



Principles and Practices for Groundnut Seed Production in India

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Abstract

Seed production is a specialized farming controlled by various rules and regulations and requires different treatment than the commercial crop. A successful seed producer should be well versed with the crop and its production, packaging and storage technologies and improved varieties and their characteristics besides being aware of various seed acts and regulations in operation in the country. This publication deals with brief introduction of the crop, its origin, taxonomy and reproductive biology and status of groundnut improvement in India to create awareness about the crop and provides information on the procedure of release and notification of varieties, seeds acts and regulations, protection of plant varieties and farmers' rights act, seed systems prevailing in India and different classes of certified seeds and their production practices and quality standard requirements. In the last few sections, the publication deals with the management of seed crop, important varieties released in India, crop processing, packaging and storage. All those who wish to undertake groundnut seed production or wish to promote groundnut seed production will benefit from this publication as it will prepare them well with the basics of seed production in groundnut.

Principles and Practices for Groundnut Seed Production in India

M Madhan Mohan and SN Nigam

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**International Crops Research Institute
for the Semi-Arid Tropics**

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Introduction

Cultivated groundnut (*Arachis hypogaea* L.) or peanut, is a self-pollinated annual legume crop, widely grown for its high quality edible oil and food use in the tropical and warm temperate regions of the world. The crop is grown in more than 100 countries. The major groundnut producers are China, India, Nigeria, USA, Senegal, Myanmar, Indonesia and the Sudan (undivided). Groundnut is grown on nearly 20.88 million ha worldwide with a total production of 34.66 million tons and an average yield of 1660 kg ha⁻¹ (FAOSTAT 2012). Developing countries account for over 97% of world groundnut area and 95% of total production. India is the second largest groundnut producing nation in the world with an annual production of 5.64 million tons pods after China, which has an annual production of 15.71 million tons pods.

Groundnut seeds contain 48–50% oil and 26–28% protein. They are also a rich source of dietary fiber, minerals and vitamins. Over the years, the food use of groundnut has increased. Oleic acid, a monounsaturated fatty acid, and linoleic acid, a polyunsaturated fatty acid, account for 75–80% of the total fatty acids in groundnut oil (Mercer et al. 1990). High oleic acid groundnut has longer shelf life and flavor stability than normal oleic acid groundnut (Mugendi et al. 1998).

Groundnut is adapted to varying agroclimatic conditions and soils. It is primarily grown in rainy (*kharif*) season (June/July to September/October) under rainfed conditions in India, which accounts for 83% of the total area under the crop in the country. The remaining 17% of the area is cultivated mostly in the postrainy (*rabi/summer*) season (October/November to March/April) with irrigation or on residual soil moisture. A new cropping season, viz, spring (February/March to June/July) is becoming popular in northern India especially in Uttar Pradesh. Groundnut cultivation in the rainy season is mainly concentrated in semi-arid and arid parts of Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Rajasthan states in India. In most countries in Asia and Africa, the rainfed groundnut is grown under low input conditions; hence yields can vary substantially from year to year due to biotic and abiotic stresses. The crop is grown either as sole crop or mixed/intercropped with other crops in rainy season. Commercial cultivation of groundnut in both developed and developing countries is carried out as a sole crop under high input conditions.

Origin, taxonomy and reproductive biology

Genus *Arachis* belongs to the family Fabaceae (syn: Leguminosae), subfamily Papilionaceae, in the subtribe Stylosanthinae of the tribe Aeschynomeneae (Taubert 1884). The cultivated groundnut is native to South America. Central Brazil is its probable center of origin extending from the southwest of Mato Grosso do Sul State (and the adjacent border of Paraguay) to the south of Goias (Valls 2000).

It is believed that groundnut has been grown in diverse regions of South America for more than 5000 years, and from there, it has spread worldwide (Freitas et al. 2007). The African continent is regarded as a secondary center of diversity of groundnut (Gibbons et al. 1972).

The cultivated groundnut (*A. hypogaea*) is an allotetraploid ($2n=4x=40$) with AABB genomes (Fig. 1). Groundnut flowers are typically papilionaceous and zygomorphic with a reduced pedicel (Fig. 2). Husted (1936) was the first to study the morphology of the somatic chromosomes of *A. hypogaea* and report about a pair of conspicuously short chromosomes called 'A' having median centromere and another pair with satellite chromosomes named 'B', characterized by unusually long secondary constriction. The position of the centromere in 'B' was sub-terminal. Smartt et al. (1978) first designated them as the 'A' and 'B' genome, respectively. Stalker (1991) reported another species, *A. glandulifera* Stalker (*A. spinaclava* Krap. & Greg.), in section *Arachis* with a highly asymmetrical karyotype, distinctly different from 'A' and 'B' genomes; he designated this as the 'D' genome (Singh and Simpson 1994).

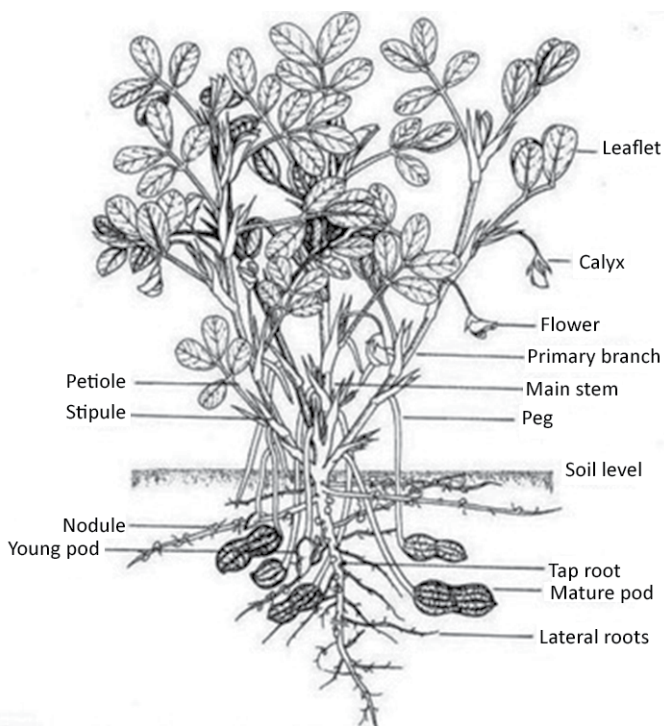


Figure 1. A schematic presentation of a groundnut plant.

Groundnut is a self-pollinated leguminous crop (with less than 1% cross-pollination) but cross-pollination up to a maximum of 10% was reported from locations where honeybee activity was high (Hammons 1964, Knauff et al. 1987). Outcrossing can result in natural hybridization (Nigam et al. 1983) and genetic instability (Smartt 1960).

Groundnut seed is very delicate and is highly sensitive to different stresses before, during and after harvest including storage. Figure 3 illustrates different parts of a groundnut seed.

The classification of cultivated groundnut by Gregory et al. (1951) was a comprehensive study in which groundnut was divided into two large botanical groups, Virginia and Spanish–Valencia, on the basis of branching pattern as described by Richter (1899). The presence or absence of reproductive axes (inflorescence) on the main stem and the arrangement of reproductive and vegetative axes on the primary laterals were the most important criteria for classification. The main axis was denoted as n and the primary, secondary and tertiary lateral branches $n+1$, $n+2$ and $n+3$, respectively.

The Virginia group (subspecies *hypogaea*) is characterized by the absence of reproductive axes on the main stem. It is also characterized by ‘alternate branching pattern’, ie, having alternate pairs of vegetative and reproductive axes on the cotyledonary lateral and other $n+1$ branches. The Spanish–Valencia group (subspecies *fastigiata*) is characterized by ‘sequential branching pattern’, ie, presence of reproductive axes in a continuous series on successive nodes of lateral

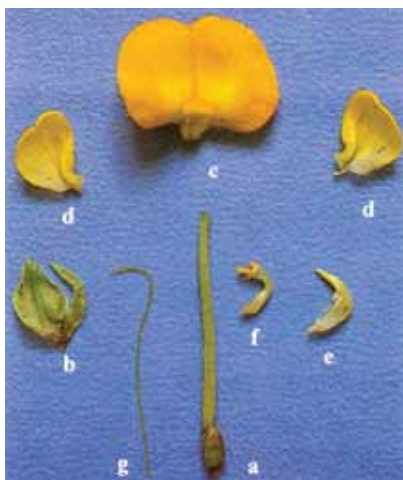


Figure 2. A dissected groundnut flower: (a) Hypanthium, (b) Single and fused sepals, (c) Standard petal, (d) Wing petal, (e) Keel petal, (f) Stamens and (g) Style and stigma.



Figure 3. Parts of a groundnut seed.

branches, on which the first branch is always reproductive. The reproductive axes are also borne directly on the main axis at higher nodes (Ramanatha Rao and Murty 1994).

The cultivated groundnut was also classified by Bunting (1955, 1958) and extended by Smartt (1961) with the taxonomic treatment of Krapovickas and Rigoni (1960) and Krapovickas (1968). The cultivated groundnut *A. hypogaea* (Linnaeus 1753) has two subspecies, viz, *hypogaea* (Krapovickas and Rigoni 1960) and *fastigiata* (Waldron 1919). The comprehensive subspecific classification of *A. hypogaea* is summarized in Table 1 as described by Ramanatha Rao and Murty (1994).

Table 1. Classification of cultivated groundnut (*Arachis hypogaea*) and traits associated with different botanical varieties.

Characters	Subspecies <i>hypogaea</i>		Subspecies <i>fastigiata</i>	
	Botanical variety <i>hypogaea</i>	Botanical variety <i>hirsuta</i>	Botanical variety <i>fastigiata</i>	Botanical variety <i>vulgaris</i>
Foliage	Dark green	Dark green	Lighter than <i>hypogaea</i>	Lighter than <i>hypogaea</i>
Growth habit	Procumbent, decumbent or erect	Procumbent	Erect or decumbent	Erect or decumbent
Branching pattern	Alternate	Alternate	Sequential	Sequential
Main axis	40–50 cm	About 1 m	Primary branches shorter than main axis	Primary branches shorter than main axis
Floral axes on main stem	Absent	Absent	Present	Present
Inflorescence	Simple	Simple	Usually simple	Compound
Stem hairiness	Less hairy	More hairy	Sub-glabrous to moderately hairy	Hairy
Maturity	Medium to late	Very late	Short duration	Short duration
Seed coat color	Tan, red, white, purple or variegated	Tan, red, white, purple or variegated	Tan, red, white, yellow, purple or variegated	Tan, red, white or purple
Seed size	Very large to small	Large to small	Medium to small	Medium to small
No. of seeds pod ⁻¹	Usually two	Two to four	Two or two to four; rarely five	Two
Pod beak	Not very prominent	Strongly beaked and ridged	Absent or prominent or slight	Present or absent
Seed dormancy	Present	Present	Absent	Absent
Botanical type	Virginia defined by Gregory et al. (1951)	Peruvian runner defined by Gibbons et al. (1972)	Valencia defined by Gregory et al. (1951)	Spanish defined by Gregory et al. (1951)

Krapovickas and Gregory (1994) proposed two new botanical varieties of subspecies *fastigiata*, viz, var *peruviana* and var *aequatoriana* in addition to the existing var *fastigiata* and var *vulgaris*. The microsatellite markers revealed a large dissimilarity among germplasm accessions representing *A. hypogaea* varieties so far included in the same subspecies *fastigiata* (*aequatoriana* + *peruviana* vs *fastigiata* + *vulgaris*), a subject that deserves further investigation (Freitas et al. 2007). The characters used to characterize a germplasm accession are given in “Descriptors for Groundnut” published by IBPGR and ICRISAT (1992) (Annexure I).

