Integrated Practices to Manage Diseases, Nematodes, Weeds and Arthropod Pests of Groundnut in Ghana

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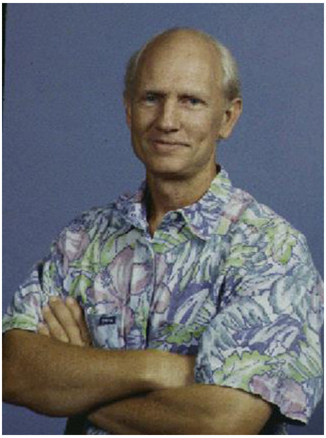
Dedication

The manual is dedicated to the late Dr. Jack E. Bailey, one of the initial scientists from North Carolina State University, USA, who helped make the Peanut CRSP a reality. He is remembered for his kind heart and love for people; and the late Mr. S. Osei-Yeboah, a highly committed scientist of the Peanut IPM project, CSIR-Crops Research Institute, Kumasi, Ghana, who passed away before the manual was published.



Dr. Jack E. Bailey

Mr. S. Osei-Yeboah

Preface

Groundnut (*Arachis hypogaea* L.) is an important crop in Ghana and it is grown throughout the country, particularly by smallholder farmers. Production is affected by several constraints, including poor soil fertility, several fungal and viral diseases, nematodes, weeds, many foliar, soil and storage pests, scarce sources of improved varieties, as well as limited knowledge in seed production, harvesting and processing. These constraints greatly reduce yields, quality and market value of groundnut and discourage many farmers from growing the crop, even in major production areas. This manual, "Integrated Practices to Manage Diseases, Nematodes, Weeds and Arthropod Pests of Groundnut in Ghana", has been prepared by scientists from CSIR-CRI following several years of on-farm research and demonstrations using Farmer Field Schools in Ashanti, Brong Ahafo, Eastern and Volta regions, which are major groundnut production areas in Ghana. We hope the manual will serve as a source of reference for students, teachers, research scientists, farmers and agricultural managers to identify and manage the constraints to increase productivity and income from groundnut. Development, production and distribution of the manual was made possible as part of the research projects of the previous Peanut Collaborative Research Support Program and the current Feed the Future Innovation Lab for Collaborative Research on Peanut and Mycotoxin, both supported with funding from USAID.

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Introduction

Groundnut (*Arachis hypogaea* L.) plays an important role both as a food and cash crop in Ghana. It is, thus, grown throughout the country. Several constraints, however, affect production of the crop. These include inexperience in site selection; attack by diseases (fungal and viral), nematodes, weeds, foliar, soil and storage pests; scarce sources of improved varieties as well as limited knowledge in seed production and socio-economics. The production constraints and integrated strategies to manage them are discussed in this manual under site selection, germination test, land preparation, field layout and planting patterns, diseases (viral and fungal), nematodes, weeds, foliar, soil arthropod and storage pests, characteristics of elite groundnut lines, seed production and economics.

What are the objectives of the manual?

The manual has been prepared to help you:

- Select appropriate site for groundnut production
- Conduct germination test before planting groundnut
- Do good land preparation for groundnut production
- Know types of field layouts and planting patterns for groundnut production
- Identify and manage major diseases (viral and fungal), nematodes, weeds, and foliar and soil arthropod pests of groundnuts
- Identify and manage major storage pests of groundnuts
- Know characteristics of elite groundnut lines
- Follow seed production practices, harvest, drying, storage, manual shelling and use of the full belly sheller
- Know the economics for adopting groundnut integrated pest management (IPM) and agronomic production practices

What are site selection, germination test, land preparation, field layout and planting patterns, diseases (fungal and viral), nematodes, weeds, foliar, soil and storage pests, characteristics of elite groundnut lines, seed production and economics of adopting IPM production practices?

Site selection

The following should be assessed for site selection:

Accessibility, fertility, availability of earthworm cast, disease and arthropod pests' pressure, soil depth and stubborn weeds.

Germination test

Germination test involves demarcation of the area, making trenches, sorting and counting of 100 seeds into trenches and covering, counting germinated seeds and taking decision on whether to use the seeds or not.

Land preparation

The types of land preparation methods are slash and burn, ploughing and minimum tillage.

Field layout and planting patterns

Planting involves the use of rope and sighting poles, construction of ridges, mounds and beds.

Diseases

Major diseases are viral (rosette), fungal (early and late leaf spots) and rust.

Nematodes

Nematodes that are major pests of groundnut include; the stubby root nematode (*Paratrichodorus* spp.), root lesion nematode (*Pratylenchus* spp.), ring nematode (*Criconemella* spp.), root knot nematode (*Meloidogyne* spp.) and spiral nematode (*Helicotylenchu*s spp.). *Paratrichodorus* spp. transmit viral diseases. Rhigonematids, non-plant parasitic nematode, could be found in the gut system of millipedes collected from the rhizosphere of groundnut plants.

Weeds

Major weeds include: False groundnut (*Arachis pintoi* (Krap. and Greg.), wild poinsetia (*Euphorbia heterophylla* L.), Flor de conchitas (*Centrosema pubescens* Benth), Tropical Kudzu (*Pueraria* spp.), speargrass (*Imperata cylindrica* L. Beauv.), purple nutsedge (*Cyperus rotundus* L.), siam weed (*Chromolaena odorata* (L.) King and H.E. Robins), itch-grass (*Rottboellia* *conchinchinensis* (Lour) W. Clayton) and tropical spiderwort (*Commelina bengalensis* L.).

Arthropod pests

Groundnut is attacked by foliar (aphids – *Aphis craccivora* Kock (Homoptera: Aphididae) and soil (white grub – *Lachnosterna* spp., Coleopterea: Scarabeidae; millipede – Myriapoda: Diplopoda; symphilid – Myriapoda: Symphyla; red ant – Hymenoptera: Formicidae; termite – e.g. *Microtermes* or *Macrotermes* spp., Isoptera: Termitidae; earwig – *Anisolabis* spp., Dermaptera: Forficulidae; wireworm or click beetle – Coleoptera: Elateridae and mealybug – Homoptera: Pseudococcidae) pests.

Storage pests

Major groundnut storage pests include the groundnut borer or groundnut weevil – *Carydon serratus* (Olivier), Coleoptera: Bruchidae; rust-red flour beetle – *Tribolium castaneum* (Herbst), Coleoptera: Tenebrionidae; rice moth – *Corcyra cephalonica* (Stainton), Lepidoptera: Pyralidae; and tropical warehouse moth – *Ephestia cautella* (Walker), Lepidoptera: Pyralidae.

Characteristics of elite groundnut lines

Two groundnut lines released as varieties by the Variety Release Committee for cultivation in Ghana are CSIR-CRI-*Yenyawoso* and CSIR-CRI-*Otuhia*.

Seed production

Seed production involves field isolation, seed selection and treatment, seed bed preparation, fertilizer application, adequate pest management, rouging, harvesting, drying, storage and shelling.

Economics

Economics of adopting IPM and agronomic practices for groundnut production deal with costs and returns on production.

Site Selection

S. Osei-Yeboah, M. Owusu-Akyaw and M.B. Mochiah

- The site and size of the farm to be planted should fulfil the objectives of the farmer.
- The site should be accessible and managed within the limits of manpower, budget, transport, etc.
- Timing of site selection is very important.
    - Make a preliminary site selection when a crop is in the field, ideally around flowering time.
    - This allows the crop to be used as an indicator of yield levels to be expected at the site.
    - Soil fertility differences will be visible.
    - Site with uniformly distributed deep green weeds could be considered as fertile.
- Earthworm cast – Site with a lot of earthworm (Fig. 1) cast is an indication of its suitability to support crop growth.

