of groundnut

- To act as a national repository for groundnut genetic resources
- To develop linkages with national and international organizations for research on various aspects
- To develop consultancies and expertise

However, in consonance with the changed scenario, in the previous version of the perspective plan of NRCG (Vision-2020), a new mandate has been proposed follows:

- Conduct basic and strategic research to enhance production, productivity and quality of groundnut
- Act as the national repository of working collection of groundnut germplasm and information on groundnut research
- Establish relevant institutional linkages
- Offer consultancy and training, and
- Provide logistic support and coordination mechanism for generation of location-specific technology through the All India Coordinated Research Project on Groundnut.

3 GROWTH

3.1 Infrastructure

At its inception in 1979, the Centre functioned in an old-tiled building with 18 hectares of land leased by the then Gujarat Agricultural University at it Junagadh campus (now known as Junagadh Agricultural University). While the basic laboratory facilities were being developed at this site, a plan for new infrastructure was developed in keeping with the research requirements. This plan took a concrete shape in the year 1991.

3.1.1 Laboratories

In 1991, the Centre shifted to a new four-storey laboratory-cum-office building. This laboratory-cum-office building was constructed by CPWD during 1988-1991 and was inaugurated on 30th September 1991 by Shri Balram Jhakkar, the then Union Agriculture Minister.

Today, this building provides laboratory facilities to the scientists in the disciplines of Plant Pathology, Entomology, Soil Science, Agronomy, Plant Breeding, Genetic Resources Microbiology, Plant Physiology, Biochemistry, and Biotechnology. There is a central laboratory housing very costly equipments. Besides laboratories, the building also houses a library, a museum, a conference hall and an auditorium (seating capacity 156). In addition to the main building there are other buildings like annexe lab, farm office, farm store, seed store, canteen, garages and a guest house.

Some facilities like weather station and rain out shelters (ROS) for work on drought and water-use-efficiency have been created with funds from a joint ACIAR-ICRISAT-ICAR project. The Centre has now many modern state-of-the-art equipments viz. Trinocular fluorescent microscope with photography attachment, ELISA reader, Fermenters, PCRs, Electrophoresis systems, Gas chromatograph, Portable photosynthesis system, Water potential system, Ultra centrifuge, High speed refrigerated centrifuge, UV-VIS spectrophotometers, Atomic absorption spectrophotometer, HPLC, NIR Analysis system, Nitrogen analyzer, Image analyzer, Osmometer, Growth chambers, Ultra low temperature deep freeze (-40°C and -80°C), and Water purifying system, etc.

3.1.2 All India Coordinated Research Project on Groundnut (AICRPG):

Centres of All India Coordinated Research Project on Groundnut

The AICRPG was originally located at Akola, from where it was shifted to NRCG, Junagadh in the year 1987. Under this project, the country is divided into five zones keeping mainly the agroclimate of the region in view. The coordinated inter-disciplinary location specific research is being conducted in collaboration with the SAU's, several ICAR Institutes and KVK's. The Director with the help of principal investigators/scientists of the NRCG coordinates the research programmes decided in the technical meetings of the AICRPG at the national level. At present there are five main seventeen supporting centres under the umbrella of AICRPG.

3.1.3 Library

The library started functioning with a collection of only 134 books and 8 journals during the year, 1980-81. The collections of the library gradually increased to more than 1700 books. About thirty international and an equal number of Indian journals are being subscribed to. The library regularly receives 85 different newsletters and 116 annual reports from various research and other organizations in the country and abroad. The library also maintains user-friendly electronic databases like AGRIS, CAB, J-Gate, etc.

3.1.4 Computer facilities

The centre has taken a lead in computerization of all aspects of research, administration and finance. At present more than 50 computers spread across various sections are linked by a high-speed LAN system. Internet facilities are available with a 24-hour broad band VSAT connection.

3.1.5 Farm land

Initially the Centre was operating with 18.26 ha of land inside the GAU campus. In 1986, the GAU leased out a separate area of 100 ha land on the Junagadh-Ivnagar Road where the Centre is presently located. The development of the 100 ha land, the major part of which was actually rocky with a little top-soil, was done in phases. However, so far only about 50 ha land could be made really cultivable. Almost the whole area of the farm has now been enclosed within a stone-masonry wall an only a small portion is fenced. There are eight dug wells and two tube wells in the farm and an extensive network of underground irrigation channels.

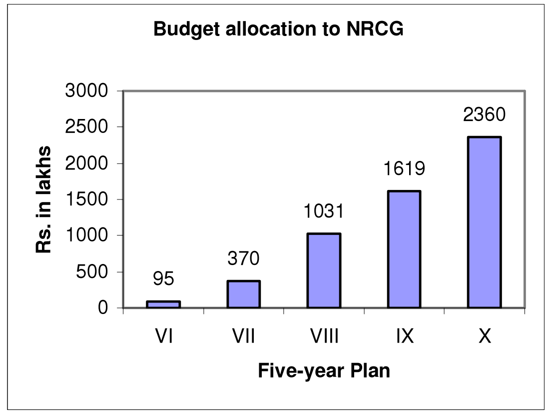
3.1.6 Residential quarters

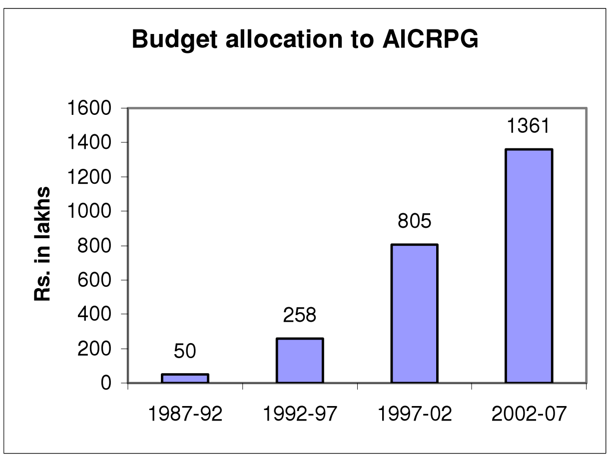
The residential facilities for staff include four type I, eight type II, 16 type III, 14 type IV, and one type V quarters. Two new type V quarters are being constructed. An overhead tank

(1.20 lakhs litres) is available for water supply to residential quarters. Construction of two type V residential quarters and 1.5 km compound wall is in progress.

3.2 Budget

The Government of India has been very generous all the while in granting financial assistance to the NRCG. Since its establishment in 1979 the budgetary grants grew successively from a meager sum of Rs 95 lakhs for the sixth five-year plan, to Rs 370 lakhs for seventh plan, Rs. 1031 for eighth plan, Rs. 1696 for ninth plan and now Rs. 2360 for the current i.e. tenth five-year plan. The figures are inclusive of both plan and non-plan budgets. During the tenth five-year plan period the budget allocation to NRCG was Rs 8.78 crores for Plan and about 15 crores for non-plan, while that for the plan scheme AICRPG was Rs. 18.12 crores. This reflects a substantial increase over the budget allocation of Rs.16.2 crores (plan + non-plan) to NRCG and Rs 7.4. crores to the plan scheme AICRPG for the ninth five-year plan period.





In addition to the grants received from the ICAR, the centre is able to obtain additional few crores of rupees through several externally funded research projects sponsored by various public and private sector agencies.

3.3 Manpower

The approved manpower of the centre gradually grew to reach a maximum of during the ninth five-year plan. Subsequently, during the tenth plan the status quo was maintained. The sanctioned scientific manpower for NRCG during the tenth five-year plan is 40. In addition, another 61 scientific personnel are engaged on groundnut improvement programme under the umbrella of AICRPG at 22 centres scattered across the length and breadth of country. At both NRCG and AICRPG centres, adequate technical personnel support the research activity. Unfortunately, at NRCG, owing to its establishment in a rather remote part of the country and some associated problems, about 50% scientific positions remained vacant during past several years. This situation is likely to improve in future.

The total approved strength and discipline wise break-up of scientific positions approved and the projected requirements are given below:

Approved manpower for the Xth five year plan

Category	Number	Occupancy (as on 31.03.2006)	
		On position	Vacant
1. Scientific	39+1(Director)	21	19
2. Technical	43	41	2
3. Administrative	17	15	2
4. Supporting	19	19	None
TOTAL	**119**	**96**	**23**

4 SALIENT RESEARCH ACHIEVEMENTS

The achievements of this Centre are presented in two sections. In this first section, the very significant accomplishments are given in brief. In the second section, basic, strategic and applied research findings are presented.

4.1 Crop Improvement

4.1.1 Elite germplasm accessions identified

The working collection was characterized for various desirable characters viz. agronomic, biochemical, and resistance to biotic and abiotic stresses. Several promising accessions were identified for high pod yield, high oil content, high shelling outturn, high seed protein, bold seeds with HPS character, high seed viability, high water use efficiency (WUE) and tolerance of soil moisture deficit, high temperature, cold, and soil salinity besides iron up-take efficiency, and resistance to major diseases and insect-pests.

4.1.2 Assembly and characterization of germplasm

About 4385 accessions of cultivated groundnut originating from 68 countries are being maintained. Nine germplasm catalogues have been published since 1984.

4.1.3 Breeding for high productivity

Five breeding lines, HO 24 Red (derived from cross M 13 x NCAc 17500), NFP 101 (TMV 7 x Chico), NFP 140 (MK 374 x Flournner), HPS 17 (M13 x PI 314817) and RB 90 (Robut 33-1 x NCAc 17090), were found to have high oil (over 52 per cent) content. CGC 4018, tested in AICORPO trials, was released as a national variety under the name Girnar1. From the segregating material generated at the NRCG, four high yielding cultivars viz. GG5 and GG 7 for Gujarat, HNG 10 for Rajasthan, and AK 159 for Northern-Maharashtra have been developed by the respective centres of the AICRPG.

4.1.4 Breeding for high peg strength

High peg strength from five donors was incorporated in five high yielding spreading type cultivars (M 13, GG 11, GAUG 10, Karad 4-11 and C 364).

4.1.5 Inheritance and linkage of qualitative characters

Inheritance and linkage of 30 qualitative traits were determined. Expression of twenty-nine plant characters was found to be determined by major nuclear genes while one variegated mutant was maternally inherited. A linkage map for the genes governing four pod characters was proposed. Genetics of late leaf spot and rusts was worked out.

4.1.6 Alien gene transfer for groundnut improvement

Over 600 interspecific hybrids were produced. Partially fertile interspecific hybrids were isolated from the cross cv. Co 1 x *A. chacoense*. Autotetraploids of *A. duranensis*, *Arachis* sp. GK 30008 and *A. otavioi* were produced.

4.1.7 In vitro and genetic transformation studies

In-vitro methods for high frequency regeneration of groundnut through induction of multiple shoots and somatic embryogenesis (both primary and secondary) and embryo rescue techniques for overcoming interspecific incompatibilities were developed.

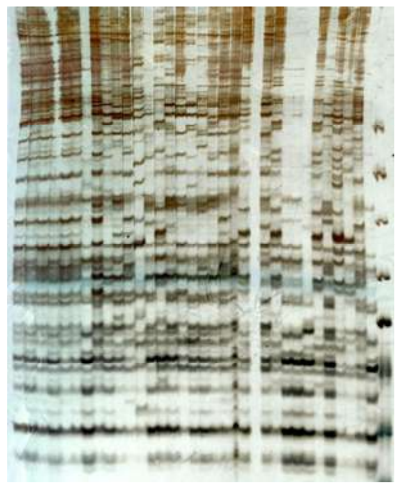
High-frequency multiple-shoot regeneration in groundnut

High-frequency somatic embryogenesis in groundnut

4.1.8 Protocols for DNA fingerprinting and genetic transformation

Protocols for eliciting DNA polymorphism in groundnut germplasm accessions and commercial cultivars were developed.