Groundnut improvement in India

It is believed that groundnut was introduced into India in the first half of 16th century by the Spaniards (Krapovickas 1968). Purposeful introduction of improved varieties of groundnut in India was made towards the end of the 19th century. In 1884, the Mauritius variety was introduced into Pondicherry and Madras from Mauritius. During 1901–02, the Bombay Department of Agriculture introduced Coromandel variety of groundnut from Pondicherry, Spanish and Virginia varieties from USA and Small Japan and Bold Japan from Japan (Achaya 1990). In the crop improvement history of groundnut, two years, 1905 and 1961, represent important landmarks. Groundnut cultivar ‘Spanish Improved’, a pure line selection from ‘Spanish’ groundnut from USA was officially released in 1905 for cultivation in the Bombay–Karnataka region of old Bombay state. In 1961, C 501, a Virginia bunch cultivar derived from a cross between D 3 and Ah 477 made at Ludhiana, was released for cultivation in India. Between 1906–60, 12 cultivars were released for cultivation in different parts of the country. These cultivars were developed either by pure line or mass selection in local/introduced varieties. Prominent among these were AK 12-24 and TMV 2 (both Spanish types and released in 1940). The Virginia runner types, viz, Karad 4-11 and T 28 were released in 1957 and 1960, respectively. During 1961–79, 28 more cultivars were released. Of these, 11 originated from hybridization and 17 were mass/pure line selections (Nigam et al. 1993).

Groundnut breeding in India received a big impetus in 1980s when 30 new cultivars were released. Of these, 80% were cross derivatives. These new cultivars included 20 Spanish, 7 Virginia bunch and 3 Virginia runner types. Among these, Girnar 1, ICGS (FDRS) 10 and ICGV 86590 were resistant to foliar diseases and ICGS 11, ICGS 37 and ICGS 44 were adapted to postrainy (*rabi*/summer) season. Till date, more than 130 groundnut cultivars belonging to different habit groups have been released in the country under the aegis of the ‘All India Coordinated Research Project on Groundnut

(AICRP-G)' of Indian Council of Agricultural Research (ICAR) and the breeding programs of state agricultural universities (SAUs) (Rathnakumar et al. 2010).

The breeding methods followed in developing groundnut varieties in India include introduction, mass selection, hybridization followed by selection (pedigree, bulk and single seed descent methods), backcrossing and mutation breeding. Most of the gains in yield in improved varieties have come from increase in seed size, seed weight and number of pods per plant (Manivel et al. 2000, Rathnakumar et al. 2010).

Release and notification of varieties

The system of official release of crop varieties in India was formalized in 1964 with the establishment of the Central Variety Release Committee (CVRC) at the national level and State Variety Release Committee (SVRC) at the state level in various states. In 1969, the functions of CVRC were taken over by the then newly constituted Central Seed Committee (CSC), which advises the central and state governments on matters arising from implementation of the Indian Seed Act 1966. The State Seed Sub-Committee can release a variety at the state level, but only the CSC can issue a notification of such releases. Only notified varieties can be certified under the formal seed production program.

As per Seed Rules of 1988, varieties of foreign origin may get provisional notification after one year of testing at 15–20 locations in a season. For regular notification, however, two additional years of testing is required. Seed Certification Agency notified under the Indian Seed Act or any certification agency established in any foreign country, provided the certification has been recognized by the Government of India (GoI) through notification in the Official Gazette, can certify the Foundation and Certified seeds (Nigam et al. 2004).

Important groundnut varieties released and notified since 2000 in India are listed in Annexure II.

Seed Acts and regulations

Indian Seed Act

The Indian Seed Act was enacted by the GoI in 1966. Indian Seed Act 1966 and Seeds Rules 1968 with Seeds (Control) Order 1983 are the legal instruments for regulating production, distribution and the quality of seeds for sale and for matters

connected therewith. The quality of seed sold for agricultural purposes is regulated through compulsory labeling and/or voluntary certification. These legal instruments have been further modified/amended as and when needed to meet the changing requirements of the agriculture scenario. Seeds of various crops except landrace varieties/types have been placed under the Open General License under new Export and Import Policy 2002–2007 to encourage export of seeds in the interest of farmers.

Protection of Plant Varieties and Farmers' Rights Act

The Indian Patent Act 1970 excludes agricultural and horticultural methods of production from patentability. The *sui generis* system for protection of plant varieties was developed integrating the rights of breeders, farmers and village communities and taking care of the concerns for equitable sharing of the benefits. The Protection of Plant Varieties and Farmers' Rights Act (PPV&FR Act) was passed by the GoI in 2001 after it became signatory to the Trade Related Aspects of Intellectual Property Rights Agreement (TRIPS). The objectives of the PPV&FR Act are to provide for the establishment of effective system for protection of plant varieties and for the rights of farmers and plant breeders, to stimulate investment in research and development and facilitate growth of the seed industry and to ensure availability of high quality seeds and planting materials of improved varieties to farmers. The Protection of Plant Varieties and Farmers' Rights Authority (PPV&FR Authority), India is operational since 11 November 2005. At present, it is accepting the applications for 57 notified crop species.

Farmers' Rights

In India, the farming community is the largest producer of seeds to meet the bulk of national seed requirement. India's *sui generis* law recognizes the farmer as a cultivator, as a conservator of the agricultural gene pool and as a breeder of several successful varieties. This recognition, among other facilities/benefits, entitles the farmer to register a variety bred/developed by him/her with appropriate authority and seek protection in a manner as a breeder of a variety under this act. Further, this act allows the farmer to save, use, sow, re-sow, exchange, share or sell his/her farm produce including seed of a variety protected under this Act in the same manner as he/she was entitled before enforcing this Act. However, the farmer is not allowed to brand his/her seed with the breeder's registered name of the variety.

Breeders wanting to use farmers' varieties (traditional varieties, folk varieties and landraces) for creating 'essentially derived varieties' cannot do so without the express permission of the farmers involved in conservation of such varieties. According to PPV&FR Act, the use of farmers' varieties to breed new varieties will have to be paid for. Genetically modified varieties will be categorized under 'essentially derived varieties' that are more or less (essentially) the same as the parent variety retaining the whole genetic structure, except for limited, specific changes.

The PPV&FR Act provides for compensation to farmers in case the seed supplied by the breeder/seed company is spurious and/or of bad quality and fails to perform as promised by the breeder or the seed company.

Breeders' Rights

On registration, a breeder has complete rights of commercialization (right to produce, sell, market, distribute, import or export, ie, full control over formal production and commercialization) for the registered variety, either in person or anyone he/she designates. Infringement of Breeders' Rights is punishable with substantial fines, including jail terms.

Seed systems in India

Seed is the basic and most critical input for enhancing production, productivity and economic returns from agriculture. The response of all other inputs used depends on the quality of seeds used. The direct contribution of quality seed alone to the total production is about 15 to 20% (Ayyappan 2011) and it can be further raised synergistically with efficient management of other inputs. In order to bring about rapid transformation in the Indian agricultural economy, timely availability of quality seeds and at affordable price is essential.

Formal seed system

Ensuring supply of quality seed to farmers is the responsibility of the state governments, in collaboration with the state and central seed producing agencies in India. The state governments prepare a plan indicating their requirement of Breeder, Foundation and Certified seeds for each year and ensure their proper multiplication and distribution. The public sector seed companies/state governments forecast seed demand for various crops three years in advance. However, public

sector seed agencies have been only partially able to meet the seed requirement of the farmers. They rely mostly on local traders, local market and farmers' own-saved seed to meet a major part of their seed requirement. In the local markets, graded and cleaned commercial produce is often sold as seed. In spite of release of many varieties at national and state levels, the old varieties such as TMV 2, JL 24, AK 12-24, SB XI and J 11 continue to dominate groundnut cultivation in the country. New varieties have not reached the farmers as their seed is not available in required quantities. Sometimes new varieties have also failed to fulfill farmers' expectations. Shortage of quality seed continues to be one of the major constraints for spread of new improved varieties and realizing their yield potential. Notwithstanding the improvement in the seed replacement rate for groundnut from 14.29% in 2007–08 to 17.04% in 2008–09, it remains low in comparison to the need and requirement (Tiwari et al. 2011). In general, production of the Breeder seed of groundnut varieties in AICRP-G often exceeds the indented quantity. However, this has not resulted in significant increase in the seed replacement rate in groundnut. There appears to be some disconnect in the formal seed production chain.

Although the Indian seed market is one of the largest, it is almost exclusively supplied by locally produced seeds. In the past, the Indian seed industry was dominated by public sector seed companies. However, following the easing of government regulations and the implementation of a new seed policy in 1988, the private sector seed companies started playing a major role in seed development and marketing particularly in crops where hybrid cultivars are grown. There are more than 100 private seed companies operating in India. Unlike the crops where 'hybrid' cultivars are grown, the organized private seed sector has shown little interest in production and marketing of seed of legume crops due to reasons such as low seed multiplication ratio (1:5 to 1:10 in groundnut), bulky nature of the produce, quick loss of seed viability, high cost of transportation, low profit margins and self-pollinated nature of the crops which allows farmers to save their own seed.

National Seed Project

ICAR is the nodal agency for organizing, production and supply of Breeder seed of crops and of seed production technologies. In order to address the issue of shortage of quality seed and promote research in the area of seed, the All India Coordinated Research Project (AICRP) on Seed was launched in 1979 and named National Seed Project (NSP), with 14 centers in different SAUs. This project now has 35 Breeder Seed Production Centres and 23 Seed Technology Research Centres in the country

at various SAUs/ICAR institutes. The AICRP-NSP (Crops), now coordinated by the Directorate of Seed Research (DSR), Maunath Bhanjan, ensures production of adequate quantities of Nucleus and Breeder seeds of high quality as per national requirement. During 2005–06, ICAR launched a mega seed project 'Seed Production in Agricultural Crops & Fisheries' to strengthen the seed production infrastructure of 85 cooperating centers of SAUs and ICAR institutes. Besides ensuring quality control arrangements, the central sector scheme provides for transport subsidy on movement of seeds to the Northeast region and other hilly areas, establishment and maintenance of seed bank, seed village scheme, assistance for boosting seed production in private sector, human resources development and assistance for seed export. The DSR maintains close linkages with the AICRP on field crops, SAUs, Seed Division [Department of Agriculture and Cooperation (DAC), Ministry of Agriculture (MoA), GoI], public and private seed companies, Seed Certification Board and PPV&FR Authority.

Public sector seed agencies

The public sector seed producing agencies include central and state government sponsored/supported seed producing entities, Department of Agriculture (DoA), SAUs, ICAR institutions and the cooperative seed sector. At the national level, two corporations, viz, National Seeds Corporation Ltd (NSC) and State Farms Corporation of India Ltd (SFCI), are the major players among the public sector seed corporations. Recently, another public sector company, viz, National Seed Association of India (NSAI), has also entered in seed business. Four seed associations, viz, Seed Association of India, Association of Seed Industry, Indian Seed Industry Association and All India Crop Biotechnology Association joined together and formed NSAI in May 2007. NSAI was registered under the Societies Registration Act, XXI of 1860.

The NSC was established in 1963 and the SFCI in 1969. The main function of NSC was to produce Foundation and Certified seeds, and SFCI was established initially to increase the food production of the country. Later on, SFCI was also entrusted with the production of Foundation and Certified seeds of high-yielding varieties and now with Test Stock Seeds besides its regular program. It is the largest seed producing agency with its own farms in the country. Both are under the administrative control of DAC, MoA, GoI. In addition to these national level seed producing agencies, there are 15 state level seed corporations, 22 State Seed Certification Agencies (SSCAs) and 104 state seed testing laboratories in different states.

Description of different classes of seed

In the formal seed production system in India, the following classes of seed are recognized: Nucleus seed, Breeder seed, Foundation seed and Certified seed. Often Registered seed is omitted and Certified seed is produced directly from Foundation seed. Due to low seed multiplication ratio in the case of groundnut, two stages of production, viz, Stage I and Stage II, in Breeder and Foundation seeds are permitted to enable production of substantial quantity of Certified seed. The seed production chain adopted in groundnut is presented in Table 2.

The originating institution of a variety can authorize another breeder/institution to produce Nucleus and Breeder seeds of its variety. This arrangement is often resorted to at Breeder seed stage to produce large quantity of seed to ensure production of sufficient quantity of Certified seed at the end of seed production chain.

