GROUNDNUT SEED PRODUCTION MANUAL FOR UGANDA

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GROUNDNUT SEED PRODUCTION MANUAL FOR UGANDA

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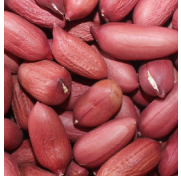

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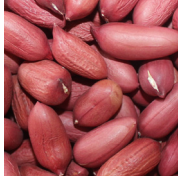


LISTS OF ABBREVIATIONS

AOSCA	Association of Official Seed Certification Agencies of the US
CBO	Community Based Organisation
CBSS	Community Based seed system
CEDO	Community Enterprises Development Organisation
CGIAR	Consultative Group on International Agricultural Research
DAFF	Department of Agriculture, Fisheries and Forestry
ISTA	International Seed Traders Association
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
NARO	National Agricultural Research Organisation
NaSARRI	National Semi-Arid Resources Research Institute
NGO	Non-Governmental Organisation
NSCS	National Seed Certification Services
NTSL	National Seed Testing Laboratory
USTA	Uganda Seed Traders Association

FOREWORD

A good crop stand and subsequently an impressive yield starts with sowing healthy seeds. In Uganda, the seed sector for many crops, that of groundnuts inclusive, is faced with many constraints. The primarily challenges include: limited supply of foundation seed, poor seed quality control, poor demand estimation and inadequate distribution systems. Secondary constraints include the often long testing process before a new variety is released and registered, lack of established grades and standards.

The supply of groundnut seed to producers has been hampered by a number of factors. Biophysical factors include: low seed multiplication rate, quick loss of seed viability, self-pollinated nature of the crop, sensitivity to heat and moisture and susceptibility to a myriad of pest attacks. Costs related to marketing include bulky nature of the produce resulting in high costs of transportation and low profit margins. The above constraints make private sector actors less attracted to groundnut seeds systems, leaving the task of providing seed of improved groundnut varieties to farmers in required quantities and affordable price with the public sector seed agencies. Unfortunately, the public sector seed agencies have not been able to meet the demand for good quality seed of improved groundnut varieties in Uganda. There remains a large gap between the seed demand and seed supply, resulting in low area coverage by improved varieties. Unless enterprising and progressive farmers and supportive NGOs become seriously involved in seed production, this situation is likely to remain unchanged.

Studies on economic performance of 14 improved groundnut released at NaSARRI - Serere, compared with 2 local varieties demonstrated positive returns for improved varieties and negative returns for local varieties. These varieties have been tested in various agroecological zones throughout Uganda thereby making them even more relevant now as climate change emerges as a growing challenge to sustained agricultural productivity. Therefore, adoption of improved groundnut varieties would significantly contribute to improving the livelihoods of resource constrained farmers.

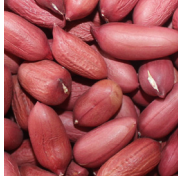
Moreover, the Groundnut breeding programme at NaSARRI is committed to continue to generate high quality seeds necessary to mitigate the adverse effects of emerging production challenges.

This manual provides salient information on recommended groundnut seed production practices, costs-benefits of producing different varieties to help farmers make important decisions. The manual also features a review of the current seed law, certification and monitoring standards. It is carefully written in simple language without compromising its scientific quality.

It is hoped that this manual reaches the intended users as we strive towards sustainable groundnut seed production, productivity and subsequently improved livelihoods for the communities we serve. Given its utility, I recommend that this manual be translated into several vernacular languages to benefit a wider section of the groundnut farming community.

I sincerely thank our Development Partners for their contribution towards the production of this manual. The Management of NARO and NaSARRI commend the team that put together this document. We expect that more of such useful documents will be availed to the public.

Dr Beatrice Akello Omonuk
Director of Research NaSARRI



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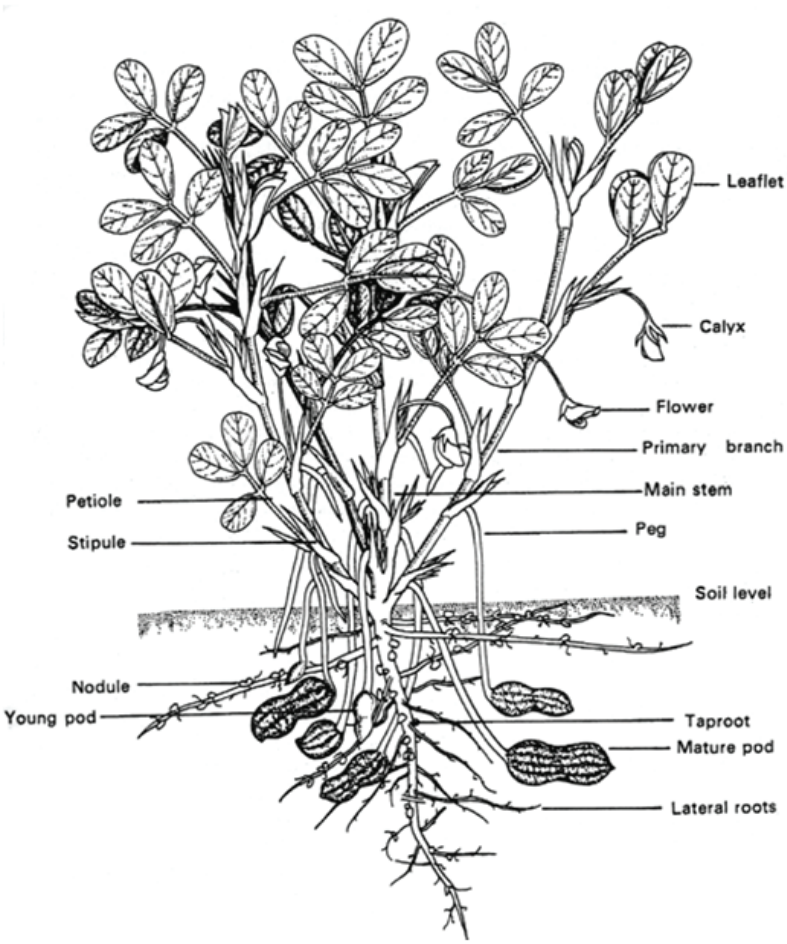
INTRODUCTION

1.1 THE GROUNDNUT PLANT DESCRIPTION

Cultivated groundnut (*Arachis hypogaea* L.), also commonly known as pul, emaido, ebinyebwa, njugu in some of the languages where it is produced in Uganda, belongs to genus *Arachis* in subtribe *Stylosanthinae* of tribe *Aeschynomenea* of family *Leguminosae*. Groundnut is an annual self-pollinating, indeterminate, herbaceous legume that grows to a maximum height of 60 cm. Natural cross-pollination occurs at rates of less than 1%. The fruit is a pod with one to five seeds that develops underground within a needlelike structure called a peg, an elongated ovarian structure.

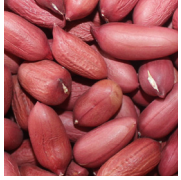


Adapted from: Nigam *et al.*, 2004

1.2 GROUNDNUT BOTANICAL TYPES

Cultivated groundnut has two subspecies *hypogaea* and *fastigiata*, with the former having two botanical varieties (*hypogaea* and *hirsuta*), while the latter has four botanical varieties (*fastigiata*, *vulgaris*, *peruviana* and *aequatoriana*), differing in plant, pod and seed characteristics (Krapovickas and Gregory, 1994; Ntare *et al*., 2008). Commercially grown cultivars belong to the market class Virginia or runner (subsp. *hypogaea*), Valencia (subsp. *fastigiata*), and Spanish (subsp. *vulgaris*) as detailed below.

Variety *hypogaea*: no flower on the main axis (or main stem); alternate and sequential reproductive and vegetative branches; inflorescence simple; vegetative branches moderate to profuse; primary branches



longer than main stem; growth habit spreading, intermediate, or erect; usually two seeds per pod; pod beak not very prominent; seed size medium (runner market type) to large (Virginia market type); testa colour generally tan (red, white, purple, or variegated also exist); cured seed dormancy moderate; maturity medium to late. Examples includes Serenut 1R, Serenut 2, Serenut 3R, Serenut 5R, Serenut 7T, Serenut 8R, Serenut 9T, Serenut 10R, Serenut 11T, Serenut 12R, Serenut 13T and Serenut 14R.

Variety *fastigiata:* These are characterised by floral axes on main stem; sequential branching; inflorescence usually simple; vegetative branches sparse; primary branches shorter than main stem; growth habit upright; two to four seeds per pod; pod beak absent, slight, or prominent; seed size small to medium; testa colour tan, red, white, yellow, purple, or variegated; cured seed dormancy little. Examples include Redbeauty, Acholiwhite

Variety *vulgaris:* These are characterised by floral axes on main stem; sequential branching, primary branches shorter than main stem; growth habit upright; mostly two seeds per pod. Examples include Serenut 4T, Serenut 6T, Amasoga.

These botanical classifications have implications on agronomic practices. In Uganda over 90% of the market share is dominated by Virginia and Spanish. Most Valencias are landraces generally superior in their taste and aroma to the other two market type. They are however, low yielding and susceptible to major diseases of groundnuts in Uganda. All the 14 commercial varieties are Spanish and Virginia market types.

Fig.1: Variations among the three groundnut botanicals; left to right: Spanish (e.g. Erudurudu red); Valencia (e.g. Acholiwhite/Redbeauty); Virginia (e.g. Serenut 7T)

1.3 IMPORTANCE OF GROUNDNUT IN UGANDA

In Uganda, groundnut is a staple legume and fast becoming a cash crop (Okello *et al*., 2010; 2013). Groundnut seeds contain 40 - 50% oil, 20 - 50% protein and 10 - 20% carbohydrate depending on the variety. With the costs of animal protein becoming increasingly prohibitive, groundnut is becoming an even more important source of protein. Groundnut seeds are rich in vitamin E, niacin, falacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine and potassium (Savage and Keenan, 1994). One kilogram of groundnuts provides approximately the same energy value as 2 kgs of beef, 1.5 kgs of cheddar cheese, 9 litres of milk or 36 medium size eggs (Woodroof, 1983). Groundnut is consumed raw, roasted, blanched, as peanut butter, crushed and mixed with traditional dishes as a sauce or as binyebwa, a cooked paste. It is also an excellent source of cooking oil and groundnut cake and haulms (straw, stems) are commonly used as animal feed. Groundnuts thrive under low rainfall and as a legume it improves soil fertility by fixing nitrogen. Therefore, the crop generally requires few inputs, making it appropriate for cultivation in low-input agriculture by smallholding farmers (Smartt, 1994). As a cash crop, it gives relatively high returns for limited land area and is well adapted to the hot, semi-arid conditions of Uganda. These multiple uses of groundnut make it an excellent cash crop for domestic markets as well as for foreign trade.

Presently in Uganda, the area under groundnut cultivation is estimated at 260,000 ha, representing 24.6% of total arable land (UBOS, 2010). Groundnut production grew at the rate of 2.85% per year (Table 1). Onfarm pod yields average 720 kg/ha of dry pods compared to potential onstation yields of 3,000 kg/ha. The yield gaps are attributed to a combination of factors such as unreliable rains, mostly non-irrigated production, traditional small-scale farming with little mechanization, pressure from pest infestations and diseases, the use of low-yielding seed varieties and increased and/or continued cultivation on marginal land, political instability, unsupportive oilseed policies and weak extension services. Research efforts have, since the 1920s released 24 varieties, the most recent being the Serenut 1-14 series. These varieties have helped to alleviate some of the production problems listed above. However, the market and field stability of these varieties, in light of emerging stresses, calls for continuous research while at the same time keeping crop improvement, quality and safety linked to practical applications.