Protocol for *Agrobacterium* mediated genetic transformation and subsequent regeneration of putative transformants was optimized. Work for transformation of groundnut cultivars for expressing relevant genes conferring resistance to peanut stem necrosis virus (PSNV) and defoliating pest *Spodoptera* has been initiates



DNA polymorphism in wild and cultivated groundnut species

4.2 Crop Production

4.2.1 Developing suitable agronomic practices

Paired-rows-planting was found to be efficient in not only biomass production and pod yield but also in inter row water harvesting, especially in rain-fed situations. The paired rows also help in criss-cross planting of groundnut was found to increase the yield by 14 per cent over the traditional parallel-rows planting.

Inter-row water harvesting in groundnut

Groundnut-sesame intercrops

Intercropping groundnut with sunflower resulted in further increase in pod yield by 18 per cent. Sesame, cotton and castor are some other highly compatible crops for intercropping with groundnut.

Groundnut crop was successfully introduced in the non-traditional areas of NEH region.

Terrace and contour farming of groundnut in NEH region

4.2.2 Critical production factors

Fertilizer was found to be most critical production factor limiting groundnut production during rainy season. The other important critical factors identified are: improved variety, plant density, and plant protection.

4.2.3 Ideotypes

Ideotypes with desirable morphological, phenological and physiological attributes were proposed for Spanish and Virginia forms.

4.2.4 Soil moisture stress management

Critical stages at which soil moisture is detrimental to pod yield were identified. Cultivars GG 2, NCAc 17090, TAG 24, and Girnar 1 were found to be tolerant to soil moisture stress. Water deficit stress imposed for 20-25 days after germination followed by two frequent irrigations at 5-day interval, and then a regular 10-day cycle were found to increase pod yield by 25 per cent over the normal irrigated crop. Under soil moisture stress condition SLA was found to be negative and significantly related to carbon delta (C13/C12 ratio) vis-a-vis water use efficiency (WUE).

4.2.5 Seed drying and storage

Seed drying and storage methods were standardized and a drying and storage technology was developed to prevent rapid loss of seed viability in rabi/summer groundnut. In this technology groundnut pods after initial drying in shade is stored with desiccant like CaCl2 in polyethylene lined gunny bags. The seeds remain viable (>80 per cent) for the next rabi/summer sowings. This technology will be very useful to the small groundnut farmers in the eastern and north-eastern parts of the country.

4.2.6 Nutrient requirement

Spray of aqueous mixture of 0.5 per cent $FeSO_4$ + 0.02 per cent citric acid @ 500 litres per hectare, 30, 40, 60 and 75 days after emergence, controlled the iron chlorosis. Application of sulfur @ 20 kg/ha in furrow at the time of sowing its elemental form or as gypsum, phosphogypsum or pyrite increased the pod yield by 25 per cent over control.

4.2.7 Effective strains of Bradyrhizobium and Plant Growth Promoting Rhizobacteria

Two strains of *Bradyrhizobium*, IGR 6 and IGR 40, which were identified at this Centre, increased the pod yield of bunch groundnut by 9-18 per cent and 6-14 per cent, respectively. Inoculation of groundnut with rhizobial culture, TAL 1000 increased pod yield by 18 per cent over the control. Three PGPR isolates viz. PGPR 1, PGPR 2, and PGPR 4 (all fluorescent pseudomonads) were found to increase yield by 7-10% in multi-location testing.

4.2.8 Utilization of groundnut by products

Economically viable technologies were developed for production of enzyme cellulase from groundnut shell and amylases from groundnut cake by microbial fermentation. It was also shown that groundnut shell can be used as a very good substrate for growing mushroom.

Oyster mushroom growing on groundnut shell

4.3 Crop Protection

4.3.1 Disease management

Management of major foliar diseases through agronomic practices, biocontrol agents and use of plant products was studied. Early planting, plant spacing of 45X10 cm, intercropping groundnut with pearl millet and pigeon pea (1:3), foliar spray of aqueous neem leaf extracts (2-5%) with BCR of 1:2.26 and use of biocontrol agents, *Penicillium islandicum*, *Verticillium lecanii* were found useful in managing major foliar fungal diseases.

4.3.2 Integrated disease management

The individually effective components were suitably integrated and tested for management of major foliar fungal diseases during the kharif seasons (1988-1990). Suitable IDM module with CBR of 1:3.63 was developed.

- Seed treatment with Carbendazim @ 2g/kg seed or Mancozeb @ 3g/kg seed or *Trichoderma* @ 4 g/kg seed for controlling seed borne fungal pathogens
- Soil amendment with castor cake, mustard cake, or neem cake @ 500 kg/ha for controlling soil borne pathogens causing stem and collar rot
- Spray of neem seed aqueous extract (5%) or crude neem oil (2%) in Teepol for controlling foliar fungal diseases

4.3.3 Management of aflatoxin contamination

Several genotypes including released varieties, germplasm lines, bold-seeded genotypes, breeding lines and wild *Arachis* species were screened for resistance to seed colonization and less aflatoxin production by two virulent isolates (NRPL 3000 and V 3734/10) of *Aspergillus flavus* under artificially inoculated conditions.

- Genotypes resistant to seed colonization by *A. flavus*:

  Breeding lines: CGC 2, CGC 7, 1-4, 1-7, GAUG1 x NCAc 927, S230xPI337394F, Latur33xPI337394F, HPS 1, HPS 17, B99-1, & B95
  Germplasm accessions: Ah 71223, Ah 20, GRP 34, NCAc 1855, NRCGs 698, 912, 8770, 8972, 8974, 376, 839, 878, 4324, 7211
  Wild *Arachis* species: *A. cardenasii, A. duranensis*
- Genotypes supporting less aflatoxin production:

  KRG 1, RSB 87, S 230, TMV 7, TMV 12, B 95, B 99-1, GRP 34, ICG 239, 671, 7277, 5363
- Seed treatment with 2% aqueous rock salts, asafetida and turmeric powder and 3 day win row drying were found useful in preventing aflatoxin contamination.
- Sun drying, exposure to fumes of cow dung and spray of 1% common salt were found useful in detoxification of aflatoxin.

4.3.4 Integrated pest management

An effective integrated pest management system was developed to control insect-pests and thus enhance pod yield by 43 per cent.

- Shielding groundnut crop with 1-2 row of castor and pearl millet.
- Growing a single row of soybean (trap crop) after every 4 rows of groundnut
- Keeping 10 pheromone traps per hectare for leaf minor and 8 traps for *Spodoptera* and *Helicoverpa*
- Three sprays of insecticide mixture (2 per cent crude neem oil + 0.02 per cent Phosphomidon + 0.04 per cent Endosulfan) at 15 day intervals
- Application of Bt @ 300-500g/ha for control of *Spodoptera* and *Helicoverpa*

4.4 Technologies Transferred

The Centre has developed the following low cost technologies for the groundnut farmers/users.

- Paired-rows and criss-cross planting system
- Effective *Bradyrhizobium* strains for inoculation of rabi/summer groundnut
- New drying and storage methods for retention of seed viability of rabi/summer groundnut
- Use of aqueous extract of neem leaves and other plant derived products for controlling diseases
- IPM in groundnut
- Girnar 1, a multiple resistance groundnut variety
- A simple, rapid and economical instrument viz. *arachilipometer* was developed for estimation of oil content in the kernels of groundnut samples
- Several bulletins were published on various technologies developed at the centre describing groundnut varieties of India, plant protection measures, quality and nutritive value, micronutrients requirement, weed control, water management, biological nitrogen fixation and seed viability.
- The centre has transferred the technologies developed, directly to the farmers of several villages of Junagadh under the Institute Village Linkage Programme (IVLP) of the ICAR.

4.5 Basic, Strategic and Applied Research Findings since inception of the Centre

4.5.1 Basic

- The anatomical and genetic basis of high-peg strength was identified.
- Inheritance patterns of 30 qualitative traits and resistance to late leaf spot and rust were worked out.

- A linkage map for the genes governing pod characters like reticulation, constriction, pericarp thickness and shape of beak was proposed.
- Loss of seed membrane integrity was found to be associated with loss of seed viability in storage.
- Short duration dormancy, was found to be controlled by factors present in testa while long-duration dormancy by those present in cotyledons and embryonic axis.
- Maintenance of high relative water content of leaf at low leaf water potential was found to be an attribute for drought tolerance in groundnut.
- An inverse relationship was observed for the first time, between the oil content and specific gravity of kernels of groundnut cultivars.
- High contents of reducing sugars and free amino acids were found to promote susceptibility of genotypes to major foliar diseases while the high contents of phenolics were found to impart resistance.
- A glue-trap was improvised for catching male moths of leaf miner.

4.5.2 Strategic

- Over 4400 accessions of cultivated groundnut were assembled and evaluated for agronomic and quality characters and 9 germplasm catalogues have been published since 1984.
- Thirty-eight accessions representing 35 wild *Arachis* species from five sections of *Arachis* were maintained.
- Nine donor parents for high peg-strength were identified.
- Seed protein profiles of fourteen species of the three sections of the wild *Arachis* species were studied.
- Over 600 interspecific hybrids were produced between *Arachis hypogaea* and eighteen wild species.
- Over 2000 early generation derivatives having high yield and resistances to biotic stresses were selected from nine interspecific crosses.
- In-vitro methods for rapid multiplication through induction of multiple shoots and somatic embryogenesis were developed.
- The critical limits of deficiency and toxicity levels of iron, manganese, copper, boron and molybdenum were determined.
- Strains of *Bradyrhizobium* tolerant to low or high temperatures were identified.

- Inoculation of effective phosphate-solubilizing bacteria together with phosphorus fertilizers/rock phosphate was found to enhance phosphorus uptake.
- Seven new diseases viz. *Alternaria* leaf blight, powdery mildew, *Sclerotium* leaf blight, *Phoma* leaf spot, *Excerohilum* leaf spot, *Fusarium* leaf spot, and *Colletotrichum* leaf blotch affecting groundnut were identified.
- Fourteen genotypes possessing multiple disease resistance were identified.
- Sources of resistance to colonization of *Aspergillus flavus* with less load of aflatoxin were identified.
- Techniques of management of aflatoxin contamination were studied.
- Epidemiology of early leaf spot, late leaf spot, *Alternaria* leaf spot and rust was studied.
- Biocontrol agents for *Sclerotium rolfsii* were identified and their potential was studied.
- Dried leaf powder of *Eucalyptus* sp. was found to be useful in controlling seed infections.
- Extensive surveys were conducted to assess the distribution and monitoring of PStV in Gujarat state.
- Genotypes resistant to jassids, aphids, and leaf miner were identified.
- Yield loss and economic threshold levels for jassids and were determined.
- Biocontrol agents like *Empoasca kerri* and *Balclutha hortensis* were identified and their effectiveness was studied.

