Vision 2050

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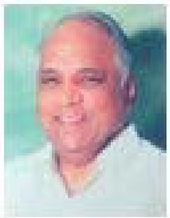
SHARAD PAWAR



कृषि एवं खाद्य प्रसंस्करण उद्योग मंत्री
भारत सरकार
MINISTER OF AGRICULTURE &
FOOD PRECESSING INDUSTRIES
GOVERNMENT OF INDIA

MESSAGE

The scientific and technological inputs have been major drivers of growth and development in agriculture and allied sectors that have enabled us to achieve self reliant food security with a reasonable degree of resilience even in times of natural calamities, in recent years. In the present times, agricultural development is faced with several challenges relating to state of natural resources, climate change, fragmentation and diversion of agricultural land to non-agricultural uses, factor productivity, global trade and IPR regime. Some of these developments are taking place at much faster pace than ever before. In order to address these changes impacting agriculture and to remain globally competent, it is essential that our R&D institutions are able to foresee the challenges and formulate prioritised research programmes so that our agriculture is not constrained for want of technological interventions.

It is a pleasure to see that Directorate of Groundnut Research (DGR), Junagadh, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision-2050 document. The document embodies a pragmatic assessment of the agricultural production and food demand scenario by the year 2050. Taking due cognizance of the rapidly evolving national and international agriculture, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish DGR all success in realisation of the Vision-2050.

(SHARAD PAWAR)

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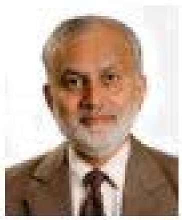

FOREWORD

The Indian Council of Agricultural Research, since inception in the year 1929, is spearheading science and technology led development in agriculture in the country. This is being accomplished through agricultural research, higher education and frontline extension undertaken by a network of research institutes, agricultural universities and Krishi Vigyan Kendras. Besides developing and disseminating new technologies, ICAR has also been developing competent human resources to address the present and future requirements of agriculture in the country. Committed and dedicated efforts of ICAR have led to appreciable enhancement in productivity and production of different crops and commodities, which has enabled the country to raise food production at a faster rate than the growth in demand. This has enabled the country to become self-sufficient in food and emerge as a net food exporter. However, agriculture is now facing several challenges that are expected to become even more diverse and stiffer. Natural resources (both physical and biological) are deteriorating and getting depleted; risks associated with climate change are rising, new forms of biotic and abiotic stress are emerging, production is becoming more energy intensive, and biosafety concerns are growing. Intellectual property rights and trade regulations impacting technology acquisition and transfer, declining preference for farm work, shrinking farm size and changes in dietary preferences are formidable challenges.

These challenges call for a paradigm shift in our research approach to harness the potential of modern science, innovations in technology generation and delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive.

It is an opportune time that the formulation of 'Vision-2050' by ICAR institutions coincides with the launch of the national 12th Five Year Plan. In this Plan period, the ICAR has proposed to take several new initiatives in research, education and frontline extension. These include creation of consortia research platforms in key areas, wherein besides the ICAR institutions, other science and development organizations would be participating; short term and focused research project through scheme of extramural grants; Agri-Innovation fund; Agri-incubation fund and Agri-tech Foresight Centres (ATFC) for research and technology generation. The innovative programme of the Council, 'Farmer FIRST' (Farmer's farm, Innovations, Resources, Science and Technology) will focus on enriching knowledge and integrating technologies in the farmer's conditions through enhanced farmer-scientist interface. The 'Student READY' (Rural Entrepreneurship and Awareness Development Yojana) and 'ARYA' (Attracting and Retaining Youth in Agriculture) are aimed to make agricultural education comprehensive for enhanced entrepreneurial skills of the agricultural graduates.

I am happy to note that the Vision-2050 document of Directorate of Groundnut Research, Junagadh has been prepared, based on the assessment of present situation, trends in various factors and changes in operating environment around agriculture to visualize the agricultural scenario about 40 years hence and chalk out a demand-driven research agenda for science-led development of agriculture for food, nutrition, livelihood and environmental security, with a human touch.

I am sure that the 'Vision-2050' would be valuable in guiding our efforts in agricultural R&D to provide food and nutritional security to the billion plus population of the country for all times to come.

Dated the 24th June, 2013
New Delhi

(S. Ayyappan)

मूंगफली अनुसंधान निदेशालय
(विगत नाम : राष्ट्रीय मूंगफली अनुसंधान केन्द्र)
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Indian Council of Agricultural Research
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PREFACE

The groundnut is the fourth most important source of edible oil and the third most important source of protein in the world. Groundnut is a leguminous plant and can easily be cultivated even on marginal lands with low inputs. It is one such plant, all parts of which contribute to the economy of the farmers. The seeds can be used directly as food stuff or crushed for expulsion of oil. The expeller cake, which contains about 7% residual oil, can be solvent-extracted for recovery of residual oil. Both the expeller and solvent extracted cakes are used as cattle feed-supplement. The groundnut shell is used as a fuel for industrial boilers either directly or in form of compressed-and-extruded briquettes. In its root nodules, groundnut harbours *Rhizobium* bacteria, which in every crop season fix about 150-200 kg atmospheric nitrogen in a hectare. The foliage obtained after stripping the pods provides a nutritious fodder for cattle.

In the last decade direct consumption of groundnut has increased so much that instead of being considered merely an oilseed crop, it is now being recognized as a supplementary food, an oilseed, and a forage crop.

As an outcome of release of several improved groundnut varieties along with improved crop production and protection technologies, the productivity of groundnut crop has improved over the years. The quantum of improvement, however, does not meet the expectations.

Envisioning a long-term road map for attaining a cherished goal of enhancing crop productivity by developing improved technology entails visualizing developments in several areas of science and the possible industrial production of several gadgets which may not be in the reach of Indian farmers today but would be available at affordable prices twenty years hence.

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Drawing up a Strategic Framework, clearly identifying goals and approach for decades to come, is by no means a simple task. It requires giving such flights to one's imagination which are based on probable development in all the fields of science and their convergence for application in agriculture. This **'Vision 2050'** document is an outcome of such an exercise. The ideas and contents covered in this document have been generated during discussions among the scientists of DGR hence credit goes to one and all.

I should like to express our gratitude to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for emboldening us to write this **'Vision 2050'** for DGR. I should also like to thank Dr. S. K. Datta, Deputy Director General (Crop Science) and Dr. B.B. Singh, Assistant Director General (O&P), ICAR, for providing constant encouragement and guidance. The contributions of all the scientists of DGR in bringing out this document are gratefully acknowledged.

DGR, Junagadh
June 15, 2013

(J.B. Misra)
Director

Preamble

Agriculture will continue to be the vocation of millions of Indians in decades to come as providing food security to fellow Indians would be a compulsion for engaging at least a half of the population in food production.