The annual rate of growth (ROG) for yield and production areas are estimated at 0.74% and 3.60%, respectively (Table 1), suggesting that the increases in production were mainly due to area expansion rather than increases in productivity.

Table 1: Status of groundnut among grain legumes in Uganda

Crop	Area			Yield		Production	
	Ha	ROG (%)	% of total area	Kg/Ha	ROG (%)	MT	ROG (%)
Common Bean	917,000	2.72	12.14	491	-4.55	450,667	-1.96
Groundnut	257,667	2.85	3.41	718	0.74	185,000	3.60
Soybean	151,000	0.77	2.00	1177	0.75	177,667	1.53
Pigeonpea	90,000	1.38	1.19	1015	0.23	91,333	1.61
Cowpea	77,000	2.16	1.02	1074	2.02	82,667	4.23
Peas	26,600	0.15	0.35	626	1.36	16,663	1.51
Chickpea	8,051	2.51	0.11	547	-0.65	4,400	1.85
Total/average	**1,527,318**	**2.37**	**20.22**	**807**	**0.23**	**1,008,397**	**0.34**

Source: FAOSTAT (2012); area, yield and production are 2008-2010 averages; Rate of growth (ROG) are for 2001-2010

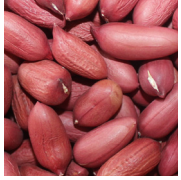
Projections

It has been projected that production of groundnut would have positive growth through 2020 (Table 2). Overall, the country's groundnut production would outstrip the national demand. ROGs of groundnut are expected to grow at 2.73% per annum, respectively.

Table 2: Projected Production and National demand

	Production (1000 MT)			ROG (%)	Demand (1000 MT)			ROG (%)
	2010	2015	2020		2010	2015	2020	
Beans	480	575	662	3.71	464	545	641	3.30
Soybean	182	219	255	3,35	177	215	257	3.80
Groundnuts	193	224	253	2.73	186	214	251	3.80
Pigeonpeas	145	196	253	5.65	105	124	151	3.80
Cowpea	52	53	55	0.68	52	53	55	0.68
Chickpea	6	9	12	6.08	4	5	6	3.95
Total	**1,058**	**1,276**	**1,490**	**3.68**	**987**	**1,156**	**1.362**	**3.27**

Source: Tsedeke et al., 2012. ROG figures are for 2010 and 2010 period



TECHNICAL ASPECTS IN GROUNDNUT SEED PRODUCTION

2.0 ENVIRONMENTAL REQUIREMENTS

2.1 SOIL

Groundnuts grow best on friable soils that are well drained, well aerated, loosely textured and well supplied with calcium, potassium and phosphorous. The soil should also contain moderate amounts of organic matter. Heavier clay soils and those that tend to have surface crusting are unsuitable due to their high resistance to peg penetration and pod expansion. Soils that are predominantly clay also result in the loss of a large number of pods at harvest since most of them remain in the soil. In addition, pods harvested from clay soils tend to carry a lot of soil resulting in lengthy periods of drying which may predispose them to molding and hence aflatoxin contamination of the kernels. Groundnut grows best in slightly acidic soils with a pH of 6.0 to 6.5 but a range of 5.5 to 7.0 is acceptable. Saline soils are not suitable since groundnut has a very low salt tolerance.

2.2 MOISTURE REQUIREMENT

Groundnut seed has a high demand for water during germination. For good germination, optimum soil moisture is required to facilitate the 35 - 40% water intake by imbibing seeds. Seeds should be planted when moisture levels are favourable for rapid germination and growth. Rapid germination and vigorous growth help the young plant to counteract diseases.

2.3 CLIMATE

Groundnuts are adapted to a wide range of climatic conditions;

Temperature: Optimum temperatures are 27 - 30 °C for seed germination and vegetative growth and 24 - 27 °C for reproductive growth. Dry weather is required for ripening and harvesting. Groundnuts are day neutral and flowering initiation is unaffected by photoperiod.

Rainfall: Between 450 mm and 1250 mm of evenly distributed rainfall is required annually for good growth and yield. Early maturing small seeded varieties require 300 - 500 mm while medium to late maturing large seeded varieties need 1000 - 1200 mm rainfall.

Groundnuts have various physiological mechanisms for avoiding the effects of drought and an extensive root system which is able to exploit moisture reserves at deeper layers of soil. Even during drought, groundnuts will always form some pods. Although considered a drought tolerant crop, there are varietal variations to drought tolerance and therefore irrigation may be necessary. Groundnuts are best grown where the rainfall is reliable and/or where access to irrigation is available.

2.4 CULTIVARS

The class of parental seed will depend on the class of seed one has opted to produce. The parental seed should be obtained from authorized sources. The seed procured for sowing should be handled carefully and stored in a cool dry place.

Seed selection: Certified seed of adapted varieties purchased from a reliable source seed should be used. In case of farmer saved seed, it should be pure (true to type or unadulterated), graded (medium-size), undamaged, fully developed and free from discolouration and fungal infection with a germination rate of above 90%. Germination tests on seeds should be carried out one week before sowing and the seed rate

adjusted accordingly. Several other factors must be considered when deciding on a variety. These include yield, resistances to major pests and disease, grades, farmer preferences e.g. seed colour (Western, Central and Southern regions of Uganda prefer red types whereas northern and eastern regions do not have a particular kernel colour preference), growth habit, and maturity periods. The "perfect variety" possessing all the necessary traits for diverse environments does not exist, so it makes good sense to plant a couple of different varieties to reduce the production risk. Pods should be shelled 1 - 2 weeks before sowing and only good quality seed should be selected for sowing. It is always recommended to test the germination capacity of seed prior to planting. Planting two or more varieties with different maturity dates permits efficient use of limited harvesting and curing equipments. It is good practice to purchase certified groundnut seed at regular intervals, preferably every 2 - 3 years. The seeds must be free from contamination, irrespective of the sources of supply.

Seed dressing: Groundnut seed is susceptible to a number of soil pathogens particularly fungi that cause seed decay and seedling death. Seed treatment prior to planting will protect the seed and seedlings from these pathogens and increase the plant stand in the field. Two seed dressing fungicides, Mancozeb and Thiram, are currently registered for use on groundnuts Complete coating of the seed is essential and the use of a mechanical mixing apparatus is strongly recommended. Comprehensive directions for the use of these agents are indicated on the label. While treating seeds care should be taken so as to avoid injury to seed radicles.

Box 1: Summary of recommended practices

Agronomy aspect	Recommended practice
Climate	Rainfall: 450 - 1250 mm per year Temp: 24 - 30^{0}C
Region in Uganda	Low to mid-altitude
Soils	Sandy or sandy loam, or loamy sands
Fertilizer	60 kg ha^{-1} NPK
Rotation	With cereals or cassava, sweet potato, sunflower
Land preparation	Before on-set of rains, to a fine tilth
Planting time	When moisture is adequate and stable in soil Sow to a depth of 5 - 6 cm
Seed dressing	With fungicide e.g. Mancozeb and Thiram
Spacing	*Semi-erect types*: 45 X 10 -15 cm e.g. Serenut 1R, Serenut 2, Serenuts 7T, Serenut 8R *Bunch types*: 45cm X 7.5-10 cm e.g. Serenut 4T, 5R, 6T
Weeding	2 - 3 times
Irrigation	Where possible and necessary

Dormancy: Seed dormancy has been defined as the failure of an intact, viable seed to complete germination under favourable conditions (Bewley, 1997). Dormancy allows plants to survive unfavorable environmental conditions. Mature groundnut kernels are dormant to some degree. However, the period of dormancy depends on the variety, botanical group and storage conditions. Seed dormancy in groundnuts is predominant among the Virginia varieties. For instance Serenut 3R has a dormancy of at least 45 days; Serenut 5R has a dormancy period of at least 30 days. The other commercial varieties have no dormancy period and sprout in the field when harvesting is delayed. Environmental factors can break the dormancy. It is absent in Spanish and Valencia groundnut or is naturally broken several weeks after seed maturity. Non-dormancy results in field sprouting especially if harvesting is delayed. This reduces seed yield and quality considerably. Some Virginia type groundnuts can have a dormancy of 4 or more months. Chemical products such as ethylene (3.5ppm) induce excellent germination. Ethephon® can also be used to break dormancy in groundnuts. Exposure to high temperatures (40 - 45°C for 15 days) can also break the dormancy.

The key growth characteristics of adaptable cultivars in Uganda are shown in Table 3.

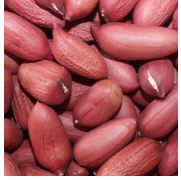


Table 3. Key attributes of adapted commercial groundnuts cultivars in Uganda

Variety	Year released	Negative attributes	Positive attributes	Special trait
Serenut 1R	1998	• Rosette susceptible • Leafminer Susceptible • Susceptible to Aflatoxin contamination	• Big bold red seeds • Resistant to leafspots; • Drought Tolerant	• Confectionery type • Soft shell (easy to shell) • Stay green
Serenut 2	1998	• Leafminer Susceptible • Difficult to shell	• Big bold tan seeds • Resistant to Leafspots and Rosette virus • Good for condiments, flour	• Highly Drought Tolerant • Tolerant to Aspergillus colonization and aflatoxin contamination
Serenut 3R	2002	• Long dormancy (45 days) • Weak pegs at harvest(pods remain in soil) • Bitter to taste when raw • Susceptible to Aflatoxin contamination	• Resistant to leafspots; • Tolerant to Drought • Resistant to Rossete	• High oil • Good for butter
Serenut 4T	2002	• Susceptible to leafminer and leafspots and rosette virus • Small seeds Difficult to shell • Susceptible to Aflatoxin contamination	• Good for Confectionery and butter • Early maturing	• High shelling return (73%) • Tolerant to Aspergillus colonization and aflatoxin contamination
Serenut 5R	2010	• Susceptible to leafminer • Susceptible to Aflatoxin contamination	• Medium to large seeds • Tolerant to drought; • Resistant to rosette virus • Resistant to leafspot	• Short dormancy (about 30days) • confectionery type • Good attractive red colour
Serenut 6T	2010	• Leafminer Susceptible • Susceptible to Leafspot • Susceptible to Aflatoxin contamination	• Rosette resistant • Medium to big seeds • Easy to shell • Early maturing (90 days)	• Very Tall bunchy groundnut • very easy to harvest • Confectionery type
Serenut 7T	2011	• Leafminer Susceptible • Susceptible to Aflatoxin contamination	• Drought tolerant, • Uniform mat-type growth • Rosette and leafspots resistant • Big pods and Seeds • Stay green	• Easy to shell (soft pods) • Confectionery Type • Good for condiments, flour
Serenut 8R	2011	• Leafminer Susceptible • Susceptible to Aflatoxin contamination	• Drought tolerant, • Uniform mat-type growth • Rosette and leafspots resistant • Stay green	• Bunchy groundnut very easy to harvest • Deep red with faint dark stripes attractive market colour • Good for butter
Serenut 9T	2011	• Leafminer Susceptible	• Very sweet Drought tolerant, • Uniform mat-type growth • Rosette and leafspots resistant; • Easy to shell • Stay green	• Tolerant to both Aspergillus colonization and Aflatoxin contamination • Tolerant to thrips attack • Best Tan confectionery
Serenut 10R	2011	• Colour intermediate tan and red. • Premium market prefers red seed coat • Susceptible to Aflatoxin contamination	• Rosette and leafspots resistant; • Drought Tolerant • Stay green	• Leafminer tolerant
Serenut 11T	2011	• Leafminer Susceptible • Susceptible to Aflatoxin contamination	• Drought tolerant, • Rosette and leafspots resistant; • Easy to shell	• Giant pod and seeds • Confectionery type
Serenut 12R	2011	• Leafminer Susceptible • Medium seed size • Susceptible to Aflatoxin contamination	• Drought tolerant, • Rosette and leafspots resistant; • Stay green	• Very Tall bunchy groundnut • Very easy to harvest • Deep red attractive market colour • Confectionery Type
Serenut 13T	2011	• Leafminer Susceptible • Susceptible to Aflatoxin contamination	• Drought tolerant; • Rosette • Resistant; Easy to shell (soft pods) • Good for butter and condiments • Stay green	• Uniform light tan attractive seeds
Serenut 14R	2011	• Leafminer Susceptible • Susceptible to Aflatoxin contamination	• Drought tolerant, • Rosette and leafspots resistant; • Stay green	• Confectionery Type