4.5.3 Applied

- A high-yielding spanish bunch genotype (CGC 4018) having earliness, multiple resistance to foliar diseases and insect pests, and moderate drought tolerance was released by the name Girnar 1.
- Two high-yielding virginia cultivars NFP 101 and NFP 140 are in AVT stage II.
- Cultures NRGS 7 (early spanish) and NRGS 9 (virginia bunch) are in IVT.
- Three breeding lines were identified as potential HPS lines.
- Five breeding lines were identified for high-oil content.
- Nineteen breeding lines possessing resistance/moderate resistance to one or more biotic stresses were identified.

- Six genotypes possessing drought tolerance and three having moderate cold-tolerance were identified.
- Segregating material from 133 crosses was distributed among cooperating centres and entries selected from such material at various centres are now in the AICRPG trials.
- A paired-rows planting pattern resulting in 20-27 per cent higher yield over the conventional planting pattern was developed.
- Critical factors such as sowing time, fertilizer requirement, plant density, plant protection measures and irrigation requirement have been identified and defined. Fertilizer was identified as the most critical factor for kharif groundnut.
- Beneficial effects of application of gypsum were demonstrated for adoption.
- Crops suitable for intercropping with groundnut were identified and their agronomy was studied. Intercropping with mungbean increased total yield by 18 per cent.
- Mulching with wheat straw resulted in yield increase by 22 per cent and that with polyethylene sheet by 15 per cent.
- Foliar application of iron was found to be effective in ameliorating iron-deficiency-chlorosis.
- Application of fertilizers and micronutrients were found to be beneficial for nodulation whereas the practice of growing tall intercrop and pearl millet were found inhibitory to nodulation.
- Protocols for integrated disease and pest management in groundnut were developed.
- Two *Bradyrhizobium* strains IGR 6 and IGR 40 were developed for rabi-summer groundnut cultivation.
- Three PGPR strains viz. PGPR 1, PGPR 2, and PGPR 4 were developed for rain-fed groundnut cultivation.
- Economically viable technologies were developed for production of enzyme cellulase from groundnut shell and amylases from groundnut cake by microbial fermentation.

4.5.4 Commercially viable technologies

Name of the equipment/technology/ variety/process etc. developed	Application/use	Output capacity	Patent obtained/applied
Product: PGPR biofertilizer	As biofertilizer for enhancing yield of groundnut crop	Application as seed treatments enhanced the pod and haulm yield by 10%	Being applied
Process: Production of cellulase enzyme from groundnut shell	Cellulase is used in industries engaged in bio-polishing fabrics/garments, bio-stone washing, animal feed, textile, food industry etc.	1800-2000 IU cellulase/ 100 g groundnut shell	Being applied
Process: Production of amylases from de-oiled groundnut cakes	The amylase is used by the industry engaged in textile desizing, starch syrup, alcohol production, food processing, baking, starch liquefaction, milling, pharmaceutical, animal feed, bio-treatment of organic waste, etc.	226 IU amylase/g cake	Being applied
Equipment 1. Two pheromone traps (improved) 2. Insect trap	The trap gives 60 to 90 % more catches of *Spodoptera litura* in groundnut. The other trap was developed for *Helicoverpa armigera* in Pigeon pea ecosystem. This is a very simple gadget for collecting micro-insects like thrips, jassids, mites etc.	60 to 90 % more efficient in trapping the male insects	Application filed
Process: Mass multiplication and formulation of biocontrol agents	For the management of fungal pathogens of groundnut and other crops	Is to be developed	Being filed

5 IMPACT ASSESSMENT

5.1 Growth

During 1900 to 1910, the area under groundnut in India was only about 0.23 million ha. Subsequently by the end of the past century, it reached 7.68 million ha. Thus, the decennial annual compound growth rate during this period indicates that the growth in area (17.2%) was the major factor for the increase in groundnut production during 1951-1960. After 1970, however, the growth in productivity (2.5% during 1971-80;

8.2% during 1981-90 and 6.64% during 1991-2000) contributed more towards enhancing production rather than growth in area.

Decadal annual compound growth rates (%) of groundnut in India (1950-2000)

Period	Area	Production	Productivity
1951-1960	17.21	21.60	3.72
1961-1970	4.77	0.17	-4.38
1971-1980	-1.07	1.41	2.51
1981-1990	5.86	14.58	8.22
1991-2000	-4.06	-1.98	6.64

5.2 Input-Output Assessment

The production function depicts the relationship between the input and output. In groundnut cultivation, the vital independent variables that determine groundnut productivity are seed, fertilizers, rain-fall etc. A unit increase in fertilizer application increases the output by 1.5 units. However, a unit increase in seed would decrease the output by half a unit. This aspect is very important as groundnut farmers have a propensity of practicing a high seed rate.

5.3 Gaps and Shortcomings

- There is a gap of 30-40 per cent between exploitable yield and the yield potential of the crop. Majority of farmers do not reach anywhere near the yield potential farmers
- There is lack of comprehensive information on the socio-economic conditions of groundnut based production system.
- The current approach of research relies heavily on the experts/scientists to identify problems of farmers/end users rather than farmers and end users identifying the problems for research.
- Inadequate linkage and coordination between the scientists of NRCG and the State Departments of Agriculture.
- Inadequate interaction among scientists, traders and industry for commercialization of technologies developed by NRCG.
- The future of groundnut crop lies in its utilization as a food crop rather than merely an oilseed crop.
- The information on the nutritive virtues of groundnut and its value-added preparations is insufficient.

- Although nearly 130 groundnut varieties have thus far been released in India, the studies show that only a small number of varieties have actually found their place in farmer-fields due to inadequate extension activity.

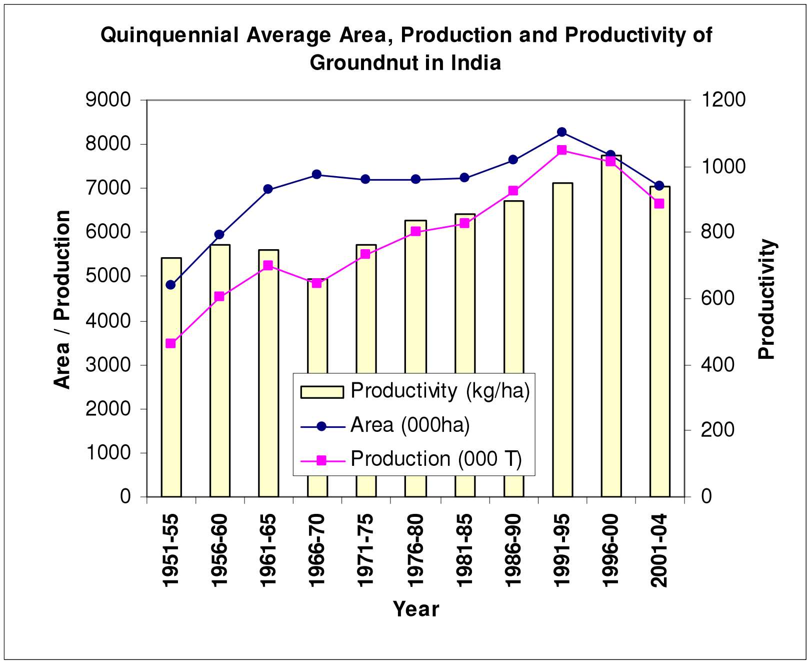
5.4 Lessons Learnt, Suggestions and Options for Future

- With improved crop management practices the gap between yield potential and actual yield realized by the farmers can be narrowed down.
- Socio-economic studies on groundnut based production system will help identify and prioritize research needs.
- Farmers' participation at every stage of technology generation may reduce the time gap between the generation and adoption of technology by farmers.
- Interaction between scientists of NRCG and the officers of the State Departments of Agriculture should be enhanced.
- The two-way interaction between scientists, traders and industrialists will be helpful in commercializing the technologies developed.
- Transfers of Technology (TOT) Units need to accelerate the dissemination of the technologies developed.

6 SCENARIO AND SWOT ANALYSIS

6.1 Scenario

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops of India and contributes about 30% of the total domestic supply of oil. Originally believed to a native of Brazil, groundnut is now grown throughout the tropics, and its cultivation is extended to sub-tropical countries also. With about 8 million tonnes of annual production, India ranks second after China in groundnut production in the world. The productivity of India, however, is quite low (ca. 1000 kg/ha) compared to that of the USA (ca. 3000kg/ha), China (2600kg/ha), Argentina (ca. 2100kg/ha) and Indonesia (ca. 1550 kg/ha).



The crop can be grown successfully in places receiving rainfall of 500 to 1250 mm. The crop performs best on the sandy loam and loamy soils and also black soils with good drainage and takes from 90 to 135 days for maturity. In India, the crop is cultivated both in rainy and post-rainy seasons. The major area comprises marginal lands where crop is grown under rain-fed conditions. India accounts for about 35% of the global area under this crop and about 30% the global production of groundnuts. Andhra Pradesh and Gujarat are the major groundnut producing states of India. Karnataka, Tamil Nadu, and Maharashtra are the other major groundnut growing states. Rajasthan, Madhya Pradesh, and Uttar Pradesh also contribute substantially. Groundnut is also grown in Bihar, Chhattisgarh, Goa, Haryana, Jharkhand, Kerala, Nagaland, Orissa, Punjab, Tripura, Uttaranchal and West Bengal. Although average national yield of groundnut is low (1000 kg/ha), a few farmers of Maharashtra have realized as high a yield as 7,000 kg/ha. So far, more than 130 varieties of groundnut have been released at national level (see Appendix –I for details).

The groundnut kernels are valued for both oil and protein contents. The seeds contain about 48% oil, 25% protein and 18% carbohydrates and are rich source of B-complex vitamins especially thiamine and nicotinic acid but deficient in fat soluble vitamins A and D and almost lacking in vitamin C. The bulk of the produce is crushed for expulsion of oil. The cake that is left behind after expulsion of oil is very rich in protein and is used widely as cattle feed concentrate and also as manure. A large quantity of groundnut cake is exported to other countries. The groundnut shell is generally used as fuel, mulch, and litter for poultry and cattle house.

The economically important pests of groundnut in India are leaf miner, tobacco caterpillar, *Helicoverpa armigera*, hairy caterpillar, white grub, aphid, jassid, thrip, pod borer, termite, bruchid beetle (*Caryedon serratus*), and rodents. Among the fungal foliar diseases early leaf spot, late leaf spot and rust are most important while *Alternaria* leafspot, and veinal necrosis are gaining importance. Among the seed borne diseases collar rot, stem rot, and dry root rot are economically important. Bacterial wilt, bacterial leafspot, and bacterial pod rot have also been reported. Among viral diseases peanut bud necrosis, peanut mottle, peanut clump and peanut stem necrosis are economically important.

The fertilizer requirement of groundnut crop is much less than those of cereal crops. On an average, 10-20 kg N (preferably as ammonium sulfate), 20-60 kg P_2O_5 and 15-45 kg K_2O per ha for rain-fed situations and 10-30 kg N, 20-75 kg P_2O_5, and 20-75 kg K_2O per ha for irrigated crop have been recommended. Under rain-fed conditions, application of gypsum @ 500 kg/ha, as a source of sulfur and calcium, is also required. Among the micronutrients, iron is considered an important nutrient in calcareous soils.

6.2 SWOT Analysis

With this national scenario in the background, the salient features of a detailed analysis of the strengths, weaknesses, threats and opportunities for the groundnut as a crop and the groundnut research system in India is presented below.

