Potential of Groundnut in North Eastern States of India

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Cover photo : Groundnut cultivation in terrace at Imphal, Manipur.

Back page: A panoramic view of hills in Manipur showing rice crop in the valley and groundnut and other crops on Jhum land.

Preface

Groundnut (*Arachis hypogaea* L) is an important food legume and oilseed crop of tropical and subtropical areas grown in about 90 countries between latitudes 40°S and 40°N in different agro-climatic regions. Though it is now being cultivated on about 25 million hectare of land in several countries, India, China, USA, Senegal, Indonesia, Nigeria, Brazil and Argentina are the major groundnut producing countries. It is an energy rich crop, but grown mainly on energy-starved conditions of poor fertility soils and rainfed (85 % rainfed) areas and about 70% of the world peanut production occurs in the semi-arid tropics with average yield is around 800 kg ha^{-1}, lower than the world average (1300 kg ha^{-1}). The production of groundnut corresponds to the area under the crop. In India, groundnut shares 3.91 % of the gross cropped area (14.8 % by total oilseeds) producing 24.6% of the world groundnut production. There are fluctuating trends in area and production of groundnut in India, however, it is grown on an area of about 8 million hectare, producing about 8 million tonnes.

Presently, India has the largest groundnut area (32% of the world) and also till 1992 was the chief-producer of groundnut in the world. From 1993 onwards, China became the highest producer of groundnut and India stands second mainly due to higher productivity in China than India. This is mainly because, in India, the crop is mostly grown as rainfed in dry lands, often subject to the vagaries of the weather. Now to meet the demand of increasing population, to introduce the groundnut as food crop in India, the production of groundnut has to be increased tremendously.

Though the average groundnut yield, in India, is around 1 t ha^{-1} the non-traditional groundnut area in NE states harvest 3-3.5 t ha^{-1} of pods in about 100-120 days and in many countries out side India, the productivity is quiet high. This clearly indicates that there is tremendous scope to increase the groundnut yield through its introduction to new areas Thus expansion of groundnut cultivation in the non-traditional areas of north east is the alternative and efforts are being made, since last one decade, to popularize groundnut in these areas. Also as the crop is grown mainly as rain fed and so far only 19.4 % area could be brought under irrigation, the expansion of groundnut in the north eastern areas, where the water is present in plenty, provide a solution to increase the production and productivity of groundnut.

As the groundnut crop is new for the NE states, this book will provide basic information on the groundnut cultivation in NE states to increase its productivity and availability. It may also serve as reference for the technological options and package of practices, pinpoint the major thrust areas and required strategies to promote groundnut cultivation in the NE region.

The data presented in this book has been taken from published articles, reports, the all India coordinated research project on groundnut (AICRPG), Inter-institutional collaborative trials on groundnut conducted by NRCG and ICAR Research Complex for NEH region, in Meghalaya, Tripura and Manipur, the station trials of ICAR Research Complex for NEH Region in Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland, Tripura, and the Assam Agricultural University (AAU), Jorhat .

We, thankfully, acknowledge the contribution of ICAR scientists from ICAR Research Complex for NEH region, NRCG and AAU situated in the remote areas of extreme north-east and western most parts of the country, who have worked very hard and generated valuable informations on various aspect of groundnut, which has been compiled in this book.

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Contents

1. Introduction

The groundnut (*Arachis hypogaea* L) is an important food legume of tropical and subtropical areas and presently grown in about 90 countries under different agro-climatic regions between latitudes 40°S and 40°N. It ranks 13th among the principal economic crops of the world. South America, with largest area of acid soil in the world, is the native of *Arachis* where it is distributed from south of the Amazon to the eastern slopes of the Andes and grown for more than 1500 years by Red Indians. Though world-wide groundnut is now being cultivated on about 25 million hectare (m ha) of land in several countries, it is mainly grown on large scale in India, China, USA, Senegal, Indonesia, Nigeria, Brazil and Argentina. It is an energy rich crop, but usually grown in energy-starved conditions under low soil fertility and rain fed areas as about 70% of the world groundnut production occurs in the semi-arid tropics with average yield around 800 kg ha^{-1}, much lower than the world average (1300 kg ha^{-1}). As a result, the productivity is less than 1000 kg ha^{-1} in more than 50% of the groundnut growing countries of the world, between 1000-2000 kg ha^{-1} in 40% of the countries and only 10 % of the groundnut growing countries had the productivity above 2000 kg ha^{-1} (FAO, 2001).

India has a cultivation history of growing groundnut around 250 years and now it is grown in about 260 districts, mostly as rainfed crop on well drained soils in low (750 mm annual) and medium (750-1000 mm annual) rainfall areas. The production of groundnut corresponds to the area under the crop. Between the decades of 60s and 70s, there is practically little difference in productivity (700-800 kg ha^{-1}) indicating that the increase in production was largely due to the expansion in areas. But, in recent years, the increase in productivity is the main reason for increased production. The average area, production and productivity of last 10 years are 7.78 m ha, 7.79 m t and 990 kg ha^{-1}, respectively. Presently, India has the largest groundnut area (32% of the world) and also till 1992 was the chief-producer of groundnut in the world. From 1993 onwards, China, due to higher productivity than India, became the highest producer of groundnut and India stands second. This is mainly because, in India, the crop is mostly grown as rainfed in dry lands, often subject to the vagaries of the weather conditions.

In order to meet the demand of increasing population, both as oilseed as well as food crop, the production of groundnut has to be increased. As the productivity of groundnut cannot be increased after certain limit, and its area in the traditional groundnut-growing belt is decreasing, the expansion of groundnut cultivation in the non-traditional areas of north east is area of the alternatives and efforts are being made, since last one decade, to popularize groundnut in these areas. Though, the average yield of India is around 1 t ha^{-1}, the experiments have demonstrated that northeast has the yield potential of 3-3.5 t ha^{-1} of groundnut pods in 100-120 days. This clearly indicates that the yield potential of groundnut has not been exploited even by 30% and there is tremendous scope to increase the production and productivity through introduction of the crop in the entirely new areas where nutrients and water are not a limiting factor. In this book an attempt has been made to synthesize the knowledge of groundnut cultivation and technologies developed so far in the north eastern states, to identify the proper package of practices and to pin point the major thrust areas, and strategies for promotion of groundnut cultivation to increase its productivity and availability in the NE region.

2. North Eastern States, Their Climate and Soil Types

The North East of India constitutes the "Seven Sisters" states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. It lies between 21°57' to 29°26' N latitude and 89°45' to 97°17' E longitudes and has a total geographical area of 24.9 m ha. The North east states are considered as non-traditional areas for groundnut cultivation as the crop is not grown traditionally in large areas. The entire region is characterized with varied physical and climatological conditions with an altitude of 50-3000 m above msl and climate ranging from tropical to temperate. It is a high rainfall area and most of the rainfall in these states is received under the influence of the southwest monsoon with 75 % of the annual rainfall occurring in June-September. The topography of the region is mountainous except Brahmputra valley and the Brahmputra and the Barak are the two principle rivers governing the network of drainage system. The climate is humid subtropical and the mean annual rainfall varies from 980-11420 mm, with a mean minimum and maximum temperatures 18.3 and 29.9°C, respectively.

As sudden changes in topography result in climate changes within short distance, entire NE region has distinct climate variations. The daily mean temperature in the plains of Brahmaputra and the Barak valley as well as in Tripura and in the western portion of Mizo hills is about 15°C in January, whereas in other parts of the region, the temperature ranges between 10°C-15°C. From April onwards it rises and in July, the mean temperature ranges from 25°C to 27.5°C except the south-eastern portion of Mizo hills and Shillong. During October, mean daily temperature in the hilly areas ranges between 20°C and 25°C, whereas in plains it is above 25°C. The lowest temperature is experienced below freezing point in the upper Himalayas in Arunachal Pradesh.

Except for Assam and Manipur valleys the region has low to medium sunshine hours, loamy sand to sandy loam textured soil (alfisol haplaquent) acidic in reaction (pH 4.5-5.5). The north-eastern region is the largest stretch of acid soils in India where lands are very complex geo-morphologically. There is a good depth of soil in NE region and most of the soils are low in CEC (cation exchange capacity), pH strongly to medium acidic, dominated by inceptisol (45%) and entisol (28%). This region suffers from severe soil erosion due to rugged topography, high rainfall and shifting cultivation. Both surface and sub-surface soils of the hilly region are highly leached exhibiting poor base saturation with low CEC (below 25%) and soil acidity in general and subsoil acidity in particular are the major limiting factors for low productivity potential of these soils. With about 20 m ha soil having pH less than 7.0 and about 10 m ha less than 5.5 in NE regions, cultivation of any crop and so of groundnut is bound to occur on these acid soils where Al-toxicity in upland terraces, Fe and Mn-toxicities in valleys

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and Ca, P, Mg and K, deficiencies in both situations are major concerns. Poor fertility of upland soils, which is highly acidic, is due usually to a combination of these factors. Besides these low water holding capacity, susceptible to crusting, erosion and compaction makes these soils low productive.

The brief description of the situations and climates of various NE states and their groundnut growing areas are mentioned separately in the following lines.

Arunachal Pradesh

Arunachal Pradesh, the land of the down-lit mountains and originally known as north east frontier agency (NEFA) is a thinly populated sprawling hilly tract in the eastern most part of Himalayas. It is surrounded on three side by the international boundary with Bhutan to the west, China to the north, Burma to the east and Assam to the south. Except for thin strips of flat land adjoining Assam, Arunachal is terrain of timeless tranquility and entirely mountainous. Owing to rapid change in topographic and altitude, the climatic conditions of Arunachal tend to change within short distances. The territory receives wide rainfall from May to early October, being June and July the wettest month. Nearly 80 % of the Arunachal population is engaged in agriculture and jhuming is the traditional method of agriculture. The groundnut is being grown in plains of Arunachal mainly in East Siang since a decade.

Assam

Spread beneath the foothills of the eastern Himalayas dominated by mighty river Brahmaputra and sharing boundaries with all the NE states, Assam is virtual paradise on earth. Having the largest number of tribes, in NE states with variety of traditions, culture, dress, dance and way of life add colour to the landscape. Assam is rich in oil, coal, limestone, dolomite and natural gas. Tea is the major industry and with nearly 800 tea gardens in the state, contributing 16% of world tea production and 55% of the country. Besides, Assam is the largest producer of the golden coloured 'Muga Silk' in the world.

Assam has sub-tropical climate with high rainfall and high humidity. The Brahmaputra valleys represents three broad climatic regions, viz. eastern, western and middle with annual rainfall of 245, 1983 and 1527 mm and mean annual temperatures (MAT) of 23.5, 24.5 and 24°C, respectively. The annual rainfall of Barak valley is 4103 mm and MAT 24.9°C. In both Brahmaputra and Barak valley, the natural water availability exceeds the water need during the rainy and summer seasons. This renders the soil moist for seven to nine months and the climate of these regions qualify for udic moisture regime. Of the 23 districts, the groundnut cultivation has been reported in Jorhat, Nagaon, Darrang, North Lakhimpur and North Cachar hills.

Manipur

In the land of jewels of shelters the meeteis and two dozen other colourful tribes in its plains, valleys and hills, Manipur belongs to the temperate rainy climate region with dry winter and hot summer a sub-tropical monsoon climate. Average warmest temperature ranges between 25 and 31°C. Rainfall is relatively abundant and widespread, varying from a maximum of 259 cm at Jiribam to only 97 cms at Wanghal. December to February is cold and March to May is the hot weather. The monsoon starts from May and lasts up to September and the season of retreat of monsoon is from September to November. Paddy is the main crop of the state, maize, sugarcane and groundnut is cultivated in the foot hills of Thoubal, Ukhral and Senapati districts. The state has made significant endeavor in the agriculture with rice production.

Meghalaya

The abode of clouds, Meghalaya is endowed with nature's bounties. It is home of the Khasi, Jaintia and Garo tribes. The climate of the state, as a whole, may be described as cold, chilly and frosty in the highest region of the central plateau, mild and pleasant in the regions where the central plateau meets the two border areas, but not moist and oppressive towards the border of Bangladesh and Assam. The mean maximum and minimum temperature is around 30°C and 12°C, respectively at Shillong. The average relative humidity is 76%. Practically the whole of the state is covered by the south-western monsoon which normally begins from May and last up to October. The southern border area of Jaintia Hills district receives the highest amount of rainfall where the two wettest places in the world viz. Cherrapunjee and Mawaynram are situated. The rainfall in the state is heavy in comparison with other states. Jhuming is practiced on large scale and are of the biggest problem of the state. Rice and maize are the main crop, however, the potential for agriculture expansion is limited due to the terrain. Groundnut is being practiced on the uplands and also after rice in West Garo hills, East Garo Hills, Ri-Bhoi and Umroi districts. It is cultivated on Jhum land with very high yield

Mizoram

Known as land of enchanting hills, Mizoram is famous for its vast expense of jagged mountain ranges shrouded mystically in reddish-blue haze. Mizoram stands like a lone sentinel at the north-eastern corner of India and with steeps and rugged hill ranges, it offer a lust green forest. The hills run in ridges from north to south with an average height of 900 m and highest point being Blue Mountain at 2165 m. Teawng and Sonai are the important rivers. Mizoram enjoys a pleasant climate, with moderate humidity. In summer the temperature varies between 20°C and 29°C, while in winter it varies between 11°C and 21°C. There is little or no rain during winter. The entire territory is under the direct influence of monsoon. In the higher ridges it is fairly cool and pleasant even at the hottest season of the year. Mizoram gets a substantial amount of rainfall with an average of 254 cm per annum. Agriculture is the only occupation in Mizoram. The state is famous for its fibreless ginger and paddy is chief food followed by maize. Of the three districts in Mizoram, the groundnut in grown mainly in Kolasib area of Aizawl touching Tripura and Assam on the hill slopes of Jhum lands.