For pictures of these varieties refer to Appendix A (page 31)

FIELD OPERATIONS

3.1 LAND PREPARATION

Good land preparation is critical for maximum moisture retention, precision planting, fast uniform seed germination and emergence and effective weed and disease control. Land should be prepared early (six weeks before planting), before the rains start, so that sowing can take place early in the rains. A well pulverized seedbed with sufficient planting depth coupled with recommended spacing, good germination, weed control and good moisture retention is imperative for good yields (Fig.2). All crop residues and weeds should be completely removed or well incorporated into the soil, and seed beds should be smooth to provide good soil-to-seed contact after sowing. While opening land using hand hoe or ox plough, one should adhere to the above recommendations. Those who can afford tractors for land preparation, should deep turn the soil to bury crop residue and weeds, using a disc plough, 3 - 4 weeks before planting. In wet, low lying areas it may be worth considering using ridges in which to plant groundnuts. The use of ridges can prevent waterlogging, and improve weed control and harvesting. Ridges should be made at, or just before, sowing and they should be flat-topped.

3.2 FERTILIZATION APPLICATION

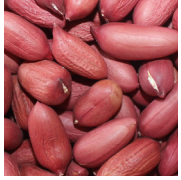
Groundnut does well in soils that are rich in organic matter. Fertilizer levels would depend on the results of soil tests and the productivity levels targeted for the crop. Groundnuts respond better to residual fertility than to direct fertilization. If a well-fertilized crop precedes groundnuts, direct fertilization may not increase the yield or quality of the groundnuts. In addition to major nutrients N, P, and K, calcium (Ca) is a critical nutrient in producing high quality groundnut seed. There must be sufficient amounts of Ca in the top 8 - 12 cm of soil after the entry of the peg. Characteristics of Ca deficiency include a dark plumule, slow germination and emergence, low seedling survival, poor growth, poor pod filling (pops) and a weakened plant. In tests, seed germination averaged 92% when the Ca level was greater than 420 ppm but decreased to 52% when the Ca level decreased to 200 ppm. It is important to maintain near to neutral soil pH levels (as high or low levels may create either deficiency or toxicity of micro-nutrients) and Ca to K ratios of less than 3 to 1. Excessive K in the podding zone interferes with Ca uptake and results in pod rot and pops (unfilled pods or wind nuts). Regardless of soil tests, it is advisable to apply 150 - 200 kg ha^{-1} Ca to small-seeded varieties and 300 - 400 kg ha^{-1} to large-seeded varieties at the time of peak flowering. The gypsum/lime (depending upon soil pH) should be applied as side placement followed by light inter-row cultivation to mix it with soil and remove weeds. Do not apply potassium fertilizers after the groundnuts have emerged. Foliar sprays of nutrients are generally ineffective or not economically viable, except to prevent or correct some micronutrient deficiencies. It is also important to monitor Mg, B, and Zn levels closely in seed production fields. They can interfere with the availability of other nutrients and their toxicity or deficiency can affect plant growth and production. A soil test is advisable before recommendations are made. However if soil test results are not available, the general fertilizer recommendation is:

NPK kg /ha: 25 kg of N - 50 kg of P_2O_5 - 100 kg of K_2O

Farm Yard Manure (FYM) or Compost: Apply 10 - 12 t ha^{-1}; 25 - 30 days before sowing. Introducing manure in a crop rotation also helps to increase the organic matter content of the soil and improve its structure.

3.3 PLANTING

Time of planting: The current global weather changes make it difficult to standardize the planting date. However, farmers should plant as soon as there is adequate and consistent moisture in the soil to ensure good germination and subsequent plant growth. Timely planting should take advantage of periods of higher rainfall and avoid end of season drought effects.



Inoculation: Before sowing, a Rhizobium inoculum should be applied to groundnut seeds, especially when the soil is being used for the first time. Inoculation with Rhizobium bacteria stimulates nodulation on the roots, thus, causing the plant to provide its own nitrogen and consequently reducing the need to apply large quantities of nitrogenous fertilizer. When inoculating seeds, they should first be dampened and then mixed thoroughly with Rhizobium inoculant at 168 grams / 36 kg seed.

Sowing: Sow groundnut seed in rows and at the recommended spacing (Fig.2). Groundnut spacing depends on the growth habit of the variety, botanical type, seed mass and germination rate of the seed-lot. The recommended space between rows is 45 cm while the recommended spacing between plants within a row is:

- Semi-erect types: 10 - 15 cm (e.g. Serenut 1R, Serenut 2, Serenut 7T, Serenut 8R)
- Bunch types: 7.5 - 10 cm (e.g. RedBeauty, Serenut 4T, Serenut 6T)

Row spacing can be reduced from 45 cm to 30 cm, if desired, and this will allow earlier ground cover and help prevent serious weed problems. Generally, 150,000 plants/ha are recommended for dry land production and 300,000 plants/ha for irrigated land. The weight of seeds required to sow one hectare is called the seeding rate (SR). This depends on the varietal characteristics, seed quality and planting density.
The SR is calculated as follows:

$$SR = \frac{\text{Density (plants/ha)} \times \text{Weight of 100 seeds (g)}}{10 \times \text{seed viability (\%)} \times \text{shelling yield (\%)}}$$

Planting groundnut plants closer together results in individual plants setting fewer pods, but over a short period of time. Overall, this will ensure that the pods will be of a similar age and stage of development and, therefore, make it easier to decide when to harvest (Okello *et al*., 2010). Wider spacing will produce fewer yields per unit area. It is important to sow groundnut seed in rows and at the right spacing as this helps to achieve the correct seed rate, reduce the incidence of rosette disease, ensures a more uniform pod maturity, better quality seed and maximizes yield. Row planting eases operations like: weeding, spraying, disease and pest identification, estimation of plant population/yield per unit area, determining seed rate, supervision and harvesting. Therefore plant at the recommended plant population based on a given row spacing and seed count. Sowing at 5 - 6 cm depth ensures that the plant develops and produces optimally. Seed that germinates slowly as a result of deep planting, takes longer to emerge and a substandard plant will be produced. Shallow planting of seed (less than 5cm) can only be considered when enough moisture

Fig.2: Row planted groundnut crop

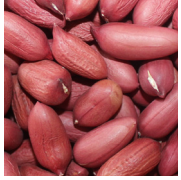
is available and the climate is moist. In situations where moisture is not limiting 5 cm to 6 cm is the ideal planting depth. Seeds must not be sown immediately after heavy rains since they imbibe too much water, which causes rotting. This also results in excessive soil compaction which may hinder germination. Long duration varieties (120 days and above e.g. Igola) should only be planted with the first rains in the first season. Short to medium duration varieties can be planted in either season. Early planting generally improves yields and seed quality.

Isolation distance: In general, natural cross pollination in groundnut is almost absent. However, at locations where bee activity is intense, depending on the variety and season, natural cross pollination can occur. Therefore, it is essential to have adequate isolation distance between varieties in seed production fields to help prevent contamination with pollen from other varieties and mechanical mixtures. Where natural cross pollination is almost negligible, an isolation distance of 3 - 5m between varieties is required for all classes of certified seeds. Isolation distance should be determined for each location, season, and variety depending upon the extent of natural cross pollination.

Rotation: Prolonged monocropping on the same field increases the build-up of pest and disease. A well planned, crop rotation system can ensure good yields of high quality groundnut. In order to reduce risk in the farming system, groundnuts should be grown in rotation with other crops, especially grass type crops. Groundnuts have been shown to improve the yield of subsequent cereal crops up to 20%. One of the best crop rotation systems is one in which a grass fallow is followed by groundnuts. Fewer diseases are also present in groundnuts following a grass crop. Usually groundnuts also produce a better crop on fields that have been fallowed. To avoid the build-up of pests and diseases, groundnut should not be grown continuously on the same land. A rotation of 3 years or longer can usually reduce disease, pest and weed problems. Because of the incidence of pests and soil-borne diseases, groundnut should not be grown after cotton, although cotton can be used in rotation after groundnut. Crops such as soybean, tobacco, tomatoes and certain other vegetables may cause a build-up of nematodes and soil-borne diseases and, therefore, should be avoided in rotation with groundnuts. Cereals, such as maize, sorghum and millet are good rotational crops, and other clean-weeded crops such as cassava, sweetpotato and sunflower can also be used. Circumstances may force a farmer to plant groundnuts in succession in which case disease problems can be expected, especially leaf and pod diseases. This can be improved by deep ploughing which may reduce the disease problem.

3.4 WEED CONTROL

Fig.3: Clean weeded groundnut crop



Weeding: A seed production field should be weed free as weeds not only affect productivity and other field operations but also interfere with rouging. Further, the presence of weed seeds in produce may disqualify it for certification. Weeds can significantly lower the groundnut yield by competition, interference with harvest and by harbouring pests and diseases (alternate/alternative hosts). At harvest time, some weed seed will be harvested along with the groundnut, so that your seed will be contaminated with weed seed. Groundnut is inherently a poor weed competitor particularly 3 - 6 weeks after sowing; therefore, effective early weed control implies good control of weed throughout the growing season and this will translate into higher yields. Weeds can be controlled by using cultural, mechanical, physical and chemical means. A combination of these approaches provides the most successful results. However, the ultimate choice depends on the species of weeds involved and the level of infestation. Generally, 2 - 3 weedings are recommended, the first before flowering and at least one additional weeding during pegging. Once pegging begins, soil disturbance near the plant should be avoided or kept to a minimum, so as not to interfere with the developing pods. Instead weeds at this stage should be removed by hand-pulling. Weeding by hand pulling to avoids disrupting soil and damaging the pegs (Fig.4). Crop rotation may reduce certain species of weeds. Pre- and post-emergence herbicides may be used to eradicate weeds.