6.2.1 Strengths

- India has the largest area and production of groundnut
- The crop can be grown in a variety of soils
- Inherent drought tolerance to some degree
- Being a legume mostly grown in semi-arid tropics, has a low threat vis-à-vis agro-ecological sustainability
- Can be introduced into non-traditional areas easily, especially, rice-fallow and residual-moisture situations
- Large germplasm collection and a large number of released cultivars
- Can be used as oil and edible crop and for value added products

- Wide national network of research
- A holistic approach to boost production and productivity through Technology Mission.
- High export potential of HPS groundnut and extractions
- Low production and export subsidies give an added advantage in the WTO regime

6.2.2 Weaknesses

- About 80% area is rainfed
- Little scope for bringing additional area under irrigated groundnut
- Low seed multiplication rate that slows down spread of improved cultivars
- High cost of inputs especially that of seed
- Lack of modern processing facilities for value-addition
- No special incentives for HPS type production
- Aflatoxin contamination
- Non-availability of varieties for exports
- Lack of private sector investment in groundnut research
- Very low position in the global trade

6.2.3 Opportunities

- Integrated management of the various stresses to stabilize productivity
- Increasing area by extending cultivation to paddy-fallow, residual moisture situations, intercropping and replacing low-value crops
- High input-output packages for irrigated rabi/summer and spring crops
- Water management and conservation techniques
- Exploitation of intercropping systems
- Diversification of value-added products for food in domestic and export markets
- Utilization of groundnut byproducts for producing useful products
- Identification of specific locations for high quality export-oriented production
- Special research and development efforts for export oriented production of groundnuts free from aflatoxin

- Development seed production and distribution system for fast replacement of seed and spread of new cultivars
- Improvement of post-harvest and processing technology at farm and industry level
- Possibility and potential of private sector for investment in groundnut research
- Scope for research on groundnut marketing

6.2.4 Threats:

- Instability in production due to failure of monsoon and changing rainfall pattern
- Crop replacement and shift from groundnut to lower risk crops
- Shifting consumer preference other edible oils
- Unforeseen and new emerging problems in nontraditional areas
- Differential quality of the produce hindering diversification as food and export
- The WTO regimes may hinder free flow of germplasm into India
- High domestic price compared to the international trade
- Competition from countries like China and the USA

7 PERSPECTIVE

The demand for oilseeds in the year 2025, at the present consumption rate, is estimated to be about 34 million tonnes. The present contribution of groundnut to total oilseeds is about 40 per cent. Assuming that the groundnut will account for a similar percentage of total oilseeds production in 2025 AD, the total demand for groundnut will be about 14 million tonnes. Hence, to meet the gap of 5.8 million tonnes an annual growth rate of about 2.2 per cent will be required. The area of land under groundnut, which now is about 8.5 million ha in the traditional areas, is not likely to go up though the projection made by the National Commission for 2000 AD was 9 million ha. It is assumed that most of the area under groundnut cultivation will continue to remain rain-fed. Thus the high growth rate (2.23 per cent) obtained during the first few years of Oilseeds Mission will be difficult to sustain in the long-run especially when competition from other oilseeds and cheaper oil sources is taken into account. Considering the future demands and probable diversification of uses, the following areas will be focus of research.

Groundnut farming, in India, is less input intensive and less uniform than cereal crops. Hence, the pest system is unlikely to drastically change unless a new devastating pest turns up. No specific problem associated with breakdown of resistance has cropped up so far and even clear races of the pests are yet to be found. Hence, a strategy of pest management at the present level of varietal diversity and integrated pest management with moderate degree of resistance will be ideal. In the heavily irrigated areas, especially in the Indira Gandhi Canal area in Rajasthan there is a likelihood of soil salinity developing in about 10 years unless a foolproof irrigation management system is developed. Similarly, the long-term consequences of groundnut cultivation in the non-traditional areas are not predictable right now unless the areas are studied thoroughly. A good scope of improvement in the rabi/summer cultivation of groundnut is visualized which calls for varieties with cold, high temperature and drought tolerance, and fresh seed dormancy, an efficient water management system, and utilization of residual moisture. The irrigated areas can be utilized for maximum economic returns as commercial ventures. If a realistic productivity target of 1200 kg/ha (about 25 per cent increase in productivity and near world average) is kept for kharif and 2000 kg/ha for rabi/summer (about 33 per cent increase in productivity) the total production expected with available area would be about 10.7 million tonnes. The yield levels of the cultivars released in recent years are nominally higher than the cultivars released a decade back. This fact points a possible existence of a genetic plateau in yield level. To rise beyond such a plateau is a serious challenge to the researchers which will call for ingenuity, efforts and will require a time frame of not less than fifteen years. The novel biotechnological approaches in crop improvement, especially to incorporate resistance to certain insect-pests and diseases, and quality characteristics, will have to be encouraged. The infrastructure available at the NRCG is quite adequate but that available at the cooperating centres under AICRPG may need further strengthening.

Thus, to overcome instability and stagnation in production and productivity in the traditional groundnut areas by realization of existing yield potential/attainable yield through crop improvement and innovative crop husbandry and, by enhancing the yield potential are to be addressed.

A strong and feasible means of meeting the challenge of sustaining and improving groundnut production and productivity is the spread of groundnut cultivation in the non-traditional areas especially, in the residual-moisture and paddy-fallow systems. If the economic feasibility of groundnut in these areas can be sustained and if unforeseen agro-ecological problems do not crop up, an addition of about 0.5 million ha of highly productive area to the total groundnut area is expected by 2020

AD. So, a full-throated effort to exploit the scope of extending cultivation to non-traditional areas is essential.

Many groundnut varieties released during past 10 years have not reached the farmers. Saturation of vast area (0.5 m ha) with quality groundnut seed i.e. certified seed under the present seed production system is impossible even at 5 per cent replacement rate. During 1995-96 the requirement of breeder seeds was 7513q, however, 6097q of seeds could be produced. At a growth rate of 2.2 per cent, the requirement of 12666q of breeder seed in 2020 AD is visualized. Seed constraint is likely to increase with the commercialization and increase in area of groundnut. The public seed production network will not be able to meet the demand. It is also unlikely that private seed firms will enter into groundnut seed production system. A possible solution is to involve the farmers in quality seed production system. This may lead to a decline in the seed cost also. As the major part of the non-traditional areas will be under the rabi/summer cultivation, the seed produced in these areas tend to lose viability by the next cropping season. So, to meet the seed requirement of these areas a higher demand on groundnut seed produced in other traditional areas is envisaged. Reduction of such demand will require the development of cheap storage techniques for storing the seed *in situ* without loss of viability. This can be developed with the existing knowledge within a period of three years if the field infrastructure and other logistics are properly taken care of. Establishment of a special seed-grid may also be considered to cater to the needs of these non-traditional areas. Hence, strengthening the breeder seed production system by addressing the weak links in the present system has to be addressed.

Groundnut oil has now cheaper competitors like palm oil, the international prices of which are likely to continue to be lower than the domestic price of groundnut oil in future and so diversified use of groundnut as a rich source of protein, as confectioneries, peanut butter etc. is a must if groundnut agriculture has to survive as commercial enterprise in the liberal global market. This diversification, in turn, will call for efforts, at least partially different than those made for groundnut for oil. A growth in consumerism is expected to lead to the introduction of various groundnut products in the next ten years at least in the urban higher income strata of the society. Therefore, the work on quality aspects of groundnut as a food will have to be initiated soon. Competitiveness in relation to groundnut export from the strongest competitor, the USA, may decline due to the subsidy restrictions of the World Trade Organization but the competition from China is unlikely to change in the near future. The fact that

Indian groundnut fetches less price than other competitors though the taste and flavour characters are the key has to be dealt with because in such cases the incentive for export development will be meager. In the opinion of export organizations like Indian oil Products and Exporters organization, by 2020 AD the export of groundnut as the percentage of total production may be two per cent against the value of one per cent at present. It is very difficult to have a projection for use of groundnut as food because even now an organized industry has not developed so far. However, on the basis of the qualitative trends available, it can now be assumed that about 10 per cent of the total groundnut production is used for food purpose. A potential use of groundnut is as fodder and forage crop. Some wild perennial species of *Arachis* of the Section *Rhizomatosae* have already been identified as promising. To ensure sustenance of groundnut as a remunerative crop, it is essential to emphasize on the research on quality characteristics for confectionery purposes including the aflatoxin management of groundnut. Therefore, the future of groundnut lies in its diversification into various value-added products for food, and feed with improved nutritional and confectionery qualities to meet domestic and export market requirements.

8 ISSUES AND STRATEGIES

The examination of existing scenario, strengths, weaknesses, opportunities and threats and the perspective emerging out of it has led to the identification of four major issues. The issues and the strategies to be employed to tackle them are described hereunder.

8.1 Issue 1

Stagnation of overall groundnut productivity within a narrow range, instability of production and productivity, non-realization of existing yield potential/attainable yield in majority of the traditional groundnut areas and organic farming.

To overcome the stagnation in productivity, the two-pronged approach is required to be followed which would on one hand include development of improved varieties with enhanced stress-tolerance and simultaneous development of improved crop management practices on the other hand. Since, due to relatively a high cost of cultivation, the rain-fed traditional system becomes risk-prone, the crop management strategy to be developed should be low input demanding for minimizing risk-associated losses. The sustainability, both economic and ecological, is at stake in the rain-fed system and so the major attention in the crop management system has to be paid on integrated pest, nutrient and water management systems. An important approach to minimize risk and enhance the efficiency of resource utilization would be to develop well defined and economically viable intercropping systems— one based on groundnut and the other based on the wide spaced crops like cotton, banana and coconut. Such intercropping systems would not only check the decline in the existing area of groundnut but would also offer an opportunity for expansion of area.

The research conducted thus far indicates that stagnation or even decline in groundnut productivity in Saurashtra and Rayalseema regions of the country is due primarily to a slow and steady decrease in soil organic carbon. In these areas, the monocropping of groundnut is practiced and hence there is very little recycling of crop residues as most of the plant parts (including roots) of groundnut is removed at harvest. Therefore development of a technology for restoring the organic carbon content of these soils will help sustain productivity of groundnut in these areas.

Crop Season and Productivity

Season	Sowing	Harvest	Yield (kg/ha)
Kharif (rainfed)	June-July	September-October	600-1800
Rabi (residual moisture/ minimal irrigation)	October-November	February-March	1200-1800
Rabi-summer (irrigated)	January-February	April-May	1500-2000

The traditional rabi/summer groundnut crop, based on assured irrigation, is much less risk-prone than the kharif crop and has much higher average yield. Hence an important strategy would be to evolve technologies specifically for the rabi/summer crop which will rely chiefly on cultivars superior input utilization efficiency under high input conditions. This will lead to an assured increase in productivity where sufficiently assured moisture source throughout the season is available. In addition to the rabi/summer crop, another potential area of interest will be to encourage the spring crop in states like Haryana, Punjab and U.P., just after the harvest of wheat crop. In the past, groundnut used to be an important kharif crop in some parts of these states but changing cropping interest has now almost obliterated the crop. For this, however, cold tolerance in the crop will have to be incorporated to make the spring crop a technical feasibility. The stagnation of yield level due to non-exploitation of yield potential of available varieties is an issue which can easily be solved by optimum management practices whereas improving the yield-potential itself will have to be achieved by two strategies— one that of sustaining the yield potential by introducing resistance to stresses and the other of enhancing the yield potential itself. Considerable work has been done with the first strategy but the success obtained so far is a moot question. The process for the second strategy has also been initiated. For both the approaches the biotechnological as well as conventional tools and will have to be innovatively applied. Identification and development of molecular markers for various desirable traits will hasten the selection process while the development of transgenic varieties expressing novel genes for tolerance of stresses and/or enhancing the quality will lead to enhanced productivity and export-worthiness. The maintenance, database generation and utilization of wild species and the available germplasm will be a mainstay for the work needed. Sharing of the material generated especially from the difficult and distant crosses with the partners in the national network will hasten the generation of location specific improved cultivars.