Nagaland

Nagaland is a narrow strip of mountainous territory between Brahmaputra valley of Assam and Myanmar. A land surrounded in mystery soaked with charm, Nagaland is a picture-postcard pretty with hills and valleys, rivers and rivulets. This was a forbidden territory of fierce warriors till recently, and now there are 16 distinct tribes in Nagaland each with their own dialect and customs, but with love of music, dance pomp and pageantry as the common factors in all of them. The Nagaland is situated in a hilly terrain hence the climate is bracing and healthy. In winter the temperature falls considerably, although, in the inhabited area, snowfalls are very rare. The summer temperature ranges between 24.4°C and 32.8°C. The annual rainfall occurring mostly between April and October averages between 681 mm and 925 mm.

About 75% of the population is involved in agriculture and rice is the most important crop. State has a unique land holding pattern and 90% of the area is privately owned. However, only about one third area is cultivable. The main pattern of agriculture is jhuming and terrace cultivation. Nagaland has immense wealth of mineral, along the eastern belt, there is a rich vain of coal, lime stone, iron, nickel, cobalt chromium and marble. Groundnut is popular near Kohima.

Tripura

Tripura is a world of hills and dales, dense forest, undulating grasslands, murmuring rivulets and ancient monuments. It is surrounded by Bangladesh on all sides, except for a narrow neck in the north-east where it borders on Assam and Mizoram. Tripura has a hot and humid climate with temperature ranging between 10°C to 35°C. The normal average rainfall in the state is 2300 cm. Humidity becomes the maximum in June and minimum in April. Rainy season is from May to October. About 55% of the land in Tripura is under forest and only 24% area is available for agricultural use with rice, wheat, jute, mesta, sugarcane, potato and oilseeds being the principal crops. Tripura is divided into three districts south, north and west Tripura and groundnut has scope of its cultivation in all the three districts on the uplands and 'Tilla lands' during kharif seasons and medium lands after rice crop during rabi season.

3. Groundnut Cultivation in North Eastern States

3.1 Status and scope of groundnut cultivation

The cropping system, in the NE states, revolves around rice and maize. The total food grain requirement of the region is about 8 m t, however, only 6 m t is produced in these region and there is a shortfall of about 2 m t food grain. This needs to be met with increased production and productivity. Rice, maize and pearl millet are main cereal crops. In Manipur, Assam and Tripura rice productions and productivity is very high mainly due to low land rice cultivation, however, in other states and uplands the productivity in below national average and sometimes extremely low due to severe mineral deficiencies and toxicity of Al, Fe and Mn. Productivity of rice and maize under upland terrace and 'Tilla' land is very low owing to light texture, Al toxicity and low P content in soil. Moreover, in most of the hill region shifting (Jhum) cultivation, a primitive form of agriculture, is still dominant in an area of 1.73 to 2.5 m ha. Although upland rice crop in the NE region is not remunerative because of low and erratic yield (650 kg ha^{-1}) as against national average (more than 2500 kg ha^{-1}) its cultivation is crucial as a subsistence crop. Changeover to groundnut, a more tolerant crop to mineral stresses, with modern agricultural technologies may bring substantial yield increase in these areas.

Groundnut is a recent introduction in the NE region and the uplands, rice and maize fallows and river bed constitutes important ecosystem for groundnut. In Assam, Arunachal Pradesh, Manipur, Meghalayas and Mizoram, it was introduced during middle of 1980's while in Tripura and Nagaland it was introduced earlier. In Assam, rapeseeds, mustard and sesamum are the principal oilseed crops occupying major oilseed area. The groundnut is grown in 7000 ha of 13 districts in Assam during kharif as well as rabi seasons, however, there is a wide scope of increasing area under groundnut specially in the Brahmaputra river bed ("char" areas) during rabi season. Potential districts for rabi groundnut are Kamrup, Nalbari, Barpeta, Darrang, Sonitpur, Jorhat, Golaghat, Sibsagar, Lakhimpur, Dibrugadh, Tinsukhia etc. However, rabi crop face excessive rains during sowing time. Groundnut can also be profitably grown as an intercrop with citrus in Tinsukia district.

The flat lands, river valleys and foot hills upto mid altitude of the region offer the place where groundnut is grown in patches. Recent experiences with groundnut cultivation in NE states reveals that during kharif season, groundnut performs well on a well drained soil in the entire NE states. The crop remains almost disease and pest free till 80 DAS (days after sowing) and yield more than 1000 kg ha^{-1}. Experimental results clearly indicate that groundnut crop has high potential in the NE states. While a good number of groundnut varieties were found promising under mid-altitude conditions, none of them did well under high altitude situations. Experimental results of the station trial compiled by Munda et al (1997) clearly indicated that, in Meghalaya, more than 100 entries of groundnut were screened and as high as 3000 kg ha^{-1} pod yield was obtained from ICGS 76 under good management practices. In Arunachal Pradesh (Basar), groundnut registered highest pod yield of 3440 kg ha^{-1} and at Tripura, maximum pod yield of 3970 kg ha^{-1} was obtained with variety ICGS 44. At Langol foot hills of Manipur, highest pod yield of 3200 kg ha^{-1} was obtained. In Mizoram (Kolasib), bold seeded variety, ICGV 88365 gave as high as 3760 kg ha^{-1} of pod yield. Production potential of groundnut found to be very high on silt loam soils adjoining the river valleys of Nagaland with a production potential of more than 3000 kg ha^{-1}.

If, we look at the productivity of rice and maize in uplands of NE region which is quiet low, groundnut can be a better substitute for upland rice and maize in certain areas (Fig. 1- 4). It can be grown in river beds, in potato and mustard fallow during spring season as sole crop or intercrop with rice and maize, and in the upland acid soils as an alternative to less remunerative local rice and minor millets. It can also be grown in sequence after rice or maize or as intercrop within rice and maize upland situations. Rice + groundnut intercropping (3:1) has also been found to be remunerative over the sole rice crop. Citrus, guava, potato, large cardamom, zinger, cassava, curcumin, sweet potato, arecanut, and rubber, are major horticultural and plantation crops and the groundnut can be very easily intercropped with these crops either regularly or up to three years of start of plantation. The farmers grow groundnut with minimum effort as it has got less management problem compared to rice and maize. Moreover, it requires less fertilizer inputs for its production except the seed cost for which farmers may maintain seed materials themselves. Looking to the potential market value of groundnut in NE region, its cost of cultivation and net economic return was worked out for Meghalaya under different cropping system (Table 1).

Table 1. Cost of cultivation (Rs. ha^{-1}) of rice and maize based cropping system with groundnut as an associated crop (Munda et al. 1997).

Cropping system		Cost of cultivation (Rs. ha^{-1})	Total return (Rs. ha^{-1})	Net return (Rs. ha^{-1})
Rice (sole)	2025	5505	5073	540
Maize (sole)	2549	6029	6373	344
Groundnut (sole)	6625	8490	16562	8072
Rice + Groundnut	5100	7000	12750	5750
Maize + Groundnut	3850	6000	9625	3625

Cultivation of groundnut in Rice-based cropping system (RBCS) has become popular and area is increasing in the entire NE region. In lower altitude of Assam, Meghalaya (Garo hills), Manipur, Tripura, second crop of groundnut is grown during rabi season under residual moisture or with minimum irrigation and further expansion in the river beds and on the terraces after rice is anticipated. Farmers of these states are adopting the rice-groundnut sequence in low land because of following reason.

- The problems of the rice after rice where the insect pest perpetuate round the year resulting in decline in productivity and profitability of the rice-r i c e cropping system;
- Including groundnut in the rice based cropping system will sustain crop production, improve soil health, and break the build up of serious insect-pests and diseases.
- Groundnut crop requires less number of irrigations and provides better nutritional and financial security than other crops.

Thus, groundnut has got high potential for its cultivation in NE region and various situations provide scope for expansion of additional 0.5-1 million ha area under groundnut in the NE states which may result in additional production of about 1-2 million tonne of groundnut. Further the adoption of groundnut will not only increase productivity per unit area but also bridge the gap of oilseed requirement and production of the regions.

3.2. Cropping seasons and situations

Monsoon (June to October), winter (November to February) and summer (March to May) are three dominant seasons, round the year in NE states of India, accordingly kharif, rabi and summer are three groundnut growing seasons. Most of the rainfall in these states is received under the influence of the south-west monsoon between June and October. Kharif is the main cropping season lasting from April to September, which also coincides with the monsoon season. Crops are also grown during rabi and summer season utilizing irrigation facilities, residual moisture in the soil. There are following situations in which groundnut is mainly grown in the NE states:

Seasons	Situations
Kharif	Rainfed upland
Rabi	Rainfed on residual moisture/ minimal irrigation situations
Summer	Irrigated medium land (Rice plains)
Summer	River bank and riverbed fallow on residual moisture

The time of sowing in NE states is little earlier than in plains. The groundnut, during kharif season is sown from April to July in NE states and harvested accordingly during September. During Rabi, it is sown in September-October and harvested in January-February. The summer season groundnut is sown during January-February and harvested during May-June.

Besides various cropping seasons, there are several cropping patterns for groundnut in NE states, which mainly depend upon the land use, rainfall, moisture and climate (Table 2).

Table 2. Land use situations and cropping pattern for groundnut in NE states

Situations	Cropping patterns	Crop(s)
Rainfed, Upland and Jhum land	Single cropping	Groundnut
	Mixed cropping/ intercropping	Rice + Groundnut, Arhar +Groundnut Groundnut + Red gram Groundnut + Maize Groundnut + French bean Groundnut + Sweet potato Groundnut + Field bean Groundnut + Zinger Groundnut + Cassava Groundnut + Rubber (initial 3 years) Groundnut + Citrus (initial 3 years)
	Sequential cropping	Groundnut - Groundnut Groundnut - Mustard Groundnut - Horse gram Groundnut - Green gram Groundnut - Potato Groundnut - Cassava
Rainfed Medium land	Sequential cropping	Rice - Groundnut
Irrigated Medium land	Sequential cropping	Rice - Groundnut - rice
Low land, un-irrigated (residual moisture)	Sequential cropping	Rice - Groundnut
River bed	Single cropping	Groundnut

Kharif Season

Kharif is the main season for groundnut in India and so is in the NE states also where it is grown as sole as well as intercrop on upland in patches during rainy season. During kharif season both the bunch and runner type groundnut cultivars are grown. However, during rabi and summer seasons only bunch and sometimes semi-spreading groundnut cultivars are grown. The runner type being longer in duration and sensitive to high temperature, are not grown during rabi and summer season as it may not set good number of pods and may caught rain during harvest. Due to low disease pressure and more sunshine hours, the rabi and summer season crops produce more yield than the kharif crop. Farmers go for dry sowing on adequate available moisture during rabi and summer seasons, but kharif is done after good rain.

Rabi Season

The groundnut is grown as rabi crop in Manipur, Tripura, Meghalaya and Assam by sowing the same during September to November in the rice and other fallows. In high rainfall area, such crop is sown on ridges to avoid water logging. This crop is grown particularly on upland and medium land with adequate moisture content. The rabi crop is spreading fast in Manipur, Tripura and Assam, replacing other oilseed crop in rice fallows. Sowing of groundnut depends on the harvest of rice, maize or any other kharif crops. The time of sowing again region and situation specific and vary from September to November. The upland areas known as 'tilla' in Tripura, which otherwise remains fallow from November to March, are suited for groundnut production during rabi season, if light irrigations are given at the time of moisture stress.

Deposition of silt and nutrient replenishment every year due to flood, the riverbeds provides an ideal situation for growing groundnut under residual moisture content. This cultivation is picking up fast in Assam, Manipur and Tripura. The yield potential of groundnut grown in river bed is very high and yield of 3000 kg ha^{-1} is commonly observed, however, yield up 5-6 t ha^{-1} are also realised in the river bed of Brahmputra.

The groundnut during rabi season in mid and high attitude can be grown along with polythene mulch to avoid low temperature effect and consideration of moisture. The low temperature during middle of crop growth is the major draw back, which reduces the growth, affecting yield. Experiments conducted at Manipur, Barapani, Meghalaya, Assam and Sikkim have sown the potential of polythene mulch for rabi season groundnut. It may cover a vast area which otherwise go fallow.

