Groundnut Cultivation Technologies for North Eastern Hills of India

A. L. Singh, M. S. Basu,
G. C. Munda, M. Dutta, N. P. Singh, D. P. Patel
and Mausumi Raychaudhuri

NATIONAL RESEARCH CENTRE FOR GROUNDNUT
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
P.B. 5, JUNAGADH - 362 001, GUJARAT, INDIA

Groundnut Cultivation Technologies for North Eastern Hills of India

A. L. Singh and M. S. Basu,
National Research Centre for Groundnut
(Indian Council of Agricultural Research)
P.B. 5, Junagadh - 362 001, Gujarat, India

G. C. Munda[1], M. Dutta[2], N. P. Singh[2], D.P. Patel[1]
Mausumi Raychaudhuri[3]
ICAR Research Complex for NEH Region
[1]Umiam 793103, Meghalaya
[2]Lembucherra-799210, Tripura
[3]Imphal 795004, Manipur

March, 2006

Citation : A.L. Singh, M. S. Basu G. C. Munda, M. Dutta, N. P. Singh, D.P. Patel and Mausumi Raychaudhuri, 2006**.** Groundnut Cultivation Technologies for North Eastern Hills of India. National Research Centre for groundnut (ICAR), Junagadh, India. pp 40.

Published by : DIRECTOR,
NATIONAL RESEARCH CENTRE FOR GROUNDNUT
P.B. 5, JUNAGADH 362001,
GUJARAT, INDIA

Telephone : 91-0285-2673041/ 2672461

Fax: : 91-0285-2672550/ 267382

E-mail : alsingh16@gmail.com

Printed at : Metro offset,
Nr Sub Marketing Yard,
Dolatpara, Junagadh
Ph : 0285-2661254

Cover photo : Groundnut cultivation in NEH

Back page photo : A bumper groundnut crop in Meghalaya

Preface

The groundnut, an important oilseed and food legume crop of tropical and subtropical areas, is being cultivated on about 25 million hectare of land in about 90 countries under different agro-climatic regions between latitudes 40ºS and 40ºN. However, on large scale it is mainly grown in India, China, USA, Senegal, Indonesia, Nigeria, Brazil and Argentina. 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, became the highest producer of groundnut and India stands second.

There are fluctuating trends in area and production of groundnut in India, however, it is grown on an area of about 8 million hectare, mostly as rainfed in dry lands under vagaries of the weather conditions producing about 8 million tonnes due to its low productivity and so far only about 20 % area could be brought under irrigation. However, the demand of groundnut is increasing due to increase in population as well as to introduce the groundnut as food crop. This calls for the tremendous increase of groundnut production in India. Though the average groundnut yield, in India, is around 1000 kg ha^{-1}, the non-traditional groundnut area in NE states harvest 3000-3500 kg ha^{-1} of pods in about 100-120 days clearly indicating its potential for introduction in these areas to increase the production and productivity of groundnut. Thus, since last one decade, joint efforts were made by the scientists of NRCG, Junagadh and ICAR Research Complex for NEH Region, to develop suitable technologies for cultivation of groundnut in the north eastern hill region, where the water is not a limiting factor.

Now the cultivation of groundnut crop need to be popularized in the NE states. This bulletin, being brought out by NRCG, Junagadh and ICAR Research Complex for NEH region, is very timely providing tested technologies and strategies to promote groundnut cultivation to increase its productivity and availability in NEH region. The scientists, situated in the remote areas of extreme north-east and western most part of the country, have worked very hard, generated valuable informations on various aspect of groundnut and done a commendable job which have been compiled in this bulletin.

Authors

Contents

1. Introduction

The groundnut (*Arachis hypogaea* L) which ranks 13th among the principal economic crops of the world, is an important food legume and oilseed crop of tropical and subtropical areas and presently grown in about 90 countries under different agro-climatic regions between latitudes 40ºS and 40ºN. Though world-wide it is being cultivated on about 25 million hectare of land in several countries, on large scale it is mainly grown in India, China, USA, Senegal, Indonesia, Nigeria, Brazil and Argentina. It is oil and protein rich an energy giving crop, but usually grown under energy-starved conditions of low soil fertility and rain fed areas and about 70 % of the world groundnut production occurs in the semi-arid tropics with average yield of around 800 kg ha^{-1}.

In India the groundnut, which was introduced around 250 years ago, is the most important oilseeds crop of the country. Now it is grown on an area of about 8 million hectare (m ha), in 260 districts, mostly as rainfed crop on well drained sandy soils in 500-2000 mm annual rainfall areas producing about 8 million tonnes (m t). Up to 1960s the groundnut, in India, was grown only in rainy season (Kharif), but from 1971-72 its cultivation started in winter (Rabi) and summer also where it showed higher yield potential than Kharif. 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 during 80s, particularly during 1988-89, the productivity has crossed one tonne (1132 kg ha^{-1}) mainly due to favorable season and transfer of available technologies through Technology Mission on Oilseeds. The average yield of the crop during 1990-2000 was 994 kg ha^{-1} with a maximum of 1214 kg ha^{-1} during 1998.

Presently, India has the largest groundnut area (32% of the world) and also till 1992 was the chief-producer of groundnut in the world. But, from 1993 onwards, China, due to its higher productivity than India, became the highest producer of groundnut and India stands second. In the present scenario of increasing population as well as malnutrition problem, the production of groundnut has to be increased to meet its demand both as oilseed as well as food crop. As groundnut is an energy rich crop requiring more energy for oil and protein synthesis, comparative to other crops, its productivity 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 alternative where the yield potential of 3000-3500 kg ha^{-1} of pods are easily achieved in 100-120 days against 1000 kg ha^{-1} as the average yield of India.

In north-east, though the roasted groundnut is used for the past 30-40 years, the cultivation of groundnut started only about 25 years ago and till today it is mainly used as snack food. More over its agronomy and phenology are not well studied on these acid soils of NEH region which many a times results in poor yield. Thus efforts were made during the last one decade, to popularize groundnut in these areas where there is tremendous scope to increase the production and productivity through introduction of the new crop varieties in the areas where nutrients and water are not a limiting factor. In this bulletin an attempt was made to synthesize the important findings, 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. Soil, Climate and Crop seasons

The north east lies between 21°57' to 29°26' N latitude and 89°45' to 97°17' E longitudes with a total geographical area of about 25 m ha and constitutes the "Seven Sisters" states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. However, the north east hill region includes Sikkim and all these states except Assam. These north eastern hills (NEH) are considered as non-traditional areas for groundnut cultivation as the crop is not grown traditionally in these areas.

The NEH 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 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. 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. With sudden changes in topography results in climate changes within short distance, the entire NE region has distinct climate variations and low to medium sunshine hours.