Vegetable oils are essential ingredient of Indian cookery. No wonder, in India oilseeds are the second largest commodity after cereals in acreage, production and value. A wide range of oilseeds crops are grown in India. Groundnut, rapeseed-mustard, sesame, safflower, linseed, niger and castor are the major traditionally cultivated oilseeds. Soybean and sunflower have gained considerable ground in the past few decades. Among the non-conventional sources of edible oils, rice-bran and cotton seed have found their place, and among the plantation crops coconut is most important. Efforts are also being made to promote oil palm plantations in India.

With a view to giving a fillip to scientific research for enhancing productivity of this crop, Govt. of India decided to carve out the component of groundnut from the Directorate of Oilseeds Research, Hyderabad and establish an independent research unit exclusively for groundnut– a crop, which then accounted for 43% of total area under oilseed crops and 60% of total production. Accordingly, the National Research Centre for Groundnut (NRCG) came into being on the 1st October, 1979. The selection of Junagadh (21°31' N; longitude 70°36' E; altitude 200 m above mean sea level) for establishing the NRCG was most appropriate as the crop was already quite popular among the farmers of Saurashtra. In 1992, the All India Coordinated Research Project on Groundnut (AICRPG) was brought under complete administrative control of NRCG. While during the XI five-year plan; the Govt. of India rechristened the NRCG as the Directorate of Groundnut Research or DGR in short.

Since its inception, the DGR has strived hard to conduct and coordinate scientific research for developing new technologies to enhance the productivity of groundnut in India. Although over the years, the productivity of groundnut has improved significantly yet the extent of improvement has not been of the order that was expected and required.

In times to come, the DGR would require a much enhanced financial and policy support from the ICAR so that it is able to further refine the production technologies that are capable of bringing about a remarkable improvement in productivity of groundnut in India. The Vision 2050 document puts the planning and resolve of DGR for conducting and managing such scientific research on groundnut crop into a perspective.

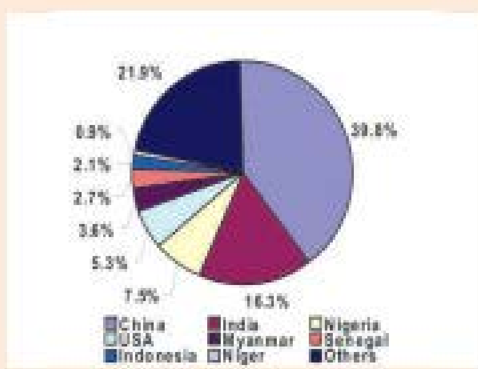
Context

Groundnut (*Arachis hypogaea* L.) is an important oilseed and food legume crop of tropical and subtropical world. It is annually grown on about 24 million ha of land in about 120 countries under different agro-climatic zones between latitudes 40°S and 40°N. It belongs to family Fabaceae and is the most widely cultivated annual legume crop worldwide. The light and sandy-loam soils are most suitable for cultivation of this crop but it can be profitably cultivated on a variety of soils including light and heavy textured soils. Compared to several other crops, groundnut is able to survive in much less favourable agro-climate conditions and needs 105-120 days to mature. It requires warm growing season with well distributed rainfall in the range of 500-1000 mm. Though a native of South America, groundnut is presently cultivated mainly in the semi-arid regions of Asia, Africa and American continents. China, India, Nigeria, USA, and Myanmar, are the top five producers of groundnut and together contribute nearly three-fourths of the global production.

Triennial (2008-10) averages of area, production and yield of major groundnut producing countries

Country	Area (lakh ha)	Production (lakh tonne)	Yield (kg ha^{-1})
China	44.0	149.4	3390
India	55.2	61.1	1105
Nigeria	25.4	28.3	1119
USA	5.2	19.7	3796
Myanmar	8.4	13.4	1590
Senegal	10.3	10.2	975
Indonesia	6.4	7.8	1240
Niger	6.9	3.2	466
Others	78.3	82.0	1047
World	240.1	375.1	1562

Source: FAOSTAT



Share of countries in global production

The global production scenario

Groundnut is generally grown under low input and rain-fed conditions across wide range of environments where frequent drought adversely affects the productivity. The groundnut productivity is below 1000 kg ha^{-1} in about 50% of the groundnut growing countries, 1000-2000 kg ha^{-1} in 35-40% of the countries, and more than 2000 kg ha^{-1} inonly 10-15% of the countries. The world average yield of groundnut is about 1560 kg ha^{-1} and about 70% of production comes from areas in semi-arid and arid tropics.

Potential of groundnut as a crop

- Can be grown on marginal soils and its cultivation improves soil fertility
- High plasticity for adaptation to adverse climatic conditions
- C3 crop with high energy conversion efficiency
- Genetic diversity exists in germplasm for desirable traits
- More than 190 varieties are available for diverse agro-climatic regions
- Fits well in cropping systems and at certain places two crops can be taken in a year
- High biological nitrogen fixation potential
- Being a cover crop, prevents soil erosion
- Dual purpose varieties available for food and forage purpose
- Very high potential for export and value-added products
- Trained human resource and well developed infrastructure for scientific research is available
- AICRP-Groundnut provides a platform for multi-location evaluation of technologies in diverse agro-climatic zones
- Kernels being rich in energy and protein have potential of providing food and nutritional security
- Foliage can be used as fodder and other by-products for industrial applications
- Opportunities for institutionalizing contract farming

The triennial (2008-10) averages of area, production and yield indicatethat annually 375 lakh tonnes of groundnuts are produced in the world from a cropped area of 240 lakh ha with an average productivity of 1562 kg ha^{-1}.

Nutritive value of groundnut

The groundnut kernels contain 45-51% oil and 25-30% protein and are the fourth most important source of edible oil and the third most important source of protein in the world. Though high in fat groundnuts primarily contain "good" fat (unsaturated and free from *trans* types) and help to maintain blood cholesterol levels and therefore friendly to heart.

Groundnut oil is good from both nutritive and culinary points of view as it contains good quantities of MUFA (oleic acid, 40-50%) and PUFA (linoleic acid, 25-35%). With its high oleic/linoleic ratio, groundnut oil has a relatively longer shelf-life. The tocopherol, (approx. 0.9 mg/g oil) an antioxidant present in groundnut oil prevents development of rancidity.