Summer Season

The summer crop of groundnut is mainly irrigated and has high yield potential. It is grown under assured irrigation and nutrient management and has less infestation of weed and insects pests and diseases. Though the time of sowing varies from region to region and situations, it is commonly sown during January-February and harvested during May-June and Assam, Manipur and Tripura are the main states where groundnut is grown as summer crop. However, it is also gaining popularity in Garo hills and other low lying areas of Meghalaya. In some area groundnut is grown during spring season after harvest of potato and toria. Due to high productivity, it is worthwhile increasing groundnut area under summer crop in NE States where water is not a limiting factor. This will automatically increase the production, as there is little decrease in rabi and summer area in India during recent years. The low temperature during germination is the main drawback of such cultivation. However, use of polythene mulch enhances the germination, increase initial growth by increasing temperature during early growth stages.

3.3. Strategic research initiatives

Looking to the scope and importance of groundnut cultivation in north east states and to be ready with the unforeseen situations a full-fledged programme "Sustainable farming systems for non-traditional areas with special emphasis on eastern and north-eastern parts of India" was developed for 25 years perspective plan of the NRCG. Under this Programme a full-fledge Inter-institutional collaborative project on the "Development of sustainable production technologies for promotion of groundnut cultivation in non-traditional areas of eastern and north-eastern India" with following three sub-projects was developed:

i. Management of Al-toxicity and related problems of acid soils,
ii. Impact of groundnut cultivation on socio-economic conditions of farmers and
iii. Impact of groundnut cultivation on ecological sustainability

The NRCG, Junagadh and ICAR Research Complexe for NEH Region are executing this collaborative project from 1997. The experiments are being conducted at Barapani (Meghalaya), Imphal (Manipur), Lembucherra (Tripura), Gangtok (Sikkim), Tura (Meghalaya), Kolasib (Mizoram) and Jharanapani (Nagaland) and also at NRCG, Junagadh under the defined objectives mentioned below:

- Survey of groundnut field in relation to mineral nutrients deficiencies and toxicities of Al, Fe and Cd load in kernel for recommending suitable package of practices to the groundnut growers
- To find out the critical limits of macro- and micro-nutrients in the plant and soil and their disorder sign in groundnut grown in acid soils
- Evaluation of potentialities of nutrient consumption by groundnut genotypes in acid soils and their screening for tolerance of Al toxicity.
- Delineation of macro- and micro-nutrients through Long-term fertility trials.
- Studies on the organic farming approaches.
- Studies on the mechanism of Al-toxicity tolerance of groundnut in acid soils.
- Impact of groundnut cultivation on ecological sustainability and socio-economic conditions of farmers in NEH Region.

4. Research and Technological Developments

4.1 Crop improvement

As NRCG, Junagadh maintains more than 5000 germplasm lines and has access to 120 released cultivars of groundnut, our first and foremost effort is to select the suitable genotypes for these regions through screening and yield trials. Once the genotypes, which grow well in NE region and can tolerate acid soils, are identified one can go for developing high yielding genotypes for acid soils through breeding and biotechnological approaches.

4.1.1 Varietal development and identification of promising one

Several groundnut varieties were tested during mid 80s to mid 90s in the NE region under all India coordinated research project on groundnut (AICRPG). Later on under Inter-institutional collaborative trial the recently released varieties were evaluated during 1997 to 2002 Kharif seasons for their pod yield, and tolerance of Al- and Fe-toxicities and Ca- and P- deficiencies, early and late leaf spot diseases and tested for their suitability and immediate introduction of these in NE regions.

In a series of experiments on the evaluation, nearly 60 groundnut varieties were tested with optimum fertilizer and spacing for their yield under various agroclimatic situation of NE region during various seasons and the groundnut varieties identified for their cultivation in various NE states (Chaudhary, 1993; Chaudhary et al, 1990; Deka et al, 1995; Munda et al, 1999; Nair et al, 1983; NRCG, 2000, 2001, 2002; Singh et al, 1999). The new groundnut verieties identified for NE states are given in Table 3.

Table 3. Promising released groundnut varieties identified for various NE states

States in NE Region	Promising new varieties
Arunachal Pradesh	ICGS 76, Girnar 1,
Assam	ICGS 76, Girnar 1, ICGS 11, GG 2
Meghalaya	ICGS 76, ICGV 86590, TKG 19A, BAU 13
Manipur	ICGS 76, ICGV 86590, TKG 19A, BAU13
Mizoram	ICGS 76, ICGV 86590, ICGS 44
Nagaland	ICGS 76, ICGV 86590, ICGV 87187
Tripura	ICGS 76, ICGV 86590, TKG 19A, DRG 12, OG 52-1

- The ICGS 76, is a two seeded Virginia bunch cultivar from ICRISAT, released during 1989 for Southern Maharashtra, A.P., T.N and Karnataka with 72.0 % shelling out turn, 42.5 % oil and 44.0 g 100-seed wt.

- The ICGV 86590 is a 3-4 seeded, multiple disease and insect pest resistant, Spanish bunch cultivar from ICRISAT, released during 1991 for Peninsular India with 62.0 % shelling, 41.6 % oil and 33.0 g 100-seed wt.

- The Girnar 1 is an early maturing, multiple resistant, Spanish bunch cultivar most suited for rainfed, released during 1988 from NRCG, Junagadh for Western Maharastra A.P., T.N. with 71 % shelling 50 % oil and 33 g 100-seed wt.

- TKG 19A is a Virginia bunch bold and attractive kernels variety of BARC and K.K.V Dapoli, released during 1993 for rabi summer and kharif season of Konkan region with 63.0 % shelling, 46.0 % oil and 61 g 100-seed wt qualifies for HPS grade.

Through all India coordinated research project on groundnut (AICRPG) a number of groundnut genotypes comprising of germplasm accessions, advanced breeding lines and released cultivars were evaluated in NE region under various agro-climatic conditions. Initially these genotypes were tested for their suitability and yield for immediate introduction of these in NE regions and based on the multi-location testing the genotypes performing well in NE states, suitable for diverse agro-ecological regions with high yield potential and resistance to major diseases and pests are listed in Table 4.

Table 4. The groundnut genotypes recorded more than 1500 kg ha^{-1} yield in NE states

States	Groundnut Genotypes Spreading	Bunch
Arunachal Pradesh	NRCG Accs. 3225, 6556	NRCG 6346 and RCG 3
Assam		NRCG 3012 and 6556
Manipur	NRCG Accs. 3174, 3209, 3225	ICGS 44, ICGS 65, RCG 3, ICGV 88336, 92224, 87232, 87242, 87867, 88376, 89235
Meghalaya	NRCG Accs. 510, 3174, 3225,	ICGV 86326, 86188, 87191, 86236, 87189, Dh 8, AISS 2117, AIS 9140, JL 24, ICGV 88347 (medium duration), ICGV 92224 (short duration), ICGV 86742 and ICGV 86745 (drought resistant), ICGV 86518 and ICGV 86252 (insect pest resistant) and HPS 9704, 9706 and BAU13 (bold seed)
Mizoram	NRCG Acc. 3209, 6556, 3174	ICGV 88336, 88366, RCG 3, NRCG 5953
Nagaland	NRCG 6556, 3225	ICGV 87187, RCG 3, NRCG Acc.5453, 6346
Tripura		ICGV 87138,87129,87144,87123

The NEH soil due to high organic matter and loose structure provide scope for large seeded groundnut and HPS 9704, 9706 and BAU13 are the promosing bold seed genotypes for NEH region (Fig. 5). As NEH region falls under high rainfall and humidity, three foliar diseases (ELS, LLS and Rust) were predominantly occurring in those region and cultivars ICGV 86590 and ICGS 76 showed comparatively better resistant to these than other genotypes. As soil acidity, Al-toxicity, and Ca- and P-deficiencies are the main problems of the region, the groundnut cultivars showing high yield could sustain these adversities. The four consecutive years of study in the Inter-institutional collaborative trials have shown that the average pod yield of recently released groundnut cultivarts, in NEH region, was more than 1000 kg ha^{-1} (more than the national average) and groundnut cultivars ICG 76, and ICGV 86590 and TKG 19A were most suitable and hence recommended for the NEH Region.(NRCG, 2001, 2002)

4.1.2. Screening for acid soils and Al-toxicity tolerance

In a collaborative project between ICAR Research Complex in NEH and NRCG, Junagadh initiated during 1997, the foot-hill upland of ICAR Res. Complex, Imphal, (Manipur) and Barapani and `Tilla' lands of Lembucherra (Tripura), were identified as hot spot for screening for soil acidity and Al-toxicity. Accordingly, systematic screening started by growing 100 germplasm lines in acid soils having nearly pH 5.0, under fertilized (50 kg/ha P + 2500 kg/ha lime) and unfertilized (control) conditions and the performance of genotypes were assessed for pod yield and their tolerance of Al and Fe toxicities, Ca and P deficiencies. Over 300 genotypes were tested in three phases of 100 genotypes (each for two years) and based on the six years (1997-2001) of study, the soil acidity and Al-toxicity tolerant and sensitive genotypes were identified:

- Al-toxicity tolerant genotypes: ICG 813, 1001, 1021, 1048, 1056, 1064, 1355, 3606, 86644, 10271, 10465, 10964, 11183, 11954 and RCG 3.
- Al-toxicity sensitive genotypes: ICG 2120, 4407, 6727, 6855, 7288, 7600, 7787, 7821, 10580, 11748.

The mineral analysis of plant show that the groundnut plant grown in acid soils contained extremely high Al-concentration (960-2500 ppm) and high Fe

(1600 ppm) and Mn (1200 ppm) content and low Ca (1.2%) and P(0.15%) content in their tissues.

Fifty five groundnut genotypes were screened for their tolerance of Al-toxicity under simulated conditions in sand culture pot experiments at 1000 μM of Al, where Al-toxicity symptoms on roots and subsequently on plant growth were noticed causing reduction in growth and yields. Based on these parameters and relative performance of the genotypes under normal and Al-stress conditions for consecutive four years, the tolerance and sensitive genotypes were identified. The Al-toxicity tolerant genotypes were NRCG 7599 and 1038, 3498 and, FeESG 8 (Fig. 6 and 7).

4.1.3. Nutrient efficient genotypes

As Al-induced P and Ca deficiencies are the main problem of the area and the fertilizers are becoming costly, efforts were made for the selection of nutrient efficient genotypes which can grow and yield well under low available nutrients where the normal genotype show deficiency. The groundnut seed from NE region showed low Ca content sometimes below 300 ppm causing low shelling and viability, however the minimum Ca content in seed, for good germinability and vigour, is reported to be above 400 ppm (NRCG, 2001).

The experiments conducted at NRCG Junagadh (NRCG, 2002) for four consecutive years identified following nutrient efficient and inefficient genotypes:

- P-efficient : GG 5, NRCG Acc 7085-1, 6919, 1308, 3498, and SP 250A
- P-inefficient : VRI 3, B 95, PBS 16003, 20012 and 18057
- Ca-efficient : ICGHNG 88448, and NRCG Acc. 7085-1, 6155,
- Ca-inefficient : BAU 13, TG 26, NRCG 7472 and 162

In field study several genotypes were screened for their tolerance of P deficiency stress at 3.65 mg kg^{-1} available P in Manipur, Assam and Meghalaya and varieties ICGV 80338, ICGV-88348, ICG (FDRS)-40, ICG (FDRS)-50 were the highest yielder without P application and were resistant to Tikka leaf spot. (Abrahim et al, 1988; Kailash kumar and Raychaudhuri, 1997)

4.2. Crop production technologies

4.2.1. Cropping seasons and optimum sowing time

Like other parts of the country, kharif, rabi and summer are the three groundnut growing seasons being followed in NE states of India. In north eastern hills the kharif crop is gaining familiarity and now it is being grown in almost all the states in mid hills. Also efforts are on to introduce the crop at high altitude of Arunachal pradesh, Meghalaya and Sikkim using polythene mulch technology. In Meghalaya, Nagaland, Arunachal Pradesh and Manipur, it is grown on hill in terraces and foot hills on recently cleared Jhum (shifting cultivation) land. However, in Tripura it is grown on eroded tilla land and also on plain land. The optimum sowing time for groundnut in NE states is generally in between 15th May to 15th June as the rainy season starts early in these regions. However, state-wise optimum sowing time for various season as observed by the authors and various workers is given in Table 5 (Deka et al, 1996, 1997; Munda et al, 1997; Munda and Patel 1989).

Table 5. Optimum sowing time of groundnut in various NE States

Crop seasons	Optimum sowing time	States
Kharif	15th May - 5th June	Arunachal Pradesh, Manipur, Meghalaya Mizoram, Nagaland and Sikkim
	1st - 15th June	Assam
	5th May - 10th June	Tripura
Rabi (winter)	15th September to 5th October	Assam, Meghalaya, Manipur and Tripura,
Spring (Summer)	5-25th January	Assam, Tripura, Manipur

In Meghalaya a field experiment conducted on sowing date during rainy seasons with four groundnut cultivars, JL 24, Girnar 1, ICGS 44 and ICGS 76 sown on 5th and 20th May and 6th and 20th June showed that groundnut sown at all the four dates showed good plant stand and growth but the crop sown on 20th May produced highest yield and sowing of 20th June registered lowest pod yield.(Munda and Patel, 1989). Further pod yield was drastically reduced when sowing was done in the first week of July and onward (Table 6).