Nucleus seed. Nucleus seed is produced from the basic seed stock (Nucleus seed or Breeder seed), available with the originating breeder or institution under the direct supervision of the originating or a sponsored plant breeder following the progeny row method. The Nucleus seed represents the highest degree of purity in seed. True to type plants (representing diagnostic characteristics of a released variety) are selected individually from the space planted basic seed stock to produce Nucleus seed. The number of selected plants depends upon the quantity of Nucleus seed to be produced taking the seed multiplication ratio of the crop into account. These

Table 2. Seed production chain in groundnut in India.

Production season/year	Production stage	Agency responsible
I	Nucleus seed	Institution/breeder, who developed the variety
II	Nucleus seed to Breeder seed Stage I	Institution/breeder, who developed the variety or authorized sponsored breeder
III	Breeder seed Stage I to Breeder seed Stage II	Institution/breeder, who developed the variety or authorized sponsored breeder
IV	Breeder seed Stage II to Foundation seed Stage I	Public/private sector seed agencies or Department of Agriculture (DoA)
V	Foundation seed Stage I to Foundation seed Stage II	Public/private sector seed agencies or DoA
VI	Foundation seed Stage II to Certified seed	Public/private sector seed agencies or DoA
VII	Distribution of Certified seed to farmers for cultivation	Public/private sector seed agencies or DoA

selected plants, while growing, are monitored for their plant characteristics in the field, and for pod and seed characteristics after harvest. Only those plants, which fully conform to the diagnostic characteristics of the variety under multiplication, are retained individually. In the following season, these plants are space planted in progeny rows and each progeny is again monitored carefully at preharvest and postharvest for diagnostic characteristics of the variety under multiplication. Any progeny deviating from these diagnostic characteristics is rejected. The selected plants are then bulked to form Nucleus seed stock (Nigam et al. 2004).

Breeder seed. Nucleus seed is used to produce the Breeder seed. Similar to the Nucleus seed, the Breeder seed is also produced by the breeder who developed the variety or by the institution where the variety was developed or by other SAUs under the direct supervision of a breeder of the concerned crop working in that university. The Nucleus seed is multiplied to obtain Breeder seed Stage I, which in turn is multiplied to obtain Breeder seed Stage II. Breeder seed is genetically 100% pure. The Breeder seed crop is sown at the normal recommended plant density. The required isolation distance is maintained between two groundnut varieties in seed production plots. Breeder seed does not have any prescribed certification standards. However, as per the Indian Minimum Seed Certification Standards, “Breeder seed should be genetically so pure as to guarantee that in the subsequent generation, ie, certified Foundation seed conform to the prescribed standards.”

Breeder seed is used to produce the Foundation seed and is not available for general cultivation. The availability of Breeder seed of notified varieties in required quantities is essential to promote and sustain the certified seed production chain. Public sector seed producing agencies, DoA and other institutions can place their indent for Breeder seed requirement with the Seed Division, DAC, MoA, GoI. Private seed companies and individuals can also submit their requirements to the NSAI, who consolidate the requirements and place the indent with the Seed Division. These indents are then screened and compiled variety-wise, state-wise, agency-wise and sent to the Deputy Director General (Crops), ICAR, who, in turn, sends these consolidated indents to Project Coordinators of the respective crops for making arrangements for production of Breeder seed through SAUs, ICAR institutions and public sector seed producing agencies. The DoA of different states also place indents directly to their SAUs and Breeder seed production agencies in the state for production and supply of Breeder seed of popular national varieties and state-released varieties, not covered by Breeder seed production program organized by the DAC through ICAR.

Although no certification for Breeder seed is required by law, the ICAR has devised a system of monitoring of Breeder seed production program to ensure quality control and production of required quantity of Breeder seed to maintain seed production chain in the country. Monitoring teams are constituted region-wise and they consist of: (i) Breeder of the variety, the concerned Project Director or his nominee and representative of NSC at the national level; and (ii) Breeder of the variety, Nodal Officer (Seeds) or his nominee from the SAU and Assistant Director of Seed Certification of that locality at the state level.

The Breeder seed production (BSP) proforma used to record the performance of Breeder seed production is given in Table 3. The proforma is submitted to the concerned crop Project Coordinator and the Seed Division, DAC, MoA, GoI at the national level and the Nodal Officer (Seeds) at the state level.

The color of Breeder seed tag attached to each seed bag is golden yellow (Fig. 4). The unit packing quantity is either 30 kg or 40 kg.

Table 3. Proforma used for monitoring performance of Breeder seed production (BSP) program.

BSP proforma no.	Content	Authority concerned
I	Allocation of Breeder seed production target	Issued by the concerned crop Project Coordinator for GoI indent and respective Commissioner of Agriculture for state indent
II	Schedule of production and expected availability of Breeder seed	Submitted by the producing breeder
III	Monitoring Team Report ¹ Flowering stage (60 DAS) Maturity and harvest stage (90 DAS) Seed lot inspection	Submitted by the producing breeder
IV	Variety-wise Breeder seed production – Final Report	Submitted by the producing breeder
V	Grow-out Test Report	Scientist in-charge of grow-out test
VI	Supply of Breeder seed (national varieties) to seed producing agencies identified by the Seed Division	Submitted by the producing breeder

1. DAS = Days after sowing.
For seed lot inspection, see box on p. 14.

Seed lot inspection

Assignment of a lot number for all kinds of seed lots is mandatory. The seed lot should have five parts, viz, Month and Year code, Production location code, Processing plant code/Production center code, Seed class code and Seed lot code. For example, the seed lot MAR 12-22-VGD-BS-02 indicates:

MAR 12: Crop harvested in March 2012

22: Seed crop raised in Tamil Nadu (22 refers to the state code)

VGD: Seeds processed at Vaigai Dam

BS: Breeder seed

02: Seed produced as 2nd lot in the year 2012

Foundation seed. This is the offspring of Breeder seed or occasionally the progeny of Foundation seed. Similar to Breeder seed, two stages of Foundation seed multiplication are also permissible in groundnut. Foundation seed is produced on government farms or farms owned by seed producing agencies or at research stations/seed production centers by SAUs or by competent seed growers under strict supervision of the SSCA. The Foundation seed crop is sown at normal recommended plant density. The required isolation distance is maintained between two groundnut varieties in seed production plots. The seed production fields are regularly inspected by the seed producing agencies, which are responsible for getting the produce certified by the SSCA. The breeder and originating institution help to maintain genetic purity and identity of the Foundation seed conforming to the standards prescribed for this class of seed. The color of Foundation seed tag attached to each seed bag is white (Fig. 4).

Registered seed. This is the offspring of Foundation seed or Registered seed. It is genetically pure and is used to produce Certified seed or Registered seed. It is usually produced by progressive farmers according to technical advice and supervision provided by the SSCA. In India, Registered seed production is often omitted and Certified seed is produced directly from Foundation seed.

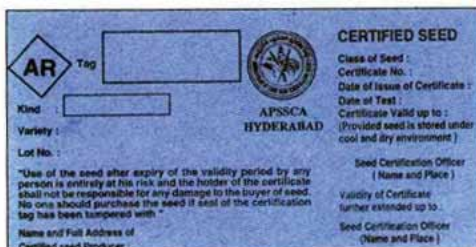
Certified seed. This is the offspring of Foundation, Registered or occasionally Certified seed. It is usually produced by progressive farmers after completing certain formalities. In order to be certified by the SSCA, the seed must meet the prescribed standards regarding purity and quality. The Foundation seed producing agencies normally identify the farmers and enter into an agreement with them to produce Certified seed. The farmers should retain the original tags of parent seed until all



Breeder seed tag



Foundation seed tag



Certified seed tag

Figure 4. Tags used to identify different classes of seed in groundnut.

the inspections by the SSCA are completed. Certified seed is available for general distribution to farmers for commercial crop production. The color of Certified seed tag is azure blue (Fig. 4).

Standards for Foundation and Certified seed production

Each class of seed has its own prescribed seed standards, which are to be met by the seed growers for certification. The following are some of the field and seed certification standards set by the Central Seed Certification Board, MoA, GoI (Table 4), which are to be followed uniformly across the country.

For groundnut seed production, no disease is designated (Rattan Lal Agrawal 1995). However, care should be taken to remove the diseased plants and proper management should be undertaken to control the spread of diseases to get quality produce.

Monitoring and inspection

Field inspection/monitoring by a team of technically qualified personnel, constituted by a duly authorized seed certification agency of a state, and postharvest tests, wherever prescribed, are mandatory for certification of Foundation/Registered/Certified seeds. Based on field inspection and seed analysis reports and results of a grow-out test, the seed certification agency may issue or deny the certificate.

Table 4. Seed certification standards in groundnut¹.

Factor	Class of seed	
	Foundation	Certified
I. Land requirement		
No groundnut variety grown in the selected field	For the past two seasons	For the past two seasons
II. Field standards		
Isolation distance required from the fields of other groundnut varieties (m)	3	3
Isolation distance required from the fields of same variety not conforming to the varietal purity requirements for certification (m)	3	3
Presence of off-types at final inspection (maximum) in the field (%)	0.1	0.2
Minimum number of field inspections (anytime from the initiation of flowering till maturity)	2	2
III. Seed standards		
Pure seed (minimum) (%)	96	96
Inert matter (maximum) (%)	4	4
Off-type plants (maximum) at the final inspection in the field (%)	0.1	0.2
Other crop seed (maximum)	Nil	Nil
Weed seeds (maximum)	Nil	Nil
Germination of the hand-shelled seeds (minimum) (%)	70	70
Moisture content for hand-shelled seeds (maximum) (%)	9	9
Moisture content under vapor proof containers for hand-shelled seeds (maximum) (%)	5	5

1. Source: Tunwar and Singh (1988).

Post-harvest tests

Assessing the planting value of the Foundation and Certified seeds by laboratory tests is an essential test carried out by the officials of the SSCA. The officials draw representative samples from the seeds produced under certification program and subject them to germination and other purity tests required for conforming to varietal purity. The minimum weight of the sample taken for analyzing groundnut is 1000 g pod. The methods adopted for varietal purity tests are given below.

Examination of seed in the laboratory. Examination of morphological characters of the seed, color reaction to certain chemicals, properties of seedlings, response of

seedlings to controlled environment, growth stimulants and stable plant characters are used to detect cultivar trueness.

Examination of seedling growth in a growth chamber or greenhouse. All plants must be examined for distinguishing characters during the whole period or for a period specified by originating breeding institute and deviations from the standard sample of the same variety are recorded.

Field plot tests or grow-out test. The samples drawn from the lots are grown in the field along with standard checks. Growing plants are observed for the varietal purity and also seedborne infection. Grow-out test helps in the elimination of substandard seed lots.

DNA-fingerprinting. Recently DNA-fingerprinting has become available to verify the genetic purity of a variety.

Registration for Foundation and Certified seed production

The farmers, who are interested in producing Foundation/Certified seed, have to register with the SSCA. They have to fill in the 'Seed farm sowing report' (see box on p. 18) in triplicate for which the proforma can be obtained from the office of Assistant Director of Agriculture (ADA) (Seed Certification). After paying the appropriate fees fixed by the state government, the seed production field is registered by the Deputy Director of Agriculture (DDA) (Seed Certification) with the SSCA. After registration, a copy of the seed farm sowing report is given to the ADA (Seed Certification), another copy to the Seed Certification Officer (SCO) of the concerned block and the third copy to the seed producer/farmer.

Once a seed production field is registered, the SCO inspects it to verify if the prescribed standards of land requirement, field and seed for a particular crop are met. The SSCA has the authority to refuse certification of any seed production field or any seed lot that does not conform to the minimum standards prescribed for that particular crop, either for field or for seed or for both (Rattan Lal Agrawal 1995). However, a seed producer aggrieved by a decision of the SSCA can make an appeal on payment of fees to such authority as specified by the state government under section 11(1) of the Seed Act, 1966. Normally, the special permission for re-inspection of the field can be sought from the ADA (Seed Certification) by paying the required fees (75% of the field inspection fees).