The region has loamy sand to sandy loam textured soil (alfisol haplaquent) acidic in reaction (pH 4.5-55). 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.

About 10 m ha soil of NEH region is having pH less than 5.5 in NE regions, where Al-toxicity in upland terraces, Fe and Mn-toxicities in valleys and Ca, P, Mg and K, deficiencies in both situations are major concerns of crop production. Low water holding capacity, crusting, erosion and compaction make these soils low productive and poor fertility of upland soils, which is highly acidic, is due usually to a combination of these factors.

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 seasons 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

Time of groundnut sowing in NE states is little earlier during kharif season than in plains as it is sown from April and during rabi, it is sown in September-October and summer season groundnut is sown during January-February and harvested during May-June.

a

b

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

b. A bumper crop of groundnut in upland terrace at Umiam, Meghalaya

3. Groundnut areas and its potential in NEH

The entire North East states are considered as non-traditional areas for groundnut cultivation as the crop is not grown traditionally in the area. The uplands, rice and maize fallows,flat lands, river valleys and foot hills up to 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. In Assam, Arunachal Pradesh, Manipur, Meghalaya and Mizoram, it was introduced during middle of 1980's while in Tripura and Nagaland it was introduced earlier. The crop remains almost disease and pest free till 80 DAS (days after sowing) and yields more than 1000 kg ha^{-1}. 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. The groundnut crop has high potential in the NE states, with a good number of varieties found promising under mid-altitude, but none of them did well under high altitude.

In Arunachal Pradesh, groundnut has found place as *kharif* crop in the thin strips of flat land adjoining Assam in East Siang, where it is being grown since a decade. In Assam, the groundnut cultivation has been reported in Jorhat, Nagaon, Darrang, North Lakhimpur and North Cachar hills, however, as rabi crop, it can be grown in all the districts in rice fallows. In Manipur, groundnut is cultivated in the foot hills of Thoubal, Ukhral and Senapati districts. In Meghalaya, 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. In Mizoram, the groundnut is grown mainly in Kolasib area of Aizwal touching Tripura and Assam on the hill slopes of Jhum lands. In Nagaland groundnut is popular near Kohima. In Tripura, groundnut is being cultivated in all the three districts south, north and West Tripura on the uplands and 'Tilla lands' during *kharif* seasons and medium lands after rice crop during *rabi* season.

The cropping system, in the NE states, revolves around rice and maize, the productivity of which 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, is still dominant. The 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}). Changeover to groundnut, a more tolerant crop to mineral stresses, with

a

b

a. A local watershed and surrounding medium-land ready for rabi-groundnut cultivation in Tripura after rainy season.

b. Fields showing various stages of rice cultivation (transplanting to harvest) in Tripura. In one field rice is ready for harvest while in another it has been harvested and readyd for rabi-groundnut sowing.

modern agricultural technologies may bring substantial yield increase in these areas.

The station trials compiled by Munda et. al.,(1997) clearly indicated that, in Meghalaya, as high as 3000 kg ha^{-1} pod yield was obtained from ICGS 76 under good management practices. In Arunachal Pradesh (Basar), groundnut registered 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}.

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. Citrus, guava, large cardamom, zinger, cassava, curcumin and 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 adoptability to groundnut due to less management problem compared to rice and maize requires less fertilizer inputs for its production.

The 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 in the NE states which may result in additional production of about 1-2 m t of groundnut. Groundnut in Rice-Based Cropping System (RBCS) is becoming popular and area is increasing in the entire NE region. Deposition of silt and nutrient replenishment every year due to flood, the riverbeds provide 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 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 reported in the river bed of Brahmputra. In 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. Adopting the rice-groundnut sequence in low land is beneficial as groundnut in the RBCS sustains crop production, improves soil health, breaks build up of dangerous insect-pests and pathogens, requires less number of irrigations and provides better nutritional and financial security than other crops.

a

b

a. Groundnut cultivation in terraces in Manipur.

b. Groundnut in terrace-cropping with bunds for raising fodder and plantations crops in Manipur.

4. Cultivation technologies developed

The groundnut crop is new in NE states and for a good harvest, it needs specific package of practices. The Assam Agricultural University, Jorhat, ICAR Research Complex for NEH Regions in Meghalaya, Manipur, Tripura, Mizorum, 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 for realizing maximum yield and developed package of practices for north eastern states of India. However, these production technologies are being refined time and again and based on the recent informations, the sustainable technologies are being highlighted here.

4.1. Improved groundnut cultivars

To introduce a crop in an area it is first and foremost effort to select the suitable genotypes for the regions through screening and yield trials and once these are identified one can go for developing high yielding genotypes. In this mission, several groundnut varieties were tested during mid 80s to mid 90s in the NE region under AICRPG. From mid 90s onwards, in an Inter-institutional collaborative trial, the recently released varieties were evaluated 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 in NEH regions. The season wise following groundnut varieties are identified:

Kharif season	**:**	ICGS 76, ICGS 44, ICGV 86590, BAU 13, CSMG 84-1, TKG 19A, OG 52-1, and Girnar 1
Rabi season	**:**	ICGS 76, OG 52-1, ICGS 44 and Girnar 1

From a series of trials, nearly 60 groundnut varieties were tested, with optimum fertilizer and spacing, under various agro-climatic situations of NE region and the groundnut varieties identified for their cultivation in various NE states are listed below:

a

b

a. A field trial for evaluation of groundnut genotypes at ICAR Research Complex for NRH at Barapani, Meghalaya.

b. Scientists of NRCG, Junagadh and ICAR Research Complex, Barapani visiting the groundnut experimental fields at Barapani.

NE States	Promising groundnut cultivars
Arunachal Pradesh	ICGS 76, Girnar 1, CSMG 84-1
Assam	ICGS 76, Girnar 1, ICGS 11, GG 2, CSMG 84-1, GG 20
Meghalaya	ICGS 76, ICGV 86590, TKG 19A, BAU 13, CSMG 84-1, GG 13
Manipur	ICGS 76, ICGV 86590, TKG 19A, BAU 13, CSMG 84-1, GG 20
Mizoram	ICGS 76, ICGV 86590, ICGS 44, CSMG 84-1, GG 13, GG 20
Nagaland	ICGS 76, ICGV 86590, ICGV 87187, CSMG 84-1
Tripura	ICGS 76, ICGV 86590, TKG 19A, DRG 12,OG 52-1, GG 20

- 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, 42.5 % oil and 44 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 g 100-seed wt.
- The Girnar 1 is an early maturing multiple resistant Spanish bunch variety of NRCG, released during 1988 for rainfed conditions of western Maharastra, A.P., T.N., and Junagadh with 71 % shelling, 50 % oil and 33 g 100-seed wt.
- TKG 19A is a Virginia bunch, bold and attractive kernel variety of BARC and K.K.V Dapoli, released during 1993 for R/S and Kharif season of Konkan region with 63.0 % shelling, 46.0 % oil and 61 g 100-seed wt. qualifies for HPS grade.
- BAU 13 is a Virginia bunch, bold seeded cultivar released during 1993 from Birsa Agricultural University, Kanke. It contains 50.1 % oil, and having a shelling out turn of 64.6 % with 55.1 g 100 seed mass. It is recommended for cultivation in the states of Bihar, U.P., Rajasthan, Gujarat, maharastra and T.N.