Table 6. Performance of groundnut varieties to various sowing dates at Barapani, Meghalaya (Source : Munda and Patel, 1989)

Sowing dates	Pod yield (kg ha^{-1})
5th May	2530
20th May	3290
5th June	2660
20th June	1820
C.D. (5%)	280
Groundnut cultivars	
JL 24	2260
Girnar 1	2070
ICGS 76	3080
ICGS 44	2860
C.D. (5%)	340

In a field experiment in Gossaigaon, Assam, the groundnuts cv. JL-24 and Girnar-1 sown on 1st and 15th June performed better with the later sowing date and at 30:40:30 kg NPK ha^{-1} (Kalita et al, 2000). During pre-rabi season in Shillongani, Assam, four sowing dates were evaluated on three varieties where maximum yield of 1188 kg ha^{-1} was recorded when sown on 25th September and yield declined significantly beyond October 5 (Sharmah and Debnath, 1997). The high yielder varieties were ICG (FDRS)10 and ICGS 5. In another trial mulching treatments increased number of pods, kernel weight and pod yield and the crops sown on 15th September and 1st October produced higher yield than those sown later(Dutta et al, 2000). During spring season the mean yield of 6 groundnut cultivars grown at Sonitpur was 1.91 t pods ha^{-1} when sown on 5th January which decreased to 1.30 t ha^{-1} if sown on 15th March(Ahmed, 1992).

4.2.2. Planting density

As only about 70% groundnut seed germinate under field condition, maintenance of optimum plant population is an important aspect in groundnut cultivation. The seed rate depends upon seed size of the variety grown and spacing adopted. In India, the most common spacing for bunch type of groundnut is 30 x 10 cm and for spreading it is 60 x 10 cm, accordingly the seed rate is 100-110 kg kernel ha^{-1} and 90-95 kg kernel ha^{-1} respectively for bunch and spreading genotypes. However, in a series of field trials, in NE States, with a number of groundnut cultivars sown at different row spacings (30, 40, 50 or 60 cm), the optimum spacing has been workout to be 40 x 10 cm for bunch groundnut and 60 x 10 cm for semi-spreading and spreading groundnut during rainy seasons and 30 x 10 cm for bunch groundnut and 60 x 10 cm for semi-spreading and spreading during rabi and summer season. (Dwivedi & Gautam, 1992; Munda & Patel, 1989; Munda et al, 1997)

4.2.3. Weed management

North-eastern region, being a high rainfall area, the weed infestation is a severe problem of the groundnut during kharif season. However, during rabi/summer season there are lesser weeds. The dominating weeds in these region are *Digitaria marginata, Panicum repens, Bidens pilosa, Eleusine indica, Galinsoga parviflora, Ageratum conyzoides, Boerria hispida* and *Ambrossia artemissifolia* L.

Removal of these weeds by hand weeding up to 60 DAS reduced the weed and resulted in the highest net returns. Several combinations of hand weeding, herbicides (pendimethalin and butachlor) and mechanical weeding were compared where two hand-weeding, and pendimethalin (@ 1 kg ha^{-1}) with one hand-weeding at 40 DAS, were found equally effective in reducing weed population, and increased pod yield of groundnut to 2.49 and 2.36 t ha^{-1}, respectively, as compared with 0.71 t ha^{-1} in un-weeded controls (Singh et al 1996). In another experiment on various integrated approaches of weed control in groundnut, in NEH region, pendimethalin at 1.0 kg a.i. ha^{-1} + one hand weeding at 50 DAS was most effective and ranked next to the maintenance of complete weed free crop by hand weeding twice at 25 and 50 DAS (Hazarika, 1993). Pendimethalin controlled all categories of weeds and produced 2240 kg ha^{-1} pod yield. The maximum net return of (Rs 17,540 ha^{-1}) was obtained by application of 1 kg ha^{-1} pendimethalin + one hand weeding, followed by 1 kg ha^{-1} butachlor + one hand weeding (Rs 16, 790 ha^{-1}) both of which are recommended (Hazarika, 1993; Singh & Hazarika, 1995).

4.2.4. Fertilizers and Nutrient managements

Liming and Ca fertilizers

Due to high rainfall and leaching, most of the soils in the NE states are acidic in reaction with low base and cation exchange capacity (CEC) and poor fertility (Fig. 8). To bring the acid soil to neutral and productive it require liming as liming increases mineralization of soil nutrients (Singh, 2000). The Lime requirements (LR) of NEH states, varies from 3.2-27.2 t ha^{-1} depending upon the texture, pH and organic matter content, however, application of lime equivalent to 25 % (2 t ha^{-1}) of LR was good enough (NRCG 2000, Raychaudhuri et al, 2003). A good soil has about 75 % Ca saturation, 10 % Mg saturation and 2.5-5.0 % K saturation. The critical limit of exchangeable Ca^{2+} is 1.5 meq 100 g^{-1} soil and Mg^{2+} is 0.5 meq 100 g^{-1} soil, for groundnut (Singh 1999). The Mg deficient soil has less than 4 % Mg saturation. The critical level of available K in soil is 108 kg ha^{-1}.

Liming is more economical and easy to adopt by farmers and in case of groundnut return per rupee invested on lime is twice when applied as fertilizer in furrows. The $CaCO_3$ at 1/4 of LR applied in rhizosphere at sowing was at par with surface application of full LR for groundnut. The effects of $CaCO_3$ and gypsum on groundnut yields and on soil physical properties were studied where both $CaCO_3$ and gypsum increased yield and exchangeable Ca, but the pH was increased due to $CaCO_3$ only. The liming increases solubility of Fe and Al phosphates and helps to retain phosphates in Ca-phosphates form. In NEH, calcium carbonate is present in Dimapur and near Cherrapunji area which has to be mined and used for groundnut. Besides lime, the press mud from sugar factory and basic slag from paper and other factories are the other liming material. The paper corporation of India, Nogon paper mill in Assam, and sugar mills in Assam and Mizoram produce a lot of Ca rich material and the same could be used in place of lime. The sludge of paper mill contains 60-80% $CaCO_3$ depending upon the period of exposure to the atmosphere after removal from sludge tank. Application of lime stone powder (2.5 t ha^{-1}) and lime sludge 1.25 t ha^{-1} raised the yield of groundnut by 1710 and 1890 kg ha^{-1}, respectively in soil pH 5.5. Some of them are sold as IRL-clay conditioner, Bhushakti and Tata slag powder. Press-mud, a waste product of sugarcane mill possessing nearly 13 % organic matter and 42 % Ca, was an effective source of ameliorant. Basic slag applied on the basis of LR doses, contains as much P_2O_5 as SSP. The lime should be fine enough to pass 10 mesh sieve, but for basic slag the recommended size is 30-40 meshes. The effectiveness of basic slag, lime sludge and dolomite are rated to be 111%, 108% and 98% as against 100% for limestone with groundnut and pulse crops.

Application of lime at ¼ th of LR (2000-2500 kg ha^{-1} CaCO3 or equivalent paper mill sludge) in furrows every alternate year sustains the productivity of rice-groundnut system. In a collaborative trials, application of 2-2.5 t ha^{-1} lime was beneficial and increased upto 50 % yield of groundnut (Fig. 9-10) (NRCG, 2001, 2002). The cropping pattern needs to be adjusted in the wake of liming to realize maximum benefit. The deciduous tree species (teak, mahua, grass root) have high Ca and hence they can be used as mulch in acid soil.

Nitrogen, phosphorus and potassium fertilizers

Though nitrogen requirement of groundnut is much higher (150-200 kg ha^{-1}) than cereals because of its high protein content, it is capable of meeting 60-80% nitrogen requirements from symbiotic nitrogen fixation by root nodules and only 20-40% by soil nitrogen. The Spanish and Valencia bunch groundnut, because of lesser crop duration and nitrogen fixation respond more to nitrogen than the Virginia. The Native *Bradyrhizobium* is not abundant to fix adequate N at most of the places in NE states thus inoculation with *Bradyrhizobium* is must to meet the nitrogen requirement. Though it fixes atmospheric nitrogen to meet the

N requirement, the nitrogen supply to groundnut is very crucial and deficiency is observed in between 10-45 DAE and at pod formation stages. During reproductive stage, N is mobilized continuously from leaves to the developing pods and hence deficiency may occur at this stage too. For these reasons 30-40 kg ha^{-1} of the nitrogen should be supplied externally through any available N sources half at the start of the crop cultivation and half at the time of pod filling as booster (Singh 1999). However, in the highly eroded soils of Mizoram and Tripura where the groundnut is being grown first time and *Bradyrrhizobium* inoculum is not there, highest pod yield was recorded with 80 kg N ha^{-1} (Laxminarayana, 2001).

Phosphorus and potassium fertilizer is most important in groundnut as it promotes root growth, multiplication of *Bradyrrhizobium,* helps the crop to tide over the moisture stress and finally enhance pod filling and yield. The critical P level for groundnut in acid Alfisols of NE States are 6.5 ppm available P in soils and 0.17% in shoots (Singh et al, 1999). Application of P and K increased pod yield, shelling percentage and N, P and K uptake. Looking to the high P requirement of groundnut and its low availability in acid soil of NE region a series of experiments were conducted and the single super phosphate (SSP) and rock phosphate were recommended as the source of phosphorus.

Experimental results revealed that responses up to 90 kg P_2O_5 ha^{-1} as SSP and 75 kg K_2O ha^{-1} as MOP enhanced pod yield of groundnut, but the optimum economic dose was 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} in most of the NE states (Munda et al, 1997). In NE region, where soil is strongly acidic below 4.5 pH and P content is very low, single super phosphate (SSP) when used, majority of its water soluble P is fixed to unavailable form. But, this soil acidity on the other hand helps the release of phosphate from RP. Thus, to keep the amount of readily available form of P, blending of these two, as shown below, depending upon soil acidity is beneficial.

Soil acidity pH	Rock phosphate (RP)	SSP
4.0-5.0	90%	10%
5.1-6.0	80%	20%
6.1-7.0	50%	50%

Optimum time of application of RP is 3-4 weeks before sowing. It is desirable to use ground rock phosphate with particle size of 60-100 mesh. Accordingly several experiments were conducted to find a solution to use cheap source of phosphorus like insoluble rock phosphate (Mussorie RP, Udaipur RP) and a mixture of RP and SPP at 3:1 was best. However, in an experiment rock phosphate (RP) and SSP at 60 kg P_2O_5 ha^{-1} along with 20 kg N ha^{-1} + 40 kg K_2O ha^{-1} showed similar results (Table7).

Table 7. Pod yield of groundnut cv. ICGS 44 as influenced by various sources of phosphatic fertilizers in Meghalaya (Source: Munda *et al* 1997)

Sources of phosphatic fertilizer	Pod yield (kg ha^{-1})
Control	1880
FYM 10 t ha-1	2492
Enriched *FYM 5 t ha^{-1}	2658
Enriched* FYM 10 t ha^{-1}	2792
Rock phosphate @ 60 kg P_2O_5 ha^{-1}	2242
SSP @ 60 kg P_2O_5 ha^{-1}	2317
Rock phosphate @ 60 kg P_2O_5 ha^{-1} + 20 kg N + 40 kg K_2O ha^{-1}	2767
SSP @ 60 kg P_2O_5 ha^{-1} + 20 kg N + 40 kg K_2O ha^{-1}	2733

* FYM + Rock phosphate @ 60 kg P_2O_5 ha^{-1} incubated for a period of 25-30 days

Sulphur and micronutrients

Study, indicated that by and large 30 kg S ha^{-1} proved to be optimum as single super phosphate, elemental sulphur, gypsum, SSP or ammonium sulphate in NE states where increase in pod and haulm yields, protein index and S uptake was observed. The residual sulphur in soil after the harvest of groundnut crop was more in the treatment receiving elemental sulphur, due to the fact that reduced form of sulphur present in elemental sulphur requires more time for oxidation to transform into sulphate form.

Acid soils are deficient in B and Mo. The high rainfall and hilly topography leach down these micronutrients causing low availability. Response to Zn, B and Mo showed that pod and haulm yields increased by application of 12.5 kg $ZnSO_4$ ha^{-1} over control. Seed dressing with 0.5-1.0 kg ha^{-1} ammonium molybdate is advisable. Soil application of borax at 1 kg B ha^{-1} (5 kg borax ha^{-1}) corrects B deficiency and increased pod yield.

4.2.5. Biofertilizers and Integrated nutrient management

As groundnut cultivation is new in NE states an excellent response of *Bradyrhizobium* and PSM was observed in groundnut in all these states, with phosphatic fertilizer and lime (Fig. 11). However, their effect was only marginal without P and Ca. The soil amelioration with lime and P increased the productivity of groundnut. The groundnut crop inoculated with PSM and *Bradyrhizobium* showed green canopy but the crop without *Bradyrhizobium* and PSM showed stunted growth with chlorotic leaves, poor nodulation and N and P deficiency symptoms.