Fig. 1. Earthworm cast on groundnut field

- To reduce the level of off-types due to volunteer plants, field selected must not have been planted to another variety during the previous year or season.
- Randomly determine soil depth by inserting a cutlass into the soil (Fig. 2.). If penetration is 10 cm or more, the soil is deep enough to accommodate the crop. Any depth less than 5 cm should be disregarded as it may be too compact or stony (Fig. 3). Stony soil has low water holding capacity that may cause wilting of plants during erratic rainfall (Fig. 4).

Fig. 2. Testing soil depth with cutlass

Fig. 3. Groundnut planted on soil with underground stones exposed through erosion

Fig. 4. Wilting groundnut plants planted on drought-prone stony field

- Avoid soil with a history of high soil arthropod and disease pressure.
- Avoid bare land, waterlog area and undulating terrain.
- Consider soil factors (drainage, texture, moisture and slope).
- Consider the distribution of weeds over the site, number and types and avoid areas with difficult to control weeds.

Germination Test

M. Owusu-Akyaw, M.B. Mochiah and E.A. Asiedu

- Seed germination test must be conducted by pegging or demarcating an area (Fig. 5).
- Dig trenches for different varieties, one metre long, 20 cm apart and 2.5 cm deep (Fig. 6).
- Sort and count one hundred seeds (Fig. 7) and put in each trench (Fig. 8).
- The seeds must be uniformly spaced in the trenches (Fig. 9).

Fig. 5. Line pegging for germination test

Fig. 6. Making trenches for germination test

Fig. 7. Sorting and counting seeds for germination test

Fig. 8. Placing seeds into trenches for germination test

Fig. 9. Seeds uniformly spaced in trenches for germination test

Fig. 10. Counting germinated seedlings

- Loose soil must be used to cover the seeds, after which the seeds must be watered to field capacity.
- The trenches must be covered with leaves in order not to expose the seeds to the impact of heavy rain drops.
- Monitor and water the seeds when necessary.
- Start counting at the beginning to the end of seed emergence (Fig. 10).
- The number of seeds that emerge from each trench should be used to calculate per cent germination.
- Seeds with germination percentage from 80 and above will be accepted for planting. Below this, fresh seed must be sought.

Land Preparation

G. Bolfrey-Arku

Importance of good land preparation

- Facilitates timely sowing.
- Improves seed germination and seedling establishment.
- Reduces the frequency of weed control in the crop cycle which saves cost

The under listed methods of land preparation can thus be used:

Slash and burn

- Slash (Fig. 11) and controlled burning (Fig. 12) provides a clean field free of weeds at time of planting.
- The slashed vegetation, if not too thick, may be gathered (Fig. 13) and used for mulching, especially in the minor season planting in the south and drier areas in the north.

Fig. 11. Land preparation by slashing

Fig. 12. Burning gathered stubble after slashing

Fig. 13. Gathering stubble to be used for mulching

Ploughing

- Initial ploughing should be carried out at optimum moisture range and not at excess or under limited moisture conditions in order to obtain better tilt.
- If possible, plough the land immediately after harvesting of the previous crop. Ploughing should be 15 – 20 cm deep. Depth beyond 20 cm deep is generally not considered good for groundnut cultivation.
- Ploughing should be followed by harrowing to level the land.
- Un-harrowed land creates deep gulleys which may collect rain water and impair seed germination (Fig. 14).
- Pre-emergence herbicide, if desired, must be applied at optimum soil moisture soon after planting.

Fig. 14. Un-harrowed ploughed land with gulleys

Minimum tillage

- Minimum tillage is particularly important for sandy soils since it helps to conserve moisture and reduces soil erosion.
- Gulleys are created (compared with ploughing that may impair seed germination.
- Slash vegetation to ground level (Fig. 11) and when weeds are about knee high (Fig. 15) spray pre-plant herbicide (Fig. 16).
- Appropriate and available herbicides like Glyphosate, 2,4 – D or Paraquat can be used. 2,4-D can be mixed with Glyphosate for pre-vegetation control of *Euphorbia heterophylla*.
- Wear protective clothing when applying herbicide (Fig. 17).

Fig. 15. Weeds at knee-high ready for spraying

Fig. 16. Minimum tillage by spraying with herbicide (note: nozzle is by side not in front of applicator)

Fig. 17. Posture of fully protected person ready to spray herbicide for land preparation

Field Layout and Planting Patterns

M. Owusu-Akyaw, M.B. Mochiah and I. Adama

- To obtain optimum plant population (Fig. 33) groundnut should be planted in rows using rope (Fig. 18) or sighting poles (Fig. 21).
- Other planting patterns are, however, adopted by farmers leading to under (Figs. 34, 35, 36 and 37) or over (Fig. 38) population of the plants.

Rope Planting

- For rope planting, pegs should be lined up (50 cm apart) at both ends of the field and the rope drawn along the pegs in straight line (Figs. 18 and 20).
- The distance between the rows or two ropes should be 50 cm (about the length of the metal portion of crocodile machete) (Figs. 18 and 19).
- The seeds should be sown within the rows or along the rope at the distance of at least 15 cm (about one third of the length of the metal portion of crocodile machete) (Fig. 19).
- Sticks measured at these lengths should be cut and used for the layout and planting (Fig. 19).
- One seed should be planted per hill.
- Sowing should be done when the rains have come to stay.

Fig. 18. Rope planting

Fig. 19. 50 cm stick for measuring distance between rows (top) and 15 cm stick for planting distance within rows (bottom)

Fig. 20. Planting along ropes

Sighting Pole Planting

- For sighting pole layout, three poles (Fig. 21) are needed to obtain a straight line.
- Two of the poles are placed at opposite ends (Fig. 22) and the third positioned in between (Fig. 23) to obtain a straight line (Figs. 24 and 25).
- Sowing should be along the poles.
- Starting from the pole at one end, the pole is either moved to the left or right at a distance of 50 cm (distance between two rows) using the 50 cm reference stick (Figs. 19, 25 and 26 – arrowed).
- The 50 cm stick is thrown close towards the next pole to be used for the next marking of the distance and sighting of the pole (Figs. 27 and 30 – arrowed).

- The first position of the pole is marked with the foot and sowing is started with the 15 cm measured stick towards the next pole (Fig. 28).
- The procedure is repeated when the sower reaches the second (Fig. 29) and third poles (Figs 31.).
- At the end of the third pole all three would be in a straight line (Fig. 32) to continue with the procedure of sowing towards the opposite direction.
- The sighting pole layout as well as the sowing can be performed by one person without any difficulty.

Fig. 21. Three sighting poles to be used for layout

Fig. 22. Two sighting poles placed at opposite ends

Fig. 23. Placing third sighting pole in the middle to align the three in a straight line

Fig. 24. Three poles aligned in a straight line

Fig. 25. Distance between two rows measured from first pole using 50 cm stick (arrowed)

Fig. 26. First pole moved and fixed to end of 50 cm stick (arrowed)

Fig. 27. 50 cm stick thrown towards second pole (arrowed) and former position of first pole marked with the foot

Fig. 28. Sowing started with the 15 cm stick from the position marked towards second pole

Fig. 29. 50 cm marking (arrowed) and positioning of second pole

Fig. 30. 50 cm stick thrown ahead (arrowed) and sowing continued towards the third pole

Fig. 31. 50 cm marking (arrowed) and positioning of third pole

Fig. 32. Three poles aligned in a straight line at end of the third and procedure repeated towards opposite direction

Fig. 33. Improved line planting (using rope or sighting poles) to obtain optimum plant population (per sq. m)

Other Planting Patterns

- Some farmers ignore rope or sighting pole planting complaining that it is tedious.
- They plant haphazardly on ridges (Fig. 34), mounds (Fig. 35) or beds (Figs. 36 and 37) that may lead to low plant population.
- Others too plant at very close spacing leading to over population of the plants (Fig. 38).