Proforma for seed farm sowing report¹

1. Name of the farmer
 2. Crop and variety (sown for certification)
 3. Category of seed (intended for production)
 - a. Foundation seed
 - b. Certified seed
 4. Rainfed or irrigated (field)
 5. Seed farm location
 - a. Village
 - b. Taluk
 - c. District
 6. Area
Different crops/varieties around the boundaries of the seed production plot
 - a. North
 - b. South
 - c. East
 - d. West
 7. Previous crop and variety (grown in the field)
 8. Seed source
 - a. Producer
 - b. Tag no.
 - c. Lot no.
 9. Seed rate per acre
 10. Date of sowing
 11. Anticipated date of harvest
 12. Details of fees paid²
 - a. Field Inspection charges at ₹50
 - b. Seed Testing charges at ₹30
 - c. Registration charges at ₹25
- Signature of the farmer

1. Additional notes are given in parentheses for clarification.

2. The fee for different activities varies with the state and is applicable as in 2012. The above fees are applicable in Tamil Nadu. Since farmers' holdings are small, the area is normally mentioned in acres (1 acre = 0.4 ha). A single seed lot can have a minimum of 1 acre and a maximum of 25 acres.

Seed production, processing and marketing

The farmer/seed producer should consult the local ADA to ascertain seed demand of different crops and their specific varieties. This will help in better planning of the seed production program and marketing of the seed produce after harvest. The seed quantity that is produced over and above the requirement of the DoA has to be sold through other licensed private seed sellers or to the local farmers.

Before undertaking seed production program, the seed producer has to get a 'Seller License' from the Deputy Director (Seed Inspection) to sell the seeds by paying ₹ 50 as fees and a 'Processing Unit License' by paying ₹ 3000 as fees to process the harvested produce as seed. The processing unit should have a room to store the processed produce, drying yard and a weighing balance. These two licenses need to be renewed once in three years. The seed producer should also be aware of the seed processing unit maintained by the DoA, if any, in the vicinity. For groundnut, hand processing is easier and convenient to farmers. Proper drying and curing of the harvested produce is essential to ensure its high quality.

The simplest and easiest way for a farmer who intends to produce seed is to enter into an agreement with the local ADA to produce seed (Foundation/Certified) on his/her behalf, enabling him/her to meet the assigned target by the state government. In this arrangement, the seed producer is the ADA and the owner of the land is the farmer. As usual, the SCO carries out the field and seed lot inspection. The Assistant Seed Officer (ASO) of the concerned block, who works under the ADA, assists the SCO and the farmer in this regard. The harvested produce is transported to processing unit of the Agricultural Extension Centre (AEC), where processing and tagging is done. The farmer is paid for the total processed quantity produced by him/her along with subsidies, if any, by the concerned ADA. In Tamil Nadu, the price of Foundation and Certified seed is determined based on the prevailing local price in the market. Over the local market price, additional amount of ₹ 3 (for Foundation seed) or ₹ 2 (for Certified seed) is added along with ₹ 10 per kg, which is a subsidy from Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) of the GoI.

Informal seed systems

Most of the farmers either save their own seed for the next season or buy it from other farmers or in local markets, where seed sold is non-descript or mixed, resulting in low productivity of the crop (Nigam et al. 2004). In leguminous crops, where seed multiplication ratio is low and seed is bulky [such as groundnut, chickpea (*Cicer*

arietinum L.), pigeonpea (*Cajanus cajan* (L.) Millsp.) and others], informal seed sector plays a significant role in making the seed available to local farmers.

In the informal seed sector, enterprising farmers and small seed traders produce/procure seed of varieties released in the public domain and sell it to the farming communities. If farmers and companies sell their seeds by indicating quality parameters through their label (opal green color tags) without certification, these seeds are known as 'Truthful seed'. This system was introduced by the government in 1960. These seeds do not need permission from government but seed law will regulate the quality mentioned on the label. Seed producers should maintain field and seed standards suggested for quality seed production as per the Seed Act.

The ICAR institutes and SAUs are also involved in organizing the participatory seed production in farmers' fields and providing latest seed production technologies to the farmers in order to improve their capacity for quality seed production. Unless farmers produce their own seed of improved varieties, they are likely to stay with old varieties for a long time thus suffering loss in productivity. Several schemes have been suggested to promote the informal seed sector to overcome the shortage of good quality seed. The following are the few important schemes in operation in India as described by Nigam et al. (2004).

Seed village program

The public sector seed producing agencies, SAUs or non-governmental organizations (NGOs) can provide interested farmers/self-help groups with Foundation seed of improved cultivars available in public domain, along with technical guidance, to undertake seed production at the village level. The seed growers are free to sell their seeds to other farmers.

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Starting with a small quantity of seed of new cultivars (for example, 2 kg pods) obtained from public institutions, a farmer can generate enough seed to cover larger area (1 ha) with improved cultivars in three seasons. A part of the produce of Foundation seed obtained from public institutions is recycled to produce the Foundation seed again and the remaining part is advanced in seed production chain. This process is repeated each season to produce enough quantity of quality seeds (Deshmukh et al. 2001).

Contract seed production

Local traders enter into agreement with selected farmers to produce quality seed of the improved varieties for them to market. However, it is necessary to educate both the farmers and traders in the technical aspects of groundnut seed production, processing and storage.

Management of seed crop

A seed production crop requires more care and attention than that required by the commercial crop. A healthy crop meeting the prescribed standards of seed certification is essential for a successful seed production program (Fig. 5). Nigam et al. (2006) have discussed in detail principles and practices involved in achieving sustainable high yields in groundnut. In the following sections, only salient points with respect to different cultivation aspects are given.



Figure 5. A healthy groundnut crop.

Cropping season

The optimum range of air temperature for growth and development in groundnut is between 25°C and 30°C. Temperatures above 35°C can be detrimental to groundnut production. In peninsular and western India, two crops of groundnut can be grown in a year, ie, the first crop in the main *kharif* (June/July–September/October) season and the second in the *rabi* (November/December–March/April) or summer (January/February–April/May) season. In the *kharif* season, yields are generally low due to high incidence of diseases, insect pests, drought and cloudy weather. Even where the management level is high with irrigation and plant protection, yields are rarely comparable to those that are obtained in the *rabi*/summer season. If irrigation facilities are available, seed production in *rabi*/summer season can be highly profitable due to high yields (>2.5 t ha⁻¹) obtained in the absence or low incidence of diseases and insect pests and plenty of sunshine. However, the seed produced in *rabi*/summer season is often associated with low germination and quick loss of viability due to high temperatures prevailing at the time of harvest and drying and curing. The problem of low germination in seed produced in *rabi*/summer season can be overcome by following proper drying and curing practices and by avoiding direct exposure of pods to the sun.

Choice of variety and seed rate

The choice of a variety for seed production program will depend on the demand of the farmers and preference of the trade. It is also influenced by release of new varieties for the region and the seed indents raised by the DoA of the state. However, as denotified varieties cannot be certified, they cannot be included in the formal seed production program. Preferably, the chosen variety should also have resistance/tolerance to diseases and insect pests prevailing in that locality. Once the variety is finalized, care should be given to select the parental seed. It is essential that the appropriate class of certified parental seed is used to produce the desired class of certified seed. The parental seed (Nucleus or Breeder or Foundation seed) should be obtained from the authorized sources and the attached seed certification labels should be preserved till the next seed crop is certified. The seed procured for sowing should be stored carefully in a cool and dry place. The seed rate depends on the recommended plant spacing for the region and 100-seed weight of the variety under multiplication. It could vary from 125 kg ha⁻¹ for small-seeded variety to 150 kg ha⁻¹ for large-seeded variety. In case of large-seeded varieties, only medium sized seed obtained after grading should be used. Germination test on seeds should be carried out one week before sowing and the seed rate should be adjusted accordingly.

Selection of field and land preparation

For quality seed production, assured growing conditions are required. A well-drained field, free from soilborne diseases, insect pests, crop residues/stubbles and weeds, and with good fertility status and irrigation facilities is ideal for seed production. Besides having easy accessibility for monitoring/inspections, it should be away from commercial crops to avoid contamination from seedborne viral diseases. The ideal soil for groundnut is light colored, sandy, loamy sand or sandy loam texture, with pH ranging between 6.0 and 6.3.

Continuous monocropping of groundnut in the same field is not advisable, as it leads to build up of diseases and insect pests in the soil. A field which had groundnut in the past two seasons should not be selected to avoid contamination of the seed crop from volunteer plants of the previous crops. If this is impossible to follow, the variety under seed multiplication should be the same as was grown in the previous seasons with equivalent or higher class of certified seed. Ideally groundnut should be rotated with a cereal crop, or follow a two-year crop rotation. A proper crop rotation can result in higher yields and in substantial savings in disease control and fertilizer requirements.

After clearing stubbles and plant residues carried over from the previous crop(s), the field should be plowed to a depth of 15–20 cm. Very deep plowing should be avoided because it encourages pod formation in deeper soil layers rendering harvest more difficult. Groundnut is sown on flat beds or ridges or raised beds separated by furrows. The width of the raised bed varies depending upon soil type, irrigation system in use and available equipment for land preparation and bed formation. In addition to higher yields, sowing on raised beds with 0.4 to 0.8% slope is beneficial as it allows easy drainage of excess water, avoids compaction of seed beds and facilitates field operations as all movements are restricted to furrows.

Soil amendments and fertilizer and nutrient requirements

Maintaining optimum soil pH (6.0–6.3) is essential as it affects the availability of nutrients to plants and their nitrogen fixation process. The acidic soil (pH <5) can be ameliorated by applying limestone (calcium carbonate) or calcium hydroxide in appropriate form and quantity. It should be mixed thoroughly into the soil before or at the time of land preparation. The rate of application of lime depends upon the type of lime, soil type and depth of application. As a general recommendation, it would require 1.5 t ha⁻¹ of lime to raise the soil pH from 5.0 to 6.5. As groundnut

grows well in soils rich in organic matter, farm-yard manure (FYM) at 10–12 t ha⁻¹ should be incorporated into the soil.

A comprehensive need-based fertilizer application strategy based on soil testing is essential. The balanced use of fertilizers is essential to increase the crop productivity. Groundnut can make effective use of residual fertilizers left over from the previous crop. Groundnut responds to residual soil fertility better than the direct application of fertilizers. So, it is better to fertilize the preceding crop well to build up residual fertility for the following groundnut crop.

Fertilizer doses will depend on the level of targeted yield and status of different nutrients in the soil. In general, groundnut needs about 20–40 kg N, 40–90 kg P₂O₅ and 0–60 kg K₂O ha⁻¹. In addition to major nutrients, calcium (Ca) is a critical nutrient for producing high quality groundnut seed. Calcium is essential for pod and seed development and ensuring good seed germination. There must be enough available Ca in the top 8–12 cm of soil for direct absorption by developing pegs and pods. It is important to maintain Ca to potassium (K) ratio of less than 3:1. Excessive K in the podding zone interferes with Ca uptake and results in pod rot and pops (unfilled pods). Regardless of soil tests, it is advisable to apply Ca at 150–200 kg ha⁻¹ to small-seeded varieties and 300–400 kg ha⁻¹ to large-seeded varieties at the time of peak flowering. Since there is little residual effect of gypsum, it is necessary to repeat the application every season. As Ca and sulfur (S) are relatively immobile in plant tissue and are not translocated in sufficient quantities from the root to developing pods, application is therefore made as close to the pod zone as possible.

Deficiency or toxicity of magnesium (Mg), boron (B), Zinc (Zn) and S can affect plant growth and production. Their levels in the soil should be closely monitored. Deficiency of B affects seed development resulting in discolored cavity (hollow heart) on the inner face of cotyledons. In case of Zn deficiency, zinc sulfate at 25 kg ha⁻¹ as enriched FYM, and borax at 10 kg ha⁻¹ as basal application should be applied. Normally, application of super phosphate and gypsum alleviates S deficiency, if any.

Isolation distance

It is essential to have adequate isolation distance between varieties in seed production fields to prevent contamination with pollen from other varieties and mechanical mixture. In India, where natural cross-pollination is almost negligible, an isolation distance of 3 m between varieties is required for all classes of certified seeds.