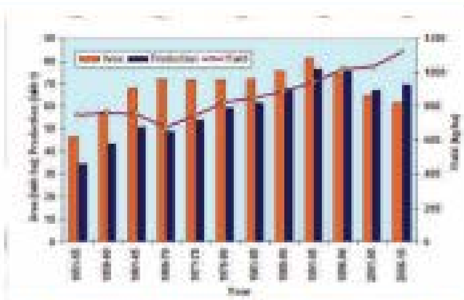
The Indian scenario

Since 1951, the largest area under this crop was 87.1 lakh hectares in 1989-90; the highest production was 96.6 lakh tonnes in 1988-89; while the highest productivity was of 1460 kg ha^{-1} in the 2007-08. Currently, six states viz. Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, and Rajasthan account for nearly 90% of the groundnut area. Madhya Pradesh, Uttar Pradesh, Orissa, West Bengal, Chhattisgarh, Jharkhand, Punjab, Goa, NEH states and Kerala also contribute to national groundnut production to various extents. In India, groundnut is cultivated mainly in *kharif* season (rain-fed conditions) with low inputs and if available with a few protective irrigations. In *kharif*, the pressures of diseases, insect-pests and weeds are high. The productivity depends largely on the quantity and distribution of rainfall over the season. An evenly distributed rainfall of 600-800 mm would generally assure a good productivity. The dry spells which often occur during pod development phase would reduce the yields and hence *kharif* productivity shows wide variations over the years.

Groundnut growing seasons in various states of India

Season	Sowing	Harvest	States
By and large rain-fed, supplementary irrigation, if available (about 85% area)			
Kharif	June-July	Sept-Oct	Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and Jharkhand
Post rainy (about 15% area)			
Rabi (residual moisture)	Oct-Nov	Feb-Mar	West Bengal, Odisha, Karnataka, Andhra Pradesh and Tamil Nadu
Summer (irrigated)	Jan-Feb	Apr-May	Gujarat, Maharashtra, Karnataka and Andhra Pradesh
Spring (irrigated)	Mar-Apr	Jun-Jul	Punjab and Uttar Pradesh

The area under *rabi*-summer groundnut system has expanded over the years. In *rabi*, the crop is grown under residual moisture of rice fallows or river beds under minimal or no irrigation and also in summer as an irrigated crop. The summer cultivation is practiced generally



Quinquennial averages of area, production and yield of groundnut in India under high input conditions and the pressures of diseases, insect-pests and weeds are much low and hence the productivity is high. Spring groundnut, cultivated after the harvest of potato/*toria*, also gives high productivity.

Trends in area, production and productivity Quinquennial averages of area, production and yield of groundnut in India

The area under groundnut in India during 1900-1910, was only 2.3 lakh ha which increased to 76.8 lakh ha by the end of century. During 1951-1960, the growth in area (17.2%) had the major contribution in increasing groundnut production in India. The area increased from 46.6 lakh ha during 1951-55 to an all time high of 81.6 lakh ha during 1991-95.

The productivity was below 800 kg ha^{-1} till 1975 but increased steadily to reach beyond 1000 kg ha^{-1} during 1996-2000. The increase in productivity was due mainly to release of high-yielding varieties and improved packages of practices, and also to a certain extent to cultivation in summer under high-input assured irrigation. Seed alone accounts for about 35-40% cost of cultivation in groundnut. Depending upon season and other inputs applied and also the yield realized, the CBR may vary between 0.7 and 5.0.

Triennial (2008-09 to 2010-11) averages of area, production and yield of groundnut in various states of India

State	Area (lakh ha)	Production (lakh tonnes)	Yield (kg ha^{-1})
Gujarat	18.47	25.96	1407
Andhra Pradesh	15.63	13.39	851
Tamil Nadu	4.49	9.52	2143
Karnataka	8.27	5.95	717
Maharashtra	3.39	4.02	1182
Rajasthan	3.31	5.24	1574
Madhya Pradesh	1.96	2.49	1265
Odisha	0.77	0.89	1161
West Bengal	0.67	1.17	1748
Uttar Pradesh	0.90	0.71	788
Chhatishgarh	0.29	0.40	1389
Others	0.36	0.36	1000
All India	**58.51**	**70.10**	**1198**

Source: Department of Economics and Statistics, Govt. of India

State-wise scenario of area, production and productivity and constraints

The triennial (2007, 2008, and 2009) averages of area and production of groundnut indicate that 91.5% of the cropped area is distributed across six states which together contribute 91.4% of total production. These states are Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, and Rajasthan. Among other groundnut growing states are Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal which together comprise nearly 7% of area and contribute about 7% of the total production. The average productivity of groundnut during the period 2001 to 2010, though ranged from 700-1460 kg ha^{-1}, the average productivity in three major groundnut growing states of the country, was in the range 510-2270 kg ha^{-1} in Gujarat, 300-1360 kg ha^{-1} in Andhra Pradesh, and 1150-1880 kg ha^{-1} in Tamil Nadu for *kharif* season and the corresponding values for the *rabi*-summer season were 1473-2390 kg ha^{-1} in Gujarat, 1400-2130 kg ha^{-1} in Andhra Pradesh and 2100-3730 kg ha^{-1} in Tamil Nadu. The productivity of groundnut in NEH region and Goa, however, is more than that of national average.

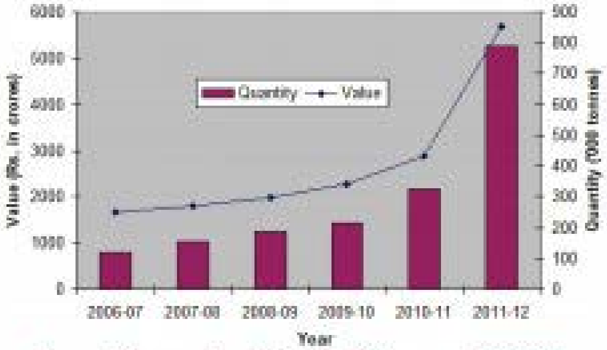
Annual growth rates in input-use, output, and total factor productivity

The total factor productivity (TFP) reflects the quantum of increase in total output due to long-term technological change or technological dynamism, but not due to increase in total inputs. A study by the National Centre for Agricultural Economic and Policy Research (New Delhi), on the basis of thirty-year data (1975-2005) indicates that:

- In Gujarat, the output growth (2.5%) was higher than the input growth (1.1%) and the TFP growth accounted for 54% of output growth while the real cost of production declined at 1.8%.
- In Andhra Pradesh, the growth rates of input-use, output, and TFP were 3.5%, 4.9% and 1.4%, respectively and share of TFP in output growth was 29%.
- Odisha showed outstanding output growth besides high growth in input-use, which led to 2.1% annual growth in TFP and this TFP growth was the cause of 28% growth in output.
- The groundnut production in Karnataka and Tamil Nadu is heading towards un- sustainability, but other states have shown moderate to high growth.

Export of groundnut

China, India, USA and Argentina are the major groundnut exporting countries of the world. During 1999 to 2002, the export of groundnut from India declined, but it registered a considerable increase subsequently. A record high export of 853 thousand tonnes was registered in 2011-12. Groundnut is exported both in-shell and kernels forms.