Fig. 34. Ridges prepared for planting Groundnut (low plant population)

Fig. 35. Groundnut planted on mounds (low plant population)

Fig. 36. Groundnut planted on beds (low plant population)

Fig. 37. Groundnut planted on beds (per sq. m) – low plant population

Fig. 38. Overpopulated groundnut plants in a farmer's field (per sq. m)

Viral Diseases

J.N.L. Lamptey and F.O. Anno-Nyako

- The most important disease of groundnut is rosette, popularly referred to as ("kwata" in the local language by farmers). It is a complex of three viral components which are
  a) Groundnut rosette virus GRV) genus *Umbravirus*
  b) Groundnut rosette assistor virus (GRAV)
  c) A satellite RNA which depends on GRV for its replication.
- The virus is transmitted principally by aphids, *Aphis craccivora* Koch (Homoptera: Aphididae) (Fig. 66).
- For effective transmission all the three synergistic agents must be present in the plant.
- The virus can also be transmitted by grafting.
- The virus is, however, not transmitted by mechanical inoculation, by seed nor by pollen.

Symptoms

- The plants are infected when young and produce progressively smaller, chlorotic, twisted and distorted leaflets, shortened internodes and thickened stems. Affected plants especially those infected young are severely stunted (Figs. 39, 40, 41 and 42) and an entire field could be devastated by the disease (Figs. 40 and 42).

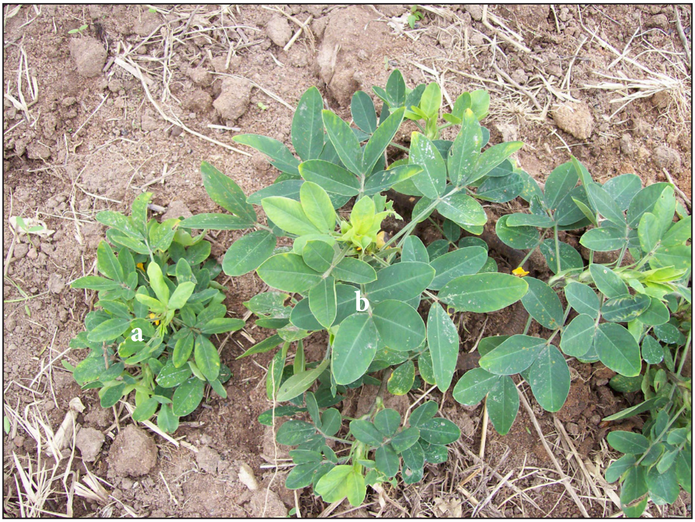


Fig. 39. Early rosette infected (a) and uninfected (b) groundnut seedlings

Fig. 40. Groundnut field heavily infected by rosette

Fig. 41. Close-up of advanced stage of groundnut seedling infected by rosette

Fig. 42. A section of large groundnut field devastated by rosette

Epidemiology

- The virus could cause up to 100% yield loss in susceptible varieties or cultivars such as *Konkoma* during years of severe epidemic (Fig. 43).

Fig. 43. Pod load (unfilled pods) of rosette – susceptible local groundnut cultivar (*Konkoma*)

Management

- Use resistant varieties such as CSIR – CRI *Otuhia* (Fig. 44) or CSIR – CRI *Adepa* as sustainable management option of the disease.
- Other management strategies are:
  a) Sow early to reduce disease incidence.
  b) Plant in rows at optimal densities to ensure adequate groundcover to reduce aphid invasion of crops; aphids are attracted by brown soil spaces uncovered by green plants.
  c) Irrigate crops during drought; factors related to stress including drought increases severity of disease.
  d) Practise crop rotation to reduce disease pressure.
  e) Use local soaps such as *Alata* (1 g/L of water) or *Amonkye* (2 g/L of water) soap to control aphid vectors. The soap should be thoroughly mashed and dissolved in the water (Fig. 45) and the solution sprayed with a knapsack sprayer wetting the plants when the weather is clear.

Fig. 44. Pod load (fully filled pods) per plant of rosette-resistant improved groundnut variety (CSIR-CRI *Otuhia*)

Fig. 45. Preparing local soap for spraying groundnut field

Fungal Diseases

J.K. Twumasi

- The most important fungal diseases of groundnut are leaf spot and rust.

Leaf Spots (also called *Cercospora* leaf spot or Tikka disease): There are two types:

i) Early leaf spot (causal agent: *Mycosphaerella arachidis* Deighton – conidial state: *Cercospora arachidicola* Hori) (Figs. 46 and 47).

Fig. 46. Groundnut field infected by early leaf spot

Fig. 47. Close-up of groundnut leaves infected by early leaf spot

ii) Late leaf spot (causal agent: *Mycosphaerella berkleyii* (W.A. Jenkins – Conidial state: *Cercosporidium personatum* Berk. & Curt) Deighton (= *Phaeoisariopsis (Cercospora) personata* Berk. & Curt. V. Arx) (Fig. 48).

Fig. 48. Groundnut leaves infected by late leaf spots

Damage

- The two species of the fungus generally attack the leaves (Figs. 46, 47 and 48), but stems and petioles (Figs. 49 and 50) as well as pods may also be affected.
- Severe infection causes defoliation (Figs. 49 and 50) and consequently results in reduced yield potential because of reduced photosynthetic activity.
- Immature pods of infected plants do not fill properly, thereby reducing yield.

Fig. 49. Groundnut stems infected by *Cercospora* leaf spots in a farmer's field

Fig. 50. Close-up of groundnut stems infected by *Cercospora* leaf spots

Symptoms

- The first symptoms of leaf spot disease are small pale spots on the lower surface of the leaflets. These spots soon turn yellow on the upper surface and later necrotic in the centre of the lesion.
- In early leaf spot, the circular to irregular lesions immediately form a yellow halo at the margins and produce spores mostly on the upper surface (Figs. 46 and 47). The mature spots are reddish-brown to black on the upper surface (Figs. 46 and 47) and brown to tan on the lower surface.
- The lesions of late spot are dark brown to black on both surfaces and produce the yellow halo only as they mature (Fig. 48). The spores are formed mostly on the lower surface.

- The early type appears 3-4 weeks before the late type, although they often overlap and are found in the same field during the season.

Disease Cycle and Epidemiology (Biology)

- The fungi over-season primarily in infected plant debris.
- Sporulation and infection are hastened by moisture and high temperatures.
- The spores are disseminated mainly by wind and when they land on wet leaf surfaces of healthy plants under favourable conditions, infection takes place.

Management

- Spray the foliage with fungicides such as Mancozeb®, Benomyl®, Bavistin® and Tridermorph®, using recommended rates.
- The systemic fungicides should not be used for more than 3-4 years since the pathogens have been found to develop resistance or tolerance to them after prolonged used.
- Practise three-year rotations.
- Apply cultural practices which induce vigorous plant growth such as proper fertilization and weed control.
- Apply sanitation to get rid of infected plant debris.
- Use resistant varieties (Fig. 51)

Fig. 51. Leaf spot-resistant (left and right) vrs susceptible (middle) groundnut varieties

Rust

Causal agent: *Puccinia arachidis* Spegazzini.

- First recorded in the former U.S.S.R. in 1910 and then in China in 1934, groundnut rust now occurs wherever the crop is grown.
- It is a serious foliar disease causing up to 50% yield loss.
- In conjunction with leaf spots, it can cause losses of 70% or more in susceptible varieties.
- In addition to the direct yield loss, rust can lower seed quality by seed size and oil content.

Symptoms

- The first symptom of groundnut rust is the appearance of yellow-orange pustules on the surfaces of leaflets (Fig. 52). The pustules enlarge and rupture, exposing brown uredinospores. As disease develops, the affected leaflets become chlorotic, then necrotic, and finally they may wither and may fall off.

Fig. 52. Groundnut leaves infected by rust

Disease Cycle

- Rust inoculum can come from various sources. They are:
  - Rust – infected crops
  - Rust – infected volunteer plants
  - Infected crop debris
- Spores can be transferred to the seed only at shelling.