Seed treatment

Groundnut seed can be infected by several fungal pathogens and attacked by insect pests during germination. In order to protect the seed and establish a good plant stand, the seed should be treated before sowing with one or combination of the following treatments (Table 5). The seed should be treated first with liquid chemicals followed by powder/dust chemicals. If the seeds are treated with bio-control agent/bio-fertilizers, then such seed should not be treated with fungicides.

In the event of postharvest seed dormancy, the seeds should be sprayed 2–3 times with Etherel 39 EC (5 ml in 1 L water) and air-dried. This procedure should be followed just before sowing.

Table 5. Details of seed treatment chemicals/bioagents used in groundnut.

Treatment	Dosage	Remarks
Fungicide	Thiram or Captan or Carbendazim or Mancozeb at 2 g kg ⁻¹ of seed (seeds should be treated 24 h before sowing)	Prevents soilborne diseases
Insecticide	Imidacloprid at 2 ml kg ⁻¹ of seed Chlorpyrifos 20 EC at 12.5 ml kg ⁻¹ of seed	Controls sucking insect pests Controls white grubs
Bio-fungicide	<i>Trichoderma viride</i> or <i>T. harzianum</i> at 4 g kg ⁻¹ of seed (dry seed treatment)	Controls seed and soilborne diseases, viz, <i>Rhizoctonia solani</i> , <i>Macrophomina phaseolina</i> , <i>Fusarium</i> spp, etc.
Bio-fertilizers	Efficient <i>Rhizobium</i> strain: 200 g Phospho-bacteria: 200 g Rice gruel: 1 L Seed required for one acre: 55 kg (1 acre = 0.4 ha) Preparation: (i) Mix bio-fertilizers, <i>Rhizobium</i> (200 g) and phospho-bacteria (200 g) thoroughly in rice gruel (1 L). (ii) Sprinkle the mixture prepared over the seeds spread on a gunny bag and mix thoroughly (iii) Dry the seeds under shade for 1–2 h and use for sowing within 24 h of treatment.	<i>Rhizobium</i> inoculation increases nitrogen uptake and the phospho-bacteria convert the non-available form of phosphorus in the soil into available form to the plants.

Sowing

Recommended plant density for the region should be followed to raise the seed crop. The plant density depends upon the growth habit of the variety selected. The row to row spacing can vary from 30 cm to 45 cm and plant to plant from 10 cm to 15 cm. Seeds are usually placed at a depth of 4–6 cm. Deeper sowing results in delayed emergence, elongated hypocotyl, poor root and shoot development, poor nodulation and decreased nitrogen fixation and consequently lower yields. In the case of shallow sowing, the field should be frequently irrigated to avoid drying of germinating seeds to ensure optimum germination and plant stand.

Once the seed beds are ready and the optimum conditions for rapid germination and emergence prevail, seeds can be drilled using a tractor or animal-drawn groundnut planter/seed drill or dibbled manually. Machine planting is preferred over manual sowing. Only one seed per hill should be sown to facilitate roguing, if needed. Gap filling, if required, must be done within 10 days after sowing (DAS).

Water management

Appropriate water management is essential to achieve early germination, uniform plant establishment and high productivity in the crop. Generally, 600–650 mm water is sufficient to raise a full groundnut crop. If soil moisture is insufficient, the field should be irrigated before or soon after sowing to ensure uniform and rapid crop emergence. A two- to three-week moisture stress soon after crop emergence followed by regular irrigation, often helps in inducing profuse flowering and uniform pod maturity. However, moisture stress during flowering can delay or inhibit flower formation. Once active pegging and pod formation have begun (about 50–60 DAS), the pegging zone (top 8–12 cm of soil) should be kept moist to improve Ca uptake, which is essential for proper pod formation, seed development, seed quality and germination in the next season. Although groundnut requires relatively less water, it cannot tolerate moisture stress at flowering, pegging, pod and seed formation stages. The seed formation stage is the most sensitive stage for moisture stress. This can be successfully overcome by applying frequent but small amount of irrigation. Groundnut does not tolerate standing water in the field. So irrigation or rain water should not be allowed to stagnate in the field and should be drained out. Excessive irrigation causes problems by promoting vine growth, diseases, peg deterioration and uneven maturity. Flood irrigation, commonly practiced in India, is not a good method of irrigation. Among various irrigation methods, sprinkler method of irrigation is more efficient and beneficial to groundnut. Lately, drip irrigation is also being used successfully in groundnut.

Weed control

Groundnut is highly sensitive to weed competition up to 45 days after emergence (DAE). A seed production field should be weed free as weeds not only affect productivity and other field operations but also interfere with roguing and field inspections by the monitoring team. It is also important to keep groundnut field weed free even at later stages of the crop because weeds interfere with harvesting and cause pod loss into the soil. Further, the presence of weed seeds in the produce may disqualify it for certification.

Application of preemergence herbicide such as Pendimethalin at 1.0–1.5 kg a.i. ha⁻¹ as spray or Fluchloralin at 1.0–1.5 kg a.i. ha⁻¹ as preplant soil incorporation followed by one hand weeding at 25–30 days after herbicide application effectively reduce the weed competition. The last hand weeding can follow the gypsum placement in the field. If no herbicide is applied then a hand weeding and hoeing may be done on 20th and 40th day after sowing.

Plant protection

Groundnut is attacked by a number of insect pests and diseases from sowing to storage. If the variety selected for seed multiplication is not resistant/tolerant to these, they need to be controlled by cultural, chemical and biological control options. But no single option for a given insect pest or disease may be adequate for maximizing the economic returns. An integrated approach to the management of diseases and insect pests is required to effectively and safely contain the damage.

Foliar fungal diseases

In India, three foliar fungal diseases, viz, early leaf spot (*Cercospora arachidicola* Hori), late leaf spot [*Cercosporidium personatum* (Berk. & Curt.) Deighton renamed as *Phaeoisariopsis personata* (Berk. & Curt.) v.Arx] and rust (*Puccinia arachidis* Speg.) are widespread, destructive and cause significant pod and haulm yield loss besides adversely affecting their quality. Early leaf spot (ELS) is more frequent in northern and western India and late leaf spot (LLS) and rust in peninsular and southern India. Typical ELS lesions are surrounded by yellow halo, and are sub-circular, dark brown on the upper surface of leaflet and light brown on the lower surface of leaflet (Fig. 6). Most of the sporulation occurs on the upper surface of leaflet. Compared to ELS lesions, the LLS lesions are nearly circular and darker and slightly rough in appearance on the lower surface of leaflet where most

of the sporulation occurs (Fig. 7). When the attack is severe, both ELS and LLS cause severe premature defoliation. Rust pustules are orange in color and appear on the lower surface of the leaflets (Fig. 8). When these pustules rupture, masses of reddish-brown spores are released. The leaves infected with only rust become necrotic and dry up but remain attached to the plant. Very often LLS and rust occur together.

The following practices help to manage these diseases in an integrated manner.

- Removal and destruction of groundnut plant debris after harvest in the field
- Removal of volunteer (self-sown) groundnut plants from the previous crop(s)
- Growing resistant/tolerant varieties
- Crop rotation with cereals and better field sanitation



Figure 6. Early leaf spot lesions on the lower surface of groundnut leaflets.



Figure 7. Late leaf spot lesions on the lower surface of groundnut leaflets.



Figure 8. Groundnut rust.

- Spraying three times with 0.1% Carbendazim 50 WP or 0.2% Mancozeb 50 WP or 0.2% Chlorothalonil 75 WP starting from 40th day of sowing at 15–20 days interval for ELS and LLS
- Spraying three times with 0.2% Chlorothalonil 75 WP or 0.2% Mancozeb 50 WP or 0.5% Calixin 80 EC or 0.1% Propiconazole 25 EC or 0.1% Hexaconazole 5 EC starting from 40th day of sowing at 15–20 days interval for rust

Soilborne fungal diseases

Among the soilborne fungal pathogens, *Aspergillus flavus* Link ex Fries (predominantly found in Asia and Africa) and *Sclerotium rolfsii* Sacc. are the most widespread. The infection by *A. flavus* and the consequent aflatoxin contamination of groundnut poses a serious quality problem that affects the trade in groundnut and groundnut products, and human and animal health (Fig. 9). *Sclerotium rolfsii* causes stem and pod rots (Fig. 10). Severely infected pods are completely covered with a white fungal growth and eventually decay (Fig. 11). Seeds from the diseased pods show a characteristic bluish-gray discoloration known as ‘blue damage’ (Fig. 12). Other soilborne diseases include collar rot/crown rot caused by *A. niger*. Soilborne diseases are becoming more prominent in several areas.

The following steps are recommended for the management of soilborne diseases.

- Removal of previous season’s plant debris after harvest
- Growing resistant/tolerant varieties
- Seed treatment with *Trichoderma viride* or *T. harzianum* at 4 g kg⁻¹ of seed or Thiram at 3 g kg⁻¹ of seed



Figure 9. *Aspergillus flavus* infected seeds.



Figure 10. Advanced symptoms of stem rot.



Figure 11. Pod shredding caused by *Sclerotium rolfsii*.



Figure 12. Blue damage of seeds caused by *Sclerotium rolfsii*.

- Soil application with *T. viride* or *T. harzianum* at 25 to 62.5 kg ha⁻¹ in conjunction with organic amendments such as castor cake or neem cake at 500 kg ha⁻¹
- Crop rotation with cereals and other crops
- Crop sanitation measures such as burning crop residues, removing weeds, and cleaning implements after cultivation (to reduce carry-over and spread of the disease)

The following additional steps are recommended for the management of *A. flavus* in the field.

- Application of FYM/compost at 5–10 tons ha⁻¹
- Application of gypsum at 400–500 kg ha⁻¹ at flowering
- Application of light but frequent irrigation during pod and seed development stages
- Avoiding mechanical damage to the pods during weeding, harvesting and curing, stripping and storage
- Harvesting the crop at optimum maturity
- Drying pods to moisture content below 8%
- Removal of damaged and underdeveloped pods from the produce
- Storage of groundnut in in-shell and at low temperature, low humidity and in moisture free conditions

Viral diseases

Two viral diseases are important in India. The first is peanut bud necrosis disease (PBNB) caused by peanut bud necrosis virus (PBNV) and transmitted by thrips, which is widespread and the second, which is of recent origin and confined to Anantapur district in Andhra Pradesh and adjoining areas in Karnataka, is peanut stem necrosis disease (PSND) caused by tobacco streak virus (TSV) and transmitted by thrips.

The PBNB symptoms include faint chlorotic spots or mottling on young leaflets followed by chlorotic and necrotic rings and streaks; petioles bearing fully expanded leaflets with initial symptoms usually become flaccid and droop and necrosis of the terminal bud soon follows (Fig. 13). In young plants, total necrosis of the plant can occur. Necrosis on older plants usually spreads up to the petiole. Stunting and proliferation of axillary shoots are common secondary symptoms (Fig. 13). Seeds from early infected plants are small and shriveled and their testae show red, brown or purple mottling. Late infected plants may produce seeds of normal size, but the testae on such seeds are often mottled (Fig. 14).

The PSND symptoms include necrotic lesions and veinal necrosis on young leaves which later spreads to the petiole and stem upwards killing the bud (Fig. 15). The plants infected within a month after sowing die due to necrosis. Proliferation of axillary shoots is also observed and the leaflets are small and show chlorosis. Pods harvested from the PSND infected plants may show necrotic lesions (Fig. 15). Often it is difficult to distinguish between PBNB and PSND in the field. Laboratory tests are required to discern between these two viral diseases.

The following steps can help minimize the damage caused by PBNB and PSND.

- Growing resistant/tolerant varieties
- Maintaining optimum plant population



Figure 13. PBNV infected plants: (left) terminal bud necrosis; and (right) axillary shoot proliferation and deformed leaflets.

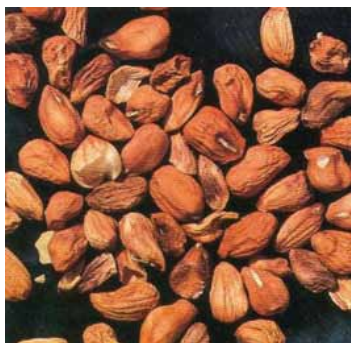


Figure 14. Seeds from PBNB infected plants.