The concept of farmer's participatory breeding may offer early solutions to some of the concerns of the farmers and also reduce the time lag in development as also transfer of technology.

Development of implements and tools for mechanized cultivation of groundnut has not received much attention in the past. Availability of an efficient groundnut harvester will enhance the productivity indirectly by minimizing the pod losses that occur currently during harvest due to manual harvesting or use of conventional implements.

New laws are being framed for both export and import of materials to protect the consumers from the harmful effect of the agro-chemical residues in the commodities. In this context the bio-organic farming is now assuming importance at global level. Organically grown food commodities fetch premium prices that compensate times more than the loss that occurs due low yields under organic farming. India with its largest cattle head in the world, a vast human resource can conveniently carve out a niche for itself in the international market of organically produced groundnuts. Hence development of technology for organic cultivation of groundnut should be a priority for the researchers.

8.2 Issue 2

Development of groundnut for diversified value-added products for enhancing its consumption as an item of food in the country and for export

In the scenario of competition of groundnut as a source of oil with cheaper sources of oil like palm oil and faster growth in area and productivity of other oilseed crops like rapeseed and mustard, the future of groundnut lies in its diversification for use as a source of nutritive foodstuff for human consumption, animal feed supplement (using groundnut kernel and groundnut cake) and fodder and forage (using haulms of cultivated and wild species). The property of groundnut that it unlike other oilseeds, can be consumed directly, enhance its chances of becoming an ancillary food crop. Groundnut already being an important export commodity, its diversification for use as food and feed is likely to further encourage and boost export.

Some Nutritious and Delicious Groundnut Preparations

However, a large chunk of groundnut needed for such diversification of domestic food industry (still at its infancy) and export has to come from a specialized cultivation system with assured inputs and management to maintain the standards of quality and thus ensure returns. An effective industry and research interface has to be established for this purpose. Cultivation of groundnut for such purpose, however, has to be a little more commercially viable, as it would require high inputs in specially identified areas. Thus, development of technology for this purpose will need a substantially different approach from that needed for low-input rain-dependent system. Special research efforts have to be initiated regarding the quality and nutrition aspects of groundnut to take care of the demands of both the domestic consumers and the importers insisting on very low levels of aflatoxins.

A decade ago, India was one of the major exporters of groundnuts in the world but now it has lost that position to China. The USA and Argentina are the other competitors. Now the EU permits import of nearly aflatoxin free (<2 ppb) groundnut only as a result the current export is confined mainly to Indonesia and Malaysia as bird and cattle feed.

Export of groundnuts from India (quantity: metric t; value: lakhs Rs.)

Item	1998-1999		1999-2000		2000-2001		2001-2002	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value
In shell								
-HPS	5900	1261	10996	2421	17110	3609	43434	9379
-NE	485	114	3508	865	3224	747	1223	267
Kernels								
-HPS	46103	113	127060	300	106648	247	61747	150
-NE	5775	13	16545	38	10084	25	6409	14
Extractions	100458	50	1961	0.7	15746	14	69183	44

HPS= Hand Picked Selection; NE= Non-edible grade exported mostly as bird feed

In addition, extending the possibilities of using groundnut by-products like groundnut shell and cakes will have to be expanded. Microbial processing of the shell and the cakes for production of industrially important enzymes holds a good promise. Use of haulms of groundnut as fodder is quite in vogue. But research for improving the quality of fodder has to be taken more seriously. A good opportunity to use vegetative propagation of perennial wild relatives of groundnut as fodder and forage crop also exists. Their cultivation of fodder grade groundnut can be practiced even in degraded lands.

8.3 Issue 3

Stabilizing groundnut farming in the non-traditional areas, especially, in the eastern and northeastern regions and introducing groundnut in coastal saline regions of the country

The efforts in the past have led to successful introduction of groundnut as a profitable crop in the north-eastern part of the country. There exists a feasibility of growing groundnut in some upland-rice areas, rice fallows and residual moisture situations However, for establishing groundnut cultivation in this region, a thorough understanding of the agricultural system and avenues for disposal of large quantity groundnut this part of the country is required. Although varieties specific for these regions are yet to be developed, trials conducted with the available cultivars have been quite helpful in identifying a few cultivars, which could be for the time being used profitably in these regions. The marketing of the produce, however, continues to be a major problem in these areas. The marketing opportunities based mainly on groundnut as food will stand a better chance than that of groundnut as a source of oil. Some of the problems like low pH, Al-toxicity, high vegetative growth and high incidence of foliar diseases, which are peculiar to these areas, need special attention. The non-availability of seed is the most important constraint identified there. Hence, a seed production network specifically involving the eastern and northeastern states has to be developed.

Thus a scope also exits for bringing and additional area of 1.75 million ha in the next ten years.

Gujarat, Andhra Pradesh, Tamil Nadu and Karnataka, the leading groundnut producing states, are having a very long coastal belt affected by salinity.

Potential for bringing additional (new) area under groundnut

States	Area (ha)
Uttar Pradesh (western region)	5,000
NEH region	25,000
Orissa and West Bengal (rice fallows)	100,000
Assam (Brahmaputra river bed and uplands)	10,000
Goa (rice fallows)	25,000
Intercropping with field and horticultural crops	10,000
Total	**1,75,000**

The salinity is slowly increasing towards the mainland and sooner or later is likely to adversely affect groundnut production in these states. Hence development of appropriate technology for groundnut production in the existing areas of these states and promoting its cultivation in the saline areas will be crucial for sustaining groundnut production. For this, technology for managing saline soils, using available water for groundnut production and development of salinity-tolerant cultivars will play a very important role.

8.4 Issue 4

Revamping of the breeder seed production system by strengthening the weak links in the existing system

To tackle the breeder seed supply system, which is the single greatest constraint in maximizing the benefits from cultivar development, will require unburdening the present system of the load of producing breeder seed of varieties, which are very old but are still in demand. As the new varieties do not reach the farmers, the demand for old varieties persists which in turn creates the demand for breeder seed of old varieties. Hence, two different approaches have to be adopted- one for the old varieties and another for the new varieties. The full chain of seed categories can be dispensed with for the old varieties. Quality seeds of these varieties can directly be produced in the farmers' fields under the coordination and supervision of the NRCG, the oilseed cooperatives, NDDB, and the state seed agencies. Encouraging seed village concept can greatly reduce the burden of producing quality seed on the public sector system.

And the quality seed grown in this way can directly go to the farmers. The time and efforts thus saved can be diverted fully for breeder seed production of new varieties. An account of breeder seed production activity in the last five years is given below.

The current seed replacement rate is about 3-5%. Once the breeder seed production and hence, ultimately the certified seed production of new varieties are boosted, the new varieties will rapidly reach the farmers and the demand for the old varieties will naturally die down. A strong measure can be subsequently be taken for de-notification of varieties older than 15 years (the minimum period of breeder's right under the UPOV 1978). The long-term aim will be about 10 per cent replacement rate.

DAC indent vis-à-vis Breeder Seed Production

Year	Number of varieties	Quantity (q)	
		DAC Indent	Production
2000-01	28	4055	2779
2001-02	36	3149	3723
2002-03	32	2983	2785
2003-04	36	3480	5029
2004-05	40	3974	5416

DAC: Department of Agriculture and Cooperation

For the non-traditional areas of the eastern and the northeastern parts of the country a special breeder seed production grid will have to be formulated to avoid the need for long distance transportation of seeds from other distant regions. Initially the responsibility can be entrusted to neighbouring states of Orissa and West Bengal.

8.5 Issue 5

Initiate research work on groundnut marketing to create an ambiance of good marketing practices in the country to protect the interest of the farmers and also consumers

Agricultural marketing is witnessing a major change owing to liberalization and globalization of markets. In this context, agriculture has to be market driven, more cost effective, competitive, innovative and responsive to high tech and information technology. Keeping this in view, the important areas of research in groundnut marketing could be as under:

a) Structure, conduct and performance analysis of existing groundnut markets
b) Cost and margins of groundnut cultivation
c) Export effectiveness of groundnut
d) Information needs of stake holders in groundnut marketing
e) Marketing of organically produced groundnut

f) Price mechanisms of groundnut

g) Supply chain management

h) Implication of WTO on groundnut marketing

i) Risk management in groundnut production

The information thus generated would be useful in enhancing competitiveness of the Indian groundnut farmers in the global groundnut market and also emphasizing market access opportunities in the wake of WTO regime.

9 PROGRAMME AND PROJECTS ON TIME SCALE FOR FUND REQUIREMENTS

On the basis of the issues discussed in section eight, the following five research programmes have been identified for the XI five year plan.

9.1 Programmes

- Development of low-risk, efficient and sustainable packages for groundnut based cropping systems in traditional rain dependant areas and also for organic farming
- Development of diversified value-added products of groundnut for enhancing domestic consumption as an item of food and for export
- Development of package of practices for maximizing groundnut production in the non-traditional areas, especially, in the eastern and northeastern regions and also for coastal saline regions.
- Strengthening of groundnut seed production systems
- Analysis of profitability of groundnut cultivation in various production systems and exploring the possibility of incentives for high/special quality produce

The research activities under each of the programmes thus identified will be pursued through one or more research projects. Each research project will be lead by a Principal Investigator and supported by Co-Principal Associates drawn from various scientific disciplines as per requirement of the project. The component research project for each programmes will be as follows:

1. **Development of low-risk, efficient and sustainable packages for groundnut based cropping systems in traditional rain dependant areas and also for organic farming**
    i. Germplasm management of cultivated groundnut and its wild relatives
    ii. Breeding and Genetic Studies on biotic and abiotic stresses
    iii. Biotechnological approaches to characterization and genetic enhancement of groundnut
    iv. Integrated pest management in groundnut based production system

v. Integrated Nutrient Management in Groundnut

vi. Studies on groundnut based cropping systems

vii. Physiological studies in relation to environmental stresses in groundnut

viii. Construction of digital library of released varieties, wild species, pest, diseases and nutrient disorders of groundnut in India

2. **Development of diversified value-added products of groundnut for enhancing domestic consumption as an item of food and for export**

    i. Breeding for large seeded and confectionery type groundnut

    ii. Assessment and enhancement of quality in groundnut and its value added products

    iii. Prevention and management of mycotoxins in groundnut

3. **Development of package of practices for maximizing groundnut production in the non-traditional areas, especially, in the eastern and northeastern regions and also for coastal saline regions.**

    i. Development of sustainable production technologies for promotion of groundnut cultivation in non-traditional areas of eastern and north-eastern states

    ii. Management of existing and emerging problems of soil and water salinity for groundnut production

4. **Strengthening of groundnut seed production systems**

    i. Nucleus and breeder seed production through AICRPG network and ICAR sponsored mega seed project

5. **Analysis of profitability of groundnut cultivation in various production systems and exploring the possibility of incentives for high/special quality produce**

    i. Analysis of impact of Front Line Demonstrations (FLDs)

    ii. Economics of groundnut cultivation in major growing areas

9.2 Prioritization of Deliverables

9.2.1 Crop Management

Low-input agronomical packages
Groundnut based cropping systems
Region specific high-yielding cultivars

9.2.2 Water management

Efficient water management technology
Water-use-efficient cultivars

9.2.3 Integrated Pest Management (IPM)

IPM package
Disease and pest resistant cultivars
Forecasting system for disease and pest incidence

9.2.4 Integrated nutrient management (INM)

INM Package
Management of salinity

9.2.5 Seed quality

Cultivars with fresh seed dormancy and prolonged viability
Package for aflatoxin management

9.2.6 Transfer of technology

Impact assessment
New value-added products of groundnuts
Technology for more economic utilization of groundnut byproducts
Electronic data base

10 LINKAGE, COORDINATION AND EXECUTION ARRANGEMENTS

The NRCG has developed strong linkages with various national and international organizations for effective implementation of research programmes. Basic information generated at the NRCG. For location specific research and testing of technology, collaboration exists with SAUs through AICRPG and some voluntary agencies. The arrangements that exists will be strengthened further.