Suitable groundnut Varieties for NEH region

- CSMG 84-1 is a Virginia runner cultivar released from CSAUAT, Mainpuri during 1992 having 63.5 % shelling, 46.8 % oil and 38.4 g 100 seed wt. It is recommended for cultivation in the states of Rajasthan, U.P., Haryana for Kharif season.
- GG 20 is a Virginia bunch, bold seeded cultivar released during 1991 from Gujarat Agricultural University, Junagadh. It contains 54.9 % oil, and having a shelling out turn of 70.3 % with 51.1 g 100 seed mass. It is recommended for cultivation in the states of Gujarat.

The average yield of groundnut in NEH region is always higher than the national average yield of India. Five years of study demonstrated that the groundnut cultivars ICGS 76, ICGV 86590, BAU 13, CSMG 84-1, GG 13 and TKG 19A were high yielding (> 2000 kg ha^{-1} pod yield) in NEH region.

Due to high rainfall and humidity, three foliar diseases (ELS, LLS and Rust) were predominantly occurring in NEH region and the 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 NEH soil due to high organic matter and loose structure provides scope for large seeded groundnut and HPS 9704, 9706 and BAU13 are the promising genotypes.

4.2. Soil acidity and Al-toxicity tolerance genotypes

In a collaborative project between ICAR Research Complex in NEH and NRCG, Junagadh, 600 groundnut genotypes were tested in various phases and based on six years of study, the soil acidity and Al-toxicity tolerant and sensitive genotypes were identified as:

- 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.

4.3. Nutrient efficient genotypes

In acid soils of NEH region, the Al-induced P and Ca deficiencies are main problems and groundnut seed showed low Ca content sometimes below 300 ppm causing low shelling and viability. Thus, an effort was made for the

a

b

a. Field evaluation of HPS groundnut genotypes, at Barapani.

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

selection of nutrient efficient genotypes which can grow and yield well under low available nutrients where the normal genotypes show deficiency and identified following nutrient efficient and inefficient genotypes:

P-efficient	GG 5, NRCG Acc 7085-1, 6919, 1308, 3498, and SP 250A, ICGV 80338, ICGV-88348, ICG (FDRS) 40, ICG (FDRS) 50
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

4.4. Cropping seasons and situations

Kharif and *rabi* summer are the two groundnut growing seasons being followed in north eastern hills. Of these, kharif crop is gaining familiarity and now it is being grown in almost all the states in mid hills. Also, efforts are on to increase the crop area during *rabi* season using polythene mulch technology. 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 seasons 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.

The *rabi* crop of groundnut is grown 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.

a

b

a. Promising Al-toxicity tolerant genotypes (ICG 10465 and 11954) in NEH.

b. Pod bearing in Al-toxicity tolerant genotypes RCG 3 and ICG 86644 at Barapani.

The low temperature during middle of crop growth is the major draw back, which reduces the growth, affecting yield during Rabi season. Polythene mulch offset the low temperature effect and have shown the potential at Manipur, Barapani, Meghalaya, Assam and Sikkim for rabi season groundnut.

The summer crop of groundnut is mainly grown under assured irrigation and nutrient management and has less infestation of weed and insects pests and diseases and has high yield potential. 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 of Meghalaya and Nagaland. 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. 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.

4.5. Optimum sowing time

The state-wise optimum sowing time for groundnut under various crop seasons/situations in NE states is given Below:

Crop seasons	Optimum sowing time	NE States
Kharif	15th May - 15th June	Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Sikkim
	1st - 15th June	Assam
	5th May - 10th June	Tripura
Rabi (winter)	15th September to 15th October with polythene or straw mulching	Assam, Meghalaya, Manipur and Tripura,
Spring/ Summer	15 January - 15th Feb. with polythene or straw mulching	Assam, Tripura, Manipur

a

b

a. Pod bearing in recently released (ICGS 76 and DRG 12) and old (JL 24), groundnut varieties grown in acid soils of Tripura.

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

4.6. Seed Rate and Spacing

Maintenance of optimum plant population, by using of optimum seed rate, is a key aspect in groundnut cultivation as about 70% groundnut seed germinate under field condition. Select good quality pods, 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. In NE states, 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 season and 30 x 10 cm for bunch groundnut and 60 x 10 cm for semi-spreading and spreading during rabi and summer seasons. 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

4.7. Weed Management

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

It is essential to keep the crop weed free up to 60 days after sowing (DAS), as the maximum damage is caused during this period and removal of these weeds by hand weeding up to 60 DAS results in the highest net returns. 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 the best.

a

b

a. A farmer exhibiting excellent pod bearing in cv. JL 24 with the groundnut crop in the background in Thoubal district (Manipur).

b. A Naga farmer showing his rich harvest of groundnut (cv. JL 24) in his Jhum land in Ukhrul district (Manipur).

After comparing several combinations of manual and mechanical weeding, herbicides (pendimethalin and butachlor) applications, two hand-weeding twice at 25 and 50 DAS and pendimethalin (@ 1 kg a.i. ha^{-1} with) + one hand-weeding at 40-50 DAS were found equally effective practices in reducing weed population and increased groundnut yield pod yield to 2.49 and 2.36 t ha^{-1}, respectively, as compared with 0.71 t ha^{-1} in un-weeded controls. Pendimethalin controlled all categories of weeds and produced more than 2000 kg pod ha^{-1}.

4.8. Soil, fertilizer and nutrient managements

Groundnut 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 and can be grown at all sites of NE states. However, the 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.

4.8.1. Soil acidity, liming and Ca fertilizers

Most of the soils of NEH region are acidic in reaction with low basic ion and cation exchange capacity making them of poor fertility. This is mainly due to high rainfall followed by excess leaching of basic element. Some of these are Mg deficient with less than 4 % Mg saturation. To bring the acid soil to neutral and productive, it requires liming which increases mineralization of soil nutrients. 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, Mg^{2+} is 0.5 meq 100 g^{-1} soil, and K is 108 kg ha^{-1} for groundnut.