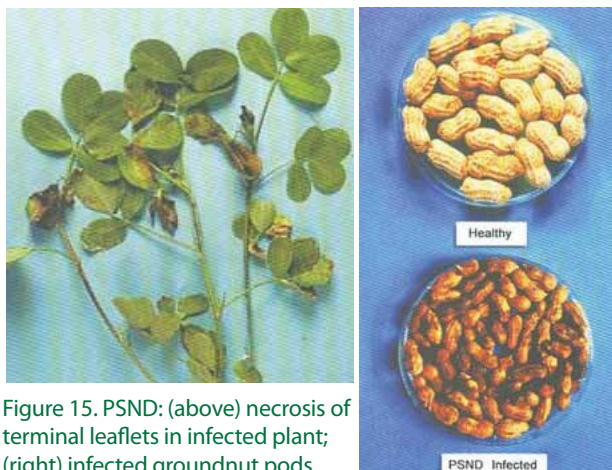


Figure 15. PSND: (above) necrosis of terminal leaflets in infected plant; (right) infected groundnut pods.

- Seed treatment with Imidacloprid (Gaucho 70 WS) at 2 ml kg⁻¹ of seed
- Adjusting sowing dates to avoid thrips migration peak at the location
- Border cropping/intercropping with fast growing pearl millet [*Pennisetum glaucum* (L.) R.Br.] or sorghum [*Sorghum bicolor* (L.) Moench] or maize (*Zea mays* L.)
- Removal of alternate weed hosts of the virus and the vector during off-season (particularly *Parthenium* in the case of PSND)
- Avoid growing sunflower (*Helianthus annuus* L.), marigold (*Tagetes erecta* L.) and other TSV susceptible crops adjacent to groundnut fields (in the case of PSND)

Foliage feeder insect pests

Although many insect species live and feed on the groundnut crop, only a few cause significant damage that results in large reduction in pod and haulm yields. Most defoliators are polyphagous and sporadic in occurrence. These defoliators inflict economic losses only when the foliage damage exceeds 25% or more, or if one or more larvae per plant are observed during the first 50 DAE. Defoliators can be ignored once the crop passes the vegetative phase (>50 DAE). Natural control processes usually keep defoliators at densities well below their economic threshold levels. However, indiscriminate use of insecticides can cause pest outbreaks that have the potential to inflict total crop loss (Wightman and Ranga Rao 1993). The major defoliators are red hairy caterpillar (RHC) (*Amsacta albistriga* Walk.) (Fig. 16), groundnut leaf miner (GLM) (*Aproaerema modicella* Deventer) (Fig. 17), tobacco caterpillar (*Spodoptera litura* Fab.) (Fig. 18) and gram pod borer (GPB) (*Helicoverpa armigera* Hübner) (Fig. 19).

The following steps should be adopted for the management of defoliator insect pests.

- Summer plowing to destroy the pupae
- Growing border/trap crop of sunflower or castor (*Ricinus communis* L.) or cowpea [*Vigna unguiculata* (L.) Walp.] to minimize infestation in the main crop
- Setting up light traps (12 traps ha⁻¹) or bonfire immediately after rains in the rainy season, particularly to attract and kill RHC moths



Figure 16. Red hairy caterpillar: (left) larva; and (right) adult moth.



Figure 17. GLM: (a) adult; (b) larva; and (c) brown blotches on leaves indicating infestation.



Figure 18. Tobacco caterpillar: (left) larva; and (right) adult moth.



Figure 19. Gram pod borer: (left) larva; and (right) adult moth.

- Setting up pheromone traps (5 traps ha⁻¹) to attract and kill particularly tobacco caterpillar moth
- Encouraging larvae predation by birds by providing perches (10 perches ha⁻¹)
- Collecting and destroying the egg masses and early instar larvae of RHC, tobacco caterpillar and GPB
- Application of nuclear polyhedrosis virus (NPV) at 250 larval equivalents ha⁻¹
- Digging a trench around the field to avoid immigration of larvae of RHC
- Application of any one of the following chemicals only as a last resort, viz, Quinalphos 25 EC at 1250 ml ha⁻¹ or Chlorpyrifos 20 EC at 1250 ml ha⁻¹ or Phosalone 35 EC at 750 ml ha⁻¹ for RHC; Dimethoate 30 EC at 500 ml ha⁻¹ or Quinalphos 25 EC at 1250 ml ha⁻¹ or Chlorpyrifos 20 EC at 1250 ml ha⁻¹ for GLM; and Monocrotophos 36 SL at 1500 ml ha⁻¹ or Quinalphos 25 EC at 1250 ml ha⁻¹ or Chlorpyrifos 20 EC at 1250 ml ha⁻¹ or Trizophos 40 EC at 800 ml ha⁻¹ for tobacco caterpillar
- Releasing *Trichogramma chilonis* at 50,000 ha⁻¹ twice (7–10 days interval) for GLM and at 100,000 ha⁻¹ at 40 DAS and 50 DAS for GPB

Sucking insect pests

Several species of insect pests feed on groundnut sap. Among these, aphids (*Aphis craccivora* Koch.) (Fig. 20), jassids (*Empoasca kerri* Pruthi) (Fig. 21) and thrips (*Scirtothrips dorsalis* Hood., *Thrips palmi* Karny., *Frankliniella schultzei* Trybom and *Caliothrips indicus* Bagnall) (Figs. 22 and 23) are common in all groundnut growing areas. Besides sucking the sap from stem and leaves they can also transmit viral diseases.



Figure 20. Aphids on groundnut: (left) shoots; and (right) flowers.



Figure 21. Hopper burn symptoms caused by jassids on foliage; (inset) an adult jassid.



Figure 22. Foliage damaged by thrips.



Figure 23. *Thrips palmi* adult (scanning electron micrograph).

The following steps should be taken for the control of sucking insect pests.

- Growing resistant/tolerant varieties
- Application of 5% neem seed kernel extract
- Conservation and promotion of predators such as coccinellids, syrphids, green lacewings and spiders in the field
- Spraying young crop (<30 DAE) either with Dimethoate 30 EC at 650 ml ha⁻¹ or Monocrotophos 36 WSC at 600 ml ha⁻¹
- Seed treatment with Imidacloprid (Gaucho 70 WS) at 2 ml kg⁻¹ of seed particularly for thrips

Soil insect pests

Several kinds of insects feed on roots and pods. Root feeders cause sudden death of plants. In the case of pod borers, the damage is usually detected when the crop is harvested. It is not easy to manage them as they are sporadic and extremely difficult to detect before the damage is done. Important soil insect pests include white grub (*Lachnosterna serrata* Fab. and *Lachnosterna consanguinea* Blanch.) (Fig. 24) and termites or white ants (*Microtermes* spp and *Odontotermes* spp) (Fig. 25).



Figure 24. White grub *Lachnosterna serrata*: (left) larva; and (right) adults.



Figure 25. Termite scarification on pods.

The following steps will help minimize the damage caused by the two soil insect pests.

White grubs:

- Deep plowing at the time of land preparation to expose the grubs and kill them
- Crop rotation with sorghum/pearl millet or maize
- Collecting and destroying the adults attracted to neem, *Ailanthus*, *Acacia*, etc near groundnut fields on receipt of monsoon showers
- Spraying neem trees close to the field with Chlorpyrifos 20 EC at 2 ml L⁻¹ of water
- Setting up light traps or bonfire to attract and kill adults
- Application of Malathion 5D at 25 kg ha⁻¹ or Carbofuran 3G granules in the furrow at 1 kg a.i. ha⁻¹ to the soil at the time of sowing as a prophylactic measure
- Seed treatment with Chlorpyrifos 20 EC at 12.5 ml kg⁻¹ seed

Termites:

- Digging the termataria and killing the queen
- Harvesting of groundnut as soon as the pods are mature
- Frequent irrigation to the crop
- Application of Chlorpyrifos dust at 30–40 kg ha⁻¹ in soil before sowing in endemic areas as a prophylactic measure

Nematodes

In certain areas/fields, plant parasitic nematodes can be a major threat to groundnut crop. The important diseases caused by nematodes are root-knot disease caused by *Meloidogyne arenaria* and *M. hapla* (Fig. 26), root lesion disease caused by *Pratylenchus brachyurus* and Kalahasti malady caused by *Tylenchorhynchus brevilineatus* (Fig. 26). Deep plowing, crop rotation with non-hosts and growing resistant cultivars are some of the economical options available to farmers to manage nematodes in the field. The cost of chemical control will be prohibitive.



Figure 26. Nematode damage: (left) galls on roots and pods caused by *Meloidogyne arenaria*; and (right) pods infested with *Tylenchorhynchus brevilineatus*.

Roguing

Normally four roguing should be carried out at different stages of crop growth, viz, seedling stage, flowering stage, podding stage and at harvest, to remove off-type groundnut plants in the seed production field. The weak, distorted, variegated, diseased and out of the row alignment seedlings should be removed and destroyed at seedling stage. The variants, not conforming to flower morphology, branching pattern, growth habit and other diagnostic characteristics of the variety under seed multiplication should be removed from the field at flowering stage. The late flowering plants and other off-types based on peg morphology and other vegetative characters should be removed at podding stage. The last roguing should be done on harvested plants to remove plants with diseased pods and off-types based on pod and seed characteristics (Nigam et al. 2004).

Harvesting

The pod maturity in a groundnut plant is not uniform because of its indeterminate growth habit. The timing of harvesting is very critical as it can significantly affect the economic yield and the quality of seeds. The easiest and most practical method of assessing the optimum time of harvesting is by evaluating the internal pericarp color of pods removed from a few representative plants in the field around the expected time of maturity. The darkening of internal pericarp is a sign of pod maturity (Fig. 27). Yellowing of top leaves and withering of old and lower leaves are also indications of maturity. The crop should be harvested when 70–75% of the pods are mature. Gleanings (left over pods in the soil) from seed production plots should not be mixed with the seed produce.



Figure 27. A matured groundnut pod.

Drying and curing

Proper drying and curing of the harvested produce is essential to ensure high quality of pods/seeds. The harvested plants are well shaken to dislodge the soil from pods and kept inverted in rows (pods facing upwards) for 2–3 days in the field before stripping the pods. Initial curing of plants and pods is usually done by allowing them to dry in windrows under ambient temperature conditions until whole pod moisture drops down to 18–20% for mechanical stripping and to 15% for hand stripping. In case of high temperatures at the time of harvesting in *rabi*/summer season, the direct exposure of pods to the sun should be avoided by arranging plants in circular heaps with pods facing inside. If a thresher is used to strip pods, it should be thoroughly cleaned before stripping for each variety. All the possibilities of mechanical admixing at the time of stripping should be eliminated. The stripped pods are sun-dried for 3–4 days to bring down the moisture content below 10% (Fig. 28). Drying under high temperature (above 45°C) can cause the loss of seed viability. Shade drying of pods is recommended to maintain seed viability for a longer period. It is important to remove all damaged, rotted and sprouted pods and only sound, mature, clean and well-filled pods should be selected for seed.



Figure 28. Heaping of dried pods.

Storage

Only undamaged, well-filled and dried pods should be stored to avoid fungal and insect pest attack. Groundnut stores better in pods than seeds. The pods should be stored in polythene-lined gunny bags or in some other safe storage structure in a well-ventilated and rodent free room. The bags should be placed over wooden planks to avoid dampness from the ground and should not be stacked too high (maximum 5 bags) (Fig. 29). Under unfavorable conditions, groundnut seed loses



Figure 29. Tagged and stored seed-pods in gunny bags.

viability quickly. In general, the lower the storage temperature, the longer the expected storage life. Storage temperatures below 13°C inactivate most insects and restrict growth and influence of other seed quality deteriorating factors. The relative humidity in the storage should be between 65% and 70%.