Export of groundnut from India (source: DGCIS)

For export purpose, two broad categories are defined- java and bold. The java types have smaller pods with constriction, kernels are oval with pink skin and the shell is thicker than the bold types. In bold types, the pods and kernels are bigger than the java type and the kernels are oblong with a red skin which becomes darker with ageing. A very stringent maximum permissible limit (2 ppb) of aflatoxin contamination in groundnut has been set by the European Union. Aflatoxin contamination is now recognized as the chief non-tariff trade barrier for export of groundnuts from India as many a Indian consignments are rejected at the destination ports due to aflatoxin levels beyond the permissible limits.

Current utilization pattern of groundnut

- In 1960s, about 80% of the produce was crushed for oil expulsion and only about 6% was used for direct consumption while the remaining 14% was used for seed.
- In the past two decades, the direct consumption (roasted and salted groundnuts, *chikki*, peanut butter and sauce) has gone up to 40% and currently about only 45% of the produce is crushed for oil expulsion.

Challenges

Possible impacts of climate change on groundnut crop

Groundnut, being a C3 plant, the projected rise in atmospheric CO_2 is likely to enhance rate of photosynthesis as the current levels of atmospheric CO_2 do not saturate Rubisco. The pod yield would also increase even if harvest index is not impacted. The relative benefits would be more under water limiting conditions as higher CO_2 will enhance water use efficiency.

> **By 2050, overall in India, the possible physical impact of climate change will be:**
>
> - An increase in the average surface temperature by 2-3°C
> - Changes in rainfall (both distribution and frequency) during both monsoon and non-monsoon months
> - A decrease in the number of rainy days by more than 15 days
> - An increase in the intensity of rain by 1-4 mm day^{-1}
> - Increase in the frequency and intensity of cyclonic storms
> - Increase in CO_2 levels (as high as 543 ppm)

Any rise in temperature leading into a regime of 25-30 °C, will promote germination and establishment of seedlings. Any increase beyond 35 °C would adversely affect germination and seedling establishment. Stomatal conductance and transpiration rate would increase with increase in temperature. The rise in temperature may lead to early flowering but cause a little reduction in harvest index and induce early leaf senescence in certain cultivars.

So far as *kharif* crop is concerned, rise in temperature would not have any significant impact to time of sowing. For summer crop, a rise by 2-4 °C would help advance time of sowing by 10-15 days in northern India thus help farmers harvest, dry and cure their produce before pre-monsoon showers. The increase in temperature, however, is likely to hasten crop maturity, especially in the peninsular India, by about 5 days in all the seasons of cultivation.

In India, nearly 85% area under groundnut crop is sown in *kharif* season which is by and large dependent on rainfall. The erratic and excessive rainfall would impact the crop adversely. Excessive rainfall early in the season would delay the opportunities for field preparations. Excessive rainfall right after sowing would hamper the germination and may even necessitate gap filling or re-sowing. Torrential rains coinciding with flowering would smother the flowers and reduce the number of pegs. Prolonged spells of cloudy weather and extra rainfall would induce profuse vegetative growth and lower the harvest index. Frequent stagnation of water in the groundnut fields during reproductive phase beyond 5-6 hours would adversely affect the yield.

In a nut shell, in most groundnut growing areas, the beneficial effects of rise in CO_2 levels are likely to outweigh the predicted adverse effects of rise in temperature. The erratic rainfall, however, may spell out its adverse impacts irrespective of increase in CO_2 levels and temperature.

Impact on soil and biological nitrogen fixation

The interrelations between the predicted climate change and consequent changes in soil are based on hypothetical scenarios and hence impact can be described at best only in qualitative terms. The rise in temperature and increase in rainfall would enhance the rate of soil erosion unless amelioration measures are in place.Experiments show that global warming will accelerate the rate of soil organic carbon decomposition due to increase in the activities of soil microflora and thus reduce fertility (C and N content) even as increasing CO_2 would increase soil organic carbon through net primary production. A small increase in temperature in low carbon soil would result in higher CO_2 emissions as compared with medium and high carbon soil thus making low carbon soil more vulnerable to warming. However, there may not be any significant effect on soil physical properties but the biological nitrogen fixation is likely to go up due to increased availability of photosynthate for sustaining the nitrogen fixation by rhizobia in the root nodules.

Impact on occurrence of pests and diseases

Rise in CO_2 may result into enhanced activity of defoliators (*Spodoptera litura,Helicoverpa armigera, and Aproaererma modicella*) due to altered foliage quality. The impact on sucking pest is difficult to predict. But heavy rainfall will negatively affect the insect population by washing off there live-stages from crop canopy.

> **Existing and potential threats to groundnut cultivation**
> - Infestation by new insect-pests
> - Spread of soil-borne diseases (stem rot, root rot, and collar rot)
> - Widespread occurrence of *Aspergillus flavus* causing contamination of kernels with aflatoxin
> - Possible replacement of area by more profitable crops in traditional belts
> - Competition from other countries in international markets
> - Changes in temperature and rainfall pattern due to climate change
> - Erratic and excessive rainfall due to climate change may force farmers to shift to another crop

The rise in temperature would influence production and survival structures of pathogens. Population of stem rot pathogen *Sclerotium rolfsi* may increase in soil. Severity of leaf spot caused by *Collectotrichum* sp., *Phyllactinia* sp. etc. may increase due to increase in temperature.

Thus new climatic conditions are more likely to have negative impacts such as a rise in the spread of diseases and pests, which will reduce yields. Some pests and disease hitherto considered uneconomical may acquire economic dimensions.

Projected demand of groundnuts in 2050

The population of India is likely to touch a figure of 1,650 million by 2050. Providing food security to such a large population would be daunting task and also a challenge to agricultural scientists for developing production technologies to bridge the gap in the demand and supply on a sustainable basis. In times to come, groundnut would play a greater role as a supplementary food crop besides continuing to be an oilseed crop. The projected domestic demand of groundnut would be about 25 million tonnes. The area under groundnut may not shrink any further and would stay around 6-7 million hectares. Considering the current national average productivity of 1200 kg ha^{-1}, a growth rate of about 4-5% in productivity is called for.

Attainable yield potential of groundnut crop

It has been shown through experiments and crop modelling that under best management practices the attainable yield potential of groundnut crop is in the range of 8000 to 11000 kg ha^{-1}. The yield gap analysis shows that in general only 40-60% of the attainable yields are realized in India. Yields of 6000-6500 kg ha^{-1} have often been realized in AICRP-G yield evaluation trials. In the year 2009-10, the average yields of 4218 and 4181 kg ha^{-1} were realized in Thiruvallur and Kancheepuram districts respectively, in Tamil Nadu. There are authentic reports of realization of >8000 kg ha^{-1} yield by a few Indian groundnut farmers. In Rajasthan, several farmers are realizing the yield of more than 5000 kg ha^{-1}. Thus envisioning a technology-driven rise in an average yields to the level of 5000 kg ha^{-1} in India may not be regarded unrealistic.