The 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 the not in proper shape) in groundnut in NEH Region. 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.

The Lime requirements (LR) of NEH region varies from 3.2-27.2 t ha^{-1} depending upon the texture, pH and organic matter content, however, furrow application of lime ($CaCO_3$) equivalent to 25 % (2 t ha^{-1}) of LR was good

a

b

a. Landscape showing acid soil of a ‘tilla’ land and its erosion due to construction of a road and heavy rainfall in Tripura.

b. Liming of acid soil before sowing of groundnut.

enough. The $CaCO_3$ at 1/4 of LR applied in rhizosphere at sowing was at par with surface application of full LR for groundnut. 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 in furrows. The $CaCO_3$ and gypsum are two sources and both 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.

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 Mizorum produce a lot of Ca rich material which could be used in place of lime. The sludge of paper mill contain 60-80 % $CaCO_3$. Press-mud, a waste product of sugarcane mill possessing nearly 13 % organic matter and 42 % Ca, is an effective source of ameliorant. Some of them are sold as IRL-clay conditioner, Bhushakti and Tata slag powder. Basic slag applied on the basis of LR doses contained 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 111 %, 108 % and 98 % as against 100 % for limestone with groundnut. Lime at $1/4^{th}$ of LR (2000-2500 kg ha^{-1} $CaCO_3$ or equivalent paper mill sludge) in furrows every alternate year sustains the productivity of rice-groundnut system. Application of 2-2.5 t ha^{-1} lime increased upto 50 % yield of groundnut.

The ameliorative role of lime and FYM was noticed in the experiments conducted at Barapani to overcome the Al-toxicity and 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%, pod yield over control. The 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.

4.8.2. Macronurtient fertilizers

Groundnut is capable of meeting 60-80 % nitrogen requirements from symbiotic nitrogen fixation by root nodules and only 20-40% by soil nitrogen. However, the nitrogen supply to groundnut is very crucial and deficiency is observed in between 10-45 DAE and at pod formation stages. 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. The Spanish and Valencia bunch groundnut, because of lesser crop duration and nitrogen fixation respond more to nitrogen

a

b

a. Groundnut crop showing effect of liming on the plant growth in Tripura

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

than the Virginia. The Native *Bradyrhizobium* is not abundant to fix adequate N at most of the places in NEH region thus inoculation with *Bradyrhizobium* is must to meet the nitrogen requirement.

The requirement of phosphorus and potassium in groundnut is very high as these fertilizers promote plant growth, enhance pod filling, shelling percentage and yield, and also enhance resistance to biotic and abiotic stresses and *Bradyrrhizobium* multiplication. For groundnut, the critical level of P in acid soils of NE region is 6.5 ppm available P in soils and 0.17% in plant shoots. Due to high P and K requirement of groundnut and their low availability in acid soils of NE region, the optimum economic dose enhancing pod yield was 60 kg P_2O_5 ha^{-1} as SSP and 40 kg K_2O ha^{-1}as MOP.

The single super phosphate (SSP) and rock phosphate (RP) both are recommended for NEH region. It is desirable to use ground rock phosphate with particle size of 60–100 mesh 3-4 weeks before sowing. Among the cheap source of phosphorus like insoluble rock phosphate (Mussorie RP, Udaipur RP) a mixture of RP and SPP at 3:1 was best. In soil having pH 5.5-6.5 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. However, in strongly acidic soil below 4.5 pH, if single super phosphate (SSP) is 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, depending upon soil acidity blending of these two, as shown below, is beneficial to make readily available form of P.

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%

Amendment of 5 t ha^{-1} FYM, poultry manure or pig manure with 60 kg P_2O_5 ha^{-1} either as SSP or rock RP was found to be best in increasing soil available P, P uptake and yield. The rock phosphate coated urea is also superior to prilled urea and urea super granule in these soils.

For groundnut, sulphur is as important as phosphorus and its deficiencies are now appearing in acid soils. Its deficiency symptoms are like nitrogen, but occur on young leaves and extend to middle showing pale yellow colour with vein showing white. To get prevent the S deficiency, 30 kg S ha^{-1} was optimum which may be applied through any sources either as single super phosphate, elemental sulphur, gypsum or ammonium sulphate.

a

b

a. Field showing acute Ca deficiency as chlorosis (control) and healthy crop in limed field in acid soil of north-east states.

b. P deficient groundnut crop with stunted growth in the plot without P fertilizer and PSM is seen in the upper and healthy crop in P fertilised and PSM inoculated lower plot in the acid soil of north-east states,

4.8.3. Micronurtients and Biofertilizers

The groundnut grown in acid soils often face B and Mo deficiency. However, the Fe and Mn are present in plenty and some times cause toxicity to groundnut. The response of Zn and Cu are also observed in some of the soil. The deficiency of B causes low filling of pod resulting in less shelling and the most common B deficiency symptom is hollow-heart of kernel in which the inner faces of the cotyledons are depressed and discolored reducing the quality of seed. To meet the requirement of Mo, seed dressing with 0.5-1.0 kg ha^{-1} ammonium molybdate is advisable. However, soil application of 1 kg B ha^{-1} (5 kg borax ha^{-1}) corrects B deficiency increasing pod yield. The pod and haulm yields increased by application of 12.5 kg $ZnSO_4$ ha^{-1} over control.

There is an excellent response of biofertilizers such as *Bradyrhizobium*, phosphorus soloubilising microbes (PSM) and plant growth promoting Rhizobacteria (PGPR) in groundnut in NEH region due new introduction of its cultivation and submergence of field for quiet some times. The responses are more with phosphatic fertilizer and lime. The groundnut crop inoculated with PSM (*Bacillus polymixa*) and *Bradyrhizobium* (NC 92, IGR 4), show green canopy but the crop without *Bradyrhizobium* and PSM show stunted growth with chlorotic leaves, poor nodulation and N and P deficiency symptoms (Fig. 12). Thus the inoculation of biofertilizers along with lime and phosphatic fertilizer is essential to save the chemical fertilizer and effective use of P fertilizers. These biofertilizer packets are available with the several standard agencies certified by the regional office of the organic farming board situated in Imphal.

As the groundnut cultivation in NE region is new, biofertilizers inoculation with nitrogen fixing *Bradyrhizobium* and phosphorus solubilizing microbe (PSM) is essential

4.8.4. Integrated nutrient management

As groundnut pod is formed in soil, it requires loose soil and the integrated use of both organic and inorganic fertilizers shows best groundnut yields with sustainable soil fertility and productivity. Various organic manures (FYM, poultry manure and pig manure) increased the pod yield over the optimum dose of NPK fertilizers in NEH region.