11 CRITICAL INPUTS

11.1 Funds

Both the main schemes namely NRCG and AICRPG will be managed through the grants approved by the Planning Commission, Govt. of India from time to time. As far as AICRPG centers are concerns only 75% of the budget is borne by Govt. of India and remaining 25% by the respective state governments. In case of NEH region, however, 100% funding is provided to centres attached to the Central Agricultural Universities.

The projected requirement of funds for XI plan period is Rs 12 crores for NRCG and Rs 18 crores for AICRPG under the head Plan. An additional fund of Rs 15 crores is required for NRCG under the Non-Plan..

In addition to the grants stated above, a substantial grant is also likely to be obtained in the form of externally-funded projects sponsored by various state and central departments, industries and international organizations. All the financial resources will be managed as per norms of ICAR.

11.2 Manpower:

The current project status of this center is that of NRC. Looking into the importance of the crop and the research need it is envisaged that the project would be upgraded to the level of an Institute and renamed as Indian Institute of Groundnut Research in the XI five year plan. Accordingly in addition to Director, there would be four more positions in the RMP cadre for managing the posts of heads of four divisions *viz.,* Crop Improvement, Crop Production, Crop Protection, and Basic Sciences. The currently approved and the projected cadre requirements in the ensuing five-year plans are given here in table.

So far as manpower under All India Coordinated Project on Groundnut (AICRPG) is concerned, at present there are 151 positions comprising 61 in scientific, 85 in technical and 5 in administrative categories distributed over five main centers and 17 supporting centers. This manpower seems to be quite adequate for the XIth plan period as well and during the subsequent plan period major additions are not visualized except for revival of the post of the project coordinator. As AICRPG is a fully plan activity the manpower required in the subsequent five-year plans would be determined on the basis of work load envisaged at the end of each plan.

Discipline-wise breakup of scientific posts for the Xth plan and projection of future requirements

Sl.No.	Discipline	Cadre Strength			
		2002-07	2007-12	2012-17	2017-22
1.	RMP (Director + Heads of Division)	1+0	1+4	1+4	1+4
2.	Plant Breeding	8	10	12	14
3.	Genetics and Cytogenetics	2	3	3	3
4.	Economic Botany	2	3	4	4
5.	Agronomy	4	4	5	5
6.	Paedology	1	1	1	1
7.	Soil Chemistry	1	2	2	2
7.	Soil Chemistry	1	2	2	2
7.	Soil Chemistry	1	2	2	2
8.	Plant Physiology	3	3	4	4
9.	Biochemistry	2	2	2	3
10.	Microbiology	3	4	4	4
11.	Plant Pathology	4	4	5	6
12.	Entomology	3	3	4	5
13.	Agril. Extension	1	2	3	3
14.	Agril. Economics	1	1	2	2
15	Computer application	2	2	2	2
16.	Agril. Statistics	2	2	2	2
17.	Plant Biotechnology	None	2	3	3
18.	Agril. Engineering	None	1	1	1
19.	Food and Nutrition	None	1	1	1
	Total	**40**	**55**	**65**	**70**

11.3 Human resource development

The scientific and technical manpower will require training (within the country and/or abroad) in the following areas for effective and timely achieving the targets of the research projects.

- Gene mapping, MAS, and disease resistance breeding
- Molecular tagging
- Germplasm management
- Quality assessment
- Drought tolerance and mineral nutrition
- Molecular-Plant microbe interaction
- Biological control of insect pests and diseases, aflatoxin management
- Insect pheromones
- Root and canopy structure
- Salinity management
- Cropping systems research
- Impact analysis
- Food security
- Data base management

12 RISK ANALYSIS BASED ON SWOT

The analysis of the risks which the researchers may have suffer while addressing each of the issues identified and pursuing the research activities envisaged to provide solutions to various problems are described below:

Programme	Possible risks
Development of low-risk, efficient and sustainable packages for groundnut based cropping systems in traditional rain dependant areas and also for organic farming	No risk is anticipated for the traditional rain dependent system. For organically produced groundnut, however, getting a premium price may be difficult.
Development of diversified value-added products of groundnut for enhancing domestic consumption as an item of food and for export	No risk is anticipated. Groundnut snacks are already popular. Groundnuts can blend well with many foodstuffs and can deliver several new tasty and nutritious food items.

Development of package of practices for maximizing groundnut production in the non-traditional areas, especially, in the eastern and northeastern regions and also for coastal saline regions.	Due to lack of proper marketing and processing facilities in the NEH region, the farmers may experience some difficulties and revert to old crops.
Strengthening of groundnut seed production systems	No risk is anticipated
Analysis of profitability of groundnut cultivation in various production systems and exploring the possibility of incentives for high/special quality produce.	No risk is anticipated

13 PROJECT REVIEW, REPORTING AND EVALUATION ARRANGEMENTS

The project reviewing, reporting and evaluation will be done regularly at various levels. Progress of research projects work vis-à-vis targets will be reviewed regularly during the meetings of Institute Research Committee (IRC).

In house review and evaluation will be done during the meetings of IRC. These meetings will be held twice a year– in January for Rabi-summer season and in May or June for Kharif season. At the IRC meetings, the project leaders will present the progress made and the future programme of work. All the scientists will participate in the meeting. The Research Advisory Committee (RAC) headed by an eminent scientist and comprising other expert members drawn from all over India will also review the progress at least once a year. The Quinquienial Research Team (QRT) will carry out its appraisal every fifth year. The utility of developments occurring elsewhere in the world will also be discussed in the meetings of such committees and suitable modifications in the research programmes, if required, will be made. The management related problems would be annually reviewed in the annual Institute Management Committee (IMC).

The reporting system developed and adopted by the council will be followed. This includes submission of quarterly and half yearly reports to Council HQ. Salient features of achievements made are highlighted in these reports and the targets set for the next quarter or six-months are indicated. The progress made during each of the financial year is compiled and published in form of annual report. A copy of this report is sent to all SAUs and ICAR institutes. The comments received from the RAC, IMC, QRT etc. are considered at various meeting for incorporation in the research projects, if required.

14 RESOURCE GENERATION

Although NRCG has about 100 ha of land its command only about XX is arable. The remaining area has very thin layer of soil layered on rock pans. Thus bringing all the area under cultivation is an arduous task and may require lot of monetary input besides time. Thus the major source of resource income at this stage continues to be the sale of farm produce. However, the resources have so far been generated and would continue to be generated from the following sources:

- Breeder seed production of groundnut
- Agro forestry products from the land not being utilized for research
- External funding of research projects from agencies like DST, DBT, NAIP, European union, ICRISAT, APEDA etc.
- Consultancy service
- Contract research
- Referral lab for the analysis of aflatoxin and other quality attributes of groundnut kernels (being proposed in the eleventh five year plan).

Considering the expertise and experience of the scientific manpower and the physical infrastructure available, the NRCG will be in a position to generate resources equal to about 10% of its annual budget.

15 OUTCOME OF INSTITUTION WITH TRADE, INDUSTRIES AND FARMERS

- The contamination of groundnut kernels by aflatoxin appears to be the main stumbling block for export oriented groundnut industry.
- There is scope for developing a separate chain of trading of superior quality groundnut especially those produced with low aflatoxin contamination risk practices.
- There exists considerable scope for research on developing groundnut based value-added products.
- The process of transfer of technology to farmers is rather slow, especially that of new groundnut varieties.

16 EXPORT POTENTIAL AND MARKETABILITY OF RESERACH OUTPUT AND ITS IMPACT ON WTO REGIME

- Technology developed at NRCG to produce industrial products like enzymes and alcohols by microbial processing of groundnut by-products (shell and cakes) holds a good potential for marketability.
- Under WTO regime the technologies developed can be patented. Hence there is a need for obtaining patents for the technology developed without much loss of time.

17 UTILITY OF RESEARCH OUTPUT TO FARMERS AND END USERS

- The training on groundnut crop production, crop protection and preparation of value-added products can help raise the economical status of the small and the marginal groundnut farmers.
- The technology for prevention of contamination of groundnut by aflatoxin is likely to benefit both producers (farmers) and processors (industry) alike.

18 ANTICIPATED CONSTRAINTS

The major constraints in enhancing the productivity are:

- ➢ Inadequate drought tolerance in released cultivars
- ➢ Cultivation of crop on marginal lands with low inputs
- ➢ Short supply of quality seeds
- ➢ Inadequate tolerance of various biotic and abiotic stresses in released cultivars
- ➢ Soil salinity and acidity
- ➢ Competition from other remunerative crops
- ➢ Slow transmission/penetration of new technologies
- ➢ Inadequate forewarning system
- ➢ Continued dependence on pesticides and lack of interest in alternate eco-friendly technologies.
- ➢ Non-availability of tools for mechanized-harvesting to minimize mechanical injuries to pods
- ➢ Aflatoxin contamination which renders the produce unfit for export
- ➢ Difficulty in further expansion of area due to lack of appropriate technology to make groundnut either more than or at least as remunerative as other crops in such areas (eastern and north eastern region, rice fallow situations, river valleys

and for spring groundnut areas in western U.P., Rajasthan, Haryana and Punjab).

18.1 General constraints

- Use of obsolete and low-yielding cultivars
- Inadequate availability of quality inputs (including seeds)
- Cultivation under energy starved conditions (marginal and sub-marginal lands) and rain-fed situations.