Reasons for poor production and productivity in groundnut

- Grown largely under rain-fed conditions (*kharif*) with low inputs and hence production highly dependent on quantum and pattern of rainfall
- Non-availability of short-duration (90 days) high-yielding varieties for specific low rainfall areas
- High seed multiplication ratio (1:8) results non-availability of quality seeds of new varieties and slows down their spread
- Difficult to develop hybrid due to cleistogamy
- Low seed replacement rate due to a low seed multiplication ratio (1:8) and high seed rate (120 – 150 kg seed pods/ha) and high volume seed crop (seed alone costs about 35% of the cost of cultivations)
- Rapid loss of seed viability in *rabi*-summer produce rendering the seeds unfit for sowing in the next *rabi*-summer
- Highly susceptible to aflatoxin contamination
- Narrow genetic base in released cultivars and cultivated germplasm
- Lack of infrastructure for post-harvest processing and village or community level storage
- Lack of incentive for producing high quality groundnuts (free from aflatoxin)
- Lack of enthusiasm for adopting high-cost technologies

Operating Environment

During last decade, research in groundnut has witnessed a sea change in its approach by the use of newer and upcoming research tools like –omics (genomics, proteomics, transcriptomics and metabolomics), nano-technology and extension tools like information and communication technologies. There is no doubt that there would surely be a complete transformation by the year 2050 in the operating environment for groundnut crop production in terms of resource use translation into productivity. The details are discussed below:

Emerging technologies for integration in agricultural research by the year 2050

- Dependable weather forecasting system
- Dependable disease and insect-pest forewarning system
- Excellent cropping system based farm advisory service having all farmers in its ambit
- Sensor based management of irrigation
- Biodegradable films for use as mulch
- All-India database on individual farmer's soil resources
- Commercial supply of crop and region specific soluble fertilizer formulations inclusive of micronutrients
- Availability cost effective water conservation products (e.g. hydrogels) for *in situ* moisture conservation
- Precipitaion of clouds (artificial rains) in drought affected areas
- Application of endosymbionts for management of biotic and abiotic stresses
- On-field storage of excess rain-water
- Installed capacity of irradiation for destruction of aflatoxin and harmful biological entities
- Nanotechnology for application of weedicides, pesticides, and fertilizers etc.
- New energy efficient agricultural machinery
-

Potential of genetic resources

A collection of over 8900 groundnut germplasm accessions and 115 wild relatives of *Arachis* species at DGR and 15,000 accessions at International Crop Research Institute for Semi-Arid Tropics is available for exploitation as a huge reservoir of genes. The available variation can be tested and utilized for developing stress tolerant cultivars by pre-breeding, mutation breeding and interspecific hybridization etc.

New plant types

- Development of new plant types with enhanced harvest index
- Development of new plant types for low thermo and photo-insensitivity

Biotechnological interventions

- The advances in genomics coupled with bioinformatics will help identify useful genes or alleles for various traits
- Development in metabolomics will unravel the biochemical mechanism of stress resistance and also identification of genes
- These useful genes thus identified can be transferred into high-yielding varieties through conventional, molecular as well as genetic engineering approaches

Management of natural resource

- Application of specialty fertilizers correcting acute deficiencies and imbalances
- For enhancing synergy between fertilization and irrigation, optimization of use of soluble fertilizer and micro-irrigation for developing protocols for fertigation technology will improve water and fertilizer productivity
- Identification of new species and strains of micro-organisms and formulation of microbial consortia to be used as bio-fertilizers and development of their delivery system and also improved IPM modules with enhanced use of biocontrol agents and botanicals will the groundnut cultivation more eco-friendly
- Development of super-soils for maximum realization of genetic yield potential

Crop diversification

- Depending on agro-ecological situation several new groundnut based cropping systems are to be identified and validated with respect to climate resilience and crop diversification
- Raising groundnut in early stages of widely spaced horticultural crops will enhance land productivity. Intercropping with tall C4

crops like maize, sugarcane, and sorghum will protect groundnut crop from heat stress in areas of high temperatures

- Crop diversification through intercropping of groundnut with pigeon pea, maize, sorghum, sesame, cotton, plantation crops or by introduction in rice and potato fallows situation or by replacing *rabi* rice with groundnut will help in improving the livelihood.
- Precision farming will minimize the gap between yields realized and the attainable yield potential

Post-harvest handling and storage

- Groundnut seeds are required to be necessarily stored in-shell as otherwise the seed viability is rapidly lost. Moreover during storage attack by storage pests especially bruchid beetle (*Caryedon serratus* O.) spoils the seed as well as the food value of kernels. Hence, development of storage technology for adoption at farm level is very much required.

Marketing and value-addition

- The prevailing *mandi* based marketing system does not allow the farmer to realize the remuneration they deserve. A productivity zone based minimum support price and nationwide procurement system may be required to sustain groundnut cultivation especially in the low productivity areas.
- Groundnuts being tasty and nutritious hold a lot of potential for value-addition. An array of processed products of groundnuts alone or in combination of other foodstuffs can be popularized for enhancing direct consumption.
- Bio-fortified groundnuts can be used as a functional food.
- Considerable scope exists for research for better and more economic utilization of shell and cakes
- Institutionalization of contract farming would fetch premium price to farmers for adopting best agricultural practices
- The export oriented processing units need to become more and more responsive to consumer preference and meet all the criteria of health and hygiene on the one hand and become a partner in the contract farming of groundnut

Risk management in relation to climate change

- Use of region specific stress tolerant varieties would be the first approach towards risk management
- Technology for management of drought by most efficient and effective use of available rain water and *in situ* conservation of soil moisture to manage drought
- Proper adoption of the plant protection measures will insulate the crop from serious damage by diseases and insect pest
- Technology of drainage and conservation of water in the field itself during the periods of excessive rains and reusing the stored water during the spells of scanty rains will protect the crop from ill-effects of excessive as well as poor rains
- Research for development of early-warning systems for drought, excessive rains, and bio-risk agents etc. would be needed to cope with the climate change induced risks

Institutions and policies

- Policies for enhancing synergies with SAUs and ICRISAT would reduce the time for research output and avoid spending on duplication of research
- Policies for intellectual property rights will have to be such that they do not jeopardize the interests of groundnut farmers and other stake holders nor cause any procedural delay in release of technology.
- A policy support for rapid phasing out of inferior varieties and production and sale of location specific fertilizer mixtures will improve groundnut productivity in a short time.