The collaborative experiments on integrated nutrient management conducted at Imphal, (Manipur), Tripura and Barapani to compare the effects of inorganic nutrients (P, K, Ca) and biofertilizers (*Bradyrhizobium* and PSM) and their interactions in acid soils, reveals that Ca and P are the key nutrients for groundnut in acid soils of NEH region and based on the several years of

a

b

a. Groundnut crop without (left) and with (right) phosphorus solubilizing microbes in acid soils of Barapani.

b. Effect of inoculation of *Bradyrrhizobium* and PSM on the root growth, nodulation and podding in groundnut in acid soils of Tripura.

experimentation, an INM practice including application of lime (2.5 t/ha) or FYM (10 t ha^{-1}) or half of both these, NPK (20:25:25) doses and inoculation of PSM and *Bradyrhizobium* is recommended throughout NEH region.

However, based on the field experiments following INM practices are being recommended for groundnut:

- In tilla land of Tripura, application of lime + P + *Bradyrhizobium* or lime + P + PSM is useful.
- In Meghalaya, FYM (10 t ha^{-1}), NPK+ *Bradyrhizobium* and NPK+ PSM were at par.
- In Manipur, the maximum yield was obtained by combined application of 2.5 t ha^{-1} lime + 50 kg ha^{-1} P_2O_5 + inoculation with *Bradyrhizobium* and PSM (>80 % increase over control) followed by P + *Bradyrhizobium* + PSM (67 %), P (50 kg ha^{-1})+ *Bradyrhizobium* (51 %) and P+ PSM (49 %).

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 and K should be placed in the furrows below the seed at sowing. Furrow application of lime at 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.

4.9. Cropping systems

The cropping intensity and productivity is low in NEH region and to increase the same it is essential to grow two to three crops either 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 and groundnut very much fit in the system as second crop as it is medium response. Groundnut can be successfully adapted as a companion crop with upland rice, maize and sugar beet. The short duration semi-dwarf rice, maize, pigeon pea and groundnut varieties are promising for intercropping. The groundnut varieties identified for intercropping systems are JL 24, Girnar 1, ICGS 76 and ICGS 44. Sole crop of groundnut produced 2.5-3.0 t ha^{-1} and its performance as intercrop in

a

b

a. Intercropping groundnut with rice (2: 4 rows) in upland at Barapani.

b. Intercropping-mixedcropping groundnut with sweet potato in *Jhum* land of NE states.

rice also gave 1.0-1.2 t ha^{-1}. Intercropping of groundnut in upland rice and maize increased maize and rice equivalent yields.

The cropping systems study on the intensity and productivity of individual crop evaluated at ICAR Res. Complex, Barapani, Meghalaya reveals that 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.

The profitable crop sequences and intercrops for NEH region are:

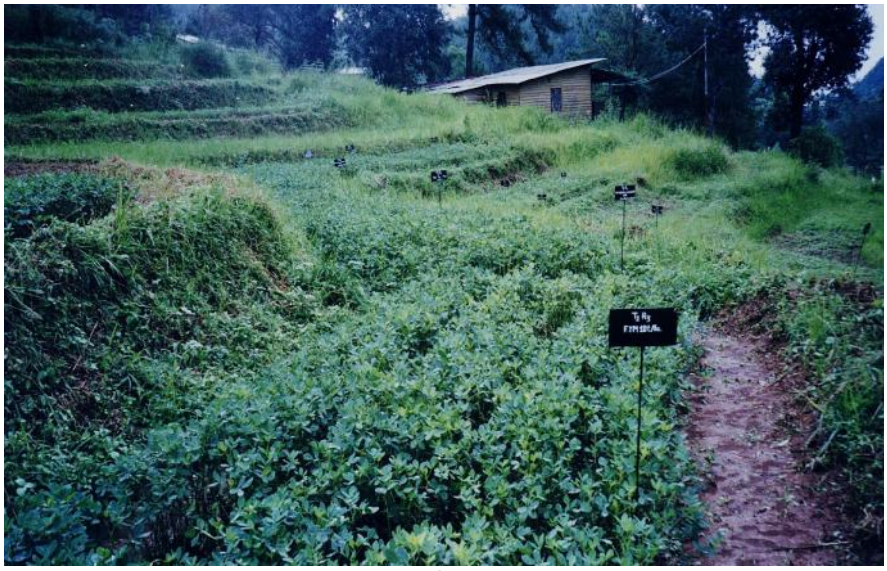
Crop sequences	**Intercropping**
Rice-groundnut	Rice + Groundnut (4:2)
Rice-potato-groundnut	Groundnut + Maize (1:1)
Rice - mustard-groundnut	Groundnut + Pigeon pea (5:1)
Maize - groundnut	Groundnut + Chili (2:2)
	Groundnut + Citrus
	Groundnut + Pineapple

4.10. Irrigation and drainage

Generally there is no moisture stress and irrigation is not required for groundnut in NEH region, but in dry years, irrigations at pre-sowing, pegging and pod formation are recommended, if there is no rain during these stages. The kharif crop in NEH is mainly rainfed, hence it may require 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.

However, due to high rainfall, drainage is essential in NEH region and to maintain a good crop and avoid damage to root system, it is generally grown on ridge and furrow system made parallel to the slope. Groundnut grown on bunds produces highest yields.

a



b

a. An experimental field with various INM practices in groundnut, at Barapani.

b. The promising INM practice (FYM) for groundnut, in highly acidic soils at Barapani.

4.11. Polythene Mulch Technology

The polythene mulch technology plays an important role for rabi groundnut in cold areas of NEH region specially in Manipur, Meghalaya and Tripura where crop face winter and temperature goes below 15°C. In Manipur, the groundnut cultivar JL 24 produced 6-7 times higher pod yield with polythene mulch in flat bed (2193 kg ha^{-1}) and broad bed furrow (1592 kg ha^{-1}) system of sowing without mulch with only 263 kg ha^{-1}. At low temperature, the germination was a week earlier, in polythene mulch, showed better soil-moisture conservation and temperature balance capacity in soil, which resulted in higher number of pods, kernel weight and higher pod yield

As polythene mulch shows better soil-moisture conservation it is useful for kharif season also. The accumulated temperature by polymulch was 3.7^{o}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.

Thus, it is apparent to use polythene mulch for rabi groundnut under rain fed condition of NEH region to achieve higher yield per unit area.