18.2 Specific constraints

18.2.1 Rainy season

- The high incidence of seed, seedling, and foliar fungal diseases; peanut bud necrosis virus, damage by *Spodoptera, Helicoverpa*, leaf miner, sucking pests and soil pests
- Soil moisture stress at different phenophases
- Lack of separate fertilizer recommendations for sole, intercropping and sequential cropping systems
- Lack of suitable cultivars for a given intercropping systems

18.2.2 Post-rainy season

Rabi

- Poor plant stand due to improper tillage and loss of seed viability
- Lack of cold tolerant varieties
- Lack of nutrient efficient genotypes
- Imbalanced nutrient management, involving cropping system as a whole
- Lack of efficient moisture conservation technique

Summer

- Lack of low and high temperature tolerant varieties
- Lack of nutrient efficient genotypes
- Lack of efficient water management practices
- Improper fertilizer application practices
- Lack of varieties and management practices suitable for salt affected areas
- Incidence of peanut bud necrosis disease

Spring

- Lack of short duration cultivars possessing fresh-seed dormancy
- Lack of low and high temperature tolerant varieties

18.3 Groundnut as a food crop

- Lack of cultivars suited more to processing rather than crushing
- Lack of information on regions better suited for cultivation of such cultivars
- Alleviation of risk associated with aflatoxin contamination of the produce

Appendix 1

List of Indian Groundnut Varieties

Region/ state	Name	Year of release	Days to maturity	Pod yield kg/ha	Additional information	
					Disease reaction	Salient features
All India	M 13	1972	130	2750	Tolerant to leaf spot	Bold pods and kernels
	TG 1 (Vikram)	1973	125	2695	Resistant to foliar diseases	Bold pod HPS Grade profuse branching but late maturity
	Kaushal (G 201)	1984	108-112	1700	Resistance to ELS	Early maturity
	Gangapuri	--	110	2000	Moderately resistant to foliar diseases	Valencia type released for MP initially but subsequently released for All India
	Dh 86	2002	125-127	3081	-	Recommended for Rabi/summer situations. High harvest Index suited Kharif cultivation also.
Andhra Pradesh	TMV- 2	1940	120-125	1025	Moderately resistance to rust	Widely adapted, well suited for Summer season
	ICGS 11	1986	110-115	2000	Tolerant to PBND	Compact plant, suitable for Rabi/summer in Maharashtra
	Girnar 1	1988	95-105	(2000R)	Resistant to leaf spots and rust	Early maturing multiple resistant variety suitable to rainfed.
	ICG (FDRS) 10	1990	105-115	2200 (K)	Tolerant to late leaf spot and BND	Suitable for Kharif season where rust and LLS diseases are problem.
	RSHY 1	1991	110-120	2480 (R)	Moderately resistant to late leaf spots, rust & BND	Suitable for Rabi residual moisture
	Tirupati 2	1991	105-110	2100 (K) 3500 (R)	Tolerant to nematode incidence Kalahasti-melody	Suitable for both season, possesses high pg strength.
	ICGV 86590	1991	105-110	1785 (K)	Resistant to rust tolerant to late	Multiple disease and

					leaf spots	insect pest resistant.
	K 134	1993	100-105	1677	Resistant to BND tolerant to late leaf spots	Early maturing with tolerance to leaf spot & drought
	Tirupati 3	1993	115-120	K 2200 R-3500	Resistance to kalahasthi	Recommended for endemic areas of kalahasthi malady
115-120	DRG 12	1994		2604	Tolerant to rust, late leaf spot and PBND	High yielding for Rabi/summer
	Kadiri 4	1997	100-110	2259	Tolerant to late leaf spot and PBND	For cultivation in Rabi in Andhra Pradesh
	JCC -88	1998	105-110	1396	Resistant to *A.flavus, A. niger* & PBND	High yielding and early maturity Suitable for Rabi/summer
	Trupati 4 (ICGS 30)	1995	100-105	2490	Appreciably least reaction to major disease	Recommended for both kharif and Rabi/summer season. Early maturity.
	Kadiri 71-1	1971	-	1390	Susceptible to foliar diseases	Efficient in fixing atmospheric nitrogen
	Kadiri 2	1978	115-120	1800	Mod. resistant to foliar diseases	Efficient nitrogen fixation, bold seeded
	Kadiri 3	1978	105-110	2100	-	Clustered short pod, suitable for summer season also.
	Kadiri 5	2002	110-115	2033	Tolerant to LLS	Drought tolerant
	Kadiri 6	2002	100-110	3100-3800(R)	-	Early maturing, suitable for rabi/summer
	ICGV 86325	1994	115-125	2700	Tolerant to rust, late leaf- spot and BND	High yielding under rainfed
Gujarat	J-11	1964	115-120	1300	Tolerant to *A. flavus* seed colonization	Collar rot and *Aspergillus flavus* invasion. Suitable for summer season also
	GAUG 1	1973	1120-125	1500		Small thin shelled pods having prominent beak

	GG 2	1983	105-110	3100		Early flowering
	ICGS 44	1988	120-125	2500R/S	Tolerant to early leaf spot and BND	Suitable for Rabi /Summer
	ICGS 37	1990	110-125	3000	Moderately resistant to late leaf spots, rust & BND	Tolerant to drought
	TG 26	1995	110-115	1596 (K) 2425 (R)	Tolerant to rust, late leaf spot and PBND	High yielding earliness and fresh seed dormancy
	GG 7 (J-38)	2001	96-105	2149	Tolerent to tikka compared to JL 24	Early Maturity
	GAUG 10	1973	125	1800	Resistant to foliar diseases	--
	GG 11	1984	-	2050	Resistant to rust	Pod bigger and 4.9% higher yield than GAUG 10 and 14.3 % higher yield than M 13
	Somnath	1990	120-125	1900 (K)	Tolerant to early and late leaf spot	High yielding, early maturing bold seeded, suitable for export purpose
	GG 20	1992	120-125	1960	Moderately resistant to foliar diseases	--
	GG 12	1992	130	1305	Susceptible to foliar diseases	Early maturity
	BAU 13	1993	125-130	2191 (K)	Tolerant to leaf spots collar rot and BND	Higher yield with bold seeded HPS for export trade
	LGN 2	2000	115-120	1500-2000	Susceptible to foliar diseases	Suitable for early sown rainfed conditions
	GG 14	2002	114-123	2159	--	High oil content
Haryana	MH 1	1975	125-130	2000	Tolerant to foliar diseases	Light green leaves and light rose kernels small pods
	ICGS 1	1990	110-115	2300 (R)	Tolerant to leaf spots	Suitable for Spring season
	CSMG 84-1	1992	125-135	2704 (K)	Resistant to rust	Rose variegated kernel colour , bold two seeded pod
	DRG 17	1994	120-125	2100 (K)	Tolerant to rust, late leaf spot and PBND	High yielding for Kharif Rainfed, tolerant to moisture stress

	HNG 10	1998	125-130	1918	Susceptible to foliar diseases	Suitable for the rainfed irrigated situation
	MH 2	1978	125-130	3000	Moderately resistant to foliar diseases	Vary dwarf plant and responsive to closer spacing 15 x 15 cm
Jharkhand	ICGS 1	1990	110-115	2300 (R)	Tolerant to leaf spots	Suitable for Spring season
	BG 1	1979	110-116	2000	Mod. resistant to foliar diseases	Bold pod, SMK 93-95%
	BG 2	1979	110-117	2200	Mod. resistant to foliar diseases	Bold pod, SMK 93-95%
	BG 3	1986	115-125	2500	Fairly resistant to early and late leaf spots	Early maturity & drought tolerant.
	BAU 13	1993	125-130	2191 (K)	Tolerant to leaf spots collar rot and BND	Higher yield with bold seeded HPS for export trade
Karnataka	Spanish Improved	1905	110-115	2400	Moderately resistance to ELS	Less Prominent beak & kernels with round end
	TMV- 2	1940	115-120	1025	Moderately resistance to rust	Widely adapted, well suited for Summer season
	S 230	1969	120	1280	Susceptible for Foliar diseases	-
	S 206	1969	120	1900	Susceptible for Foliar diseases	Reticulated pod with slight beak and constriction
	Dh 3-30	1975	125	2800	Intermediate resistant to foliar diseases	Pod with prominent beak and constriction category
	KRG 1	1981	125	1200 (Kh.) 2230 (R/S)	Susceptible for Foliar diseases	Medium sized pod suitable for summer season also.
	Dh 8	1984	115	3200	Moderately resistance to tikka, LLS & rust	Compact pant, tolerant late leaf spot, kernel rounded at one end and sharply pointed at the other.
	ICG (FDRS) 10	1990	105-115	2200 (K)	Tolerant to late leaf spot and BND	Suitable for Kharif season where rust and LLS diseases are problem.
	ICGV 86590	1991	105-110	1785 (K)	Resistant to rust tolerant to late leaf spots	Multiple disease and insect pest resistant.

	TKG 19A	1993	120-125	2260 (K)	Susceptible for Foliar diseases	Bold and attractive kernels seed qualifies for HPS grade.
	DRG 12	1994	115-120	2604	Tolerant to rust, late leaf spot and PBND	High yielding for Rabi / Summer
	R 8808	1997	110-115	2426	Tolerant to late leaf spot and PBND	High yielding and early maturity Suitable for Rabi/summer
	ICGS 76	1989	115-125	1300 (K)	Resistant to early leaf spots	A variety with two seeded pods
	ICGV 86325	1994	115-125	2700	Tolerant to rust, late leaf spot and BND	High yielding under rainfed
	DSG 1	1997	130.135	1500-2000	Susceptible to foliar diseases	Transitional zone under rainfed condition
Kerala	TG 3	1985	115-120	1200 ®	Tolerant to tikka and pod borer	Suitable for kharif and summer season.
	ICG (FDRS) 10	1990	105-115	2200 (K)	Tolerant to late leaf spot and BND	Suitable for Kharif season where rust and LLS diseases are problem.
	ICGV 86590	1991	105-110	1785 (K)	Resistant to rust tolerant to late leaf spots	Multiple disease and insect pest resistant.
	Sneha	1998	120-125	3827	-	-
	Snigdha	1998	120-125	3556	-	-
	ICGV 86325	1994	115-125	2700	Tolerant to rust, late leaf spot and BND	High yielding under rainfed
Madhya Pradesh	AK 12-24	1940	-	1250	--	Wider adaptability, suited for medium to heavy soils
	Jyoti	1971	-	1600	Susceptible for Foliar diseases	Less incidence of root rot and collar rot
	ICGS 11	1986	-	2000	Tolerant to PBND	Compact plant, Suitable for Rabi/ Summer in Maharashtra
	ICGS 44	1988	120-125	2500R/S	Tolerant to early leaf spot and BND	Suitable for Rabi /Summer
	GG 3	1994		1283	Susceptible for Foliar diseases	Early maturity, foliage remains green at harvest stage.