Human-resource development

- Capacity development of scientific and technical personnel would be necessary to implement the research programs in frontier areas especially nonotechnology and bioinformatics and also in soil-water management
- Organize national and international symposia (at least once in two years) to bring the groundnut research workers on a common platform for interaction and exchange of views
- Regular training of extension functionaries on the latest

production technologies will be crucial for showcasing new technologies and their dissemination

- Organizing conferences and symposia on groundnut based cropping systems will facilitate exchange of views on emerging concepts for research and new technologies

Salient scientific achievements of DGR and AICRPG in XI[th] five year plan (2007-08 to 2011-12)

- Conserved and maintained 9026 groundnut germplasm accessions and 115 wild species at DGR and at AICRP-G centers, 3923 germplasm accessions and 40 wild *Arachis* accessions were maintained
- Forty-two new varieties (two from DGR and 40 from various AICRP-G centers) were released for different agro-climatic zones and states
- Identified three perennial wild species *Arachis marginata*, *A. prostrata*, and *A. glabrata* for forage purpose
- Developed transgenic plants for resistance to PBND & PSND, drought & salinity, fungal diseases and other abiotic stresses
- Promising consortia of bio-fertilizers (rhizobia and PGPR) have been identified separately for *kharif* and *rabi*-summer seasons
- Packages of practices for INM andIPDM were developed
- Identified 20 promising genotypes for their tolerance of major insect pest and diseases
- Through pre-breeding with wild *Arachis* species, 40 promising genotypes have been developed for resistance to foliar fungal diseases
- Optimized tillage method, planting geometry, varieties, irrigation schedule and maturity duration for rice-groundnut cropping system for eastern states
- Worked out agronomic requirements for intercropping of groundnut with Bt-cotton in *kharif* and sugarcane in summer
- Requirements of Zn and B for rain-fed and irrigated groundnut were worked out for various zones
- During last five years 52,306 q breeder seed of 60 varieties has been produced
- In kharif 2667 and in rabi-summer 2443 FLDs were organized

New Opportunities

The groundnut researchers are going to face unprecedented challenges for improving the production and productivity of groundnut by the year 2050. Therefore the strategy would be to develop technologies for maximum realization of attainable yields in various crop growing regions. This would increase the overall production by enhancing productivity rather than bringing additional area under this crop. Being a C3 photosynthesis type grown largely in *kharif* season, groundnut is not likely to be much affected by the predicted change in climate by 2050. Adoption of best package of practices (new technology) would raise groundnut production dramatically as large variations and considerable scope for improvement exist in productivity of individual farms within and across the states of India.

Addressing the Threat of Climate Change

- Identification and development of varieties with high photosynthesis and nitrogen fixation for producing more biomass under elevated atmospheric-CO_2 in future
- Identification of areas where groundnut cultivation would face severe challenge, the potential areas where production may go up, and new areas likely to come under groundnut cultivation
- Understanding the crop biology under conditions of elevated temperature in terms of germination, vegetative growth, floral biology, crop duration and quality of produce
- Identification of varieties suitable for cultivating at high-temperature to withstand heat stress during pod filling stages
- Understanding of the behavioral and incidence pattern of insect-pests and diseases under conditions of elevated CO_2 and increased ambient temperature and RH etc.
- Understanding of soil microbe vis-à-vis nutrient availability and impact on biological nitrogen fixation

Genetic Improvement

- Identification of useful genes and their novel variants in the germplasm for developing transgenics tolerant to stresses and gene pyramiding to confer multiple stress tolerance.
- To introgress the desirable traits available in the germplasm to develop stress tolerant cultivars in agronomic background employing molecular and biotechnological approaches.

Improvement in Crop Varieties

- Varietal development through marker-assisted breeding, site-directed mutagenesis and transgenic and cis-genic approaches for:
- Early maturing and drought tolerance, high-yield coupled with desirable quality traits and in-built tolerance of biotic and abiotic stresses
- Nutrient-efficiency, cold, soil acidity and salinity tolerance, herbicide resistance and fresh-seed dormancy
- Bold-seeded with high sucrose and oleic/linoleic ratio, and free from allergen and aflatoxin.
- Development of designer groundnut with nutra-ceutical properties

Improvement in Crop Production Technologies

- Soil-management for altered physical properties and nutrient composition, refinement of fertigation technology and nanotechnology, site specific and sensor based input management for yield maximization
- Enhancement of carbon sequestration through conservation agriculture and increasing nutrient availability with interventions in cultivation practices in changing climate
- Development of highly-efficient and competitive strains of rhizobia, PGPR and phosphate solubilizing microbes to reduce the use of chemical fertilizers
- Synchronization of nutrient supply with crop demand pattern through integrating different sources of nutrients
- Exploring the possibility of growing groundnut on non-soil media

Management of Biotic and Abiotic Stresses

- Development of immunity in groundnut plants and plant ideotypes for affording tolerance to biotic and abiotic stresses
- Application of endophytes and RNAi technology for management of biotic stresses
- Enhanced resistance to foliar fungal diseases (rust, leaf spots, *Alternaria*), viral diseases (PBND and PSND) and defoliating insect pests (leafminer, tobacco caterpillar and gram pod borer)
- Identification of new and more efficient bio-control agents for their use in management of biotic stresses
- Use of nano-formulations as efficient delivery system

Basic and Strategic Research

- Evaluation of germplasm for various desirable traits at hot spots

- Creation of data-base on the basis of evaluation of germplasm at multi-locations for a large array of traits (agronomical, morphological, anatomical traits and response to various biotic and abiotic stresses)
- Identification of morpho-physiological and biochemical traits imparting tolerance of water-deficit, high temperatures and salinity for use in trait based breeding
- Identification of refuge crops for conserving bio-diversity
- Ionomics and metabolomics to identify genotypes for climate resilience
- Identification of new bio control agents for insect-pests and pathogens
- Understanding of host-parasite relationship in respect of diseases and insect pest as well as production of phytoalexins and operation of genetic switches
- Development of strong forewarning system for timely and effective management of biotic stresses
- Development of varieties and package of cultivation, harvesting, and post harvest handling for producing aflatoxin free groundnuts

IPR and PPVFR

- DNA finger print data base of cultivars and germplasm accessions
- Revamping of seed production system to ensure timely and adequate supply of quality seeds

Mechanization of Cultivation

- Development of implement and machines for laying of mulch-films and also for intercultural, harvest and post-harvest operations

Post-Harvest Storage and Utilization

- Identification of packaging material as well as temperature and RH conditions for on-farm storage and warehouse for material to be exported
- Development of technology for production of partially defatted groundnuts

- Application of seed encapsulation for storing seeds as such instead of storing in-shell. This would greatly reduce the volume for storing and transporting seeds

Expansion of Area

Scope exists for bringing some additional new areas under groundnut crop through:

- Further spread of kharif-groundnut in Rajasthan, rabi-groundnut in West Bengal, Orissa and NEH region and introduction of its cultivation in rice- fallows in the peninsular India and NEH region, potato fallows in Uttar Pradesh, Punjab and Gujarat for spring groundnut
- As an intercrop with several widely spaced field crops and plantation crops