4.12. Pest and disease Management

4.12.1. Insect and Pests

The green foliage cover of NEH region, due to a high rainfall, provides food and shelter to various insects and invites a large number of insects and pests in succession during the groundnut growing season which otherwise may not be the regular pest of groundnut. Like disease, the insect pest infestation is more during kharif than rabi and summer seasons. The major insect pests of groundnut in NEH region 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 grubs (*Holotrichia consomoina*), termites (*Odonototermis* sp), pod borers (*Euborellia stalli, E. annulipes*), and mealy bugs.

a

b

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

b. Groundnut under polythene mulch cover in pre-rabi at Umiam, Meghalaya

The jassids are serious pest from June-August after that the defoliators attack the plant, later on leaf miner, leaf folder incidence start and continued till maturity. The severe attack of leaf folder causes 16-19% yield loss and root grubs cause 12-15% of pod damage of the crops in NEH regions. White fly, field cricket and cutworm are the other insects causing considerable losses in yield. The Decamethrin and Monocrotophos are the effective insecticides 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. Use of aldicarb was most effective against pod borers and soil pests.

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) controls 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} or apply carbofuran (1.5 kg a.i. ha^{-1}) during attack. Termites feed on roots, killing the plant and to control these, apply 40-45 kg ha^{-1} chloropyriphos (2%) before sowing.

4.12.2. Diseases

In NE region, there is comparatively lesser pressure of disease than plains mainly due to low temperature. However, due to the high rainfall and humidity during *kharif* season whenever the temperature goes high, the foliar diseases develop in groundnut and some time it is devastating too. 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 disease of groundnut in NE states during kharif season. The other disease 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. During rabi and summer groundnut, there is lesser disease.

For the effective control of these diseases, the Derosal and Bavistin are most effective, however for controlling leaf spot, a fungicide mixture of carbendazim 0.05% + mancozeb 0.2% is useful and sprayed up to 50 DAS gave maximum returns with benefit cost ratio of 4.1 to 8.1. The sowing dates affected the spread of leaf spots and rusts and the 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. Thus, 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 in NEH region.

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

Several groundnut genotypes and cultivars were screened against the leaf spot and rust under natural epiphytotic infection conditions on 1 (resistant) to 9 (susceptible) scale where different disease reactions were observed by various workers who found few genotypes as tolerant, but none resistant to both the diseases. The high yielding disease tolerant genotypes are: ICGV 86687, ICGV 86675, ICGV 86680, ICGV 86590, ICGS 76 and TKG 19A, CSMG 84-1.

4.13. Harvesting and storage

In NEH region of India, rain starts during last week of April and continues till October and the groundnut crop sown during April-May mature in September, but due to high soil moisture does not show yellowing of foliage, which is the prominent maturity symptoms. Moreover, due to low temperature the groundnut takes 10-15 days more time for maturity in NEH region, thus the bunch varieties mature in about 120-135 days and the semi spreading in 130-145 days. At maturity, the pods become hard and tough and inside shell surface becomes rough with net venation and 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 fungi particularly *Aspergillus.* Delay of harvest after maturity, many a time results in stem rot and weakening of pegs, thus pod losses 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 in sun as quickly as possible to bring down the moisture content 5-7 % as higher moisture level in the produce causes production of aflatoxin by *Aspergillus flavus* (Fig. 17a). 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.

Loss of seed viability in rabi-summer produce is a serious problem in the NEH region. The drying and storage technologies developed at NRCG to prevent rapid loss of seed viability in the rabi-summer groundnut produce are useful. In this technology, the pods are dried under shade using conventional method and Directorate of Oilseeds Research (DOR) method and stored with $CaCl_2$ (100 g/ 30 kg of pods), in polyethylene lined gunny bags. This method of storage retains more than 80 % germinability even after six months of storage (at the time of rabi sowing). These drying and storage technologies have potential for groundnut growing farmers in the northeastern part of the country and hence may be used.

4.14. Groundnut as fodder crop

Groundnut 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. While increasing the cropping intensity by

a

b

a. A view of the threshing floor being used for drying groundnut pod and maize cobs under natural sunlight.

b. Luxuriant growth of perennial, rhizomatous wild groundnut species, with excellent fodder quality for rabbitry at ICAR Res Complex, Barapani.

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.

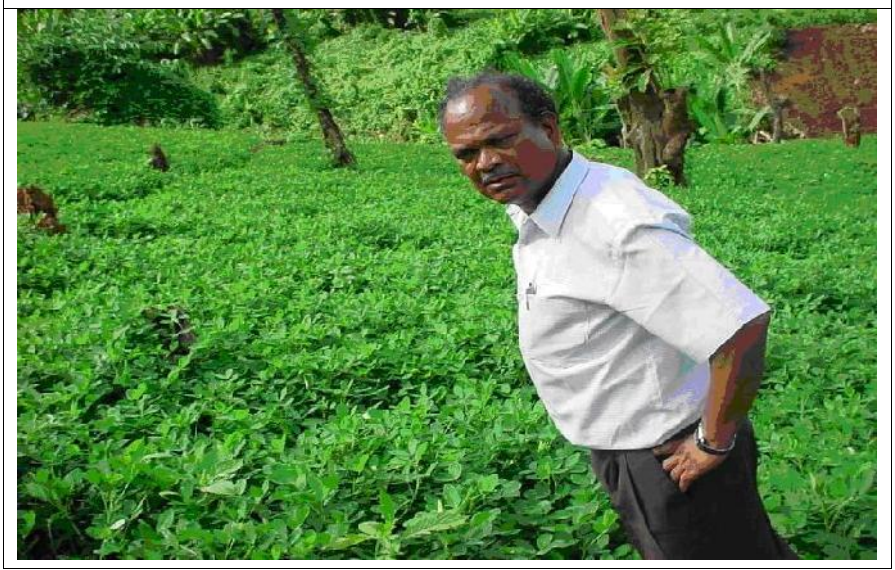
Presently NRCG is maintaining as many as 10 wild species of groundnut at Junagadh containing range of 12-20 % protein, 1.2- 6.2 % sugar and 23-35 % crude fiber. These wild species could be obtained from NRCG on demand. Of these four wild species namely *Arachis prostrata*, *Arachis marginata, Arachis appressipilla,* and *Arachis rigoni* are very promising with high growth rate and fast multiplication. The TNAU has releases a wild genotype from *Arachis rigoni for* its cultivation in India, however the *Arachis prostrata* is most promising and need further promotion. The stem cutting of these wild species, from a fully established plant of 3-6 month old, planted in field establish and cover an area of 1-2 m^2 within 3-4 months and ready for cutting in next month. Application of 2% NAA helps in establishing these wild species by developing root fast. Such unique species could be introduced in abandoned Jhum land to check soil erosion and tone up fragile eco-system.

4.15. Mechanization and Marketing

The economy of these NEH region are mainly rural and agrarian and the major problems faced by the farmers are use of mechanized farming and the purchase of seed and sale of the produce once it has been harvested, because of diverse topography, altitude and climatic conditions. There are no organized marketing and buyer for groundnut in NEH region. 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.