- High relative humidity and air temperatures of 29-30°C favour build-up of groundnut rust.
- Light and anaerobic conditions have an adverse effect upon spore germination which is also inhibited by high concentrations of spores.

Management

- Apply suspensions of Bavistin®, Mancozeb® and Tridemorph®, using recommended rates.
- Enforce quarantine regulations (to restrict diseases into and spread within the country).
- Use resistant varieties.

Nematodes

K. Osei

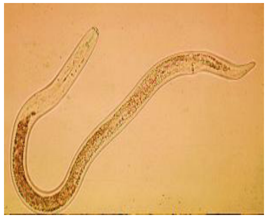
Nematodes are generally microscopic worms in the soil, plant tissues, water bodies and animals including man.

- Most nematodes cannot be seen with the naked eyes.
- Those that attack cultivated crops are called plant parasitic nematodes.
- However, they cause considerable yield losses in crops (Fig. 54), robbing the farmer of his income.

They are not readily seen and thus, their existence and the damage they cause to crops are frequently overlooked. They have therefore been appropriately nicknamed "the framers' hidden enemy."

- Nematodes that are potential pests to groundnuts are many but in southern Ghana, those found associated with the crop include; the stubby root nematode (*Paratrichodorus* spp. – Fig. 53a), root lesion nematode (*Pratylenchus* spp. –Fig. 53b), ring nematode (*Criconemella* spp. – Fig. 53c), root knot nematode (*Meloidogyne* spp. – Figs. 53d and 53e) and spiral nematode (*Helicotylenchu*s spp. – Fig. 53f). *Paratrichodorus* spp. transmit viral diseases. Rhigonematids, non-plant parasitic nematode, could be found in the gut system of millipedes collected from the rhizosphere of groundnut plants.
- Pod load of groundnut infested by nematodes e.g. *Meloidogyne* spp is seriously reduced (Fig. 54).
- Rhigonematids, non-plant parasitic nematode species were extracted from the gut system of millipedes sampled from the rhizosphere of groundnut plants.
- Nematodes were also processed from weeds sampled from groundnut fields particularly; *Verona cinerea, Brachiaria distichophylla* and *Panicum maximum*.

a. Stubby root nematode (*Paratrichodorus* spp.) Courtesy: S. Kumari



b. Root lesion nematode (*Pratylenchus* spp.) Courtesy: Thierry Vrain

c. Ring nematode (*Criconemella* spp.) Courtesy: J. Eisenback

d. Root-knot nematode (J2 Meloidogyne spp.) Courtesy: R. Erwin & H. Overmars

e. Root-knot nematode Female (*Meloidogyne* spp.) Courtesy: B. Pembroke

f. Spiral nematode (*Helicotylenchus* spp.) Courtesy: Tesa Mekete

Fig. 53 (a-f). Some of the nematodes associated with groundnut in Ghana (Photographs taken under the microscope)

Fig. 54. Pod load of groundnut plants uninfected (left) and infected with 1000 (middle) and 2000 (right) juveniles of *Meloidogyne* sp.

Management

Strategies employed for management of plant parasitic nematodes are numerous. They include:

- Exclusion (Preventing the introduction and spread of nematodes)
- Cultural and physical methods (Rotation of crops, fallows, flooding, trap crops, and antagonistic plants)
- Host plant resistance
- Organic amendments
- Soil solarization
- Biological control
- Chemical control

Exclusion

- Avoid the spread of Nematodes from farm to farm through infected planting material, farm machinery and footware.
- Use nematode-free planting material.

- Frequently clean farm machinery and footware to reduce infestation.

Rotation of crops

- Use rotational crops such as cotton and bahia grass that are non-hosts, poor hosts or antagonistic to nematodes.

Fallows

- Use fallow to manage nematode populations by starvation.
- Fallow periods of three or more years are effective.

Trap crops

- Grow trap crops which are susceptible to parasitic nematodes and follow promptly by physical destruction or herbicide treatment at the appropriate time before nematode reproduce.

Antagonistic plants

- Use antagonistic plants such as the African marigold, *Tagetes erecta*, Crotalaria species, *Crotalaria spectabilis* and *C. retusa* and the Velvet bean, *Mucuna pruriens* (very common in Ghana) that produce anti-helminthic compounds.

Host resistance

- Use groundnut cultivars such as "CSIR-Otuhia" and "CSIR-Yenyawoso" which are resistant to nematodes.

Biological

- Use biological agents such as the bacterial parasite, *Pasteuria penetrans*, the fungal egg pathogen, *Paecilomyces lilacinus* and the nematophagous fungus, *Pochonia chlamydosporia* to control nematodes.

Chemical

- Use nematicides such as Aldicarb® or Carbofuran® for the management of nematodes in groundnut fields.

Weeds

G. Bolfrey-Arku

- Weeds, most often associated with crop production, ties up a large percentage of economically active people engaged in agriculture due to its detrimental effect on crops. However, they are still the most under rated crop pests in crop production. This manual, thus seeks to change the notion of weeds as normal pests.
- Major weeds in groundnut field are assessed using a quadrat (sampling unit with definite size) that can be rectangular (Fig. 55), circular or square. The quadrat (Fig. 55 arrowed) is placed randomly in the field where weed infestation is representative. The weeds present are sorted out, counted and identified.
- The major weeds in Ghana include: False groundnut (*Arachis pintoi* Krap. and Greg. – Fig. 56), wild poinsetia (*Euphorbia heterophylla* L. – Fig. 57), Flor de conchitas (*Centrosema pubescens* Benth – Fig. 58), Tropical Kudzu (*Pueraria* sp. – Fig. 59), speargrass (*Imperata cylindrica* (L.) Beauv. – Fig. 60 and 61), purple nutsedge (*Cyperus rotundus* L. – Fig. 62), siam weed (*Chromolaena odorata* (L.) R.M. King and H. Robinson – Fig. 63), itch grass (*Rottboellia conchinchinensis* (Lour) W. Clayton – Fig. 64) and tropical spiderwort (*Commelina bengalensis* L. – Fig. 65).
- The weeds could smother the plants when poorly managed (Figs. 57 and 60) causing drastic reduction in grain yield.
- Some weeds (e.g. *C. odorata*) harbour insect pests such as *Aphis* spp. that may transmit the groundnut rosette virus disease.
- Others too affect the quality of the kernels. For example, the rhizome of *I. cylindrica* may piece through the groundnut kernels making them unattractive and also creating points of ingress by disease pathogens such as *Aspegillus* spp. that produce mycotoxins.

Fig. 55. Assessing major weeds in groundnut with a rectangular quadrat (arrowed)

Fig. 56. False groundnut

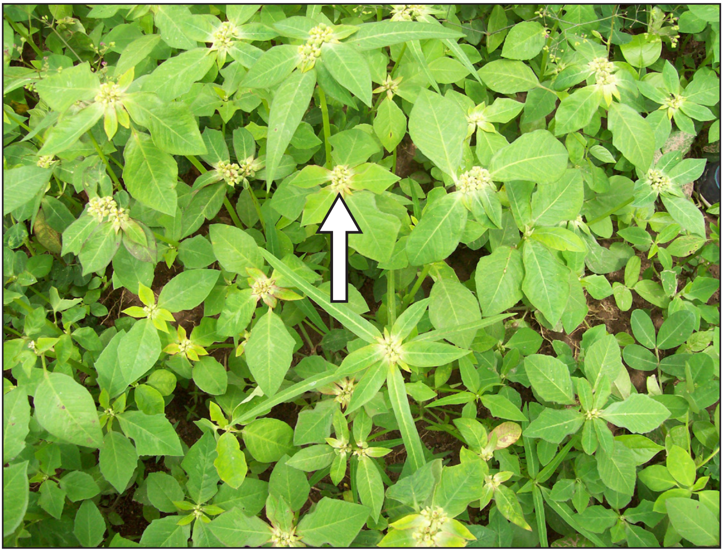


Fig. 57. Wild poinsetia (arrowed)