The integrated use of both organic and inorganic fertilizers enhances the crop yields and sustains the soil fertility and productivity of groundnut. Experimental results revealed that application of various organic manures (FYM, poultry manure and pig manure) increased the pod yield over the optimum dose of NPK fertilizers in NE States. In poor fertility soil of Mizoram the NPK in combination with different organic manures (farm yard manure, poultry manure and pig manure) showed that the pod yield increased with the increasing NPK doses up to 80-60-40 kg ha^{-1} and highest yield of 2225 kg ha^{-1} was recorded with the integration of NPK (80-60-40 kg N, P_2O_5 and K_2O ha^{-1}) + FYM @ 15 t ha^{-1} (Laxminarayana, 2001). Higher response due to organic manures amended P fertilizer was attributed to the formation or organo-metalo complex with organic lignin which decrease their susceptibility to absorption, fixation or precipitation reactions in soil and thus forming soluble complex with native as well as applied P, Ca, Mg, K etc. In Barapani, *Azolla* compost @ 10 t ha^{-1} enriched with rock-phosphate (60 kg P_2O_5/ha) gave higher pod yields (Saxena et al, 2001).

4.2.6. Results of collaborative experiments on INM

The collaborative experiments on integrated nutrient management were conducted at Imphal (Manipur), Tripura and Barapani (Meghalaya) to compare the effects of inorganic nutrients (P, K, Ca) and biofertilizers (*Bradyrhizobium* and PSM) and their interactions in acid soils where in general very good response of *Bradyrhizobium* and PSM was noted with phosphatic fertilizer and lime (Table 8 and 9) (Fig. 12).

Table 8. Influence of biofertilizers, organic and inorganic fertilizers on the pod yield of groundnut variety ICGS 76 at Barapani during 1998 kharif

Symbol	Treatments	Yield (kg/ha) Pod	% increase over control
T1	Control (no fertilizer)	1530	
T2	FYM (10 t/ha)	2800	82.4
T3	N K (20: 40)	1680	9.8
T4	NPK (20:60:40)	2310	51.0
T5	T4 + PSM (*Bacillus polymyxa*)	1500	-
T6	T4 + PSM (*Pseudomonas striata*)	1680	9.8
T7	T4 + PSM (*B. circulans*)	1980	29.4
T8	T4+ *Bradyrhizobium* (IGR 6)	2170	41.8
T9	T4+ *Bradyrhizobium* (IGR 40)	1800	17.6
T10	T4+ *Bradyrhizobium* (TAL 1000)	2430	58.8
T11	T4+ *Bradyrhizobium* (NC 92)	2700	76.5
	Mean	2054	
	LSD (0.05)	710	

Table 9. Effect of various INM components on the pod yield of groundnut variety ICGS 76 at Barapani during Kharif 1999.

Treatment	Pod yield (kg/ha)	% increase over control
Control	1400	
FYM @ 10 t ha^{-1}	2150	53.6
NK 20:40 (kg ha^{-1})	1825	30.4
NPK 20:60:40 (kg ha^{-1})	2050	46.4
B. circulans+ NPK 20:60:40Kg ha^{-1}	1930	37.9
IRG 40 + NPK 20:60: 40 kg ha^{-1}	2178	60.7
P. striata +NPK 20:60:40 kg ha^{-1}	2180	55.7
B. polymyxa +NPK 20:60:40	2200	57.1
Mean	1989	
LSD (0.05)	476	

At Tripura, application of lime + P + *Bradyrhizobium* and lime + P + PSM could increase 40 and 50 % pod yield, respectively. At Barapani, maximum pod yield (2700 kg ha^{-1}) was obtained by inoculation of NC 92 + NPK (20:60:40) against 1500 kg/ha of the control and 2310 kg ha^{-1} with NPK during 1998, however during 1999 inoculation with IGR 40, *P. striata* and *B. polymyxa* along with NPK Showed similar response (NRCG, 2000, 2001). At Manipur, liming @ 2t ha^{-1} alone increased the pod yield by 25% over no lime. The combined application of P (50 kg ha^{-1}) + *Bradyrhizobium* + PSM showed maximum pod yield (67% more over control) followed by P (50 kg ha^{-1}) + *Bradyrhizobium* (51%) and (50 kg ha^{-1}) + PSM (49%) (Table 10). Interestingly the *Bradyrhizobium* + PSM also increased 42% pod yield over control indicating the potentials of these biofertilizers (NRCG, 2001, 2002).

Table 10. Effect of various INM components on groundnut at Manipur during 2000

Treatment	Pod yield (kg ha^{-1}) Lo	L2	Mean	% increase over control
Control (without P, K and biofertilizers)	840	1130	990	
Bradyrhizobium	960	1230	1090	10.1
PSM *(B. polymyxa)*	850	1320	1150	16.1
Bradyrhizobium + PSM	1170	1650	1410	42.4
P50	1110	1430	1270	28.3
P50+ *Bradyrhizobium*	1460	1520	1490	50.5
P50+ PSM	1380	1560	1470	48.5
P50 + *Bradyrhizobium* + PSM	1470	1850	1650	66.6
Mean	1160	1450		
LSD (0.05)				
Lime (L)		214		
Fertilizer (F)		440		
Interactions (LxF)		NS		

Where L0 and L2 are control and 2 t ha^{-1} lime

Thus, based on the three years of study, it can be concluded that Ca and P are the key nutrients for growing groundnut in acid soils and an INM practice including application of lime (2.5 t ha^{-1}) or FYM (10 t ha^{-1}), half NPK doses and inoculation of PSM and *Bradyrhizobium* is being recommended for harvesting a good crop in NEH Region.

4.2.7. Cropping system research

In this approach two to three crops are grown in sequence or as intercrop. In crop sequence a crop, which is highly responsive to liming and tolerant of soil acidity, is included as a first crop in rotation. Rice is a main component of acid soil cropping system. Groundnut very much fit in the system as second crop as it is medium response. The profitable crop sequences and intercrops are given below which may be adopted in NE states.

Crop sequences	Intercropping
Rice-groundnut	Rice + Groundnut (4:2)
Rice-potato-groundnut	Groundnut + Maize (1:1)
Rice mustard-groundnut	Groundnut + Pigeon pea (5:1)
Maize - groundnut	Groundnut + Chili (2:2)
	Groundnut + Citrus
	Groundnut + Pineapple

To increase the cropping intensity and productivity, which is comparatively low in north eastern region, groundnut can be successfully adapted as a companion crop with upland rice and maize (Fig. 13). Experiments on cropping systems to study the cropping intensity and productivity of individual crop were worked out and acceptable cropping systems were evaluated at ICAR Res. Complex, Barapani, Meghalaya where cropping intensity upto 300% with higher productivity was possible with fodder maize followed by rice + groundnut and mustard cropping systems in terms of net economic return. The cropping system containing maize for green cobs followed by groundnut and mustard was found profitable (Table 11).

Table 11. Cropping systems, maize equivalent yield and economic return

Cropping systems	Total yield (Kg ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs ha^{-1})
Rice	2100	6300	765
Rice + Groundnut	2280	8760	2695
Maize	2549	6373	344
Maize + Groundnut	2660	10205	2840
Sunflower	625	4375	-1510
Sunflower + Groundnut	1385	9695	5430

The short duration semi-dwarf rice, maize, pigeon pea (ICPL 87, 105) and groundnut varieties may be promising for intercropping. The groundnut varieties identified for intercropping systems are JL 24, Girnar 1, ICGS 76 and ICGS 44. Adoption of sequential cropping with rice some times involves risk of partial or complete failure of groundnut crop grown after rice. Thus, improvement of soil health through incorporation of a crop residue or FYM is essential before taking groundnut crop.

4.2.8. Irrigation and drainage

The kharif crop in NE states is mainly rainfed, hence it requires occasional life saving irrigation, the rabi crop is grown either on residual moisture with life saving irrigation or under totally irrigated condition depending upon the situations and availability of moisture and irrigation. However, the summer crop is totally irrigated except of a few riverbeds, which sustain on residual moisture and with one or two life saving irrigation can yield high. As the rainfall is adequate for kharif and rabi seasons, generally irrigation is not required for groundnut in NE states, but in dry years irrigations at pre-sowing, pegging and pod formation are recommended. However, due to high rainfall drainage is essential in NE states and to maintain a good crop and avoid damage to root system, it is generally grown on ridge and furrow system. Groundnut (cv. JL-24) with bunding produced the highest yields.

4.2.9. Polythene mulch technology

The role of polythene mulch technology was studied in Manipur, Meghalaya and Assam during rabi season where crop face winter and temperature goes below 15°C most of the time. In Manipur, the groundnut cultivar JL 24 produced higher pod yield (2193 kg ha^{-1}) with polythene mulch in flat bed and broad bed furrow (BBF) system of sowing (1592 kg ha^{-1}) over unmulched condition which produced only 263 kg ha^{-1} and 175 kg ha^{-1}, respectively. (Sanjeev Kumar et al, 1999) Germination was recorded 10-12 days earlier while maturity was delayed by 10-14 days under polythene mulch condition. Polythene mulch had shown better soil-moisture conservation and temperature balance capacity in soil, which resulted in higher number of branches, number and weight of pods, kernel weight and thus higher pod yield. Groundnut cultivation on polythene covered raised bed system has been shown at Barapani during Rabi season where at initial stage of crop there is no weed (Fig. 14). Thus, it is apparent to use polythene mulch for rabi groundnut under rain fed condition of Manipur to achieve higher yield per unit area.

In field experiment, as rainfed crop, during 1997 to 1999 rabi season at ICAR Research Complex for NEH Region, Manipur Centre, Imphal the polythene mulch in Flat bed and Broad-bed furrow (BBF) system of sowing produced 2181 kg and 1618 kg pod yield ha^{-1} of JL 24 as compared to 1063 kg and 875 kg pod yield ha^{-1} in unmulched condition, respectively. The accumulated temperature by polymulch was 3.7°C higher from 0600-1400 hrs but little lower at 1400-2000 hrs; and wind speed in groundnut rows was faster by 0.01-0.03 ms^{-1} as compared to non-mulched plots. Faster wind speed favoured air exchange and CO_2 movement and all these interlinked factors increased NAR and photosynthetic efficiency of poly-mulched groundnut (Sanjeev Kumar et al, 2001).

4.2.10. Organic farming and amelioration of Al-toxicity

In hill agricultural, as because of low organic carbon the traditional farmers prefer shifting cultivation, the role of organic carbon is the most important. Though most of hill soils are rich in organic carbon, in permanent fields and terrace cropping no organic matter is added resulting in high hematite and soil compactness. As humic and other organic acids immobilize Al^{3+} ions by forming chelates, the harmful effect of this can be largely prevented by raising the organic content of the soil. Looking to the importance of organic matter, through collaborative experiments, various organic farming approaches were tested for organic matter enrichment as well as for amelioration of Al-toxicity in NE states. In Manipur, with TG 22 groundnut variety organic fertilizers showed its superiority over inorganic one and FYM (at 10 t ha^{-1}) alone doubled the productivity (Table 12). Application of Mustard cake (at 1 t ha^{-1}) increased 51 % pod yield over control, but when it was combined with *Bradyrhizobium,* it could increase 102 % pod yield over control. However, application of NPK (30:50:40 kg ha^{-1}) fertilizers showed 46 % increase in pod yield over control (NRCG, 2001, 2002).

Table 12. Experiments on organic farming at Manipur during 2000

S.N.	Treatments	Pod Yield (kg/ha)	% increase over control
1.	Control	950	
2.	$N_{30}P_{50}K_{40}$	1390	46.3
3.	T2 + lime (2 t ha^{-1})	1370	44.2
4.	FYM (10 t ha^{-1})	1900	100
5.	Mustard cake (1 t ha^{-1})	1430	50.5
6.	FYM+ *Bradyrhizobium*	1630	71.6
7.	Mustard cake + *Bradyrhizobium*	1920	102.0
	LSD (0.05)	355	

Table 13. Soil amelioration of Al-toxicity in groundnut variety ICGS 76, at Barapani during kharif season (Results of NRCG-ICAR Res complex Collaborative trial).

	Treatments	Pod Yield (kg ha^{-1}) 1998	1999	2000
T1	Control (no fertilizer)	1550	1625	1080
T2	FYM (10 t ha^{-1})	1983	2125	2163
T3	NPK (20:60:40 kg ha^{-1})	2022	2150	2123
T4.	Lime (2 t ha^{-1})	2261	2271	1420
T5	T2 + T4 (10 t ha^{-1} FYM + 2 t ha^{-1} Lime)	2100	2500	1747
T6	T3 + T4	2344	2950	1663
T7	T2 + T3 + T4	2021	3250	2290
	LSD (0.05)	238	225	320

The ameliorative role of lime and FYM was noticed in the experiments conducted at Barapani to overcome the Al-toxicity (Table 13). Addition of 10 t ha^{-1} FYM alone increased pod yield varying from 28-100%. Addition of 2.0 t ha^{-1} of lime, on the other hand, increased 31-46%, and NPK (20:60:40 kg ha^{-1}) increased 30-97% pod yield over control. In Manipur, soil pH increased from 4.9 to 5.6 by liming, exchangeable Ca + Mg increased by lime and lime + FYM whereas exchangeable Al was drastically reduced by lime, FYM and lime + FYM application. However, exchangeable K was not affected by lime or FYM treatments. NPK levels did not show any effect on pH, exchangeable K, Al and Ca+Mg.