Fig.4: Pegs exposed due to late weeding

Earthing: Many farmers practice earthing up (mounding soil around the plant) to allow pegs from higher nodes to enter the soil. This is an important yield limiting factor as it influences pod formation of the lower highly productive nodes, and promote growth of the stem rot causing fungus (*Sclerotium rolfsii*). It also deteriorates the quality of earlier set mature pods while waiting for the later set pods to mature. Earthing up, especially in the early stage, has an influence on plant development leading to deformed plants with poor or no production at the lower nodes. Flowers cannot develop at the nodes, and thus no pegs or pods are formed. Earthing up later in the season normally does not lead to deformed plants (as in the previous instance) but does lead to lower yields.

Roguing: This consists of manual removal of plants of other varieties present in the field intended for seed certification prior to field inspections by the monitoring team. Plants that should be rouged out include off-type plants, prohibited and other noxious weeds. A minimum of two (preferably three) roguings should be carried out before harvest to remove off-type groundnut plants in the seed production field. At the seedling stage, weak, distorted, variegated, diseased, and out of the row alignment seedlings should be removed and destroyed. At the flowering stage, 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. Similarly, at the podding stage, based on peg morphology and other vegetative characters, the remaining off-types including late flowering plants should be removed. The last roguing is done on the harvested plants to remove plants with diseased pods and off-types based on pod and seed characteristics (Table 4). Depending on the degree of contamination a field can be retained or rejected for seed production. Fields of mother seeds should have less than one off-type in 1000 and those of certified seeds, one in 200. Regular field checks allow elimination of off-types based on phenotypic characteristics of the cultivated variety. Field rouging maintains the genetic purity and can only be effective if checks are rigorously continued throughout all operations.

Table 4: Stages when to rogue groundnut seed fields

Crop Growth Stage	What Off-types Can be Seen and Rogued Out
Seedling	Volunteer plants, perennial troublesome weeds, which are larger than the crop seedlings
Early growth	Other varieties and off types taller than the seed crop variety
Flowering	Other varieties, off types which have different flower colour
Maturity	Other varieties, off types with different colour, height, maturity, etc.
Hand Harvest	Plants which differ in appearance from the seed crop variety.

3.5 DISEASES AND PESTS MANAGEMENT

Plant Protection: Diseases and insect pests affect groundnut productivity and the quality of produce (poor pod filling, low shelling outturn, small seed size, shriveled seed, seed discolouration, seed damage, low germination etc). They also interfere with recording of proper field observations. Groundnut is susceptible to a number of pests and diseases. There are a number of disease/insect pest management measures, including use of resistant cultivars, cultural, chemical and biological. Growing resistant/tolerant cultivars is the most economic and efficient measure. In case the level of resistance in a preferred cultivar is not high enough, other approaches should be combined to obtain better protection against diseases and insect pests. Recommended protection measures against major diseases and insect pests should be regularly followed during the cropping season. Comprehensive coverage of major pests and diseases of groundnuts in Uganda and their managements has been documented by Okello *et al*. (2013) in the production guide entitled 'Groundnuts production guide for Uganda: Recommended practices for farmers.' Copies are freely available online at:

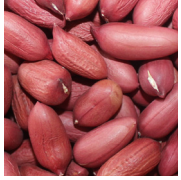
http://oar.icrisat.org/7385/
or http://pmil.caes.uga.edu/documents/UGA136/UgandaGroundnutManual.pdf

3.6 HARVESTING

Harvesting: The timing of harvesting is very critical as it can significantly affect the yield and the quality of seeds. Premature harvesting lowers the yield, oil percent, flavour and quality of seeds. Delayed harvesting after physiological maturity can result in Aspergillus flavus infection and aflatoxin contamination in pods/seeds and many pods may remain in the soil due to weakening of pegs. Non-dormant varieties will also start germinating if harvesting is delayed. Therefore, it is important to harvest at optimum maturity.

Groundnuts show indeterminate growth, which means that from about four weeks onwards the crop will continue to flower and grow vegetatively throughout the growing season. This characteristic makes it difficult to determine when optimum maturity occurs.

It is very common for the crop to still be flowering at harvest. As a result, the crop does not mature evenly and it can be difficult to determine exactly when to harvest. Therefore, at harvest, seeds on a single plant will be at differing levels of maturity. Harvesting is one of the most critical operations in groundnuts production (Fig.5). Weeds can make efficient harvesting impossible by interfering with digging or lifting. Determining when to harvest is important. Groundnut may gain 300 - 450 kg/ha and 2 - 3% in grade during the 10-day period before optimum harvest. Losses greater than 300 - 450 kg/ha may occur if the crop is not harvested at optimum maturity. In order to determine the best harvest date a farmer must scout his crop on a regular basis. Maturity affects flavor, grade, milling quality, and shelf life. Not only do mature groundnuts have the quality characteristics that consumers desire, they are worth more to the producer. Damage to pods at



the time of harvest should be avoided as much as possible since this can lead to rapid invasion of the pods by *Aspergillus flavus* / *Aspergillus parasiticus* which leads to aflatoxin contamination. Remove excessive moisture from the pods after harvesting through shaking.

i) Timing of pulling /Harvesting

The groundnut plant usually gives an indication when to harvest. In order to determine the correct harvest date, the development of the plant must be considered. The groundnuts should be harvested when approximately 75% of the pods have reached maturity. Harvesting at the right time gives the farmer the maximum yield and grade. If harvesting is too early, grading factors will be lower. If harvesting is too late, over-mature pods can lose peg strength resulting in yield loss. There are several methods to determine the optimum digging time (see below). It is therefore very important to harvest the crop at optimum maturity, as excessive numbers of over-mature or very immature pods at harvest can be reflected in high levels of aflatoxin in the product.

Fig.5: Happy farmer showing freshly harvested groundnut

ii) Harvest Indicators

As pods mature, the inside portions develop brown to black markings, while immature pods retain a fresh white appearance. The cellular layer just below the outer layer of the pod undergoes several colour changes during the maturation phase. This cellular layer is called the mesocarp. It changes in colour from white to yellow to orange to brown and finally black as the pod matures. This colour distinction can be used to estimate crop maturity with the 'hull scrape' method.

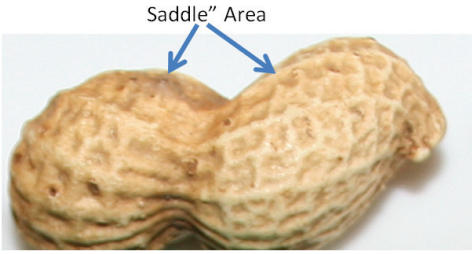
Method 1: Hull scrape method; Hold the pod with the beak pointing down and away from you. With a pocket knife, scrape away the outer hull in the area from the middle of the pod to the peg attachment point. This region is known as the saddle. Pods should be moist when the colour determinations are made. To get accurate representation of the field, collect three (3) adjacent plants from 3 - 5 locations in the field.

It is important to note the colour in the saddle area of the pod. This is where the colour changes first occur on the pod.

The colours which occur are:

Table 5: Colours in the saddle area and implications to harvest

Colours	Implication to harvest
Black	Overmature
Dark Brown	Mature
Orange / Light Brown	Close to Mature
Yellow	Immature
White	Immature to Underdeveloped



Method 2: Shell interior method. The most dependable guide to determine when to harvest is to look for pods with shells turning dark brown inside and the seed coat will be thin and tight on the kernel (Fig.4). The best time to harvest is when the crop has the highest percentage of sound mature kernels (SMK). Pull 3 - 5 plants, strip the pods, shell and examine the insides of the shells. If the majority of the pods (70% upwards) have dark markings inside the shell and the seed are plump and the true colour of that variety, then the groundnut is mature and ready for harvest.

Method 3: Seed weight. The mean seed mass is determined to estimate the maturity at successive intervals. It reaches a constant value, when the crop is mature.
Example: Suppose 3 plants harvested on 20th July gave an average seed mass of 30g, and others harvested on 21st July also gave the same mass, then the crop is mature.

Method 4: Days after Planting: This and other guides include information on the number of days after planting (DAP) that each variety needs to mature. Use the estimated period of maturity of the varieties as provided by breeder / research institution. For example, Serenuts 1R, 2, 7T, 8R, 9T, 10R, 11T, 12R, 13T, 14R matures in 100 - 110 days. Serenuts 3R, 4T, 6T matures in 90 - 100 days. Acholi White and Red Beauty matures in 85 days. However, DAP is a general estimate of maturity and it should never be used alone for determining the harvesting date. The DAP information should rather be used to schedule approximate planting date. On large acreages, it is suggested that multiple varieties be selected to allow for varying harvest dates. Groundnut varieties e.g Serenut 7T (Fig. 4), having the stay-green trait (a new trait associated with high drought tolerance) even at physiological maturity requires a different harvest management from the other non-stay green types. The estimated maturity date from research is the ideal harvest indicator.

Fig.4 Mature stay green groundnut variety showing pods with dark brown interior.

With experience farmers will become more adept at determining the maturity differences. Farmers must consider the other factors listed below in determining when to harvest, but as a general guide the crop is ready for harvesting when the following maturity levels are reached:

Virginia Varieties: Harvest when 60 to 65% of the pods are brown and black.

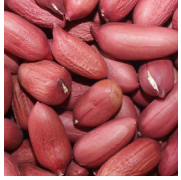
Valencia and Spanish Varieties: Harvest when 65 to 80% of the pods brown and black.

Prevailing weather conditions can also influence the determination of the harvest date, as it influences quality. Drought determines the harvest date when the soil is desiccated to such an extent that the plant withers and the seeds in the pods begin to shrivel and take on a ripe appearance. Such groundnuts must be harvested immediately.

Harvesting techniques

Two major harvesting techniques are used in Sub Saharan Africa; hand and hoe/ox drawn plough. Whichever method is used care should be taken not to injure the seeds and pod.

- **Hand harvesting/ hand pulling:** Most suitable for erect/semi erect groundnut varieties (e.g. Serenut 4T and Serenut 6T, Serenut 12R) in sandy, loam soils which are well drained. Commonly used during the rainy season when the soils are moist and soft. Hold the entire group of branches as the plant is being lifted. Hand harvest only when there is enough moisture in the soil.



- **Hoe/Ox - drawn plough:** Used for spreading groundnut varieties (Serenut 3R), on heavy soils and during dry conditions. This method is effective in lifting the entire crop from soils with a reduced pod loss. Avoid injury to pods and seed during harvesting using this method. The blades should be passed away from the pods as much as possible. A forked hoe/plough causes less pod/seed damage than unforked ones. This harvesting technique is practiced mainly during the second rains when drought usually sets in at harvesting time. Mechanical damage during harvesting with a hoe is a big problem in groundnuts. When pods are damaged, moulds will enter and produce aflatoxins. The situation becomes worse when drying takes place on bare ground.

3.7 HARVEST MANAGEMENTS

The two most important operations in handling groundnut after harvest are cleaning and drying.

Cleaning and selection at harvests: Freshly harvested groundnuts should be cleaned and sorted to remove damaged nuts and other foreign matter. It is recommended to shake the harvested plant immediately after lifting to remove soil from pods (Fig.6). This will promote faster drying and also prevent formation of fungal growth. Extra care should be taken to avoid pod damage during and after harvesting since this can lead to rapid invasion of the pods by *A. flavus/A. parasiticus* that produce aflatoxins. The harvested plants should be left in rows for final rouging. Any off-type plant (based on pod and seed characteristics) and plants with diseased pods should be removed. Gleanings (left over pods in the soil) from seed production plots should not be mixed with certified seed. Broken and rotted pods should be removed at once.