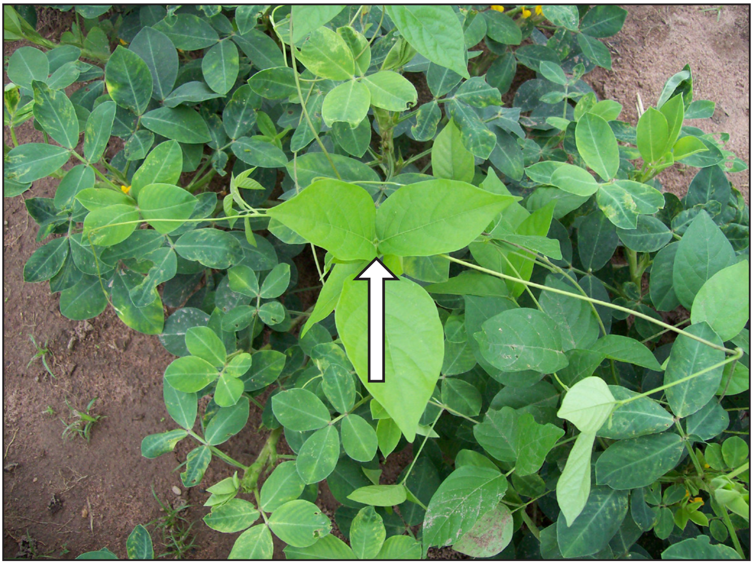


Fig. 58. Flor de conchitas (arrowed)

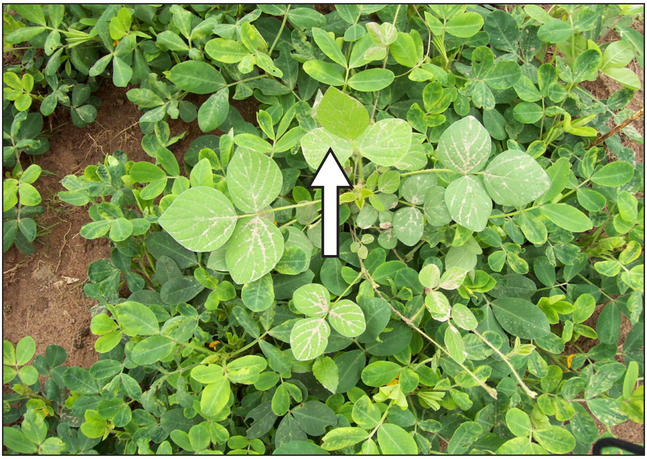


Fig. 59. Tropical Kudzu (arrowed)

Fig. 60. Scattered spear grass (arrowed)

Fig. 61. Close-up of spear grass

Fig. 62. Purple nut sedge

Fig. 63. Siam weed

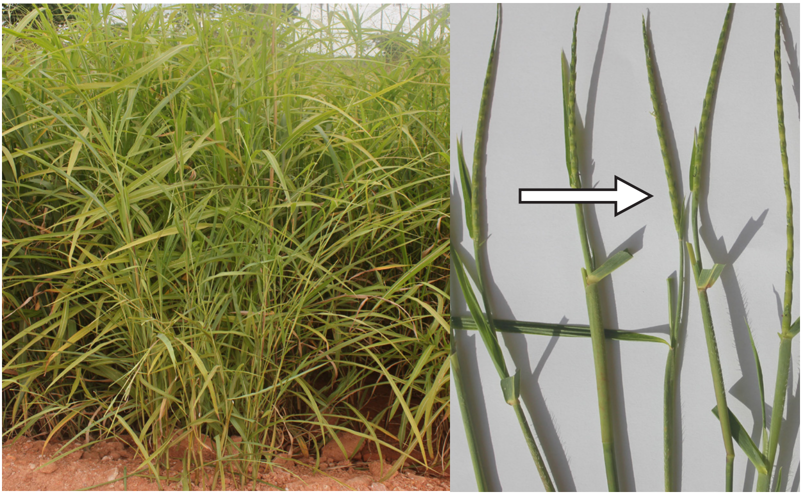


Fig. 64. Cluster (left) and inflorescence (right-arrowed) of Itch grass

Fig. 65. Close-up (left) and cluster (arrowed-right) of Tropical spiderwort

Management

- Weed control is most important in the early stages of crop growth.
- Ensure weeds do not produce seeds before management.
- Control weeds at the critical periods of three to six weeks after planting. Do not hoe after this period.
- Do hand pulling of the few weeds that appear afterwards since hand weeding may disturb the pegs.
- Use weed-tolerant varieties e.g. spreading types such as CSIR – CRI *Otuhia* that smoother weeds.
- Gather and burn or bury stubborn weeds such as *C. bengalensis* to reduce subsequent infestation.
- Practice crop rotation to prevent build-up of weeds.
- Use appropriate herbicides for difficult to control weeds.

Foliar and Soil Arthropod Pests

M. Owusu-Akyaw, M.B. Mochiah, J.V.K. Afun, J. Adu-Mensah, I. Adama, H. Braimah and B.W. Amoabeng

- Groundnut is attacked by several foliar and soil arthropod pests that may drastically reduce the yield of the crop. The damage caused by and management of these pests are described below:

Foliar Arthropods

- Major foliar groundnut pests are aphids – *Aphis craccivora* Kock (Homoptera: Aphididae).
- They are the vectors of groundnut rosette virus disease (GRVD– Figs. 39(a), 40, 41 and 42), groundnut mottle virus (GMV) and groundnut stripe virus (GSV).
- Both adult and nymphs of aphids suck sap mostly on growing tips, young foliage and flowers (Fig. 66) causing stunting and distortion of the foliage and stem.
- Serious damage is caused during drought when the crop is young.
- Winged adults are formed among the wingless ones when the population increases to a certain limit.
- The winged forms fly away to form new colonies. They secrete a sticky fluid (honeydew) on the plant which is turned black (sooty mould) by a fungus.
- Heavy rainfall promotes the development of the sooty mould that kills the plants.
- Aphids reproduce without mating. Individual adults are capable of producing about 100 nymphs in their 5-30 day life span.

Fig. 66. Aphid-infested groundnut plant (ref: Wightman and Ranga Rao, 1993)

Management

- Manage habitat to encourage predators including coccinellids (ladybirds) and a number of parasites to contribute to aphid management.
- Apply dimethoate at 200-250 ml a.i. per hectare when all terminal buds are infested, no ladybirds can be found and with at least 7-10 aphids per plant.
- Destroy all volunteer groundnut plants and weed hosts.
- Use aphid-resistant varieties.
- Physical factor, such as heavy rainfall reduces aphid population.

Soil Arthropods

Groundnut is attacked by several soil arthropods. Notably among them are white grub – *Lachnosterna* spp (Coleopterea: Scarabeidae – Fig. 69), millipede (Myriapoda: Diplopoda – Fig. 70), symphilid (Myriapoda: Symphyla – Fig. 71), red ant (Hymenoptera: Formicidae – Fig. 72), termite – e.g. Microtermes or *Macrotermes* spp. (Isoptera: Termitidae – Fig. 73), earwig – *Anisolabis* spp. (Dermaptera: Forficulidae – Fig. 74), wireworm or click beetle (Coleoptera: Elateridae – Fig. 75) and mealybug (Homoptera: Pseudococcidae – Fig. 76).

- Assess soil arthropods (Figs. 67 and 68) and avoid fields with very high populations.

Fig. 67. Digging soil for arthropod assessment

Fig. 68. Examining and counting arthropods from dug-soil on plastic trail

Fig. 69. White grub

Fig. 70. Millipede

Fig. 71. Symphilid

Fig. 72. Red ant

Fig. 73. Termite – *Macrotermes* spp.