The three years of collaborative study revealed that soil acidity and Al-toxicity induced P-deficiency (stunted growth, lower leaves with green-violet coloration) and Ca-deficiency (stunted growth, under developed upper leaves, chlorotic, small with rusty spots and not in proper shape) occur in groundnut in NEH region (Singh et al, 2001). Severe acidity and Al-toxicity caused seedling mortality that resulted in very poor yield (only 388 kg ha^{-1} pod). Application of lime and FYM increased the nutrient contents particularly of Ca and P in the plant facing Al-toxicity and increased growth and yield thus ameliorating the Al-toxicity and any one of these could be used. Nutrient use is less in NE region, so of pesticides and as such it is more or less of organic type of farming which is most suitable system of the region. Though the soils of the NE states are rich in organic matter, it is depleting fast and may pose problem in future.

4.3. Diseases and pest management

4.3.1. Diseases and their control

Due to low temperature there is less pressure of disease in the NE region, but due to high rainfall and humidity during kharif season whenever the temperature goes high, the development of foliar diseases occur in groundnut and some time it is devastating too. During rabi and summer groundnut, there is less disease. The pressure of disease is more in valley and tropical region than in hills in NE states mainly due to high temperature.

The early leaf spot (ELS) by *Cercospora arachidicola,* late leaf spot (LLS) by *Phaeoisariposis personata* and rust by *Puccina arachidis* are the major foliar diseases of groundnut occurring in NE states. The other diseases occurring in NE states are bacterial wilt by *Pseudomonas solanacearum* Smith, stem rot by *Sclerotium rolfsii Saccardo* and Alternaria leaf spot by *Alternaria sp.* Among all ELS also known as 'Tikka' is most devastating causing some times more than 50 % leaf area damage, whereas others cause non-significant damage. For the effective control of these diseases, the Derosal and Bavistin were found most effective, however for controlling leaf spot, a fungicide mixture of carbendazim 0.05% + mancozeb 0.2% was useful and sprayed up to 50 DAS gave maximum returns with benefit cost ratio of 4.1 to 8.1 (Chandra et al, 1994, 1995; Dubey et at, 1995; Singh 1993).

The sowing dates also affected the spread of leaf spots and rusts. In Assam, crop showed least incidence of these diseases and highest pod yield when planted on May 5, but the late sown crop, of June 24 and July 4, recorded the highest incidence of leaf spots and rust and least yield (Hazarika et al, 2000). In Manipur, the early and late leaf spots are best avoided by early sowing in April and early May, but after that the chemical control becomes necessary (Gupta, 1985, 1986).

4.3.2. Screening for disease resistance

About five hundred groundnut genotypes were screened against the leaf spot and rust under natural epiphytotic infection conditions on 1 (resistant) to 9 (susceptible) scale where different disease reaction was observed by various workers (Chandra et al, 1992; Chaudhary, 1988; Dubey et al, 1995; Gupta 1987) who found following genotypes as tolerant, but none resistant to both the diseases and categorized these as:

- Resistant to ELS: ISKO 8824, 8801, NRCG 1186, 1371, 6953, ISK 9001, 8916, ICGV 86302, 86707, ASK 8916, bunch NRCG accessions 512, 580, 4415, 4632 and 5953 and spreading genotypes ICGS 76 and NRCG 6428
- High yielding resistant lines: ICGV 86687, ICGV 86675, ICGV 86680 and ICGV 86694
- Genotypes ICGV 86020, ICGV 86680 and ICGV 87350 were stable and

promising for low disease reaction under varying environmental conditions.

- Significant genotype x environmental interaction (G x E) was observed for disease reaction. Both linear and non-linear components of G x E were significant and regression less than 1 and non-significant S_2 values in different years.

The reaction of groundnut genotypes to foliar fungal diseases based on field screening (1-9 scale) at Barapani, Imphal and Tura is given in Table 14.

4.3.3. Pest management

Being a high rainfall area the NE states in-compass a large number of insects and pests in succession during the crop-growing season. The green patch and forest around also provide food and shelter to various insects. As a result many new pests are being reported in the NE states which otherwise are not the regular pests of groundnut. Like disease, the insect pest infestation is more during kharif than rabi and summer seasons. Groundnut is infested by a number of insect pests, however, the major insects are leaf folder (*Nacclea vulgaris*), leaf miner (*stomepteryx subsivell Aproraemid modicella*), red hairy caterpillar (*Amsacta moori* and *A. albistriga*), leaf hopper (*Empoasca* sp.), flower beetles (*Hylabris pustulata*), white root grubs (*Holotrichia consomoina*), termites (*Odonototermis* sp), pod borers (*Euborellia stalli, E. annulipes*), and mealy bugs (Das & Ray, 1988, Gangwar et al, 1994; Munda et al, 1997; Shashikumar & Sardana, 1990).

The succession study showed that initially jassids were observed from first week of June and was serious pest upto August, simultaneously *Opicauta* beetles a defoliator attack the plant, later on leaf miner, leaf folder incidence started and continued till maturity. During flowering, *M. pustulate* population was very high. Though studies on the assessment of crop losses due to insect pest is essential to determine the threshhold for their control, systematic studies on these aspects are lacking in NE states. However, avoidable loss of 16-19% is reported from leaf folder, 12-15% of pod damage from root grubs, 30% of the crops was found attacked by mealy bugs in NE regions. The damage by white grub was recorded to the tune of 15%. White fly, field cricket and cutworm are the other insect causing considerable losses in yield.

Table. 14. Disease reaction of groundnut cultivars grown at various places in NEH region during Kharif 1998

Genotypes	Resistance to foiler diseases		
	ELS	LLS	Rust
ICGS 11	M	R	R
ICGS 44	M	M	M
ICGS 76	R	R	R
ICGV 86590	R	R	R
TG 26	M	M	M
TAG 24	M	M	M
TKG 19A	M	M	R
TGS 1	M	M	M
OG 52-1	M	M	R
Girnar 1	M	M	R
VRI 2	M	M	R
VRI 3	M	S	R
ALR 2	S	S	R
JL 24	S	S	M
Gangapuri	S	S	R
TG 22	M	R	R
DRG 12	R	R	R
HPS 9701	R	R	R
HPS 9702	R	R	R
HPS 9703	R	R	R
HPS 9704	R	R	R
HPS 9705	R	R	R
HPS 9706	M	R	R
BAU 13	M	R	R

Where R is resistant, M is moderate and S is sensitive to ELS (early leaf spot), LLS (Late leaf spot) and Rust on 1-9 scale. Data are average of observations at Imphal, Barapani and Tura in NE States.

Insecticide evaluation in NE states has shown that Decamethrin and Monocrotophos are effective against leaf folders, leaf miners and white fly, resulting in high pod yield. The thrips infestation and collar rot of groundnut are reduced by decis (0.003%) spray and bavistin seed treatment. For leaf eating pests carbaryl (0.1%) and for sucking pests monocrotophos, quinolphos, and methyl parathion all at 0.05% was most appropriate killing 100% population within 36 hrs of spray. Use of aldicarb was most effective against pod borers and soil pests. Root grub can be controlled by applying 40 kg ha^{-1} BHC (2% at the time of sowing) or carbofuran (1.5 kg a.i. ha^{-1}) during attack.

4.4. Economics of groundnut cultivation in NE states

The productivity and economics of different cropping systems were assessed by Munda et al (1997, 1999) in the mid altitude (950-1080 m msl) rainfed dry terraces of Meghalaya where maize (grown for green cobs)-groundnut-*Brassica juncea* cropping system gave the highest net returns and maize equivalent yield of 11.89 t ha^{-1}. Groundnuts were the most profitable crop, while maize grown for grain, sunflowers grown as a pure stand; rice and *B. juncea* gave poor economic returns. The estimated cost of cultivation and net return from pure groundnut crop as predicted by the authors is given in Table 15 for NE and eastern states.

The production technology for kharif season is cheap in most of the places in the NE region, however in recent year, the rabi-summer groundnut technologies have been proved to have better potential on the farmers' field in some areas than kharif. Though the crop is yet to make any dent in the agrarian sector of the NE states, the farmers have harvested good yield by adopting new technologies for rabi-summer.

Table 15. Estimated cost of cultivation of groundnut and net economic return in eastern and NE region for production of 1500 kg ha^{-1} pod yield during kharif season.

Operational cost of groundnut cultivation	NE region (Rs ha^{-1})	Eastern region (Rs ha^{-1})
1. Field preparation (up to sowing)	3000	2000
2. Cost of interculture operation and plant protection weeding twice (20 labourers), pesticides, application (Two labours) @ Rs. 70 per labour day^{-1} (*labour is cheaper in Eastern region)	2500	2000
3. Harvesting and drying (20 labourers)	1400	1000
4. Cost of input		
i. Seed (groundnut) 110 kg kernel ha^{-1} @ Rs. 40 kg^{-1} seed	4400	4000
ii. Fertilizers N_{20} P_{60} K_{30} and pesticides	1000	1000
Total cost	12,300	10,000
Total return (Rs. ha^{-1}) for 1500 kg pod yield and produced is sold @ Rs 20 kg^{-1} pod	30,000	30,000
Net economic return (Total return cost of cultivation)	17,700	20,000

5. Package of Practices for Good Harvest of Groundnut in NE States

Specific package of practices are required for a good harvest of groundnut in NE states. To develop package of practices for north eastern states of India, the Assam Agricultural University, Jorhat, ICAR Research Complex for NEH regions in Meghalaya, Manipur, Tripura, Mizoram, Nagaland, Sikkim and Arunachal Pradesh in collaboration with National Research Centre for Groundnut (NRCG), Junagadh and All India Coordinated Research Project on Groundnut (AICRPG) conducted field experiments on the varietal selection, INM, optimum agronomy and plant protection and IPM required for realizing maximum yield. Also, as the crop is new in NE states, being a non-traditional areas, the production technologies are being refined time and again and based on the recent informations available the following package of practices are being recommended. Since, the yields at farmer level are less than the one observed at the research stations, the farmers of the region should follow these practices.

Soils and land preparations

Though, groundnut can be grown at all sites of NE states, the crop does best on well drained, light textured loose and friable soil, having reasonably high calcium, pH 5.5 to 7.0, and a moderate organic matter. Soils having pH less than 5.5 need to be corrected by furrow application of 2 t ha^{-1} lime. Make good tilth of soil with two ploughing to obtain optimum germination. In terrace and flat lands of high rainfall areas, raised beds of 10-15 cm height are to be prepared to avoid water logging problems.

Varieties

- Kharif season : ICGS 76, ICGS 44, ICGV 86590, TKG 19A, OG 52-1, and Girnar 1
- Rabi season : ICGS 76, OG 52-1, ICGS 44 and Girnar 1

Seed quality and treatment

Select good quality pod, shell them manually or by using hand decorticator just before sowing as the viability in the stored kernel deteriorates fast and also there is a problem of storage pests attack on seeds. There is no need to select for larger seed, however, the seed must be tested for their germination and should be treated with Thiram @ 3 g kg^{-1} seed or Bavistin @ 2 g kg^{-1} seed before sowing to control collar rot and other seed born diseases.

Sowing time

Sowing should be done in furrows with depth of 2-5 cm below soil. The optimum time of sowing for groundnut for different situations are :

Situations	Sowing time
Kharif	15th May- 15th June
Rabi residual (River bed/ rice fallow)	15th September to 15th October with polythene or straw mulching
Summer (Irrigated)	15th January to 15th February

Seed rates and spacings

Maintenance of optimum population and spacing by using of optimum seed rate is the key to success in groundnut cultivation. As the seed rate depends upon the seed weight of the cultivars and spacings, the recommended seed rate for different botanical type groundnut and seasons are given below:

Botanical types	Seasons	Spacing (Row x Plant cm.)	Seed rate (kg ha^{-1})
Bunch type	Rabi	30 x 10	100-120
Bunch type	Kharif	40 x 10	90-110
Semi-spreading type	Kharif / Rabi	45 x 10 or 30 x 15	90-100
Spreadings	Kharif/ Rabi	60 x 10	90-100

Fertilizers and manures

In general, for obtaining high yield of groundnut, application of well-decomposed 5-10 t ha^{-1} FYM followed by 40 kg N (urea or ammonium sulphate), 60 kg P_2O_5 as single super phosphate, and 40 kg K_2O ha^{-1} as muriate of potash is recommended. All these amount of N, P K should be placed in the furrows below the seed at sowing. Acid soils are deficient in Ca, S and Mg, however, calcium requirement of groundnut is quite high mostly during pod filling stage. Furrow application of lime at ¼ to 1/3 LR or 2 t ha^{-1} as $CaCO_3$ or $CaSO_4$ every year is recommended. Gypsum at 500 kg ha^{-1} at the time of flowering should be applied to supply Ca and S to groundnut. Soil application of 10 kg Mg as $MgSO_4$ corrects Mg deficiency.