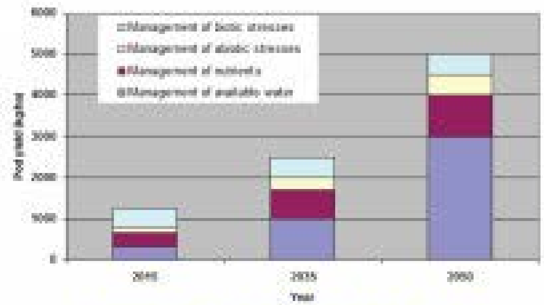
Policy Interventions

- Ensuring accessibility to international germplasm collection
- Measures to ensure multiplication of breeder seed through five-stage seed multiplication chain. Production of foundation seed onwards to be undertaken only in high productivity areas
- Timely announcement of remunerative minimum support price to ensure that groundnut cultivation remains a profitable venture
- Manufacture and supply of region specific composite fertilizers fortified with micronutrients in major groundnut growing areas
- Manufacture and supply of genuine biofertilizers and biocontrol agents in viable forms (with at least 10^8 - 10^{10}cfu or spores/g preparation)
- Incentive to farmers for adopting new groundnut varieties and institutionalization of contract farming system for cultivating groundnut for specific end use e.g. processing for peanut butter, using as biofortified food, functional food or as nutraceutical. Likewise a tag of 'Low oil', 'High protein', 'Free from aflatoxin', 'Free from allergen' should be able to fetch a premium price
- Promotion of public-private partnership for seed production of new varieties

Up-gradation of Infrastructure for Research

The existing infrastructure of DGR and AICRP-Groundnut would need augmentation in human, physical and financial resources in a span of a few years. Facilities will be required for:

- Phenotyping and work on genomics, proteomics and transcriptomics,
- Containment for evaluation of transgenics, glasshouses with controlled RH and temperature for basic and applied research, rhizotron for studies on root
- Hybridization under controlled RH and temperature
- Screening facilities for evaluation of resistance to diseases
- Quality evaluation laboratory at 2-3 centres of AICRP-Groundnut



Current and future crop production technology: change in relative contributions of various components of management

It is thus envisioned that in the year 2050, as an output of sustained scientific research, several modules of production technologies would be available for individual-farmer-field level. With backstopping of a dependable weather forecasting system and a robust quality seed supply system, the application of new technologies will help India realize average yield of 5000 kg ha^{-1} under rain fed situations and 7000 kg ha^{-1} under irrigated situations and thus once again make India the largest producer and exporter of groundnut. The new-age groundnut varieties (conventionally bred or transgenics) grown under new age package of production and protection practices would substantially improve water and land productivity.

The projected contributions of various components of technologies which would help attain the cherished goal are indicated in the figure above.

Marketing

At present the farmers sell their produce at the nearest marketing yard popularly known as *mandi*. These marketing yards are generally established at sun-district levels where the buyers purchase the produce through auction. The small farmers who need cash immediately and are not capable of holding the produce bring the same to market as soon as possible while well-to-do farmers bring their produce to market when the prices go up. Contract farming though practiced at insignificant scale for only organically produced groundnut can be developed further and institutionalized to safeguard the interest of both farmers and traders or processors alike. Necessary steps need to be taken by the state governments backed by mandatory provisions of insurance.

Organically cultivated groundnut which fetch premium price, is already being practiced by a small number of farmers. The produce is purchased in the village itself by the agents of firms concerned. The farmers are often forced to sell their produce at normal rates as the produce does not conform to the norms of organic food by certification agencies or offer of prices without any premium due to lack of demand of such groundnuts. This sector needs to be much more organized. Formation of co-operative societies by the farmers for production and disposal of organically grown groundnut may play a crucial role in protecting the interest of farmers. Since groundnut pods are of semi-perishable nature, the farmers are not constrained to resort to distress sales ever. The produce, however, is not only bulky but also prone to infestation by storage insect-pests. Hence the farmers can not hold the produce for long as buffer time is not more than 30-40 days.

As most edible oils would continue to be available at a cheaper price, markets for value-addition in groundnut would grow for diverting the produce for direct consumption in domestic as well as international markets. By 2020-25, technology would be available to avoid contamination of groundnuts with aflatoxin. The adoption of good agricultural practices (GAP) through 'contract farming' supported and nurtured by export oriented processing units and hygienic post-harvest handling and storage of produce in the processing units will help India emerge as the largest player in the international trade of groundnut.

Goals and Targets

The DGR was established in 1979 by the name National Research Centre for Groundnut (NRCG). The NRCG made its humble beginning in a small building with 18 ha farm land on Junagadh-Veraval highway. Later, NRCG acquired another area of 105 ha land on Junagadh-Gir state highway. Soon after construction of a four-storey laboratory-cum-office building at the new site, the entire establishment was shifted to the new location. This was followed by shifting of headquarters of All India Coordinated Research Project on Groundnut (AICRPG) from Akola to Junagadh in 1992 and bringing the AICRPG under the administrative control of NRCG. Subsequently, the infrastructure has been growing gradually and now this Directorate occupies an enviable position among various crop commodity research institutions. During the eleventh Five-Year Plan, the NRCG was upgraded from level of a 'NRC' to level of a 'Directorate' and the erstwhile NRCG thus became 'Directorate of Groundnut Research' or 'DGR' in short.

Mandate of DGR

- 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
- Provide logistic support and coordination mechanism for generation of location-specific technology through the All India Coordinated Research Project on Groundnut

Human Resource

The sanctioned cadre strength of DGR is 115, which comprises one RMP, 39 scientific, 40 technical, 157 administrative, and 26 skilled supporting staff. In addition, there are about 25 temporary status laborers and 50 casual laborers. The total number (about 60) of employees engaged on *ad hoc* basis as Senior Research Associate, Research Associate, Senior Research Fellow, Hindi Translator, Accounts Assistant, Electrician, Plumber, Skilled Helpers, etc. keeps on varying depending upon the availability of core budget and the positions available in the ongoing externally funded projects.

The research activities are pursued through multidisciplinary research projects. The research projects are conceived and formulated after thorough discussion in the Institute Research Committee (IRC) meetings. The IRC meetings are chaired by the Director and attended by all the scientists. The number of projects running at a given time remains 25-30. The Research Advisory Committee (RAC), which is chaired by an eminent scientist from outside ICAR system, reviews the progress of the projects and the future plan of work every year. The recommendations of RAC are submitted to the Council along with the remarks of the Director. Mid-course correction, if any, approved by the ICAR is then incorporated in the future work plans of the research projects.