Fig. 74. Earwig

Fig. 75. Wireworm

Fig. 76. Mealybugs (whitish organisms on pods)

Damage

The damages caused by soil arthropods are as follows:

- White grubs – Damage roots, pods and seeds.
- Millipedes – Bore into pods (Fig. 77) and feed on seeds.
- Symphilids – Feed on roots, pegs, young pods and seed.
- Red ants – Bore into the pod and damage the seeds.
- Termites – Feed on roots, stem and haulm that cause withering and death of the entire plant (Fig. 79); bore into pods and feed on seeds (Fig. 77); scarify pods (Fig. 78) that become fragile and, therefore, shatter or crack during harvest making them prone to invasion by aflatoxin-producing fungi.
- Earwigs – Damage pods and seeds (Fig. 80)

- Wireworms – Damage roots, pods and seeds (Fig. 81).
- Mealybugs – Suck sap from pods (Fig. 76) and damage seeds.
- Generally, damage to seeds by soil arthropod pests could promote fungal infection or mouldiness (Fig. 91) and aflatoxin development.

Fig. 77. Holes in pods damaged by termite or millipede

Fig. 78. Pods scarified by termite

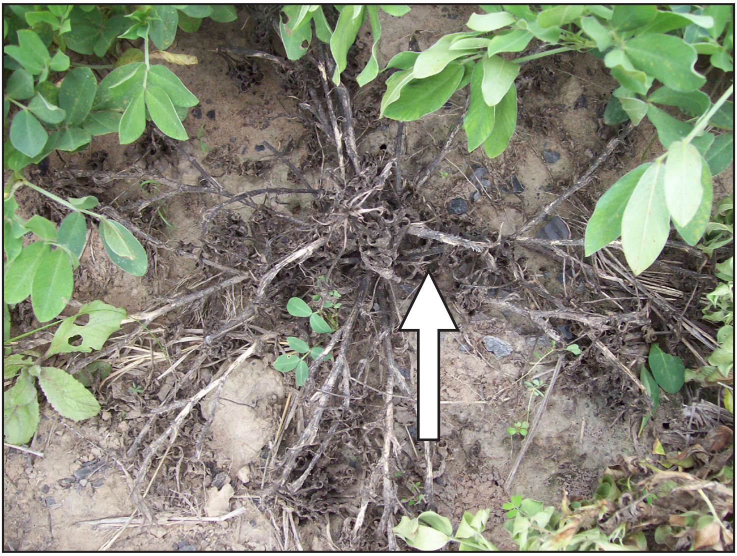


Fig. 79. Dead plant (arrowed) caused by termite damage

Fig. 80. Seeds damaged by earwig (ref: Wightman and Ranga Rao, 1993)

Fig. 81. Seeds damaged by wireworm (ref: Wightman and Ranga Rao, 1993)

Management

- Use pesticide such as Chlorpyrifos 48 EC at the rate of 20 ml in a litre of water per five metre row at planting to manage arthropod pests below economic injury level to obtain optimum plant population (Fig. 82) as against poor germination when untreated (Fig. 83).
- Enhance the build-up of populations of predators such as black ants – (Hymenoptera: Formicidae) (Fig. 84) through sugar-baiting and centipedes (Myriapoda: Chilopoda) (Fig. 85) that manage soil arthropods.
- Use granulated sugar at the rate of 150 gm per furrow along 5 m row as an environmentally safe method to bait black ants that manage soil arthropods.
- Destroy termite mounds and the queen where available.
- Generally management of soil arthropod pests reduces the risk of infection by aflatoxin – producing fungi.

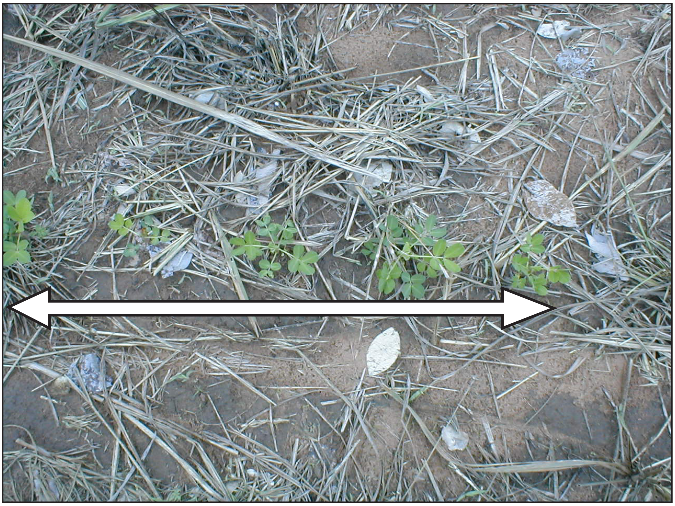


Fig. 82. Good germination (5 seedlings) per metre row of seeds planted on pesticide-treated soil (arrowed)

Fig. 83. Poor germination (one seedling) per metre row of seeds planted on untreated soil (arrowed)

Fig.84. Black ant

Fig. 85. Centipede

Storage Pests

M. Owusu-Akyaw and M. B. Mochiah

- Stored groundnut is susceptible to attack by storage insects.
- The degree of susceptibility depends on whether it is shelled and the extent to which pods or kernels are damaged before being stored.
- Insect infestation causes loss in dry mass of the kernels, increased levels of fatty acids in the oil (thereby lowering the quality) and reduction in seed germination.
- The major groundnut storage pests in Ghana include the groundnut borer or groundnut weevil – *Carydon serratus* (Olivier), Coleoptera: Bruchidae; rust-red flour beetle – *Tribolium castaneum* (Herbst), Coleoptera: Tenebrionidae; rice moth – *Corcyra cephalonica* (Stainton), Lepidoptera: Pyralidae; and tropical warehouse moth – *Ephestia cautella* (Walker), Lepidoptera: Pyralidae.

Carydon serratus

- *C. serratus* has large prominent eyes and can easily be distinguished from other storage pests by its broad hind femur.
- It is regarded as the only species that is capable of penetrating intact pods to infest the seeds. It lays eggs on pods and seeds (Fig. 86).

Damage

- After hatching of the eggs attached to the pod, the larvae penetrate the unshelled nut, eat and destroy the seed inside (Fig. 87).
- The larvae often migrate to the bottom of a stack or heap before pupating.

- Damage caused by subsequent generation is, therefore, often heaviest in bottom of the stack.
- Adult emerges leaving an escape "window" on the pod (Fig. 86).
- *C. serratus* infestation causes loss in dry mass of the kernel and increased level of free fatty acids in the oil.
- The quality and germination potential of the infested seed are reduced.
- Mould formation could be enhanced and that could lead to the risk of aflatoxin contamination.

Fig. 86. Eggs laid on pods and seeds by *C. serratus*, and exit holes on pod (ref: Wightman and Ranga Rao, 1993)

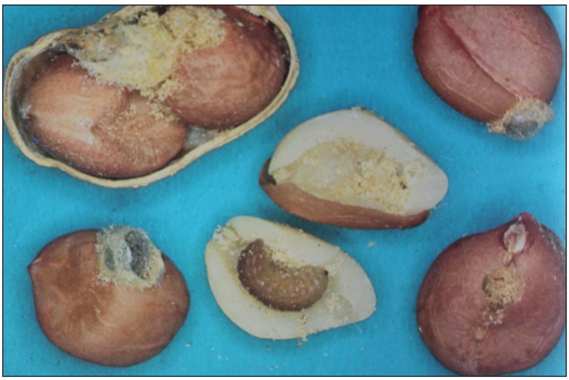


Fig. 87. Seeds damaged by *C. serratus* (ref: Dick, 1987).