Biofertilizers

As the groundnut cultivation in NE region is new, biofertilizers inoculation with nitrogen fixing *Bradyrhizobium* and phosphorus solubilizing microbe (PSM) is essential to save the chemical fertilizer and effective use of P fertilizers. These biofertilizer packets are available with the regional office of the biofertilizer board situated in Imphal.

Weed control and irrigation

Keep the crop weed free up to 60 days after sowing (DAS), as the maximum damage is caused during this period. One weeding and hoeing or earthing up of soil at 25 DAS followed by one hand weeding at 40 DAS found to be effective and economical. Application of 1 kg ha^{-1} pendimethalin or butachlor at the time of sowing + one hand weeding, at 40-50 DAS was best.

Generally there is no moisture stress during kharif season. However, during rabi and summer season crop, life saving irrigation at pegging and podding stage is required, if there is no rain during these stages.

Intercropping and crop rotation

Groundnut can also be intercropped with base crop like maize in 2:2 rows ratio and upland rice (4:2 rows ratio). Kharif groundnut can be grown year after year under rainfed condition. However, generally mustard and potato is followed in rabi season. The other profitable intercropping and crop sequences for NEH region are as follows:

- Groundnut -Mustard
- Groundnut -Radish
- Groundnut -Potato
- Maize + Groundnut (2:2) Mustard
- Maize + Groundnut (2:2) Radish
- Upland rice + Groundnut (4:2)- Mustard
- Upland rice + Groundnut (4:2) -Radish

Disease management

Dark spot surrounded by a bright-yellow ring on the leaves followed by pre-mature leaf shading is the typical symptom of Tikka. Spraying Bavistin 0.05% (1.0 g Bavistin 50 WP liter^{-1} water) + Dithane M 45, 0.2% (2.0 g Dithane M 45 liter^{-1} water) at 2-3 weeks interval for 2-3 times starting 4-5 weeks after sowing control the same.

A white weft or mycelium appears at the base of the affected plants, known as color rot in which plant turn yellow and dry up. To avoid these, treat the seed with Thiram @ 3 g kg^{-1} seed or Bavistin 2 g kg^{-1} seed before sowing.

Insects-pests and their management

The Aphids (Nymph and adults) suck the sap from the leaves and other tender parts and also act as vectors of virus diseases (rosette). Highly infected leaves turn yellow and fall down. The jassids are green soft-bodied insects, the adults and nymphs of which suck the sap from the leaves and other parts turning the leaf yellowish, cut and dry up. Thrips are polyphagus, the nymph and adults of which lacerate the leaves and tender growing parts, causing white silvery sheens. Spray of Monocrotophos 0.05% (1.4 ml Monocil 35 EC per liter water) or Dimethoate 0.05% (1.7 ml Rogar 30 EC per liter water) control all these.

Leaf miner is the small dark brown moths with conspicuous small pale-white spots on the interior margins of the forewings, the smooth greenish caterpillars of which mines the tender leaves and later on fold the adjacent leaves to feed within. To avoid damage by the leaf miner, set up light trap for attracting and destroying moths, or spray carbaryl 0.2% (4 g Sevin 50 WP liter^{-1} water).

Red hairy caterpillars are bright orange colour moths with black spots, which feed gregariously on the foliage. Dusting of carbaryl or parathion @ 25-30 kg ha^{-1} controls young larvae and spray of 2000 ml ha^{-1} Dichlorophos 100 EC dissolved in 400 liters of water controls the grown up caterpillars.

White grub cut the root and feed leading to wilting and death and to control these, treat the seed with chloropyriphos 20 EC @ 12.5 ml kg^{-1} of kernel or soil treatment with thimet (10 G) @ 20-25 kg ha^{-1}. Termites feed on roots, killing the plant and to control these apply 40-45 kg ha^{-1} chloropyriphos (2%) before sowing.

Harvesting and storage

In NE states the groundnut take 10-15 days more time for maturity, thus the bunch varieties mature in about 110-115 days and the semi spreading in 120-125 days. The crop has to be harvested at maturity stage otherwise the yield and produce quality will be reduced. The prominent symptom of maturity is yellowing of foliage which generally does not occur in NE states. The mature pods become hard and tough and inside shell surface becomes rough with net venation. The mature pods give crack sound when pressed below thumb and under finger. Harvesting before maturity, lowers yield, oil percentage and quality and there are more chances of damage from *Aspergillus*. Delay of harvest after maturity will result in stem rot and weakening of pegs, thus many pods may be left in the soil. Moreover, the Spanish and Valencia bunch varieties are of non-dormant type and will germinate in the field and reduce the yield. The bunch and semi spreading varieties are usually harvested by hand pulling when there is adequate moisture in the soil. The spreading types are harvested by digging with spade or running the blade and collected.

The produce is dried as quickly as possible to bring down the moisture content 5-7 % as higher moisture levels in the produce causes production of aflatoxin by yellow mould (*Aspergillus flavus*). The dry pods cleaned, filled in polythene lined gunny bags and stored on racks. The bags should be piled on wooden planks to avoid damage from dampness.

6. Major Constraints and Future Thrust Areas of Research

6.1. Constraints

As groundnut is a new crop in NE regions, inadequate research and development activities on this crop are the major constraints (Basu, 2001,2003; Singh et al, 2004). More over, as the area is dominated by rice crop, groundnut has received less attention and the agronomy of this crop has not been understood properly. Thus, there are some constraints in the cultivation of groundnut, which need to be removed so that farmers could adopt new technologies and increase productivity in NE regions. Some of the major problems of groundnut in NE region are highlighted here:

- The high rainfall and heavy down pour during sowing time causes problem of land preparation. Some time seed get rotten due to high moisture content and poor soil drainage.
- Excessive stem elongation due to less sunshine duration and less number of sunny days during kharif leads to lodging of crop resulting in low harvest index and yield.
- Soil acidity, Al-toxicity and Al-induced deficiencies of Ca, P and Mg.
- Phosphorus fixation in acid soil.
- Micronutrient deficiencies particularly of B and Mo.
- Low population of native *Bradyrhizobium* both in upland and rice fallow because of new introduction and change of soil microclimate from anaerobic to aerobic.
- Heavy metal load in pod and kernels.
- Occurrence of Tikka disease, late and early leaf spots during kharif when temperature and humidity goes up and high incidence of leaf miner, peanut bud necrosis, and foliar diseases during summer crop.

- Low temperature during early growth stages of rabi and summer groundnut.
- Lack of early vigour in groundnut varieties for rabi, summer seasons to combat low temperature during mid stage (particularly after 50 days).
- Release of land for groundnut for rabi season is usually delayed due to long duration rice cultivars as a results the short time available for land preparation after harvest of rice causes difficulty in achieving good tilth and hence poor plant stand.
- Poor quality seed causes patchy crop stand specially during rabi and summer seasons as there is quick loss of seed viability of the rabi and summer produce of these region.
- Lack of early maturing Spanish and Virginia cultivars, which fit in the rabi and summer cropping system as well as suited for kharif season, as long duration of Virginia bunch cultivars face pod damage by borers and termites leading to pod damage and rotting by other soil flora and fauna.
- Lack of fresh seed dormancy in Spanish bunch groundnut as the harvesting of the summer crop often coincides with early rains and provide congenial environment for *in situ* sprouting of seed.
- Lack of seed production and storage facilities in the region.
- Limited irrigation facilities for rabi crop.
- The agrarian structure, in these region, is predominated by small and marginal farmers whose investment capacity is limited.

Besides these, the prevailing land tenure system of the hill states does not motivate the farmers either to make efforts for development of cultivable land or diversification of crops. The socio-economic condition and predominance of subsistence rainfed farming under shifting cultivation system costs a regressive influence in adoption of modern technology in hill agriculture.

Lack of institutional credit, low level of fertilizer consumption, absence of oilseeds based cropping system, non availability of matching farm machineries and tools, absence of proper marketing machinery to ensure a fair and legitimate return to the producer, no infrastructure for processing groundnut, no proper post harvest technology are some of the institutional and technological problems for which the creditable success to be achieved by the production programme of groundnut is bound to suffer a set back.

6.2. Future thrusts for research and extension

Limited research has been undertaken till now to develop the package of practices for groundnut in the NE states, (Basu, 1997, 1998, 2003; Singh et al, 2004). There is need to undertake systematic and comprehensive research on all the above listed problems and aspects to develop more efficient sustainable technologies for groundnut for various seasons and agro-climatic zones, however, the most essential future research and extension activities are summarized below:

6.2.1. Research

- Development of varieties tolerant/resitant to leaf spot, aphid, leaf miner and other biotic stresses.
- Development of cold tolerant varieties and suitable technologies for colder period of November to December.
- Development of sustainable integrated nutrient management practices for various situations in NE states.
- Screening and identification of nutrient-efficient groundnut genotypes for their cultivation in the low P and Ca soils.
- Screening and identification of soil acidity and Al-toxicity tolerant groundnut genotypes for acid soils.
- Amelioration of soil acidity and Al-toxicity to raise the crop productivity.
- Development of suitable production technologies for shifting cultivation.
- Development of effective post harvest technology for rabi and summer groundnut.
- Identification and development of Spanish varieties having atleast 20-25 days seed dormancy.

6.2.2. Extension

- Frontline demonstration is to be conducted in the entire states and video film of the demonstration plots made and showed to the new farmers before adoption of the technologies.
- Monthly farmers-scientists interaction is essential to solve the farmer's problem during cropping season.
- Adequate financial support is to be provided to the Research training centres (RTC), placed in the major agro-climatic zones of these regions for transfer of latest technology to farmers through various demonstration and trainings.

6.2.3. Linkage between various agencies

- Seed producing agencies like Assam Seed Corporations, State Farm Corporation of India, National Seed Corporation, West Bengal State Seed Corporation etc., situated in these region or the nearby should take up production of Foundation/ Certified seeds of the groundnut varieties developed by NRCG and AICRPG centres and make available in these region. Breeders from Central Agricultural University, Imphal and Assam Agricultural University, Jorhat may be involved in the monitoring.
- Although various input and development agencies are expected to participate in developmental programme, their involvement is inadequate. Since they are under the control of the district administration, the Dy. Commissioner, at least, may call for formal meetings of all such agencies with research organization thrice in a year to have a threadbare discussion on the means and prospects of agricultural development in the region.

7. Technological Options and Strategic Approaches to Increase the Productivity

As the groundnut cultivation in NE states is new and it offers scope for expansion in area and production, introduction of high yielding groundnut genotypes, production and availability of quality seed, optimization of time for various operations and cultural practices, INM and IPM, introduction of cold and acid tolerant genotypes and introduction of polythene mulch and storage technologies and marketing and processing are the major strategic approaches needed for the promotion of groundnut in NE region. The brief of these all are mentioned under the following headings.

7.1. Crop improvement and production of quality seeds

- Multiplication and making availability of quality seed to the farmers through various agencies is most essential part without that the entire programme is failure. The Assam Seed Corporations, State Farm Corporation of India, National Seed Corporation, West Bengal State Seed Corporation etc., situated in this region and nearby make available of only JL 24. Now with identification of more number of groundnut varieties developed by NRCG and AICRPG centres these agencies should take the multiplication of foundation/Certified seeds through state seed farms/registered growers during rainy season, store it locally and make available in these region during the next kharif season.

- The produce of rabi/summer groundnut looses its viability fast and soon becomes unfit for sowing for next rabi/summer season. To overcome the same formation of 'seed grid' in north eastern region will be highly rewarding. The seed produced during rainy season is of better quality and hence it should be produced in enough quantity to cater the requirement of kharif as well as post-rainy season. The seed multiplication agencies should take up the seed production programme during rainy season through their state seed farms/registered growers. The seed produced during rainy season can cater the requirement of Assam, Meghalaya and Tripura in post-rainy season. Kharif produce of Nagaland and Mizoram can also suitably be redistributed during rabi/summer in adjoining areas.

- Implementation of seed village programme is necessary to increase the availability of quality seeds .
- Development of high yielding, early maturing (80-85 days) bunch varieties coupled with fresh seed dormancy for rice fallow. Two prerelease culture FeESG 8 and FeESG 10 from NRCG have been found promising which can be taken directly. Presently JL 24 and Girnar 1 are the earliest cultivars available.
- Incorporation of resistance to rust and leaf spot diseases will be advantageous for hot-humid areas. Presently, ICGS 76, ICGS 44 and ICGV 86590 and TKG 19A have been found promising.
- The conventional breeding technologies are better suited for NEH than biotechnological approaches and more research is needed to exploit the naturally occurring agro-biodiversity.