	TG 26	1995	110-115	1596 (K) 2425 (R)	Tolerant to rust, late leaf spot and PBND	High yielding earliness and fresh seed dormancy
	JGN 3	1997	105	1806		Drought tolerant
Maharashtra	AK 12-24	1940	-	1250	--	Wider adaptability, suited for medium to heavy soils
	SB XI	1965	-	1300	Susceptible to Foliar diseases	Suitable for cultivation in summer season also.
	JL 24 (Phule pragati)	1978	95	1800	Susceptible for BND	Compact bearing widely adopted
	TG 17	1982	-	2000	Intermediate resistant to Foliar diseases	Bold poded high harvest index. Fresh seed dormancy upto 30 days
	ICGS 11	1986	-	2000	Tolerant to PBND	Compact plant, Suitable for Rabi/ Summer in Maharashtra
	Girnar 1	1988	95-105	(2000R)	Resistant to leaf spots and rust	Early maturing multiple resistant variety suitable to rainfed.
	ICGS 44	1988	120-125	2500R/S	Tolerant to early leaf spot and BND	Suitable for Rabi /Summer
	TAG 24	1991	100-105	1683	Tolerant to leaf spots, BND	Early maturity
	GG 3	1994	100-105	1283	Susceptible for Foliar diseases	Early maturity, foliage remains green at harvest stage.
	DRG 12	1994	115-120	2604	Tolerant to rust, late leaf spot and PBND	High yielding for Rabi / Summer
	TG 26	1995	110-115	1596 (K) 2425 (R)	Tolerant to rust, late leaf spot and PBND	High yielding earliness and fresh seed dormancy
	JL 220	1998-99	90-95	1800-2000	Susceptible for LLS and rust	Early maturity,
	AK 159	2001	100-105	2000-2200	-	Suitable for rabi/summer also
	Kopergaon 1	1933	-	1250	Susceptible for Foliar diseases	Pod medium in size
	Karad 4-11	1957	-	1000	Resistance to ELS	Medium to long pod 1-3 seeded
	UF 70-10	1984	-	2000	Mod. Resistant to foliar diseases	Suitable for summer.
	ICGS 76	1989	115-125	1300 (K)	Resistant to early leaf spots	Two seeded pods

	BAU 13	1993	125-135	2191 (K)	Tolerant to leaf spots collar rot and BND	Higher yield with bold seeded HPS for export trade
	B 95	1993	115-125	3345	Resistant to late leaf spots and BND	Suitable for Summer cultivation, extra bold seeded, HPS grade
	ICGV 86325	1994	115-125	2700	Tolerant to rust, late leaf spot and BND	High yielding under rainfed
	Kopergaon 3	1933	90	1900	Susceptible to foliar diseases	Early maturity
Orissa	AK 12-24	1940	-	1250	--	Wider adaptability, suited for medium to heavy soils
	Kisan	1980	-	1600	Susceptible for Foliar diseases	Small pod with prominent reticulation
	Jawan	1983	-	1230 (Rainfed) 2000 (Irrigated)	Susceptible for Foliar diseases	Elongated pod with slight larger beak, medium rose kernel.
	RSHY 1	1991	110-120	2480 ®	Moderately resistant to late leaf spots, rust & BND	Suitable for Rabi residual moisture
	OG –52-1	1997	105-110	1982 (K) 3620 ®	Resistant to collar rot, stem rot, rust and leaf spot	Suitable for rainfed irrigated an residual moisture situation
Punjab	SG 84	1986	115-125	2062	Moderately resistance to tikka, LLS & rust	--
	ICGS 1	1990	110-115	2300 ®	Tolerant leaf spots	Suitable for Spring season
	Punjab 1	1953	-	1900	Resistance to ELS	Wider adaptability
	C 501	1961	-	1750	Susceptible for Foliar diseases	Suitable for sandy loam soil under irrigation.
	M 145	1968	-	2200	Mod. Resistant to Foliar diseases	-
	M 37	1980	-	1650	Mod. Resistant to foliar diseases	-
	M 197	1982	-	1800	Resistance to ELS	Bold seeded
	M 335	1986	120-125	2300	Tolerant to early and late leaf spots	High yielding and early maturity.
	DRG 17	1994	120-125	2100 (K)	Tolerant to rust, late leaf spot and PBND	High yielding for Kharif Rainfed,

						tolerant of moisture stress
	M 522	1995	110-120	2525	Tolerant to early leaf spot	Short duration and high yielding variety for irrigated condition
	CSMG -884	1998	115-125	2281	Moderately resistant to leaf spots and PBND	Bold seeded High yielding and early maturity Suitable for Rabi/summer
	HNG 10	1998	125-130	1918	Susceptible to foliar diseases	Suitable for the rainfed irrigated situation
Rajasthan	AK 12-24	1940	-	1250	--	Wider adaptability, suited for medium to heavy soils
	RG 141	1989	110-115	2100 (K)	Tolerant to late leaf spot and BND	--
	RS 138	1989	105-115	2100	Resistance to ELS & rust	Variety resembling RSB 87.
	ICGS 1	1990	110-115	2300 (R)	Tolerant leaf spots	Suitable for Spring season
	GG 7 (J-38)	2001	96-105	2149	Tolerant to tikka compared JL 24	Early maturity
	Punjab 1	1953	-	1900	Resistance to ELS	Wider adaptability
	RS 1	1953	-	1300	Mod. Resistant to Foliar diseases	Kernel medium bold
	RSB 87	1961	-	1750	Resistant to ELS and rust	
	Somnath	1990	120-125	1900 (K)	Tolerant to early and late leaf spot	High yielding, early maturing bold seeded, suitable for export purpose
	CSMG 84-1	1992	125-135	2704 (K)	Resistant to rust	Rose variegated kernel colour, bold two seeded pod
	BAU 13	1993	125-135	2191 (K)	Tolerant to leaf spots collar rot and BND	Higher yield with bold seeded HPS for export trade
	DRG 17	1994	120-125	2100 (K)	Tolerant to rust, late leaf spot and PBND	High yielding for Kharif Rainfed, tolerant to moisture stress
	CSMG-884	1998	115-125	2281	Moderately resistant to leaf spots and PBND	Bold seeded High yielding and early maturity

						Suitable for Rabi/summer
	HNG 10	1998	125-130	1918	Susceptible to foliar diseases	Suitable for the rainfed irrigated situation
	LGN 2	2000	115-120	1500-2000	Susceptible to foliar diseases	Suitable for early sown rainfed conditions
Tamil Nadu	TMV- 2	1940	115-120	1025	Moderately resistance to rust	Widely adapted, well suited for Summer season
	TMV 5	1961	120	1250	Susceptible to Foliar diseases	Mature in 110 days dormant
	TMV 7	1967	120	1400	Susceptible for Foliar diseases	Bold poded
	Pollachi 1	1968	120	1450	Susceptible for Foliar diseases	Fit for HPS type.
	TMV 9	1970	125	1150 (Kh.) 2000 (R/S)	Susceptible for Foliar diseases	Dormancy upto 15 days.
	Pollachi 2	1973	115-120	1500 (Rain-fed) 2700 (Irrigated)	Susceptible for Foliar diseases	High shelling percentage
	TMV 12	1978	115-120	1250 (Kh.) 2100 (R/S)	Intermediate resistant to Foliar diseases	Medium to bold pods shallow constriction.
	Co 1	1979	115-120	1300 (Kh.) 2100 (R/S)	Intermediate resistant to Foliar diseases	High harvest Index suited Rabi /Summer cultivation also.
	Co 2	1983	110-115	1650 (K) 2700 (R)	Moderately resistance to tikka, LLS & rust	Medium pod 1-2 seeded plumpy rose colour testa.
	VRI 1	1986	95-105	1590 (K) 1877 (R)	Moderately resistance to tikka, LLS & rust	Suitable for rainfed and irrigated condition with high shelling, fresh seed dormancy for a week.
	Girnar 1	1988	95-105	(2000R)	Resistant to leaf spots and rust	Early maturing multiple resistant variety suitable to rainfed.
	VRI 2	1989	100-105	1500 (K) 2000 (R)	Moderately resistance to tikka, LLS & rust	Bold poded, suitable to both rainfed and irrigated.
	ICG (FDRS) 10	1990	105-115	2200 (K)	Tolerant to late leaf spot and BND	Suitable for Kharif season where rust and LLS diseases are problem.

	VRI 3	1990	90-95	1668	Moderately resistance to tikka, LLS & rust	Small pods and seeds, little or no beak. Highly suitable for situation of delayed South West monsoon.
	ICGV 86590	1991	105-110	1785 (K)	Resistant to rust tolerant to late leaf spots	Multiple disease and insect pest resistant.
	K 134	1993	100-105	1677	Resistant to BND tolerant to late leaf spots	Early maturing with tolerance to leaf spot & drought
	DRG 12	1994	115-120	2604	Tolerant to rust, late leaf spot and PBND	High yielding for Rabi / Summer
	R 8808	1997	110-115	2426	Tolerant to late leaf spot and PBND	High yielding and early maturity Suitable for Rabi/summer
	VRI 4	1997	105-110	2170	--	Suitable for irrigated and rainfed cultivation in Tamil Nadu
	ALR 2	1997	105-110		Field tolerance to late leaf spot and rust	Both irrigated and rainfed condition
	BSR 1	1997	105-110	2845	Moderately resistant to leaf spot rust and PBND	Western zone of Tamil Nadu in Kharif and Rabi/Summer
	ALR 3 (ALG 63)	1999	110-115	1939	Moderately resistant to LLS and resistant to rust	Suitable for early sowing of South West monsoon
	Co 3 (TNAU 256)	1999	105-110	K 1750 R-2150	Moderately resistant to PBND and tolerant to foliar disease	Bold kernel, suitable for kharif and rabi.
	VRI 5	2001	105-110	K 2133 R 2384	Resistant to rust &LLS	Suitable for both Rabi/Summer season.
	Co 4 (TNAU 269)	2001	105-110	K 1500 R 1950	Resistant to rust &LLS	Suitable for both Rabi/Summer season.
	TMV- 1	1940	125-130	1450	Susceptible for Foliar diseases	High nodulation
	TMV- 3	1943	125	1450	Susceptible for Foliar diseases	-
	TMV – 4	1947	115-120	1450	Susceptible for Foliar diseases	-
	TMV 6	1961	115-120	950	Mod. Resistant to Foliar diseases	Suited for table purpose.
	TMV 8	1968	115-121	1600	Mod. Resistant to Foliar diseases	Dormant upto 60 days.

	TMV 10	1970	120-125	1700	Susceptible to foliar diseases	Very high oil content (54%)
	ALR 1	1987	115-120	(1840K) (2000R)	Resistant to leaf spots and rust	Suitable for rust endemic areas (Pollachi tract).
	BAU 13	1993	125-135	2191 (K)	Tolerant to leaf spots collar rot and BND	Higher yield with bold seeded HPS for export trade
	ICGV 86325	1994	115-125	2700	Tolerant to rust, late leaf spot and BND	High yielding under rainfed
	TMV 11	1977	120	1200	Moderately resistant to foliar diseases	Big pod
Uttar Pradesh	ICGS 1	1990	110-115	2300 (R)	Tolerant to leaf spots	Suitable for Spring season
	T 28	1960	-	1900	Resistance to ELS	-
	T 64	1966	-	2100	Moderately resistant to Foliar diseases	-
	Chandra	1977	115-120	2500	Moderately .resistant to foliar diseases	Bold pod
	Chitra	1984	115-120	2000	Resistant to ELS & rust	-
	MA 16	1986	120-125	(1500R)	Moderately resistant to leaf spots	Bold seeded suitable for HPS.
	CSMG 84-1	1992	125-135	2704 (K)	Resistant to rust	Rose variegated kernel colour, bold two seeded pod
	ICGS 5	1992	110-120	2385 (K)	Resistant to rust	Tolerant to drought.
	BAU 13	1993	125-135	2191 (K)	Tolerant to leaf spots collar rot and BND	Higher yield with bold seeded HPS for export trade
	DRG 17	1994	120-125	2100 (K)	Tolerant to rust, late leaf spot and PBND	High yielding for Kharif Rainfed, tolerant to moisture stress
	CSMG -884	1998	115-125	2281	Moderately resistant to leaf spots and PBND	Bold seeded High yielding and early maturity Suitable for Rabi/summer
	HNG 10	1998	125-130	1918	Susceptible to foliar diseases	Suitable for the rainfed irrigated situation

NATIONAL RESEARCH CENTRE FOR GROUNDNUT
Ivnagar Road, PO Box 5, Junagadh 362 001
Tel:0285 2673382, Fax: 0285 2672550
Email: director@nrcg.res.in
Web: http://www.nrcg.res.in