Tribolium castaneum

- *Tribolium castaneum* is a secondary pest because it is not capable of infesting sound pods.
- The adult female, therefore, lays in cracks in the testa or holes in the kernel.

Damage

- A lot of powder is produced among the damaged seeds (Fig. 88). Larvae and adults are predators of eggs of other storage pests and are also cannibalistic.

Fig. 88. Powder produced by *Tribolium castaneum* among damaged seeds (ref: Dick, 1987).

Corcyra cephalonica

- *Corcyra cephalonica* adults do not feed on groundnut. The female lays eggs among the produce.

Damage

- The larvae are mobile, damage intact kernels and feed both on the surface and within the seeds.
- They spin a cocoon which may be distinguished from those of other moth species by its opague white appearance and extreme toughness.
- The cocoon webs together kernels, frass, and cast larval skin (Fig. 89).
- Heavily infested bulk of kernels could be lifted easily by hand.
- The quality and market value and germination of such damaged seeds are completely reduced (Fig. 89).

Fig. 89. *Corcyra cephalonica* damage to and webbing of seeds (ref: Dick, 1987)

Ephestia cautella

- *Ephestia cautella* is smaller than *C. cephalonica* but both have similar life cycle and damage to kernels.

Management

Storage pests of groundnut could be managed by several methods.

These include:

- Store in the pod since most storage pests cannot penetrate the pods.
- Maintain low moisture content between 11-12% to reduce rate of insect development.
- Fumigate with aluminium phosphide tablet at the rate of one 3 gm tablet per 50 kg of kernel and cover with gas sheet for 72 hrs without affecting seed viability
- Spray with insecticide such as Actellic Super EC at the rate of 10 ml per 180 ml of water for 100 kg of pod to control storage insect pests.
- Store intact (unbroken) seeds which are not mouldy.
- Avoid storage of seeds for a long time to ensure good germination.
- Arrange bags on wooden stack to prevent direct contact with the floor and absorption of moisture.
- Seal cracks and spray floor, walls and wooden stacks with insecticide such as Actellic Super EC at the rate of 10 ml per 180 ml of water before loading produce
- Make sure that the roof of the warehouse is intact and do not leak.
- Generally, good warehouse hygiene and organization should be followed.

Characteristics of Elite Groundnut Lines

M. Owusu-Akyaw, M.B. Mochiah, I. Adama, G. Bolfrey-Arku, K.Osei and J.N.L. Lamptey

- Based on their characteristics (Tables 1a and 1b), five promising groundnut lines were selected from 30 that had been tested both on-station and on-farm since 2002. They were ICGX SM 87057, ICGU 88709, RRR-MDR 8-16, GK 7 HIGH OLEIC and F MIX 20 – 1 – 45).
- The five were further tested using Adepa and Konkoma as standard and local checks respectively and two of them, ICGX SM 87057 (CSIR-CRI-*Yeyawoso*) and ICGU 88709 (CSIR-CRI-*Otuhia*), were released by the Variety Release Committee in 2012 for cultivation throughout Ghana.
- Seeds of the two varieties are being multiplied by seed producers for distribution to farmers.

Table 1a: Characteristics of Elite Groundnut Lines Evaluated at Seven Locations in Ghana from 2002 to 2010

Lines	Plant type	Pod length (cm)	Diameter (cm)	Seed colour	Seeds per pod	Reaction to weeds	Reaction to nematodes
ICGX SM 87057	Semi erect	3.0	1.3	Dark Red	2	Succumb	Resistant
ICGV 88709	Creeping	2.7	1.2	Brown	2	Suppress	Resistant
RRR-MDR 8-16	Semi erect	2.8	1.3	Brown	2	Succumb	Resistant
GK 7 HIGH OLEIC	Creeping	2.7	1.3	Brown	2	Suppress	Resistant
F MIX 20 – 1 – 45	Creeping	2.9	1.3	Brown	2	Suppress	Resistant
ADEPA (Released/ Standard)	Semi erect	3.0	1.2	Brown	2	Succumb	Resistant
KONKOMA (Local check)	Semi erect	2.3	1.1	Light Brown	2	Succumb	Susceptible

Table 1b: Characteristics of Elite Groundnut Lines Evaluated at Seven Locations in Ghana from 2002 to 2010

Lines	Reaction to virus	Reaction to rust	Reaction to early leaf spot	Reaction to late leaf spot	Maturity (days)	100 Seed weight gm	Yield Kg/ha
ICGX SM 87057	Resistant	**Resistant**	Resistant	Moderately Resistant	90	42.0	1555 – 2748
ICGU 88709	Resistant	Resistant	Resistant	Resistant	105	52.1	1440 – 2404
RRR-MDR 8-16	Moderately Resistant	Resistant	Resistant	Resistant	105	43.4	1363 – 2495
GK 7 HIGH OLEIC	Resistant	Resistant	Resistant	Resistant	105	42.6	1248 – 2228
F MIX 20 – 1 – 45	Moderately Resistant	Resistant	Resistant	Resistant	105	43.0	1255 – 2292
ADEPA (Released/ standard)	Resistant	Moderately Resistant	Moderately Resistant	Moderately Resistant	105	40.8	1051 – 2409
KONKOMA (local check)	Susceptible	Susceptible	Susceptible	Susceptible	90	35.3	895 – 1638

Seed Production

E.A. Asiedu, M. Owusu-Akyaw and M.B. Mochiah

Field Isolation

- To reduce the level of off-types due to volunteer plants, field selected for seed production must not have been planted to another variety during the previous year or season.
- Since groundnut is a self-pollinated crop, a minimum isolation distance of 5 m is adequate.

Seed Selection and Treatment

- In order to maintain seed viability throughout the entire storage period, dry seeds must be kept in pods until the farmer is ready to plant.
- Seeds must be shelled by hand, or by mechanical means but with care to avoid breakage and damage to seed coat that may affect germination.
- Sort the seeds (Fig. 90) and select fully filled ones without wrinkles, with no sign of mechanical or insect damage or discoloration (fungal infection) (Fig. 91)
- To avoid loss of stand due to insect damage and rodents, seed must be treated with an appropriate seed dressing chemical (which are normally coloured red or blue) just before planting (Fig. 92). These chemicals are available at reputable agro-chemical shops with dosages written on their labels.

Fig. 90. Sorting seeds before planting

Fig. 91. Split (left), shrivelled and coloured (middle), and mouldy seeds (right).

Fig. 92. Demonstrating chemical seed treatment before planting

Seed Bed Preparation and Planting

- Conventional tillage could be adopted by ploughing and harrowing. In some cases ploughed fields may be ridged to improve drainage and control weeds.
- Soil that is fairly sandy, such as that found in the Transition zone of Ghana, ploughing may not be necessary.
- Groundnut requires 550 mm of rainfall to reach maturity.
- Seeds could therefore be planted in the major (April/May) and/or the minor (August/September) seasons.
- Rows are spaced at 40 cm apart and plants within rows spaced at 20 cm with one seedling maintained per hill.
- This will result in a plant population density of 125,000 plants/ha, with the seed requirement of approximately 50 kg/ha.

- Preferably the seed crop must be planted in the minor season to take advantage of the dry season for drying.

Fertilizer Application

- Groundnut is capable of fixing atmospheric nitrogen for its use.
- It may be planted in fields where maize and cowpea had earlier been planted to take advantage of the residual soil nutrients, particularly nitrogen, phosphorus and potassium (NPK).
- Where neither maize nor cowpea had earlier been planted, minimum fertilizer may be applied at 20:50:20 (NPK) kg/ha to stimulate nodule formation and enhance vegetative growth and pod formation.
- Apply minimum Calcium and Boron to enhance seed development and vigour.