7.2. Crop production technologies and management approaches

As the productivity of rice and maize in uplands of NE states is quiet low, groundnut can be a better substitute. The farmers can grow groundnut with minimum input as it poses less management problem and requires less fertilizer inputs compared to other crops like rice and maize except the high quantity of seed which farmers need to manage. For successful cultivation the recommended packages of practices (RPOP), needs to be followed. Besides these, attention is required on the following technological approaches.

- Maintenance of adequate plant density is the key factor in groundnut production and achieving optimum plant density particularly in rice fallow is a matter of great concern. The optimum sowing time, spacing and seed rate is mentioned in RPOP. During rabi residual in river bed/rice fallow polythene or straw mulch need to be followed. Groundnut planter designed by ICAR Research Complex for NEH region, Barapani, for terrace cultivation may be useful in NE region.

- The NPK requirement of groundnut is 200:30:140 kg ha^{-1}. Being legume crop it uses atmospheric N, however a booster dose of 30-40 kg N ha^{-1} is essential. Since P content of the soil in NE region is very low (<8 mg kg^{-1} soil), and P-fixation is common being acidic soil, groundnut responds to high P doses and as intercrop it responds to 20% additional P. The K content is medium and hence fertilization is must. Thus, the recommended fertilizer of NE regions is 40:60:40 kg ha^{-1} of NPK.

- Acid soils are deficient in Ca, S and Mg and application of lime is the main approach in the management of acid soil since it improves the base saturation, reduces the toxicities of Al, Fe and Mn, reduces P fixation, improves microbial N fixation and nutrient mineralization. Lime at 2.5 t ha^{-1} may increase pod yield of groundnut to the extent of 30-85%.

- Soils of Meghalaya, Nagaland and Arunachal pradesh are rich in organic matter and application of burnt limestone at 25% lime requirement (LR) decrease the soil exchangeable Al without affecting the available P. While the upland soils of Tripura, Mizorum and Assam, are mostly low in organic matter, and application of lime 2 t ha^{-1} as $CaCO_3$ or $CaSO_4$ every year is comparable to single application once in three years at full LR of slaked lime. Presently, liming at ¼ to 1/3 LR is considered reasonable for groundnut crop. The cheaper source of liming materials such as basic slag from paper mill, press mud from sugar mill is available in NEH region and may be used.

- Organic manures help in alleviating Al, Fe and Mn toxicity by formation of organo-metalo complexes, besides improving soil moisture holding capacity, develop active sites for retention of P and Ca, particularly where liming is not practicable. Supplementary application of organic matter is found to be necessary for the improvement of acid lateritic soils low in organic matter. However in soils rich in organic matter, use of rock phosphate charged with FYM or RP charged with press mud is advisable.

- Piggery, poultry and rearing of other cattle and birds etc., are the main occupation among the people of NEH region. A mixture of RP + SSP + organic manure (through poultry, piggery or FYM) is useful for yield improvement in groundnut in NE states by alleviating nutrient deficiencies which performed better than lone application of RP and SSP or in combination.

- Excellent responses of Rhizobium inoculation have been reported in a series of experiments indicating that the population of native *Bradyrhizobium* in NE region is quiet low. Multilocational trials with new strains of *Bradyrhizobium* such as IGR 6, IGR 40 and TAL 1000 in acid soil, showed increase in pod yield of groundnut by 150-700 kg ha^{-1}.Efforts should be made for their further multiplication and distribution to the farmers in this region.
- The soil of NE region, due to its looseness and high organic matter, is most potential for growing large seeded groundnut varieties for table purpose/confectionery groundnut. As the large seeded groundnut require high Ca, these may be grown with 2 t ha^{-1} lime during rainy season. The varieties TG 20 and TKG 19A have been found promising in NE states.
- One to two hand weeding followed by hoeing are sufficient to make weed free situation up to 45 DAS. Application of 1.0 kg a.i. ha^{-1} pendimethalin or butachlor in 500 liter of water as pre-emergence herbicides within 2 days of sowing followed by one hand weeding at 40-50 DAS helps in controlling weed population.
- Due to its high productivity it is worthwhile increasing groundnut area under rabi and summer crop in NE states where land remains fallow and water is not a limiting factor. As low temperature during germination and initial growth stages delay the process and are the main drawback of such situations and use of polythene mulch enhances the germination and initial growth by increasing temperature during early growth stages polythene mulch, may be popularized in this region, where ever low temperature is a problem.
- Storage of seed is the basic problem in this region. Proper storage preferably the cold storage facilities are to be created in NE states to store groundnut in large scale to overcome viability problem. Low cost technology developed by NRCG, Junagadh could be used at farmer level in these states.
- Major insect pest in this region are termites, jassids, leaf folder and leaf eating cater pillar. The tikka (leaf spot) which is more severe during maturity

is a major disease in this region the intensity of which can be minimized if crop is sown in the month of May.

- To facilitate early planting of groundnut and utilization of optimum soil moisture in rice fallows during rabi season the early duration recent rice varieties may be popularized in the area where groundnut succeeds rice.
- Though the literacy is very high in NE region there is shortage of the trained expert and technical manpower and hence there is a need of regular training for up gradation of knowledge of groundnut cultivation and post-harvest operations.

7.3. Cropping system approaches

Rice and maize are the main component of acid soil cropping system and groundnut very much fit in the system either as intercrop or as sequence crop in NE states. The profitable intercrops are rice + groundnut (3:1), groundnut + maize (1:1), Groundnut + Pigeon pea (5:1), and crop sequences are rice-groundnut, maize-groundnut, Rice-mustard-groundnut and any one of these may be adopted. The short duration semi-dwarf rice, maize, pigeon pea (ICPL 87, 105) and groundnut varieties (ICGS 44, Girnar 1, RSHY 5) may be promising for intercropping. Improvement of soil health through incorporation of a crop residue or FYM is essential before taking groundnut crop in sequence after rice as it may lead to partial or complete failure of groundnut crop after rice. Wherever sequential cropping is not feasible, intercropping groundnut with rice and maize may be taken up also groundnut intercropping with citrus, pineapple and other crop may be tried.

7.4. Various uses of groundnut in NE hill eco-system

Groundnut besides being a premier oilseed crop is also an important food crop with unique consumption in various forms, right from raw to value addition and fortification with less nutritive cereals and course grains (Basu, 1997). The haulm is also considered as an important fodder in view of its high leaf protein and easy digestibility. Groundnut shell is also used as fuel besides its use in poultry feed. With the growing food and nutritional insecurity of hundreds and thousands of malnourished, poverty striken people, particularly in remote, tribal dominated areas, groundnut can play a pivotal role in fortification of poor man's staple food to increase the level of protein, essential amino acids, vitamins and minerals in their daily diet (Basu, 1998). Groundnut has proved to be a poor man's energy nut which has the nutritional status similar to cashew at more than 6 time cheaper cost and therefore, deserves promotion.

While increasing the cropping intensity by bringing rice fallows under winter (rabi) cultivation, the pressure on land for grazing is likely to increase which, could be minimized by introducing perennial, multi-cut, rhizomatous groundnut species, as green fodder contains as high as 26 % leaf protein. Several perennial wild groundnut species are self propagating and capable of quick land coverage with excellent fodder quality. Such unique species could be introduced in abandoned Jhum land to check soil erosion and tone up fragile eco-system.

7.5. Expansion of groundnut in rice based cropping system

There is an urgent need for rapid expansion of groundnut cultivation in rice based cropping system (RBCS), as rice-groundnut rotation has following major advantages over rice-rice rotation:

- Low water requirement of groundnut as compared to boro paddy (summer rice).
- Very little use of organic and inorganic fertilizers in groundnut.
- Disruption in disease and pest cycle due to break in continuous rice-rice cropping.
- High monitory return and improvement of soil physical and chemical properties and nutritional health

7.6. Mechanizations

The tiny oil mills manufactured at Rajkot in Gujarat may be suitable for processing oil at village level in NEH regions on customer service basis and it may work round the year. Similarly, processing machines such as seed drill, thresher and decorticators manufactured at Jasdan (Gujarat) are useful for groundnut cultivation. Such implements need to be demonstrated and popularized in NE regions. Groundnut decorticator from Jasdan (Gujarat) and modified by ICAR Research complex, Barapani, is helpful in processing of groundnut. Also the focus should be, shift from subsistence farming to commercial operation, creation of small farm mechanization & agro service center, farmer's market (Kisan mandi), information technology in agriculture, infrastructure development (Agro-processing, cold storage, seed processing etc.) in NE states. The introduction of small post harvest processing equipment suitable for developing cottage industry for oil extraction and value addition locally could generate employment to the un-employed rural youths and contribute towards the economic development in the region.

7.7. Marketing approaches

Due to diverse topography, altitude and climatic conditions, the NE region offers a scope for cultivation of a wide variety of agricultural crops, as a result the economy of these states are mainly rural and agrarian. The major problems faced by the farmers are the purchase of seed and sale of the produce once it has been harvested. There are no organized marketing and buyer for groundnut in NE states. These products are sold mainly in the local markets, and mostly in the form of primary produce without significant value-addition. The supply of seed, fertilizers, farm implements for mechanization and other inputs at subsidized rate are some of the urgent need of the region which has to be attended either through government agencies or through the self-helped group person with the main objectives of increasing production and productivity through better input supply and infra-structural facilities for marketing.

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Figures on Various Practices of Groundnut Cultivation in North States of India

Fig. 1. A NRCG scientist with a groundnut farmer of Pegilekha village in Thoubal district of Manipur.

Fig. 2. FLD in farmer field exhibiting excellent pod bearing in cv. JL 24 with the groundnut crop in the background in Thoubal district of Manipur.

Fig. 3. A Naga farmer showing his rich harvest of groundnut in his Jhum land in Ukhrul district of Manipur.

Fig. 4. Earthing up of groundnut for enhanced pod bearing and filing in NEH region.

Fig. 5. Pod bearing in some promising bold-seeded groundnut genotypes in NEH region.

Fig. 6. Pod bearing in Al-toxicity tolerant genotypes RCG 3 and ICG 86644 at Barapani (Meghalaya).

Fig. 7. Performance of Al-toxicity tolerant genotype NRCG 1308 at 1000 μM Al in pots.

Fig. 8. Soil acidity and Al induced Ca and P deficiencies in groundnut.

Fig. 9. Groundnut crop showing effect of liming on the plant growth in experimental plot at Lembuchera (Tripura) having acid soil.

Fig. 10. Groundnut plant with (left) and without (right) lime in acid soil.

Fig. 11. Groundnut crop without (left) and with (right) PSM in acid soils of Barapani (Meghalaya).

Fig. 12. An experimental field with various INM practices in groundnut, at Barapani (Meghalaya).

Fig. 13. Intercropping groundnut with rice (2: 4 rows) in upland at Barapani (Meghalaya).

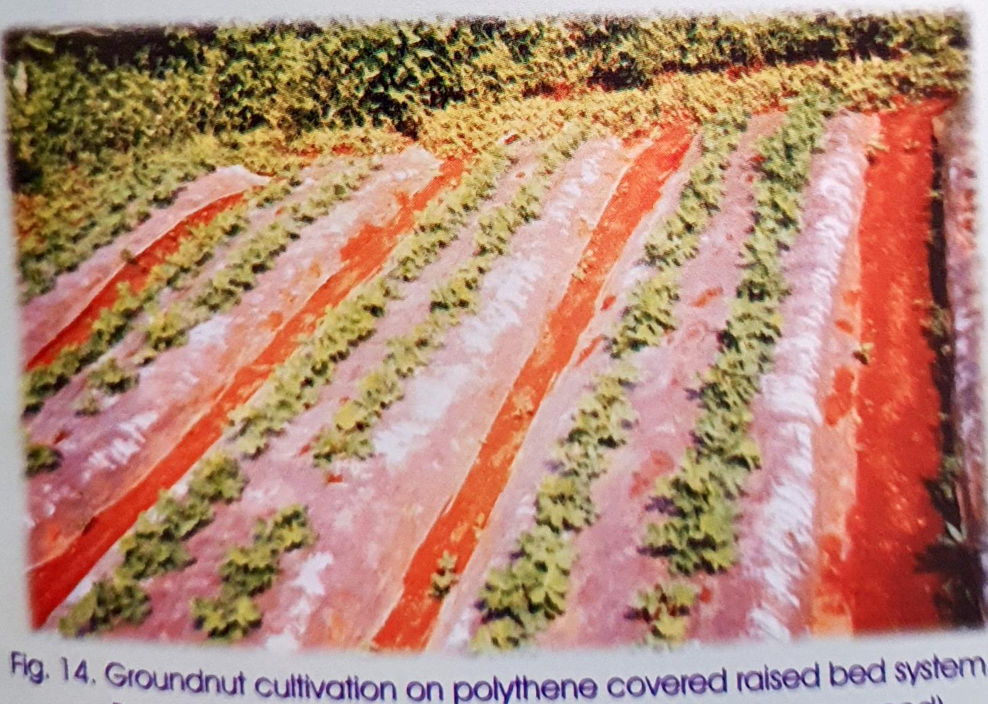

Fig. 14. Groundnut cultivation on polythene covered raised bed system at Barapani during Rabi season (Initial stage of crop, no weed).