All India Coordinated Research Project on Groundnut

An All India Coordinated Research Project on Groundnut (AICRPG) exists for multilocation evaluation of technologies developed by DGR and SAUs and a few ICAR institutes and KVKs. At present there

Mandate of AICRP-Groundnut

- Conducting multidisciplinary research on Crop Improvement, Crop Production and Crop Protection at regular and voluntary centers
- Identification of stable sources of resistance to biotic and abiotic stresses at hot spots and their utilization in varietal improvement programme through national and international collaboration
- Development of high-yielding groundnut varieties possessing resistance/field tolerance to drought; diseases and insect-pests; and high temperature, salinity and acid soils
- Development of groundnut based cropping system and economically viable production and protection technologies for exploiting the yield potential of groundnut varieties
- Demonstration of proven production and protection technologies on quality aspects through on-farm demonstrations in target areas
- Production of nucleus and breeder seed of important groundnut varieties.

are five main and seventeen supporting centres under AICRPG. For the purpose of locating the centres, keeping in view the prevailing agro-climate and cropping density of groundnut, the country is classified into five zones for identifying the problems and prioritizing research under AICRP-G.

Human Resource of AICRP-G

There are 27 Plant Breeders, 13 Agronomists, 10 Plant Pathologists, 8 Entomologists, two Physiologists, and one Cytogeneticist in addition to 85 technical and five ministerial positions. The Director, DGR also functions as the Project Coordinator. The research programmes are developed during the annual national level technical meetings of the AICRP-G.

Since its inception, the Directorate of Groundnut Research has been addressing various issues concerning productivity of groundnut crop and has developed technologies to overcome the adverse effects of various biotic and abiotic stresses through multi-disciplinary approach. The efforts in future would be for further improving productivity, quality, and utilization of groundnut under changing scenarios of climate and global market.

Missionary vision

By appropriately integrating the emerging technologies in other sphere of science and using their imagination and skills, the DGR scientists are committed to making sustained efforts through a blend of basic and strategic research and deliver such technologies which would enhance average productivity of groundnut in India from the current 1200 kg/ha to at least 5000 kg/ha by 2050 and have groundnut cultivation, more sustainable, remunerative and globally competitive.

Focus

- Identification of trait specific donors in the germplasm collection
- Prebreeding
- New pests and diseases which may emerge under the changing scenario of climate

- Management of water resources, especially of rain-water for enhanced water-productivity
- Genetic enhancement for yield and quality traits as well as stress tolerance
- Resource-use efficiency in rain-fed and irrigated conditions
- Cropping systems, crop diversification and precision farming
- Adverse impact, if any, of climate change and its amelioration measures
- Resource integration for efficient input utilization including Integrated Nutrient Management (INM), Integrated Disease and Pest Management (IDPM)
- Production of aflatoxin free groundnuts
- Development of models and forecasting tools for a dependable crop advisory service
- Product diversification, bio-fortification and value-addition and economic use of byproducts
- Development of varieties for specific end users: high oil varieties for crushing, low oil varieties for direct consumption, high protein varieties as functional food etc.
- Conservation agriculture
- Identification of the socio-economic constraints in adopting new technologies and other bottlenecks
- Marketing and export issues

Major flagship projects

Keeping in view the relative importance of different thrust areas, two flagship projects have been formulated for the XIIth plan period, these projects are.

- Development of technologies for enhancing resource use efficiency in groundnut based cropping systems - Though, a number of high yielding groundnut varieties have been developed throughout the years, technologies for enhancing the input use efficiency are still lacking. Thus, this project will focus on the development of appropriate technologies for enhancing resource use efficiency in groundnut based cropping systems.
- Development of practices for management of soil-borne fungal

diseases of groundnut – Soilborne fungal diseases, especially stem-rot caused by *Sclerotiumrolfsii*, remain a cause of serious concern in groundnut production. These diseases cause substantial yield loss and threat to groundnut due to soilborne fungal diseases is growing in proportion season after season. This project has been conceptualized to address this issue

Way Forward

Pillars of hope

- Ample scope for exploitation of genetic diversity in the available germplasm
- Possibility of development of specific stress resistant varieties (conventionally bred or transgenic)
- Wild species: a reservoir of useful genes especially for stress resistance
- Scope exists for expansion of area in *rabi*-summer (Odisha and West Bengal) and *kharif* (Rajasthan, NEH) and in spring (Uttar Pradesh, Punjab)
- Large-scale production of biological control agents and site specific fertilizers
- Greater adoption of micro-irrigation and fertigation systems to enhance input use efficiency
- Scope for development of an array of new value-added products
- Intercropping in wide-spaced plantation crops
- Potential for a positive response to increasing levels of atmospheric CO_2
- Expansion of area under irrigated crop

The DGR is fully committed to bringing about a technology-led improvement in sustainability and profitability of groundnut production system in India and better and economic utilization of the byproducts of groundnut industry i.e. shell and oil- or deoiled-cakes. The technologies available today have the potential of enhancing average national yield to the level of 2000-2500 kg ha^{-1} by the year 2020. The continued refinement of technology developed during the decades to come by convergence of progresses made in other field of science would gradually enhance the average national productivity potential to 7500 kg ha^{-1} by the year 2050. The cherished target of attaining national average productivity of 6000 kg ha^{-1} by 2050 would be attained by adopting the following strategy:

- Production of quality seed of recommended varieties in farmer participatory mode would help achieve desirable seed replacement rate and rapid spread of new varieties.
- During the decade to follow, irrigated summer and spring groundnut cultivations offer a great opportunity with a yield potential of 4000 kg ha^{-1} and hence need prompt attention.
- Use of biodegradable films can facilitate early sowing and economic use of irrigation water for enhancing water

productivity.

- Introduction of early-maturing groundnut varieties for *rabi* rice-fallows and river beds and also in traditional summer areas, and expansion of area in spring in potato fallows will result into a quantum jump in production.
- The release of varieties with enhanced insect-pest, disease and drought-tolerance would help in augmenting production.
- Introduction of large-seeded varieties in sandy-soil areas with assured irrigation and appropriate input would increase production of export quality groundnut.
- Plant protection technologies with enhanced use of biocontrol agents will make groundnut cultivation more eco-friendly.
- In the longer run, use of new formulations coupled with nanotechnology would dramatically reduce the quantities of agrochemicals used in groundnut cultivation.
- The total area under groundnut is likely to increase a little. The area lost in certain states may even be regained besides some gain in other states.
- The Information and Communication Technology (ICT) and Geographic Information System (GIS) would play an important role in rapid transfer of technology and releasing advisory to the farmers without loss of time. The farmers will be connected with advisory services while being anywhere.
- The synergies amongst the research organizations (ICAR and SAUs), seed production agencies and the line departments of central and state governments would, however, be crucial for attaining the projected yields.
- Tailor-made varieties for specific end use would be available for use as functional food, nutraceutical, high energy food etc.

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हर कदम, हर डगर
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Agrisearch with a human touch