For oil extraction the tiny oil mills manufactured in Gujarat are suitable 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. 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

a



b

a. Comparison of various INM practices on the root growth, nodulation and podding in groundnut in acid soils of Tripura.

b. Demonstration of groundnut on farmes's field at Lumkremonbhut (Umsamlem), Ri-Bhoi District, Meghalaya.

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.

4.16. Economics

Groundnut is the most profitable crop in NEH region, 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 is given in Table 3 for NEH region. 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. In the mid altitude (950-1080 m msl) rainfed dry terraces of Meghalaya, the 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}.

Estimated cost of cultivation of groundnut and net economic return in NEH region for production of 1500 kg ha^{-1} pod during kharif season are as follows:

Cost of various operations for groundnut cultivation	NE region (Rs ha^{-1})
1. Operation cost (field operation up to sowing)	3000
2. Cost of interculture operation and plant protection	2500
Weeding twice (20 labour), Pesticides, application (Two labours) @ Rs. 70 per labour day^{-1} (*labour is cheaper in Eastern region)	
3. Harvesting and drying (20 labourers)	1600
4. Cost of inputs	
i. Seed (groundnut) 110 kg kernel ha^{-1} @ Rs. 40 kg^{-1} seed	4400
ii. Fertilizers N_{20} P_{60} K_{30} and pesticides	1500
Total cost	13,000
Total return (Rs. ha^{-1}) for 1500 kg pod yield and produced is sold @ Rs 20 kg^{-1} pod	37500
Net economic return (Total return – cost of cultivation)	24, 500

5. Organic farming and value addition

Most of the soils in NEH region, though acidic, are rich in organic carbon and there is hardly any use of chemicals, fertilizers and pesticides in cultivation and hence provide congenial environment for growing organic groundnut. In hill agricultural, the role of organic carbon is the most important, but in low organic carbon, the traditional farmers do not want to give input and prefer shifting cultivation that makes agriculture throughout organic. However, in permanent fields and terrace cropping no organic matter is added resulting in high hematite and soil compactness where the organic manures need to be added. The humic and other organic acids immobilize Al^{3+} ions by forming chelates and hence raising organic content of the soil can largely prevent the harmful effect of this.

As water is not a limiting and groundnut has good pod filling in the NEH region, it has a great potential for confectionary groundnut under organic farming. But as large-seeded groundnut requires higher amount of nutrient, its management is bottleneck in production. Various combinations of nutrient studied show that large-seed groundnut required potassium in addition to P and Ca and recorded highest pod yield at P_{50} (kg ha^{-1}) + K_{50} (kg ha^{-1}) + Lime (2.5 t ha^{-1}) + FYM (10 t ha^{-1}). Under organic farming there is provision to add RP for P and gypsum for Ca and S and mined ore of other nutrients. Thus, there is a great scope for producing the large-seeded groundnut organically.

Various organic farming approaches tested for organic matter enrichment in Tripura, Meghalaya and Manipur at low soil pH (4.9-5.2), and available P (5-8 ppm) reveals that:

- The organic fertilizers showed its superiority over inorganic one and FYM (0.8, 0.6 and 0.9 % of N, P and K, respectively) alone at 10 t ha^{-1}, doubled the productivity and was best for highly eroded soils of NEH .
- Manure and slurry of piggery, poultry and rabbitry sheds, caster and neem cakes, and 'Bun' farming practice were promising organic approaches.
- In Tripura, the promising organic sources were, cowdung (10 t ha^{-1}), mustard cake (1 t ha^{-1}), and Gliricidia green leaves (10 t ha^{-1}).
- In Manipur, mustard cake (1 t ha^{-1}) increased 50 % pod yield, but if combined with *Bradyrrhizobium* increased 102 % yield. Maximum pod yield was obtained with 5 t ha^{-1} FYM + 0.5 t ha^{-1} mustard cake + *Bradyrhizobium*.

- FYM @ 10 t ha^{-1} along with *Bradyrhizobium* showed more pod yield than NPK + Lime.

Results of NRCG-ICAR Res complex vollaborative trial on organic use and its comparison with various chemicals on groundnut variety ICGS 76, at Barapani during kharif season are given below:

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

Though the soil of the NE states is rich in organic matter, it is depleting fast and may pose problem in future. Thus to maintain the organic matter, there is need to add the local manorial resources for continuous organic farming of groundnut in NEH region.

Besides being a premier oilseed crop, groundnut 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. Groundnut has proved to be a poor man's energy nut with the nutritional status similar to cashew at more than 6 times cheaper cost and therefore, deserves promotion. 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.

6. Constraints and strategic approaches to increase the productivity

6.1. Constraints

Inspite of enough research, there are some constraints in the cultivation of groundnut mainly due to inadequate development activities on this crop, which need to be removed so that farmers could adopt new technologies and increase groundnut productivity in NE regions. 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. As the area is dominated by rice crop, groundnut has received less attention for development activities. Some major problems of groundnut are:

- Soil acidity, Al-toxicity and Al-induced deficiencies of Ca, P and Mg.
- Micro-nutrient 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.
- The NEH region has high rainfall, most of which is received during the monsoon period. The high rainfall and heavy down pour during sowing causes problem of land preparation and many a time seed get rotten due to high moisture and poor drainage.
- Excessive stem elongation due to less sunshine duration and number of sunny days during kharif leads to lodging of crop resulting in low yield and harvest index.
- Delayed release of land for rabi groundnut due to long duration rice cultivars.
- Poor quality seed causes patchy crop stand specially during rabi and summer season as there is quick loss of seed viability of the rabi and summer produce of these region.
- 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).
- Lack of seed storage facilities in the region.
- Predominane of small and marginal farmers whose investment capacity is limited.

6.2. Strategic approaches

Groundnut cultivation in NEH region was introduced nearly 25 years ago and now it offers a scope for expansion in area and production. However, for its further expansion and to get rid of constraints, introduction of high yielding cultivars, 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, polythene mulch and storage technologies and marketing and processing are the major strategic approaches for the promotion of groundnut in NEH region which are briefly highlighted here.

6.2.1. Production of quality seed

- Making availability of quality seed to the farmers is most essential part without that the entire programme is failure. With identification of a number of groundnut varieties developed by NRCG and AICRPG centres, the Assam Seed Corporations, State Farm Corporation of India, National Seed Corporation, West Bengal State Seed Corporation etc., situated in this region should take the multiplication of foundation/certified seeds of ICGS 76, ICGV 86590, BAU 13, CSMG 84-1 and TKG 19A groundnut cultivars, through state seed farms/registered growers, store it locally and make available in this region. The availability of quality seeds may be increased throught implementation of seed village programme.
- As the produce of rabi/summer groundnut looses its viability fast and soon becomes unfit for sowing for next rabi/summer season, the seed produced during rainy season which is of better quality should be produced in enough quantity to cater the requirement of kharif as well as post-rainy season.
- Development of high yielding, early maturing (85-90 days) bunch varieties coupled with fresh seed dormancy for rice fallow. Two pre-release culture FeESG 8 and FeESG 10 have been found promising. Presently, JL 24 and Girnar 1 are the earliest cultivars available.