Fig.6: Freshly harvested groundnut being dried in the garden.

Drying: Groundnuts must be properly cured if desirable flavour, texture, germination and overall quality are to be maintained. Moisture reduction is the major consideration in groundnut curing and may be accomplished by natural windrow drying or by artificially drying in a mechanically control environment. At the time of harvest, groundnut pods generally contain 35-60% moisture. Once the prevailing humidity is low in the productive areas open windrow drying for 5-7 days under good conditions is usually sufficient.

In places where high temperatures prevail at the time of harvest direct exposure of pods to the sun should be avoided. This can be achieved by arranging the harvested plants in circular heaps with pods facing inside. Managing the drying system quality control is important, as constant checks must be done on groundnut kernels especially as moisture content approaches the 12% moisture level. Do not allow average moisture content to get below 8.5% for any lot with no portion of the lot containing less than 7 % moisture nor more than 10 % moisture. Drying should be rapid to prevent mould growth and the possible formation of aflatoxin. However, the drying rate must be controlled to prevent excessive slippage and splitting when the nuts are shelled.

If a thresher is used to strip pods, it should be thoroughly cleaned before use for each variety. All the possibilities of mechanical admixing at the time of threshing should be eliminated. After stripping/threshing, the pods should be dried in a bin by forcing low humidity air to evaporate the excess moisture. Or else, they

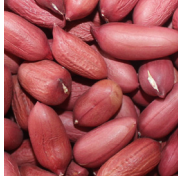
could be dried in the shade (but it would take longer). Exposure to high temperatures (above 45°C) may affect the seed quality. The moisture content in unshelled groundnut should be brought down to 8% (in case of seed 6%) for storage. Only sound, mature, clean, and well-filled pods should be selected for seed.

Packaging: The cleaned and well-dried groundnut seedpods produced should be packaged in polythene-lined gunny bags with appropriate certification tags. Each bag should be properly stitched along with a seed tag (issued by the seed certification agency in MAAIF) and sealed. The colour of the tag for Breeder seed is golden yellow, for Foundation seed is white, and for Certified seed is azure blue. The seed producer should maintain a proper record of use of seed tags.

3.8 STORAGE

It is important to remove all damaged, discoloured, rotted, immature and sprouted pods, other plant materials and soil from the produce before storage. Groundnut stores better in pods than as seeds. Under unfavorable conditions, groundnut seed loses viability quickly. Safe storage of groundnut requires an atmosphere with low relative humidity of 60 to 70 %. Storage facilities for groundnuts should be weather proof and free from insect and disease bearing litter. Buildings should have provisions for good ventilation to prevent condensation of water. Store the dry pods in gunny bags and stack them upto 10 bags high in separated stacks so that air freely circulates among them. The bags should be piled on wooden planks to avoid damage from dampness that may cause moulds to develop (Fig.7). Before bagging, pods should be dusted with Actellic Super to protect them from storage pests. Adequate air space should be provided between the surface of stored groundnuts and the floor using pallets or similar materials. Avoid storing groundnuts in buildings where the temperature may become too high (>30°C). Proper storage is important to maintain groundnut quality and prevent aflatoxin contamination. Aflatoxins are very potent cancer causing chemicals that are produced by various fungi. Thus, under no conditions should moldy groundnuts be eaten or sold. Groundnuts saved for seed must be protected from insects, rodents, as well as from high temperatures and high relative humidity. Seed retain viability longer when stored in the pod than shelled. Groundnut seeds to be used for planting should be treated with fungicides to prevent damage from seed rotting and damping off fungi in the soil. The use of dried neem leaves could also be used to control storage pests in groundnuts. Groundnut seed should not be carried over more than a year if it is to be sold as certified seed.

Fig.7: Properly dried groundnut being stored on raised wooden planks.



3.9 SHELLING

Shelling of groundnut pods for seed should preferably be done manually (Fig.8). Manual shelling can reduce damage and splitting of seeds, which can happen in mechanical shelling. At the time of shelling, any seed, which is infected, damaged, or does not conform to shape, size, and colour of the variety under seed production, should be removed. The seeds should be treated with appropriate fungicides and insecticides before sowing.

Fig.8: Hand shelling and sorting groundnut for planting.

Box 2: Recommended shelling practices

- Separate out immature pods as well as those infested with pests and diseases
- Do not shell by beating or trampling on groundnut in shells
- Manual or motorised shelling is recommended but the shellers should not damage the seeds.
- Use hand or motorised shellers specifically designed for groundnuts
- Do not sprinkle water on dry pods while using mechanical shellers. Instead, adjust (where possible) the space between blades and the sieve according to pod size to reduce breakage.
- Remove shriveled, discoloured, mouldy and damaged grains from the lot including groundnuts with damaged testa and dispose off unwanted materials.

3.10 TRANSPORT

The most frequent mode of transport for groundnuts is by road trucks or motorcycles and bicycles. Care should be taken not to overload the groundnuts and reduce on the aeration. The groundnut must be protected against rain and excessive sunshine during transportation

3.11 MARKETING

Although groundnuts in Uganda are sold mainly as grain, a number of agro-input dealers, farmer groups and seed companies are engaged in commercial groundnut seed production. Chapter four gives a detailed analysis of the average market performance of groundnut varieties in the country.

THE AVERAGE ECONOMIC PERFORMANCE OF ALTERNATIVE GROUNDNUT VARIETIES IN UGANDA

4.1 INTRODUCTION

Groundnut production has become increasingly important in Ugandan farming systems (Okello *et al*., 2010). However, a major issue is the severe yield gap when compared with international yields as well as experiment station results (Asekenye, 2012). In addition, diverse market preferences, climate change and the prevalence of major pests and diseases make it imperative to continually generate and disseminate improved groundnut varieties. Moreover, recent work by Kassie *et al*. (2011) has concluded that the generation and provision of improved groundnut seed varieties can be very important in the fight against poverty and malnutrition in Uganda. The National Groundnut Improvement Programme at the National Semi Arid Resources Research Institute (NaSARRI) in Serere, Uganda has responded to the need for improved material by releasing 14 varieties since 1998 and 10 of these releases have been accomplished since 2010.

A necessary step before promoting these improved varieties is to generate economic information so that farmers and extension workers can assess their potential. Therefore, the purpose of this chapter is to evaluate the average economic performance of the 14 NaSARRI releases and then compare their performance with two traditional varieties commonly grown by Ugandan farmers.

Methods

Enterprise budget methodology is used to analyze the economic performance of the various released varieties (Kay *et al*., 2011). Enterprise budgeting is an approach used to organise revenues, expenses and profits for a single enterprise (i.e., groundnuts in this case). The base unit for enterprise budgets for crops is usually one hectare and the primary purpose is to estimate expected costs, returns, and profits per hectare (ha) or per unit of output (kg).

As shown in Table 7, the enterprise budget first shows the gross return, followed by variable costs, gross margin (gross return minus variable costs), fixed costs and profits (gross returns minus total cost). In our analysis described below profits reflect a return to family labor and management since these two input categories are excluded from the costs in the budgets.

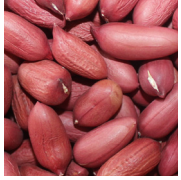
Enterprise budgets can be readily used to undertake a break-even analysis. In the budgets presented here, we calculate break even yields which are obtained by dividing total costs by the expected output price. In other words, the breakeven yield is the level of output required to cover all costs given an assumed expected output price while holding all other components of the budget constant.

Data

As indicated above, we are examining a total of 14 releases and two traditional varieties. The timing of these releases has been as follows:

Table 6: Groundnut varieties and their timing of releases

No.	Year of Release	Variety
2	1998	Serenut 1R and 2
2	2002	Serenut 3R and 4T
2	2010	Serenut 5R and 6T
8	2011	Serenut 7-14 series
1	1966	Red Beauty
1	Unknown	Amasoga



Details concerning these varieties and the main problems that they were designed to handle are provided in Table 1 of this publication. The farming practices depicted in Table 7 and the associated cost estimates are intended to reflect average production conditions in Uganda and 2012 input and output prices. The data on yields has been collected over time in ongoing farm trials conducted in various locations by NaSARRI. These estimates are intended to serve as a guide for extension personnel when examining alternative recommendations and more directly for farmers when exploring choices concerning what seed varieties to use.

Results

An analysis of the cost of production of the NaSARRI released varieties and the two local varieties reveals positive returns for improved varieties. Groundnut seed varieties that have been released more recently exhibit the highest expected returns. This could be attributed to the fact that more recent releases are an improvement of those released earlier. Serenut 8, 10, 12 and 14 are an improvement of Serenut 1 with rosette virus resistance and drought tolerance. Serenut 7, 9, 11 and 13 are improved Serenut 2 with a soft shell, sweeter taste, and big bold seeds good for both confectionery and butter. On the other hand, the returns expected from the two local varieties, red beauty and Amasoga, are not sufficient to recover the associated costs of production thereby generating loses.

As summarized in Table 8, the mean gross margins for improved varieties range between Ugandan Shillings (UGX) 1,323,000 to 6,323,000 (US $497 to US $2,377 at an exchange rate of UGX 2,660 per US dollar) with Serenut 1and 2 having the lowest and Serenut 8, 10, 12 and 14 the highest calculated gross margins. Similarly, the lowest expected profit is observed for Serenut 1 and 2 (UGX 1,223,000 or US $460) and the highest for Serenut 8, 10, 12 and 14 (UGX 6,223,000 or US $2,340).

Generally, the break even yields for all the varieties are low and achievable. Among the improved varieties, Serenut 8, 10, 12 and 14 whose seed selling prices are currently ranking highest have the lowest break even yield of 291 kg/ha while Serenut 1 and 2 have the highest at 478 kg/ha. For the two local varieties, Amasoga has the highest while red beauty has the lowest break even yield of 849 and 536 kg/ha, respectively.

These estimates are averages and can therefore increase or decrease depending on the prevailing input and output prices of a particular area. However, for farmers that follow the recommended agronomic practices (row planting, proper spacing, seeding rates, etc) their returns should not be far different from what is depicted in tables 1 and 2. Therefore, our recommendation is that different stakeholders promote and encourage the use of improved varieties in order that Ugandan farmers can enjoy the rewards associated with better seed varieties and thus can improve their livelihoods.

Summary

This chapter evaluated the average economic performance of 14 NaSARRI groundnut releases and of two local varieties. Enterprise budgeting is used to compute gross margins, profits and calculate the break-even yields for the various groundnut varieties using 2012 average input and output prices. The results demonstrated positive returns for improved varieties and negative returns for local varieties. Therefore, successful adoption of these improved groundnut varieties could play a significant role in improving the livelihoods of resource constrained farmers.

The varieties analyzed have been developed and tested in various agro ecological zones throughout groundnut growing regions of Uganda thereby making them even more relevant now as climate change emerges as a growing challenge to sustained agricultural productivity. Moreover, the results underscore the importance of improved seed varieties and thus of maintaining an active breeding programme that can continue to generate high quality seeds that can mitigate the adverse effects of new disease and rising climatic variability. Finally, the figures presented here are based on the limited data available and it is important to enhance data collection efforts so as to generate more detailed and richer analyses.