The amount of damage inflicted by insect pests during postharvest processing and storage depends on several factors such as moisture content in the produce, the form in which it is stored, level of maturity at harvest, sanitation of storage space and the quality of the material itself. Ranga Rao et al. (2010) have dealt with postharvest insect pests of groundnut and their management. The most commonly reported stored pests of groundnut are groundnut bruchid (*Caryedon serratus* Olivier), red flour beetle (*Tribolium castaneum* Herbst) and rice moth (*Corcyra cephalonica* Stainton). In case of pest outbreak in storage, fumigation with Celphos (aluminum phosphide) tablets at 3g bag⁻¹ (40 kg bag) and covering with polythene (at least 0.13 mm thick) sheet for 4–5 days by strictly following the recommended procedures is adopted. The stored produce can also be protected from storage pests by dusting the bags with 5% Lindane or 5% Malathion dust.

Packaging

The packing unit for groundnut seed-pod is either 30 kg or 40 kg. Except for the lot size, there are no specifications on packaging of groundnut seed-pods in India. The cleaned, well dried seed-pod produce should be kept in polythene-lined gunny bags for seed lot inspection by the SCO. Once the seed lot is approved, the polythene lined gunny bags with pods inside are stitched with the appropriate seed tag issued by the SSCA. For Breeder seed, the tag is issued by the producing breeder of the concerned SAU. The seed producer should maintain a proper record of use of seed tags.

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Photo credits

Figure 1	Ramanatha Rao (1988)
Figure 2	Nigam et al. (1990)
Figure 3	Nigam et al. (2004)
Figures 6 and 7	McDonald et al. (1985)
Figure 8	Subrahmanyam et al. (1995)
Figure 9	Waliyar (2002)
Figures 10–12	Mehan et al. (1995)
Figures 13 and 14	Reddy et al. (1990)
Figure 15	Prasada Rao et al. (2003)
Figures 16–25	Wightman and Ranga Rao (1993)
Figures 26 and 27	Nigam et al. (2006)
Figures 28 and 29	Ranga Rao et al. (2010)

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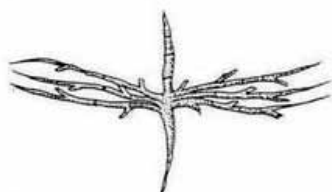
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Annexure I. Descriptors for groundnut (reproduced from IBPGR and ICRISAT 1992).

- 1. Life form
 - 1. Annual
 - 2. Perennial
 - 3. Unknown
- 2. Growth habit
 - 1. Procumbent-1
 - 2. Procumbent-2
 - 3. Decumbent-1
 - 4. Decumbent-2
 - 5. Decumbent-3
 - 6. Erect
 - 7. Others



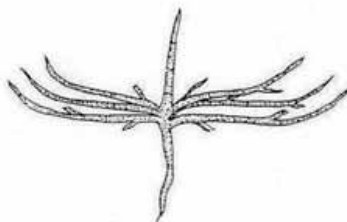
1 Procumbent-1



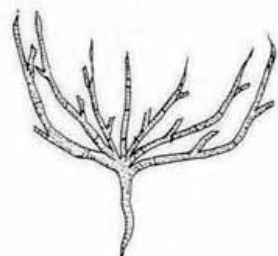
2 Procumbent-2



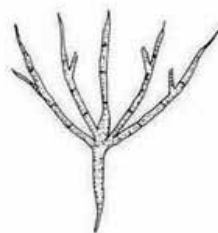
3 Decumbent-1



4 Decumbent-2



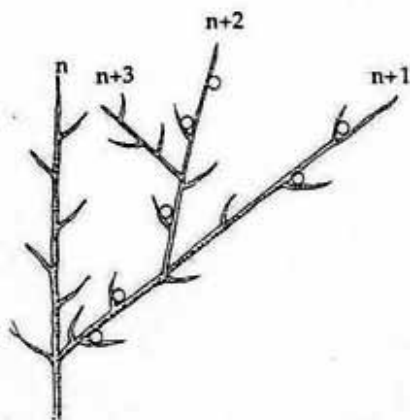
5 Decumbent-3



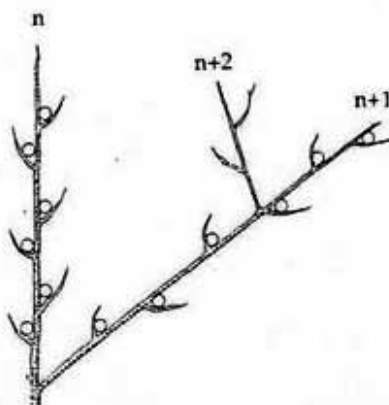
6 Erect

Growth habit

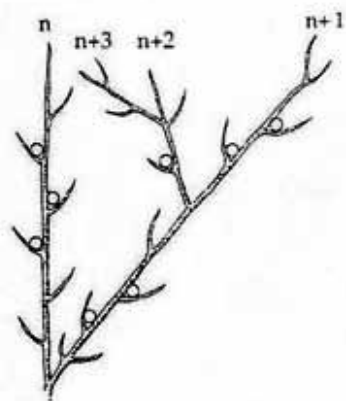
3. Branching pattern:
 Determined on (n+1)
 cotyledonary branches
1. Alternate
 2. Sequential
 3. Irregular with flowers on main stem
 4. Irregular without flowers on main stem
 5. Others



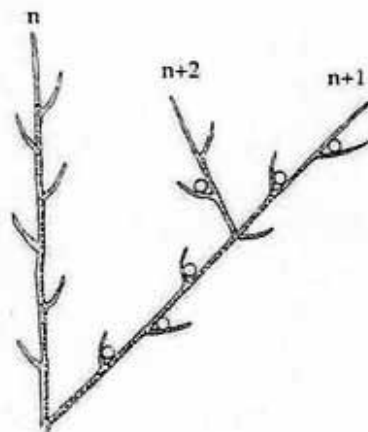
1 Alternate



2 Sequential



3 Irregular with flowers
on main stem



4 Irregular without flowers
on main stem

0 = Reproductive branch

Branching pattern

- | | | |
|-----|---|--|
| 4. | Number of branches | <ul style="list-style-type: none"> 1. Primary (n+1) 2. Secondary (n+2) 3. Tertiary (n+3) |
| 5. | Height of main stem (cm) | Measured from cotyledonary axil up to terminal bud, mean of 10 plants, recorded 60–85 days after emergence |
| 6. | Plant width or spread (cm) | Measured at the widest point, from branch tip, mean of 10 plants, recorded 45–60 days after emergence |
| 7. | Stem pigmentation on matured plants | <ul style="list-style-type: none"> 0 Absent + Present |
| 8. | Stem surface: observed on the main axis | <ul style="list-style-type: none"> 1 Glabrous 3 Sub-glabrous, hairs in one or two rows along the main stem 5 Moderately hairy, three or four rows along the main stem 7 Very hairy, most of the stem surface covered with hairs 9 Woolly (as in 7 but with long hairs) |
| 9. | Type of inflorescence | <ul style="list-style-type: none"> 1. Simple 2. Compound |
| 10. | Standard petal color | <p>Color of front face of the standard petal of fresh, fully opened flowers; Royal Horticultural Society (RHS) color codes are given in parentheses beside descriptor states:</p> <ul style="list-style-type: none"> 1. White (orange-white group 159D) 2. Lemon yellow (yellow group 6C) 3. Yellow (yellow group 9B) 4. Orange-yellow/yellow-orange (orange group 25B) 5. Orange (orange group 24A) 6. Dark orange (orange group 28A) 7. Garnet/brick red (red group 53A) 8. Others |
| 11. | Color of the standard petal markings | <p>Color of the markings (crescent) on the front face of the standard petal; RHS color codes are given in parentheses beside descriptor states:</p> <ul style="list-style-type: none"> 1. White (orange-white group 159D) 2. Lemon yellow (yellow group 6C) 3. Yellow (yellow group 9B) 4. Orange-yellow/yellow-orange (orange group 25B) 5. Orange (orange group 24A) 6. Dark orange (orange group 28A) 7. Garnet/brick red (red group 53A) 8. Others |
| 12. | Peg pigmentation | <ul style="list-style-type: none"> 0 Absent + Present |



9 Ovate



10 Obovate



11 Oblong



12 Oblong-lanceolate



13 Lanceolate



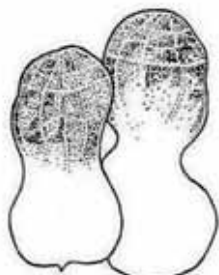
14 Linear-lanceolate

Leaflet shape

- | | |
|-----------------------------|--|
| 17. Leaflet margin | <ul style="list-style-type: none"> 1. Entire 2. Hairy 3. Wavy 4. Others |
| 18. Leaflet tip | <ul style="list-style-type: none"> 1. Obtuse 2. Acute 3. Mucronate 4. Others |
| 19. Number of seeds per pod | <ul style="list-style-type: none"> 1. 2-1 2. 2-3-1/2-1-3 3. 3-2-1/3-1-2 4. 2-3-4-1/2-4-3-1/2-3-1-4/2-4-1-3/2-1-3-4/2-1-4-3-5/3-2-4-1/3-2-1-4 5. 3-4-2-1/3-4-1-2 6. 4-3-2-1/4-2-3-1 7. 4-3-1-2/4-2-1-3 8. 3- or 4-seeded with occasional 5-seeded pods 9. Others |

20. Pod beak

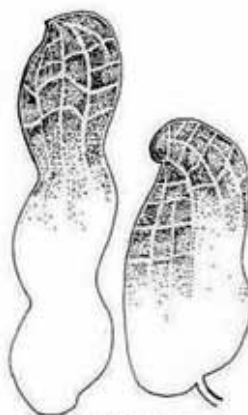
- 0 Absent
- 3 Slight
- 5 Moderate
- 7 Prominent
- 9 Very prominent



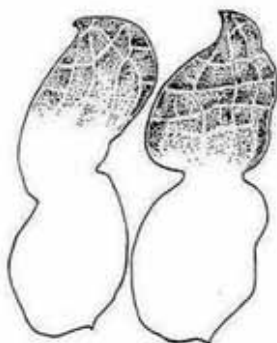
0 Absent



3 Slight



5 Moderate



7 Prominent



9 Very prominent

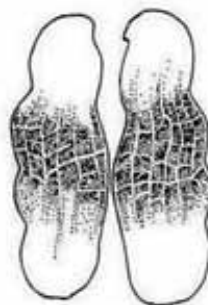
Pod beak

21. Pod constriction

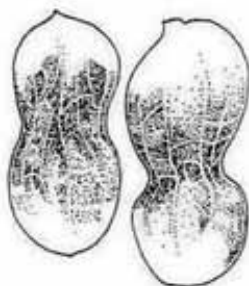
- 0 None
- 3 Slight
- 5 Moderate
- 7 Deep
- 9 Very deep