6.2.2. Management approaches

- For successful cultivation, the recommended packages of practices need to be followed. However, more attention is required on the following approaches.
- The optimum sowing time, spacing and seed rate should be followed as 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.
- During rabi residual in river bed/rice fallow polythene or straw mulch need to be followed.
- The recommended fertilizer doses of NPK are 40:60:40 kg ha^{-1} for NEH regions.
- The groundnut requires higher amount of Ca, S and Mg which are deficient in acid soils. Application of lime or gypsum is essential as 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 2-2.5 t ha^{-1} is useful for groundnut.
- 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.
- Supplementary application of organic matter is necessary for the improvement of acid lateritic soils low in organic matter as it improve soil moisture holding capacity, alleviate Al, Fe and Mn toxicity and develop active sites for retention of P and Ca, particularly where liming is not practicable. 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 alleviating nutrient deficiencies and yield enhancement of groundnut.
- Excellent responses of *Bradyrhizobium* inoculation indicate that the population of native *Bradyrhizobium* is quiet low in NE region. Efforts should be made for multiplication and distribution of new strains of *Bradyrhizobium* such as IGR 6, IGR 40 and TAL 1000 in acid soil.

- Most of the fertile soil of NEH region, due to its looseness and high organic matter, is most potential for growing large-seeded groundnut for table and confectionery purpose. The promising cultivars are BAU 13, TKG 19A and GG 20. However, as the large seeded groundnut requires high Ca, these must be grown with 2-2.5 t ha^{-1} lime during rainy season.
- It is essential to keep the groundnut field weed free up to 50 DAS, for which one to two hand weeding followed by hoeing are sufficient. 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.
- The high productivity of rabi and summer groundnut crop makes it worthwhile increasing its area in NEH region, where land remains fallow and water is not a limiting factor. However, low temperature during germination and initial growth stages are the main drawback of such situations. The use of polythene mulch, may be popularized in this region which enhances the germination and initial growth by increasing temperature during early growth stages.
- 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.
- The jassids, leaf folder and cater pillar are the major insect pest in this region. For the control of leaf eating pests, carbaryl (0.1%) and for sucking pests monocrotophos, quinolphos, and methyl parathion all at 0.05% is most appropriate.
- 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. A fungicide mixture of carbendazim 0.05% + mancozeb 0.2% was useful if sprayed up to 50 DAS. To avoid soil born diseases, treat the seed with Thiram @ 3 g kg^{-1} seed before sowing.
- There is an urgent need for expansion of groundnut cultivation in rice based cropping system, as groundnut in rice-groundnut rotation has advantages over rice-rice rotation in its low water requirement as compared to boro paddy (summer rice), very little amount of fertilizers, disruption in disease and pest cycle and high monitory return and improvement of soil physical and chemical properties and nutritional health.

6.2.3. Extension and liaison between various agencies

- Further to popularize groundnut cultivation, the large scale frontline demonstration is to be conducted in the entire NEH region. The video film of the good 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.
- Seed producing agencies situated in these region or the nearby should produce Foundation/ Certified seeds of the identified cultivars and make available in these regions. Breeders from ICAR Research complex, Central Agricultural University, and Assam Agricultural University may be involved in the monitoring team.
- Although various input and development agencies are expected to participate in regular forum, their involvement is very less. Since they are under the control of the district administration, the Dy. Commissioner, may call for formal meetings of all such agencies with research organization, at least thrice in a year, to have a threadbare discussion on the means and prospects of agricultural development in the region.
- Lack of institutional credit, low level of fertilizer consumption, non availability of matching farm machineries and tools, absence of proper marketing to ensure a fair and legitimate return to the producer, no infrastructure for groundnut processing, and proper post harvest technology are some of the institutional and technological problems for which the creditable success to be achieved in cooperation with several agencies, otherwise the production of groundnut is bound to suffer.

7. Further reading

Basu M.S.1997. Mitigating challenges of food and nutritional security in India-not merely a peanut approach. Indian Farming 29(12): 24-29.

Basu M.S.1998. Miracle Mulching for higher groundnut yields. ICAR-News Vol 4 (1) p.17.

Basu MS 2002. Aflatoxin Management in Groundnut (in 5 major languages published by UNDP, ICAR and TMOP). p 16.

Basu MS, Rathnakumar AL and Chuni Lal 2002. Improved groundnut varieties of India. National Research center for groundnut (ICAR), Junagadh, India p 28.

Basu MS, Singh NB, Rathnakumar AL and Govindaraj G 2003. Polythene Mulch Technology in Groundnut. National Research center for groundnut (ICAR), Junagadh, India p 22.

Ghewande MP, Desai S and Basu MS 2002. Diagnosis and management of major diseases of groundnut. National Research center for groundnut (ICAR), Junagadh, India p 36.

Ghewande MP, Nandagopal V, Desai S and Basu MS 2003. Integrated pest management in groundnut. National Research center for groundnut (ICAR), Junagadh, India p 19.

Munda-GC; Hazarika-UK; Saxena-DC; Raj-Singh; Patel-DP; Singh-R 1999. Performance of cropping systems under mid altitude rainfed dry terraces of Meghalaya. Indian-Journal-of-Hill-Farming. 1999, 12: 1-2, 106-110.

Munda, G.C.; Hazarika, U.K.; Raj Singh; Sarma, B. K. and Jai Singh 1997. Groundnut cultivation in North Eastern Hills. ICAR Research complex for NEH region Barapani Meghalaya 32 p.

Singh A.L. and M.S. Basu, 2005. Integrated nutrient management in groundnut-a farmer's manual. National Research center for groundnut (ICAR), Junagadh India p 54.

Singh, A.L., M.S. Basu and N.B. Singh, 2003. Potential of Groundnut in North-eastern States of India. National Research center for groundnut (ICAR), Junagadh, India p 76.

Singh, A. L., M. S. Basu and N. B. Singh 2004. Groundnut Research and its potential in North-eastern States of India. pp 160-177. In: Groundnut Research in India (Eds. M. S. Basu and N.B. Singh) National Research center for groundnut, Junagadh, India.

Singh A.L., M.S. Basu and N.B. Singh, 2004. Mineral Disorders of Groundnut. National Research center for groundnut (ICAR), Junagadh India p 85.