Table 7. Cost, Return and Profitability Estimates for Groundnut Varieties in Uganda

Description	Units	Serenut 1R & 2			Serenut 3R			Serenut 4T			Serenut 5R & 6T		
		Yield	unit (price/kg)	Total	Qnty	unit (price/ kg)	Total	Qnty	unit (price/ kg)	Total	Qnty	Unit (price/ kg)	Total
Output (dry in shell)													
Mean Yield	Kg	900	2,900	2,610,000	812	3,600	2,923,200	750	3,600	2,700,000	850	4,800	4,080,000
Maximum Yield	"	1750	2,900	5,075,000	1,060	3,600	3,816,000	870	3,600	3,132,000	1450	4,800	6,960,000
Production costs													
Variable costs													
Field Preparation													
Bush Clearing	labor	1	45,000	45,000		45,000	45,000		45,000	45,000		45,000	45,000
1st ploughing	"	1	75,000	75,000		75,000	75,000		75,000	75,000		75,000	75,000
2nd ploughing	"	1	75,000	75,000		75,000	75,000		75,000	75,000		75,000	75,000
Field leveling	"	1	30,000	30,000		30,000	30,000		30,000	30,000		30,000	30,000
Seed	Kg	100	3,500	350,000		4,000	400,000		4,000	400,000		10,000	1,000,000
Planting lines	Bundle	4	3,000	12,000		3,000	12,000		3,000	12,000		3,000	12,000
Planting	labor	1	100,000	100,000		100,000	100,000		100,000	100,000		100,000	100,000
Weeding	"	2	100,000	200,000		100,000	200,000		100,000	200,000		100,000	200,000
Harvesting	"	1	250,000	250,000		250,000	250,000		250,000	250,000		250,000	250,000
Drying and cleaning	"	1	100,000	100,000		100,000	100,000		100,000	100,000		100,000	100,000
Bagging (Labor, bag and strings)		1	50,000	50,000		50,000	50,000		50,000	50,000		50,000	50,000
Total variable costs				1,287,000			1,337,000			1,337,000			1,937,000
Gross Margin Mean				1,323,000			1,586,200			1,363,000			2,143,000
Gross Margin Max				3,788,000			2,479,000			1,795,000			5,023,000
Fixed costs													
Land rental/season	shs	1	100,000	100,000		100,000	100,000		100,000	100,000		100,000	100,000
Total Fixed costs				100,000			100,000			100,000			100,000
Total Expenditure				1,387,000			1,437,000			1,437,000			2,037,000
PROFIT Mean				1,223,000			1,486,200			1,263,000			2,043,000
PROFIT Max				3,688,000			2,379,000			1,695,000			4,923,000
Break Even Yield	kg/ha			478			399			399			424

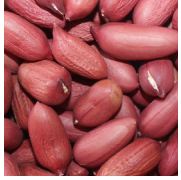
Table 7. Continued

Description	Units	Serenut 7T, 9T, 11T, 13T			Serenut 8R, 10R, 12R, 14R			Amasoga			Red beauty		
		Qnty	unit (price/kg)	Total	Qnty	unit (price/ kg)	Total	Qnty	unit (price/ kg)	Total	Qnty	unit (price/ kg)	Total
Output (dry in shell)													
Mean Yield	Kg	1,120	6,000	6,720,000	1,180	7,000	8,260,000	520	2,400	1,248,000	500	3,800	1,900,000
Maximum Yield	"	1,750	6,000	10,500,000	1,800	7,000	12,600,000	620	2,400	1,488,000	600	3,800	2,280,000
Production costs													
Variable costs													
Field Preparation													
Bush Clearing	labor	1	45,000	45,000		45,000	45,000		45,000	45,000		45,000	45,000
1st ploughing	"	1	75,000	75,000		75,000	75,000		75,000	75,000		75,000	75,000
2nd ploughing	"	1	75,000	75,000		75,000	75,000		75,000	75,000		75,000	75,000
Field leveling	"	1	30,000	30,000		30,000	30,000		30,000	30,000		30,000	30,000
Seed	Kg	100	10,000	1,000,000		10,000	1,000,000		10,000	1,000,000		10,000	1,000,000
Planting lines	Bundle	4	3,000	12,000		3,000	12,000		3,000	12,000		3,000	12,000
Planting	labor	1	100,000	100,000		100,000	100,000		100,000	100,000		100,000	100,000
Weeding	"	2	100,000	200,000		100,000	200,000		100,000	200,000		100,000	200,000
Harvesting	"	1	250,000	250,000		250,000	250,000		250,000	250,000		250,000	250,000
Drying and cleaning	"	1	100,000	100,000		100,000	100,000		100,000	100,000		100,000	100,000
Bagging (Labor, bags & strings)		1	50,000	50,000		50,000	50,000		50,000	50,000		50,000	50,000
Total variable costs				1,937,000			1,937,000			1,937,000			1,937,000
Gross Margin Mean				4,783,000			6,323,000			-689,000			-37,000
Gross Margin Max				8,563,000			10,663,000			-449,000			343,000
Fixed costs													
Land rental/season	shs	1	100,000	100,000		100,000	100,000		100,000	100,000		100,000	100000
Total Fixed costs				100,000			100,000			100,000			100,000
Total Expenditure				2,037,000			2,037,000			2,037,000			2,037,000
PROFIT Mean				4,683,000			6,223,000			-789,000			-137,000
PROFIT Max				8,463,000			10,563,000			-549,000			243,000
Break Even Yield	kg/ha			340			291			849			536

Note: Standard Bagging wt (kg) = 42 kg

Table 8: Summary of the Mean Gross Margins, Profits and Break-Even Yields for Groundnut Varieties in Uganda

Variety	Gross Margin Mean	Profit Mean	Break Even Mean Yield(kg/ha)
Serenut 1R & 2	1,323,000	1,223,000	478.3
Serenut 3R	1,586,200	1,486,200	399.2
Serenut 4T	1,363,000	1,263,000	399.2
Serenut 5R & 6T	2,143,000	2,043,000	424.4
Serenut 7T, 9T, 11T, 13T	4,783,000	4,683,000	339.5
Serenut 8R, 10R, 12R, 14R	6,323,000	6,223,000	291.0
Amasoga	- 689,000	- 789,000	848.8
Red beauty	- 37,000	- 137,000	536.1



GROUNDNUT SEED SYSTEMS IN UGANDA

The Government of Uganda recognizes both the formal and informal sectors in its policies and programmes. It has developed a young and vibrant local seed industry, with 23 seed companies currently registered and active in the market benefitting from the existence of more than 2300 registered agro dealers. Many of the companies make use of public services (NARO) that provide access to improved varieties, basic seed and quality control services, but capacities in delivering these public services are limited, which in turn limits growth and professionalism in the sector. The seed policy is in the process of being implemented. Several non-governmental organisations (NGOs) support farmer-saved and community-based seed systems. These NGOs strengthen the farmers' groups in aspects of seed production, quality assurance, agri-business management, and seed marketing. The Government of Uganda recognizes that this intermediary system fills a gap between the formal and informal seed systems.

5.1 CLASSES OF SEED

Uganda has adopted the OECD seed scheme that recognizes the following five classes of seed:

Nucleus seed: Nucleus seed is produced from the basic seed stock, Nucleus seed, or Breeder seed available from the originating breeder or institution under the direct supervision of the originating or a sponsored plant breeder following the progeny row method. True to type (representing diagnostic characteristics of a released variety selected for Nucleus seed production) plants are selected individually from the space planted basic seed stock (or Nucleus or Breeder seed plot). The number of selected plants will depend upon the quantity of Nucleus seed to be produced taking the multiplication ratio into account. These selected plants are studied for plant characteristics during the growing period 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 studied carefully during pre- and post-harvest, for diagnostic characteristics of the variety under multiplication. Any progeny deviating from these diagnostic characteristics is rejected. The selected progenies are then bulked to form Nucleus seed stock.

Breeder seed: Nucleus seed is used to produce the Breeder seed, which is done under the direct supervision of the originating or a sponsored plant breeder. It is used to increase the Foundation seed and is not available for general cultivation. Because of the low seed multiplication ratio in groundnut, two stages of Breeder seed production are permissible. The Nucleus seed is multiplied to obtain Breeder seed Stage I, which in turn is multiplied to obtain Breeder seed Stage II. However, it is essential to use only duly certified Breeder seed Stage I to produce Breeder seed Stage II. The Breeder seed crop is sown at normal recommended plant density.

Foundation seed: This is the offspring of Breeder seed or occasionally the progeny of Foundation seed. 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.

Registered seed: This is the offspring of Foundation seed and is produced under agency regulations to maintain varietal purity and identity.

Certified seed: This is the offspring of Foundation, Registered or occasionally Certified seed and is available to farmers for general cultivation. Certified seed produced from Certified seed is not eligible for further seed increase under certification. Seed of only notified varieties is eligible for certification. The agricultural universities, public and private sector seed producing agencies, authorized farmers' organisations, and registered individual farmers generally undertake Foundation, Registered, and Certified seed production programs. Each class of seeds has its own prescribed seed standards, which are to be met by the seed growers for certification.

5.2 TYPES OF SEED SYSTEMS

Formal seed system

The formal sector is fully regulated. The National Agricultural Research Organisation (NARO) coordinates variety development of all crops, except sugarcane, tea, tobacco, flowers and most vegetables. Although responsible for producing breeder and foundation seed, it cannot do it all alone so it supervises companies and farmers' associations to produce foundation seed, which is then passed on to outgrowers or to other seed companies to produce certified seed, supervised by the National Seed Certification Service (Van Mele *et al*., 2011). The classes of seeds produced include: nucleus seed, breeder seed, Foundation seed and Certified seed (Table 9).

An individual farmer can also produce Foundation and Certified seed at his/her farm by obtaining the appropriate class of parent seed (Breeder or Foundation seed) from authorized sources, maintaining the prescribed field and crop standards and getting the field inspected and produce certified by the State Seed Certification Agency. Farmers should retain the original tags of parent seed until all the inspections by the Seed Certification Agency are completed.

Groundnut seed should not be carried over more than a year if it is to be sold as certified seed.

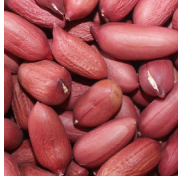
Table 9: Source of Seed and Stages of Seed Multiplication

Sr. No	Stages of Seed Multiplication	Source of Seed
1	Nucleus, IPS	Nucleus
2	Breeder-Stage I	Nucleus
3	Breeder-Stage II	Breeder
4	Foundation Stage I	Breeder I or II
5	Foundation Stage II	Foundation Stage I
6	Certified Stage I	Foundation Stage I or II
7	Certified Stage II	Certified Stage I
8	Truthful Seed	Breeder to Certified Stage II.