Weed and Insect Pest Management

- Plough and harrow fields to help initial weed management and expose some soil arthropods for predation or dehydration.
- One hand weeding could be done 2-3 weeks after planting before the canopy closes.
- Trap or use chemical means to manage common pests in groundnut including millipedes, several insects, rodents (squirrel and mice) and birds (pigeons and partridges).

Rouging

- Rouging entails the removal of all undesirable crop plants and weeds in the seed production field, so as to achieve the desired varietal, genetic and physical purity (Fig. 93).

Fig. 93. Rouging to remove volunteer plants

- Rouging thus entails the removal of off-type plants and plants that have been infected by disease or infested by insect pests.
- Off-type plants can be identified by differences in plant architecture, growth habits, maturity period and susceptibility to foliar diseases (*Anthracnose* and leaf spot) and pests.
- Problem weeds, such *Rotboelia* sp. (Fig. 64) should be removed, as well since their seeds can mix with the desired crop seed and transferred to other farmers' fields.

Harvesting, Drying and Storage

- Harvesting must be done immediately at physiological maturity.
- Leaf fall or drying is not indicator of maturity.

- The recommended method is to pull up five plants at random, remove and shell the pods, examine the inside of the shells and if darkened, the groundnut is mature (Fig. 94).
- The dark colouration coincides with the characteristic maturity period of the variety.

Fig. 94. Colouration inside Groundnut pod as indicator of maturity – less (left) to fully (right) matured pod

- Harvesting must be done by pulling the haulm.
- Care must be taken to retrieve all pods in the soil and not to damage the pods.
- Pods damaged during harvesting will predispose the seeds to storage fungi, including aflatoxin-producing pathogens e.g. *Aspergillus flavus* which causes health-risk contamination of the seeds.
- After picking, the pods must not be heaped (Fig. 95) since this will cause fungal development that can result in the production of harmful compounds such as aflatoxin.

Fig. 95. Freshly – harvested groundnut heaped before drying

- Detached pods must subsequently be dried either by spreading in mild sun (Fig. 96) or by mechanical means to reduce moisture content down between 8 and 10%.

Fig. 96. Air drying of freshly – harvested groundnut

- After drying, undamaged pods must be packaged in 50 kg bags and labelled, particularly with information such as variety name, germination percentage and seed moisture content, before storage.

- Packaged pods must be stored in a ventilated warehouse or in the cold room and sampled periodically to determine any changes in quality.
- Storage warehouse must be well ventilated to avoid fungal infection.
- Fumigate pods with phostoxin at the rate 3 gm tablet per 50 kg of kernel and cover with gas sheet for 72 hrs or spray with Actellic Super EC at the rate of 10 ml per 180 ml of water for 100 kg of pod to control storage insect pests.
- Bait with recommended rodenticides to manage rodents in the warehouse.

Shelling

- Shelling can be done manually by hand or mechanical means.

Manual Shelling

- Pods can be threshed manually by hand-splitting (Figs. 97 and 98) which is very slow, tiresome and painful as well as causing development of sores on the fingers especially when the pods are cracked on stones (Fig. 98).

Mechanical Shelling

- Can be done using the full belly sheller (Fig. 99) (courtesy: Peanut CRSP, ACDI/ VOCA and Joost Brender A. Brandis) which is less cumbersome and faster than the former method.

Fig. 97. Shelling of groundnut by hand

Fig. 98. Cracking of groundnut on stones

Use of Full Belly Sheller

- Put considerable quantity of the groundnut into the receptacle of the sheller.
- Rotate the handle of the sheller counter-clockwise.
- Collect threshed kernels in a container under the sheller.
- To reduce breakages, seeds of different sizes should not be shelled together since the machine is set according to seed size.
- Care must be taken to avoid damage to the seed coat, radicle (protrusion at the base) and the embryo since such damage would predispose seed to fungal infection and development of aflatoxin.
- Do not use sheller to thresh seeds for planting since the radicle and embryo could be damaged resulting directly in loss of germination.
- After threshing, unwanted materials, including inert matter, wrinkled, discoloured and damaged or broken seeds must be removed (Fig. 91).
- Use of the machine may result up to 7% breakages.
- It takes about 60 minutes to shell 100 kg of pods with this device as against about 72 hours per person by hand.

Fig. 99. Demonstration to farmers of mechanical threshing of groundnut with the Full Belly sheller.

Note: Shelled kernels poured into a container (right)

Economics of Adopting IPM Production Practices

A.A. Dankyi

Introduction

Although farmers are interested in yield and food security, they are equally concerned about the costs and returns on the production of their crops. Whether they market little or most of their produce, farmers are also interested in the economic returns accruing from their production activities. They are cost-conscious and will consider the cost of changing from one practice to another and the economic benefits associated with it. Quite often, farmers have complained of high cost of production and related low prices of their produce. A study that examined the production costs of IPM Farmer Field School (FFS) participants and Non-Farmer Field School (Non FFS) on groundnuts showed that adopting IPM practices saved more labour; obtained higher yields and therefore more income and food reserve for the households.

Labour Savings and Returns

Table 2 summarizes the major labour used in groundnut production between IPM-FFS farmers and Non – FFS farmers in southern Ghana. FFS farmers used less labour in all the key operations than their Non-FFS counterparts and saved 25.5 person-days of labour for all the similar operations.

Table 2: Costs and Benefits for Representative FFS and Non-FFS Groundnut Farmers

Practice	Person-days/ha (Mean)		
	FFS	Non-FFS	Difference
Clearing	15.00	19.00	4.00
Row planting	14.25	16.75	2.50
Hoe weeding	20.00	26.75	6.75
Harvesting	25.75	33.50	7.75
Shelling	3.75	8.25	4.5
Total labour	78.75	104.25	25.5
Benefits			
Farmers' average **Total Output/ha** (Unshelled in maxi-bags)	27.25	12.75	14.5
Returns to labour ratio	6	1	

Source: CRI/NCSU groundnut cost of production survey, 2006

Unshelled maxibag of groundnut = 87 kg (Source: MoFA office, Ejura, 2006) GH¢1.96 = $1. Data represent 150 farmers from 7 villages in Ejura, Ashanti region

Reasons for Reduced Labour Use

Clearing: FFS farmers had been taught on site selection and therefore chose appropriate sites for their groundnut production making clearing cheaper.

Row Planting: The use of sighting poles made planting in rows easier for FFS farmers. Further, the choice of proper soil characteristics and properties made planting also easier. FFS farmers had been taught proper soil selection.

Hoe Weeding: Good land preparation methods reduce weed pressure and FFS farmers were taught how to properly prepare their lands for planting peanuts such as minimum tillage and the use of herbicides. Good soil selection also complemented the control of weeds and made hoe weeding easier for FFS farmers.

Harvesting: Although FFS farmers had higher outputs, harvesting was easier because of good soil conditions that resulted from land preparation and weed control. Thus less labour was used by FFS farmers compared with non-FFs farmers.

Shelling: It was expected that since FFS farmers had more yield, labour for shelling would have been higher than the Non-FFS farmers but rather, it was the opposite. FFS farmers had been taught how to properly dry their groundnuts by spreading out in the shade for proper drying. Non-FFS farmers often heaped their groundnuts creating some moist conditions that probably made it more difficult to crack or shell the groundnuts by hand. Thus, more labour was needed to shell produce from Non-FFS farmers than was required for FFS farmers.

Production (Output): The output per hectare from the FFS farmers was more than twice that of the Non-FFS (Table 2), a clear indication of the benefit of adopting IPM practices in groundnut production.

Returns: With lower labour costs and higher output, it was not surprising that FFS farmers received higher net benefits than their fellow Non-FFS farmers. The net benefit for FFS farmers was nearly five times that of the Non-FFS farmers. The return to labour was in a ratio of 6:1 for FFS farmers.

Conclusion: Adopting IPM practices on groundnuts had positive returns for farmers because more labour was saved and at the same time, higher yields were obtained. Therefore, farmers are encouraged to use IPM practices.

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