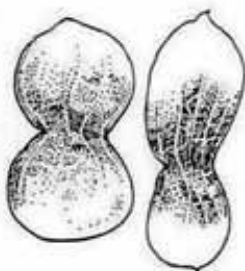
0 None



3 Slight



5 Moderate



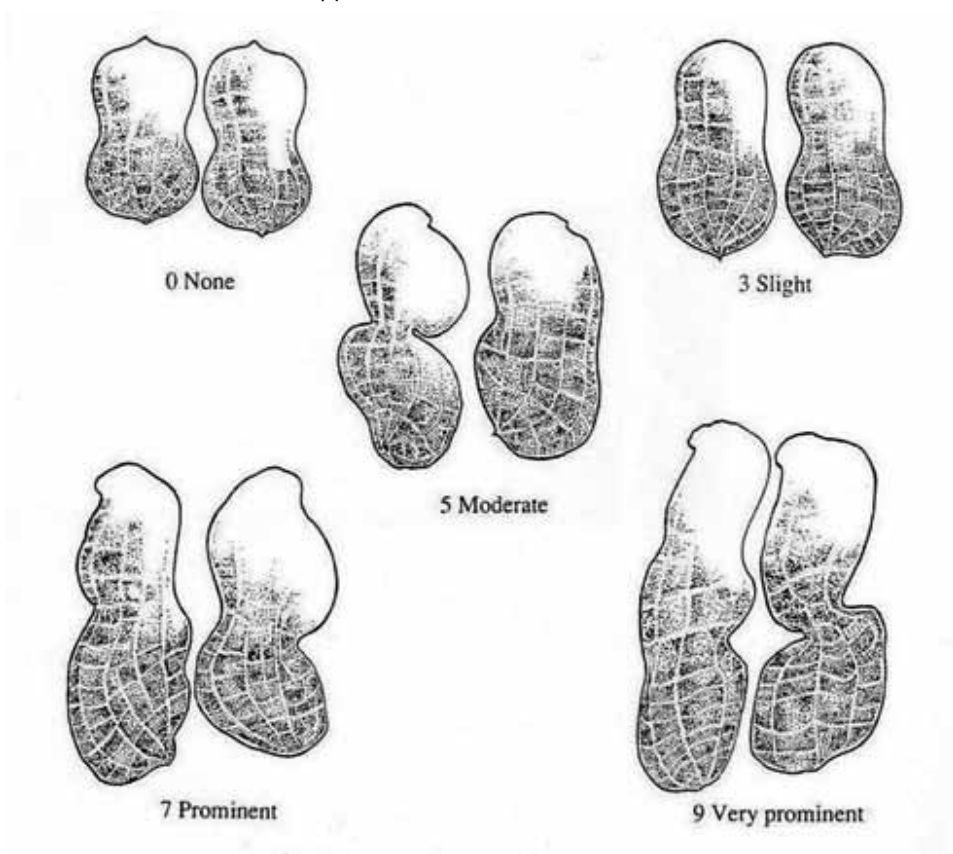
7 Deep



9 Very deep

Pod constriction

22. Pod reticulation
- 0 None
 - 3 Slight
 - 5 Moderate
 - 7 Prominent
 - 9 Very prominent

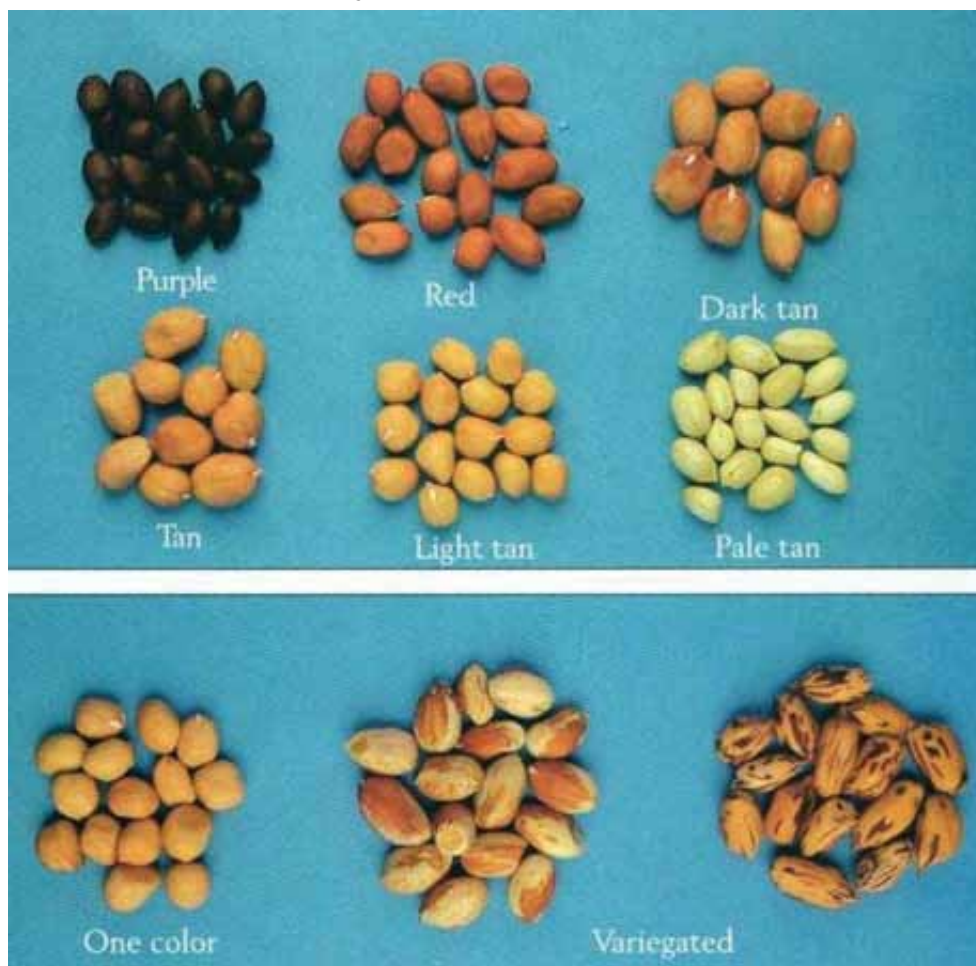


Pod reticulation

- 23. Pod length (mm) Mean of 10 mature pods
- 24. Pod width (mm) Mean of 10 mature pods measured at the widest point
- 25. Seed length (mm) Average of 10 mature seeds
- 26. Seed width (mm) Measured at the midpoint, average of 10 mature seeds
- 27. Seed weight (g) Weight of 100 random, mature, wrinkle-free seeds

28. Seed color

1. One color
2. Variegated



Seed color

- | | |
|----------------------------------|---|
| 29. Time to emergence (days) | From sowing or first irrigation |
| 30. Time to 50% flowering (days) | From emergence |
| 31. Time to maturity (days) | From emergence (9 categories) |
| 32. Fresh seed dormancy (%) | Germination immediately after harvest and number of days to 70% germination |
| 33. Seed dormancy (%) | Germination of dried seed at 14 days after harvesting and number of days to 70% germination |

Annexure II. List of important groundnut varieties released and notified at national and state level since 2000 in India¹.

Variety	Originating center ²	Year of release	Recommended state(s)/region for cultivation	Average yield (kg ha ⁻¹)	Salient features ³
Co (Gn) 4	TNAU, Coimbatore	2001	Tamil Nadu	1500 (rainfed), 1950 (irrigated)	Resistant to rust and LLS, suitable for all seasons, 53% oil content
VRI (Gn) 5	TNAU, Vridhachalam	2001	Tamil Nadu	2133 (rainfed), 2384 (irrigated)	Resistant to rust and LLS, suitable for both <i>kharif</i> and <i>rabi</i> -summer seasons, 50% oil content
Co (Gn) 5	TNAU, Coimbatore	2002	Tamil Nadu	1585 (rainfed)	Tolerant to rust, PBNB, leaf miner and <i>Spodoptera litura</i> , recommended for <i>kharif</i> season, 54% oil content
GG 7	GAU, Junagadh	2001	Gujarat and South Rajasthan	2149	Tolerant to LLS, suitable for <i>kharif</i> season, 49% oil content
AK 159	PKV, Akola	2002	Maharashtra and Madhya Pradesh	1606	Early maturity, recommended for <i>kharif</i> season, 51% oil content
GG 6	JAU, Junagadh	2003	Gujarat	2782	Suitable for summer cultivation, 50% oil content
GG 14	JAU, Junagadh	2003	North Rajasthan, Punjab, Haryana and Uttar Pradesh	2159	Tolerant to thrips, <i>Spodoptera litura</i> and leaf miner, recommended for <i>kharif</i> season, 52% oil content
TPG 41	BARC, Mumbai	2004	All India	2008	Moderately resistant to rust, large-seeded with high oleic acid/linoleic acid ratio, recommended for <i>kharif</i> season, 49% oil content
TG 37A	BARC, Mumbai	2004	All India	1900	Tolerant to collar rot, rust and LLS, suitable for both <i>kharif</i> and <i>rabi</i> -summer seasons, possesses fresh seed dormancy up to 15 days, 48% oil content
GPBD 4	UAS, Dharwad	2004	All India	1900–2200	Resistant to LLS and rust, recommended for <i>kharif</i> season, 49% oil content
SG 99	PAU, Ludhiana	2004	Punjab	2501	Tolerant to PBNB, possesses fresh seed dormancy up to 30 days, suitable for summer season, 52% oil content
JL 286	MPKV, Jalgaon	2004	Maharashtra	2231	Tolerant to LLS, rust, stem rot, thrips, leaf miner and <i>Spodoptera litura</i> , 49% oil content

Continued

Annexure II. Continued

Variety	Originating center ²	Year of release	Recommended state(s)/region for cultivation	Average yield (kg ha ⁻¹)	Salient features ³
Dh 86	UAS, Dharwad	2005	All India	4022	Tolerant to LLS and sucking pests, suitable for <i>rabi</i> -summer season, 48% oil content
Kadiri 5	ANGRAU, Kadiri	2005	Andhra Pradesh	1800–2200	Tolerant to leaf spots and drought, recommended for <i>kharif</i> season, 48% oil content
Kadiri 6	ANGRAU, Kadiri	2005	Andhra Pradesh	1800–2400	Tolerant to leaf spots, recommended for <i>kharif</i> season, 49% oil content
LGN 1	MAU, Latur	2005	Maharashtra	1487	Moderately resistant to LLS, stem rot, rust and PBND, tolerant to sucking pests, recommended for <i>kharif</i> season, 51% oil content
TMV(Gn) 13	TNAU, Tindivanam	2006	Tamil Nadu	2580	Tolerant to early- and mid-season moisture deficit stress conditions, recommended for <i>kharif</i> season, 50% oil content
VRI (Gn) 6	TNAU, Vridhachalam	2006	South Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu	2259	Tolerant to LLS, rust and PBND, recommended for <i>kharif</i> and <i>rabi</i> -summer seasons, 47% oil content
GG 8	JAU, Junagadh	2006	North Maharashtra and Madhya Pradesh	1716	Moderately tolerant to PBND, collar rot and stem rot, 46% oil content
Dh 101	UAS, Dharwad	2007	West Bengal, Odisha, Jharkhand and Assam	2877	Tolerant to stem rot and PBND, tolerant to thrips and <i>Spodoptera litura</i> , suitable for <i>rabi</i> -summer season, 50% oil content
ICGV 91114	ICRISAT, Patancheru	2007	Andhra Pradesh, Karnataka and Odisha	2000	Tolerant to rust and LLS, early maturity (100 days), tolerant to drought, recommended for <i>kharif</i> season, 48% oil content
M 548	PAU, Ludhiana	2007	Punjab	2185	Tolerant to leaf spots and collar rot, recommended for <i>kharif</i> season, 51% oil content
Kadiri 9	ANGRAU, Kadiri	2009	Andhra Pradesh	2500–3000	Tolerant to thrips, jassids, nematodes, LLS, rust, dry root rot and collar rot, recommended for <i>kharif</i> season, 52% oil content

Continued

Annexure II. Continued

Variety	Originating center ²	Year of release	Recommended state(s)/region for cultivation	Average yield (kg ha ⁻¹)	Salient features ³
Girnar 2	NRCG, Junagadh	2008	Uttar Pradesh, Punjab and North Rajasthan	2907	Large-seeded, tolerant to rust, LLS and PSND, recommended for kharif season, 51% oil content
VRI (Gn) 7	TNAU, Vridhachalam	2008	Tamil Nadu	1865	Moderately resistant to leaf miner, LLS and rust, recommended for kharif season, 48% oil content
Girnar 3	DGR, Junagadh	2010	West Bengal, Orissa and Manipur	1520	Tolerant to leaf miner and thrips, recommended for kharif season, 45% oil content

1. Source: Department of Agriculture & Co-operation (2012).

2. TNAU = Tamil Nadu Agricultural University; GAU = Gujarat Agricultural University; PKV = Punjabrao Krishi Vidyapeeth; JAU = Junagadh Agricultural University; BARC = Bhabha Atomic Research Centre; UAS = University of Agricultural Sciences; PAU = Punjab Agricultural University; MPKV = Mahatma Phule Krishi Vidyapeeth; ANGRAU = Acharya NG Ranga Agricultural University; MAU = Marathwada Agricultural University; ICRISAT = International Crops Research Institute for the Semi-Arid Tropics; NRCG = National Research Centre for Groundnut; DGR = Directorate of Groundnut Research.

3. LLS = Late leaf spot; PBND = Peanut bud necrosis disease.



International Crops Research Institute for the Semi-Arid Tropics

The **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)** is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

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