Informal seed system

The informal sector includes NGOs, farmers' groups and family farms. There is little or no government regulation. The informal sector supplies an estimated 95% of the groundnut seed (Van Mele *et al.*, 2011). Within the informal system, several programmes focus on community-based seed production. The government supports these programme, recognizing them as a bridge between the informal and formal seed systems; and aims to transform the informal system into a viable commercial sector. Programme focus on the production of quality seed and planting materials of mainly improved varieties resulting from the breeding programme run by NARO and CGIARs. The emphasis in relation to seed production practices, seed quality issues, farmers' group management, financial management, and commercial marketing arrangements differs from programme to programme. History shows that programmes are not sustainable if insufficient emphasis is given to seed entrepreneurship. Professionalizing farmers' seed producer groups into local seed businesses, for producing and sustainably commercializing quality seed of locally demanded crops and varieties for a local market, may complement the efforts of national seed companies. Uganda has some experience with this model to the extent that some groups have now registered as commercial seed enterprises (e.g. Community Enterprises Development Organisation - CEDO).

In Uganda, annual demand for certified seed outweighs supply. The public sector (research stations) and seed private sector (seed companies) only satisfy a small fraction of this requirement. Because of non-availability



of seed of newly released varieties in required quantities, the landraces (old varieties) such as Redbeauty, Erudurudu, Amasoga, Acholi white, Amasoga, Etesot and others continue to dominate the variety scene in groundnut farming in Uganda. Most of the farmers either save their own seed for the next season, or buy from the local markets, where the seed is often nondescript or mixed, resulting in low productivity. Unless farmers, participating NGOs and the private sector come forward in significant way, the demand for certified seed of groundnuts will remain unfulfilled in Uganda. As a consequence, crop productivity will remain low due to non-realization of full returns on the investment made in groundnut improvement research. Several schemes have been suggested to promote the informal seed sector to overcome the shortages of good quality seed and hasten the diffusion of improved varieties of groundnuts among the farming communities.

These include the following.

a) Local village seed systems: Under this programme interested farmers are provided with Foundation seed and technical guidance/training given by breeding institution/public sector seed producing agencies / seed companies/sponsoring NGOs to undertake seed production at the village level. The seed farmers are free to sell their seed to other farmers within or outside the village. This is suitable for groundnut that is bulky (involving large transport costs to serve large scattered farmers), with high seeding rates (requiring large amount of seed to plant), with low genetic deterioration (that can be grown for years without loss of purity) and with low seed viability (which cannot be stored for more than one year without losing germination power). Seed supply arrangements should emphasize schemes that entail low transaction costs. Therefore improving the capacity of village seed systems to maintain and distribute seed is essential to ensure sustainability. Efficient producers or a group of farmers in each village should be identified and encouraged to become entrepreneurs (Local Seed Business farmers) tasked with the multiplication and distribution of groundnut varieties. This scheme should be encouraged by a consistent supply of modern groundnut varieties (Serenuts 5-14 series) that meet market requirements and are preferred by farmers. The groundnuts department at NaSARRI is responsible for the production of breeder and foundation seed. Foundation seeds are bulked into certified and commercial seed through out-growers, farmers associations, CBOs, and/or individual farmers. The informal seed sector supplies the majority of seed planted by farmers. At local village levels, most farmers consistently obtain seed from their own harvest. If they hold insufficient seed stocks, they obtain seed from family, friends or relatives, or purchase seed from the markets. Village seed systems offer a range of local and diverse varieties that are accessible and are of acceptable quality with flexible transactions costs. However, these systems are recycling seed of old varieties with low genetic purity and have difficulties dealing with emergency seed issues. These systems are also largely inefficient at generating new varieties that are critical to improve productivity.

b) Community based seed system (CBSS): local village seed systems are working relatively well for landraces but are inefficient in supplying new varieties to farmers. A better interface between small-scale seed producers or CBOs involved in seed production with the public sector (Seed companies, stockists) suppliers of varieties and breeder seed is likely to facilitate access and availability of seed of preferred varieties to farmers. Investment in organizing or reinforcing the CBOs or small-scale producers at producing subsequent seed classes (foundation and certified) and linking them to the markets is essential.

c) Contract seed production: as the local seed sellers constitute the major source of groundnut seeds, they could promote quality seed production through contract farming of improved varieties. However, both farmers and traders need to be educated in the technical aspects of groundnut seed production, processing and storage. Contractual arrangements between producers and seed companies / processors / producers are necessary to motivate farmers to use other agricultural inputs such as fertilizers and pesticides. This assured market will guarantee sales of the harvest hence added motivation to produce.

5.3 SEED CERTIFICATION MONITORING AND INSPECTION STANDARDS

Standards for seed certification

The components of a seed programme include plant breeding, variety release, seed production, seed processing, seed certification, seed marketing and extension. These components have to be interlinked in order to function towards the desired goal. Seed certification is a system for ensuring the production of genetically pure, good quality seed of improved varieties. The task of seed certification is accomplished through various steps: determining the eligibility of cultivars, verifying that the seed source is authentic, field inspection, lot examination, sampling, seed testing, labelling, sealing and establishment/evaluation of pre- and post-control plots.

Seed certification procedures

Under regional harmonization, groundnut is among the 10 crops identified as economically vital and recommended for compulsory seed certification. In seed certification, all field inspections, lot inspections and seed testing must be done by well-trained and qualified staff. The procedures and techniques to be used are clearly set out in the seed certification hand-book to avoid decisions based on personal opinion and ensure the use of uniform criteria among the seed inspectors and analysts. The hand-book has been harmonized with provisions under OECD and ISTA. The procedures in the hand-book are reflected in the seed regulations being developed, which are in line with the harmonized regional standards. The hand-book gives a detailed account of the procedures for seed certification, which can be summarized as follows:

i. To deal in seed in Uganda, a person must first apply for registration to the National Seed Certification Services (NSCS) by filling form SR 5

ii. Any successful applicant is then registered with NSCS as a seed merchant and must be in possession of a valid registration certificate on Form SR 6.

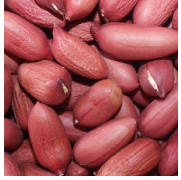
iii. With a valid Form SR 6, a seed merchant then proceeds with growing seed. Two weeks after planting, a seed grower or merchant applies to the NSCS for inspection of the seed crop by completing Form SR 7. In Uganda, this is commonly referred to as submission of planting returns. The form should clearly spell out the name of the grower, location, crop, variety and acreage among others. The origin of the seed sown for inspection and certification must be known and linked to the breeders' seed. Therefore, Form SR 7 must be accompanied by proof of origin of the seed, which is a certification label. When necessary, a letter from the breeder can be accepted as confirmation of origin of breeders' seed.

iv. NSCS registers the seed crop by completing Form SR 8, which confirms that the crop is eligible for inspection.

v. The number of field inspections depends on the crop but the minimum recommended is two (Table 10).
   - *a. Preliminary inspection is done 1 to 2 weeks before flowering. This is to give time for rouging off-types and make any other corrective measures before inspection occurs.*
   - *b. Flowering inspection is the most crucial activity in seed certification and involves cultivar identification, off-type counts to determine the degree of contamination and assessing pest/disease occurrence.*
   - *c. Pre-harvest inspection is done when the crop is physiologically mature, before harvesting. At this stage the inspector checks on the diseases and pests that occur late in the season, makes further cultivar identification, checks on off types and make counts and assesses yield.*

vi. During processing inspection, also known as post-harvest inspection or farm stock approval, the inspector checks on sorting, checks on storage facilities, estimates or confirms yields and takes samples for laboratory testing.

vii. On completing crop inspection, the inspector informs the grower of his/her recommendation for the crop by leaving behind a clearly written statement, for any operation, on which approval of the crop may depend by completing Form SR 9.



viii. Not all defects in seeds can be seen during field inspections. To confirm the value of the seed to the farmer, seed testing is done on a sample in a laboratory against various attributes as specified in the certification standards. Submitted samples are received in the laboratory from the processing plant, other farmers and NGO's. Samples originating from seed inspectors or seed analysts are referred to as official samples while the rest are private samples. Official samples are accompanied by a seed test request form.

ix. The inspector finally approves or rejects a seed crop by completing Form SR 10A.

x. A representative sample of the harvested crop is taken for a laboratory test that will lead to either farm stock approval or rejection by completing Form SR 10B.

xi. Only seed from a registered crop that has been conditioned in accordance with the provisions of seed regulations is sampled for laboratory tests and post control verification. A representative sample is taken using ISTA or other internationally recognized procedures by completing Form SR 11. The sample is subdivided into three parts.

xii. The three sealed samples are then sent to the National Seed Testing Laboratory (NTSL) as follows; one sample for laboratory analysis, a second sample for post control planting and the third sample to be held as a reserve sample.

xiii. The results obtained from the National Seed Testing Laboratory together with the field inspection reports enable the NSCS to grant or reject certification of the seed lot. Certification includes labelling and sealing.

xiv. Test results are recorded on a certificate, Form 12 A.

xv. For private samples, the test report is furnished to the sender by completing Form SR12B. All test reports of private seed samples are stamped "Not for Sale"- own use only.

xvi. Seed samples are retained and stored under optimum storage conditions for at least 12 months from the date of the original test result. Any person aggrieved by the results of the official seed test may appeal to the Head of NSCS who shall order a retest on the original sample submitted. Official labels shall be attached under the supervision of an official seed inspector.

Table 10: Schedule of field and labolatory groundnut seed certification standards for East Africa

	Seed Classes		
Field Standards	**Basic**	**C1**	**C2**
Land requirement (seasons before)	1	1	1
Isolation (meters)	5	3	3
Maximum Off-types (%)	0.1	0.5	0.5
Minimum number of inspections	2	2	2
Diseases			
Rosette virus	1/1000 plants	5/1000 plants	5/1000 plants
Bacterial wilt	0	0	0
Laboratory seed testing Standards			
Pure seed (%)	98.0	97.0	97.0
Maximum Inert matter (%)	1.95	2.95	2.95
Maximum Other seeds(%)	0.05	0.05	0.05
Minimum Germination (%)	75	75	75
Maximum Moisture content (%)	10	10	10

Sources: Obongo, 2007; Ssebuliba, 2010

Key: *1st Generation certified seed (C1)*
2nd Generation certified seed (C2)

Note: ***The seed certification standards presented in this manual are for East Africa (Kenya, Uganda Tanzania) and include Rwanda. They were arrived at after considering field and laboratory standards for the following organisations/countries: OECD Field Schemes; International Seed Testing Association (ISTA) Rules; Association of Official Seed Certification Agencies of the US (AOSCA); Kenya, Uganda, Tanzania, and Rwanda.***

In Uganda, where limited availability of seeds continues to remain a major constraint to promoting improved groundnut varieties among the farmers, it may be advisable to relax some of these standards to stimulate a seed production chain in the formal seed sector.

5.4 MONITORING AND INSPECTION

The nucleus and breeder seed do not come under the supervision of a seed certification scheme. As such, there is no prescribed monitoring/inspection procedure for them. However, the breeder responsible should ensure full conformity to diagnostic characteristics of the variety under nucleus seed production and the highest purity standards of the seed. The breeder should carry out a thorough inspection of the crop before and after flowering and at harvest to eliminate any unhealthy, abnormal and off-type plants. Breeder seed should be genetically so pure as to guarantee that in the subsequent generation, i.e. certified Foundation seed conform to the prescribed standards.

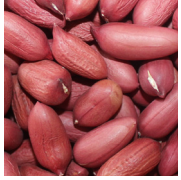
Breeder seed production: The availability of Breeder seed in required quantities is essential to promote and sustain the seed production chain to popularize newly released and notified varieties among the farmers. Although the Breeder seed does not come under the preview of seed certification, a multidisciplinary team consisting of a plant breeder, a plant pathologist, an entomologist from the breeding institution should monitor the onstation fields for Breeder seed production. At least two inspections from flowering to harvesting period are recommended. The breeder seed field is inspected 2-3 weeks before harvest to certify the conformity of the crop to diagnostic characteristics of the variety under multiplication and other prescribed standards of crop husbandry and isolation distance. Due to low seed multiplication ratio, sometimes two stages of Breeder seed multiplication (Stage 1 and Stage 2) are permissible for groundnut. Breeder seed should be genetically so pure as to guarantee that in the subsequent generation, i.e. certified Foundation seed conform to the recommended standards.

Foundation seed production: Foundation seed is generally produced at their own farms by the seed producing agencies. Like Breeder seed, two stages of Foundation seed multiplication (Stage 1 and Stage 2) are also permissible in groundnut.

Certified seed production: The Certified seed is generally produced in farmers' fields. The Foundation seed producing agencies identify farmers and enter into an agreement with them to produce Certified seed. These fields are regularly inspected by the seed producing agencies, who are responsible for getting the produce certified by the State or any designated seed certification agency comprising a team of technically qualified personnel.

A duly authorized seed certification agency or its agents organises the field and post-harvest inspections by a team of technically qualified personnel. A seed analysis report and results of a grow-out test, wherever prescribed, are taken into account before issuance of a certificate.

An individual farmer can also produce Foundation and Certified seed at his/her farm by obtaining the appropriate class of parent seed (Breeder or Foundation seed) from authorized sources, maintaining the



prescribed field and crop standards and getting the field inspected and produce certified by the designated seed certification agency. Farmers should retain the original tags of parent seed until all the inspections by the seed certification agency are completed.

Currently, the seed multiplication ratio in groundnut ranges between 1:5 and 1:10. Under assured growing conditions and high inputs, this multiplication ratio can be further increased. It is important to get a high pod yield in a seed crop to ensure lower seed prices for the farmers and more profit to seed growers.

FUTURE PLANS FOR STANDARDS FOR SEED CERTIFICATION IN UGANDA

With the newly introduced system of tamper proof seed labels, it is believed that the level of counterfeit seed will decrease, which will not only improve agricultural productivity, but will also create more market for genuine seed producers and seed dealers. The system will also be a useful asset in generating data on seed production. The sustainability of the system is however a challenge, with NSCS still under MAAIF. As the production of foundation seed improves, the industry will set a time frame for phasing out the use of standard seed in favour of certified seed. One of the future plans of MAAIF is to strengthen NSCS with sufficient resources like man power, financial resources and infrastructure to enable the unit to enforce standards. It is however not clearly understood when and how this is going to be a reality.

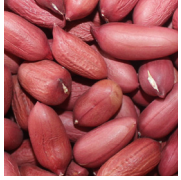
CONCLUSION

High-quality groundnut seeds production requires a high level of management that begins before planting and continues through delivery of seeds to the groundnut farmer (See page32; Appendix B). Use of high quality groundnut seeds ensure improved groundnut productivity. Organizing high quality seed production and distribution is critical to the implementation of any seed programme. Growers must plan all farm operations well in advance to ensure the seed crop has the highest priority. Producers must also keep two factors in the forefront of all decisions about their crop - namely, crop protection and maturity at harvest. These preconditions also apply to other factors that affect productivity. Pod and grain size of a specific variety are important parameters for determining seed value. The crop should be grown under appropriate climatic and soil conditions to ensure good pod formation, filling, and seed maturity. Cultural techniques must be perfectly mastered in order for the plant to attain its full potential and ensure quality production. These standards are fundamental for producers who want to sign up for commercial seed multiplication programme. The farmer must also accept controls and conform to certification standards. Continuous strong linkages with the breeding institutions, seed certifying agencies and commerce outlets (e.g. seed companies, stockists) for commerce are essential component in this seed value chain.

Box 3: Salient Steps in quality groundnut seed production

- Plan early before season's onset and have all the necessary resources in place
- Obtain pure stock groundnut seed to plant your seed crop
- Select a field free of volunteer plants, diseases and troublesome weeds
- Prepare the field well so as to control weeds, get good germination and high yield
- Plant at the right time which will give the best stand and groundnut crop yield
- Fertilize, cultivate, irrigate, spray, etc., so as to get the highest groundnut yield
- At stages when you can see offtypes, rogue them, weeds, and other crops out of the field
- Have a field day, to show your groundnut seed field (and how good it is!) to other farmers
- At crop maturity, make sure the field is clean and pure
- Harvest when the groundnut seed is field mature, in a way so as to keep the seed pure
- Dry the groundnut seed immediately down to safe moisture content
- Thresh so the groundnut seed are clean, undamaged and not mixed with other seeds
- Clean the seed, and remove all possible materials, which are not good groundnut seed
- If necessary, apply measures to control insects while the groundnut seed is stored
- Store the groundnut seed so it is kept dry and cool, protected from insects, pests, chemicals, etc.
- Talk to other groundnut farmers about the value of good seed, sell seed to them, and advise them on the groundnut crops
- Consult extension staff and researchers routinely on any problems encountered

For further information, see page 32; Appendix B



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APPENDIX A : VARIETY RELEASES 1966 – 2011

Serenut 1R

Serenut 2

Serenut 3R

Serenut 4T

Recommended Commercial groundnut varieties for Uganda

Variety	Maturity Days	Yield (kg/ha)	Year of release	Potential market use	Other remarks
Serenut 1R	100-110	2500-3700	1998	Confectionery, butter	Virginia, tan
Serenut 2	100-110	2500-3700	1998	Condiment, flour	Virginia, Red
Serenut 3R	90-100	2500-2900	2002	Butter, oil	Spanish, Red
Serenut 4T	90-100	2500-2900	2002	Confectionery, butter	Spanish, Tan
Serenut 5R	100-110	2500-3000	2010	Butter, oil	Virginia Red
Serenut 6T	90-100	2500-3000	2010	Butter, oil, confectionery	Spanish Tan
Serenut 7T	100-110	2500-3700	2011	Confectionery, butter	Virginia, tan
Serenut 8R	100-110	2500-3700	2011	Confectionery, butter, oil	Virginia, Red
Serenut 9T	100-110	2500-3700	2011	Confectionery, butter	Virginia, tan
Serenut 10R	100-110	2500-3700	2011	Butter, butter	Virginia, Red
Serenut 11T	100-110	2500-3700	2011	Confectionery, butter	Virginia, tan
Serenut 12R	100-110	2500-3700	2011	Butter, oil	Virginia, Red
Serenut 13T	100-110	2500-3700	2011	Butter, oil	Virginia, tan
Serenut 14R	100-110	2500-3700	2011	Butter, oil	Virginia, Red

Serenut 14R

Serenut 13T

Serenut 12R

Serenut 11T

Serenut 5R

Serenut 6T

Serenut 7T

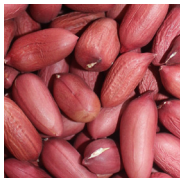
Serenut 8R

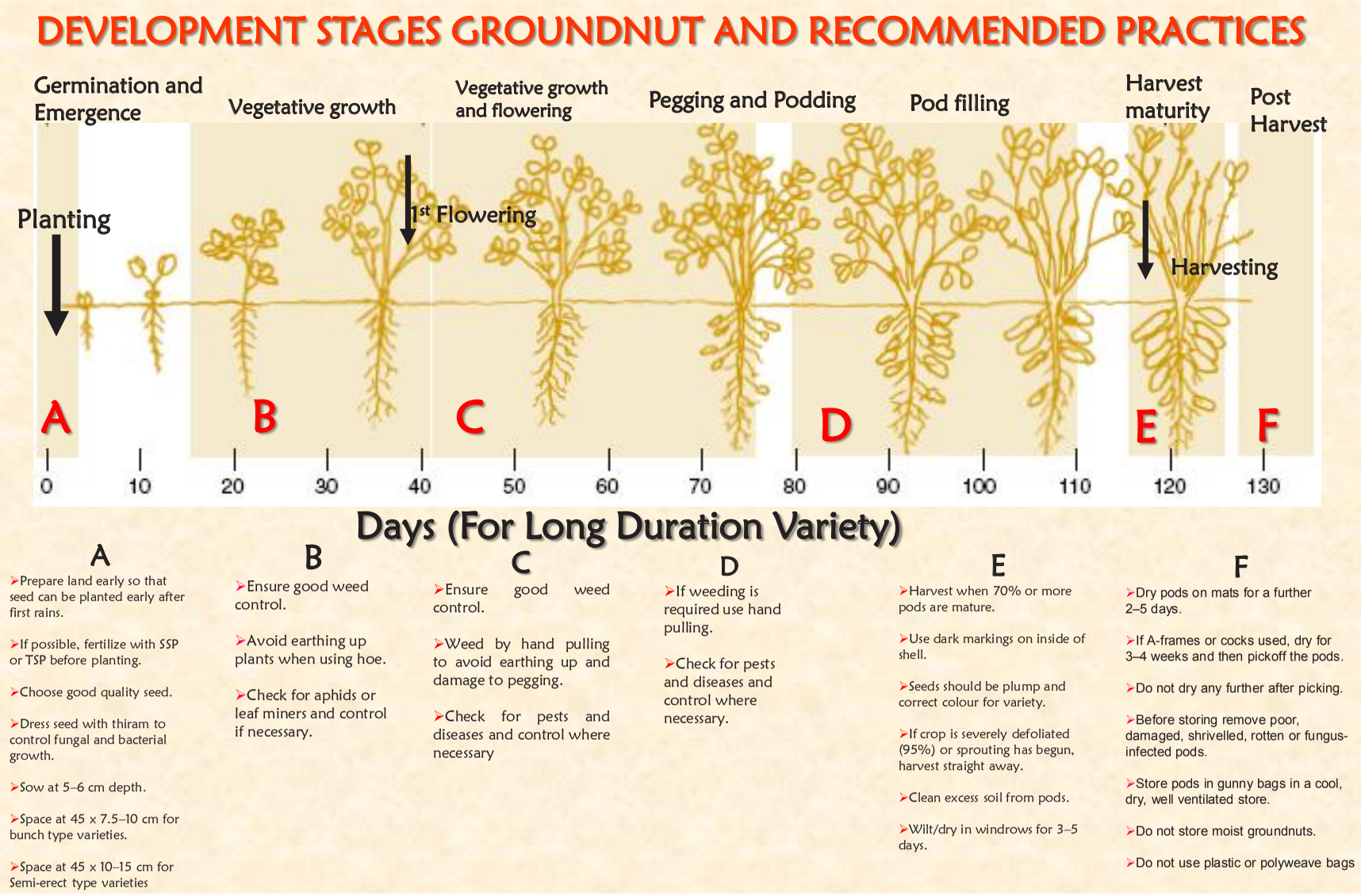
Serenut 9T

Serenut 10R

Adapted from Okello *et al.*, 2013

APPENDIX B : GROUNDNUT GROWTH STAGES AND THEIR MANAGEMENTS





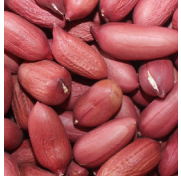
Adapted from Page *et al.*, 2002 with modifications

Fresh harvest being cured in the field.

Groundnut pods drying on cemented floor.

Hand shelling groundnuts for planting.

Cleaning / winnowing seeds.



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